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Course: Fundamentals of Environmental Science Contents UNIT 1: Basic concepts of Environmental Science .... 1 UNIT 2: Components of Environment .... 12 UNIT 3: Man, society, and environment .... 33 UNIT 4: Current Environmental issues .... 58 Netaji Subhas Open University P.G. Environmental Science PGES-CC-101

1 UNIT 1: Basic concepts of Environmental Science 1.1 Objectives 1.2 Introduction 1.3 Definition of Environment 1.4 Scopes of Environmental science 1.5 Principles of Environmental science 1.6 Environmental Ethics and Philosophy 1.7 Environmental education 1.8 Environmental awareness and education 1.9 Green politics 1.10 Summary 1.11 Questions/ Self-Assessment questions 1.12 Select Readings/ Suggested Readings 1.1 Objectives After successfully completing this unit, you will be able to: • define the environment and the types of environments • learn the different scopes of environmental sciences • learn the importance of environmental education and its goals • understand the green politics running all over the world 1.2 Introduction Environmental issues like pollution, global warming, ozone layer depletion, acid rain, deforestation, and desertification have been top-of-mind for scientists, decision-makers, and the general public over the last 40 years. These issues are seen as the biggest dangers to the earth's ability to support life, making our continued existence on the planet increasingly risky. A comprehensive awareness of how our environment supports life as well as a deep comprehension of the dynamics of these issues are necessary to address these concerns. Since no other academic field completely fulfils the aforementioned two knowledge needs, environmental science emerged as a field of study to fill this void. The ecosystem that sustains life and the numerous environmental issues are extremely complex and can only be understood via interdisciplinary research. As a result, environmental science combines methods from diverse academic fields to achieve its goals.

2 1.3 Definition of Environment The word "environment" comes from the French verb environ, which meaning to surround or encompass. Environment is the sum total of water, air, and land, as well as the relationships they have with one another, with humans, with other living things, and with property. According to the description above from the Environment Act of 1986, the term "environment" refers to all of the surrounding physical and biological elements as well as their interactions. 1.3.1 Various types of environments According to Kurt Lewin, environment is of three types which influence the personality of an individual as under: (a) Physical Environment, (b) Social and Cultural Environment, and (c) Psychological Environment. 1. Physical Environment: Physical environment refers to geographical climate and weather or physical conditions wherein and individual lives. The human races are greatly influenced by the climate. Some examples are as under: (a) In the cold countries i.e., European countries the people are of white colour. Likewise, in Asian and African countries, that is, in hot countries people are of dark complexion. (b) The physique of an individual depends on climate conditions as the individual tries to adjust in his physical environment. (d) The human working efficiency also depends on the climatic conditions. 2. Social Environment: Social Environment includes an individual's social, economic and political condition wherein he lives. The moral, cultural and emotional forces influence the life and nature of individual behaviour. Society may be classified into two categories as under: (i) An open society is very conductive for the individual development. (ii) A closed society is not very conductive for the development. 3. Psychological Environment: Although physical and social environment are common to the individual in a specific situation. Yet every individual has his own psychological environment, in which he lives. Kurt Lewin has used the term 'life space' for explaining psychological environment. The Psychological environment enables us to understand the personality of an individual. Both the person and his goal form psychological environment. If a person is unable to overcome the barriers, he can either get frustrated or completed to change his goal for a new psychological environment. But adopting this mechanism, the individual is helped in his adjustment to the environment. 1.3.2 Definition of Environmental science Environmental science is characterized as an interdisciplinary academic field that combines various academic disciplines (especially the sciences) to study the composition and operation

3 of our environment that sustains life and to comprehend the causes, consequences, and solutions to various environmental issues. Environmental science, in other terms, is the scientific study of all the elements or variables that make up or have an impact on the biophysical environment that supports life. According to some academics, environmental science is a methodological study of the environment that looks at all the biophysical conditions and anthropogenic situations that an organism lives in. 1.4 Scopes of Environmental science Numerous fields of development can benefit from the principles and methodologies of environmental sciences. As part of the subject, several areas are studied. Environmental science has a broad reach because it deals with a variety of topics or problems connected to our intricate biosphere. The subject's scope can be summed up in terms of its main areas of application and associated career options. The management of natural resources, the preservation of ecosystems and biodiversity, and the avoidance and control of pollution are the three main areas where the topic can be used. Additionally, environmental science is crucial in addressing a range of large-scale, complicated environmental problems, such as ozone layer loss, energy shortages, desertification, urbanization, population growth, and others. The subject has a pretty broad scope in terms of employment options. Environmental science has been associated with a variety of job prospects during the past 20 years. The following are some of the major career opportunities in the field: i. Industries: Businesses must demonstrate compliance with a number of environmental standards. Environmental experts are therefore required to direct industries in the adoption of clean technology, the management of pollution, the disposal of waste, and the performance of environmental audit. ii. Consultancy: Governments, businesses, and non-governmental organisations (NGOs) hire environmental consultancies to conduct various laboratory or field research that are frequently needed for environmental impact assessments (EIA) and other compliance procedures. iii. Research and development (R&D): Research and development opportunities in this field include examining the origins and effects of various types of pollution. Future clean and efficient technology development is also included. Among the typical career profiles are those of scientists, researchers, and analysts. iv. Academics: Environmental science is covered in practically every course from elementary school to graduate school. To meet this need, a considerable number of academics or teachers are needed. v. Green marketing: To sell eco-friendly products, skilled labour is needed. Marketing strategies are also including environmental quality certifications like ISO-14000, which expands job prospects. vi. Green media: Both print and electronic media need a lot of experienced workers if they are to successfully raise environmental consciousness. Articles on environmental themes are frequently published in a number of periodicals and

4 newspapers, such as Down to Earth, a publication of the Centre for Science and Environment. vii. Green advocacy: Environmental attorneys are increasingly important in ensuring that environmental standards, legislation, and programmes are implemented correctly. A common citizen is given the ability to litigate against any anti- environment activity through public interest litigation (PIL). viii. NGOs: The majority of environmental programmes are currently carried out by NGOs with funding from domestic and international organisations. Some examples of environmental NGOs include Green-peace, CI, WWF, CSE, CEE, TERI, Tarun Bharat Sangh, and Vatavaran. ix. Government employment: A variety of traditional positions are open in the government's departments and agencies, including the environment ministry, pollution control boards, national parks, and biosphere reserves. x. International organizations: To carry out projects relating to the environment, organisations like the World Bank, UNEP, IUCN, and TSBF need skilled human resources. 1.5 Principles of Environmental science Environmental science is an interdisciplinary field that draws on several facets of the biological, chemical, earth sciences, physical, and economic sciences. As a result, it cannot be governed by the rules of just one discipline. Almost all pertinent principles of physical, biological, and earth science can be used to describe different phenomenon environmental science. The ecosystem concept, however, may be regarded as the cornerstone of environmental science. The socioeconomic, philosophical, legal, and ethical principles are frequently employed to address social and environmental problems. The 'Noosystem' ideas of Barrett (1985) have only lately been applied to the analysis of complex ecological issues that take into account socioeconomic factors. The Noosystems integrates biological, socioeconomic, and physical phenomena holistically. 1.6 Environmental Ethics and Philosophy The study of environmental ethics focuses on how morality affects how people interact with the environment and its non-human inhabitants. It addresses concerns pertaining to individual rights and responsibilities that are essential to the existence and welfare of the current human civilization, foreseeable futures (of humans), and other living things on the planet. As a discipline, environmental ethics developed in the 1970s. However, American ecologist Aldo Leopold (1887–1948) is credited as being a major contributor to the advancement of contemporary environmental ethics. Traditional ethics are distinct from environmental ethics because the latter only addresses interpersonal relationships. The following three key causes have led to an increased need for environmental ethics: a. Since modern technological society has had a significant negative impact on nature, it is important to examine the ethical implications of human behaviour.

5 b. As knowledge develops, so does our awareness of the natural world and environmental issues. Additionally, this expanding knowledge is posing fresh moral dilemmas. c. The need for environmental ethics is also growing as a result of our growing moral concern that all living things have an equal right to exist on the planet. We frequently have to consider concerns that contrast human welfare with the welfare of other organisms in both daily life and developmental projects. Should we, for instance, continue to clear forests for human development while doing so at great expense to the wildlife community? In many fields, including law, sociology, theology, economics, geography, and management, similar issues are addressed. These difficult questions have answers, or at least attempts to have answers, in environmental ethics. Two worldviews are frequently noted when responding to these questions: the anthropocentric worldview and the eco-centric worldview. According to the anthropocentric worldview, man is the most powerful and superior creature on planet. The power to control nature is in man's hands. On the other side, the ecocentric worldview claims that "Nature has given us all the resources for leading a wonderful life, and she nourishes us like mother." She deserves our respect and nurturing. Environmental ethics supports an ecocentric viewpoint and suggests a number of rules to aid our decision-making in pressing circumstances. Following are important rules that are generally accepted: i. The earth exists for the good of humanity, thus we ought to cherish and revere it. ii. It is not within our power to grab everything on Earth for our own needs. iii. We shouldn't put ourselves above all other living things and we don't have the right to exterminate them. Every species has a natural right to exist. iv. We should use the earth's resources sparingly so that everyone can share in their use and enjoyment. v. We ought to refrain from wasting resources, especially on destructive weaponry. vi. Since they give us food and a variety of other essentials for life, plants and animals deserve our gratitude. vii. We shouldn't take away the right of future generations to live in a healthy, secure, and resourceful environment. viii. We should adhere to or believe in different ethical systems or faiths that teach us valuable lessons on how to treat other living things. 1.7 Environmental education The relationships between creatures, the environment, and all the elements that affect life on earth are discussed in environmental education. These elements include atmospheric conditions, food chains, the water cycle, etc. Because it is fundamental science concerning our planet and its daily operations, it is significant for everyone.

6 1.7.1 Environmental education's goals The primary goal of environmental education, according to UNESCO-UNEP (1978), is to help a person develop a rational understanding of local and global communities and to motivate him to get involved in finding solutions to environmental problems. i. Awareness: to assist people and social groups in developing awareness and sensitivity to environmental issues and related issues. ii. Knowledge: to give them exposure to a range of experiences and to give them a fundamental grasp of the environment and the issues that surround it. iii. Attitudes: to encourage children to develop a set of values, feelings of environmental concern, and the drive to actively participate in environmental conservation and improvement. iv. Skills: to assist students in learning how to recognize and solve problems. v. Participation: to give people and social groups the chance to actively participate in efforts to address environmental challenges at all levels. 1.7.2 Scopes of Environmental education The scopes of the discipline of environmental education are numerous and multilayered. Not just for kids, but for everyone, this study is crucial and required. The following is a summary of the scopes: 1. The study raises people's awareness of the different renewable and non-renewable resources in the area. The study analyses the endowment or potential, patterns of utilization, and the balance of various resources that are available for use in the future in the state of a nation. 2. It disseminates information on ecological systems and causal connections. 3. It offers crucial knowledge on the abundance of biodiversity and potential threats to the various types of plants, animals, and microbes in the ecosystem. 4. The study makes it possible to comprehend the origins, impacts, and mitigation strategies for natural and artificial catastrophes (such as floods, earthquakes, landslides, cyclones, etc.). 5. It enables one to weigh different approaches to addressing environmental problems before deciding on a different course of action. 6. The study equips environmentally literate persons with the knowledge necessary to make sound judgements and decisions for the preservation and enhancement of the environment. 7. The study highlights issues with overpopulation, health, hygiene, etc. and the contribution of the arts, sciences, and technology to eradicating or at least lessening social ills. 8. The study looks for and develops native eco-friendly skills and technology to address diverse environmental problems. 9. As resources are passed down from our ancestors to the new generation without losing their quality, it teaches the population the importance of sustainable resource use.

7 10. The study facilitates the application of theoretical knowledge and the many applications of the environment. 1.7.3 Need for Environmental education The following factors lead to the necessity for environmental protection and the justifications for environmental education: i. Because the environment is the foundation of all life, it needs to be properly managed and cared for. ii. Many issues that pose a threat to human survival could develop if the environment is consistently attacked. iii. The environment should be passed on to future generations as a part of our cultural heritage. iv. To avoid the extinction of specific environmental elements like plants and animals, some resources of the environment should be handled on a sustainable basis. v. In order to encourage healthy living, it is necessary to improve the sanity and aesthetic value of our environment. vi. The environment must be protected for its own sake because it is a part of nature. 1.7.4 Guiding Principles of Environmental education 1. Take into account the environment as a whole, including with built, natural, technical, and social structures (economic, political, technological, cultural, historical, moral and aesthetic). 2. The goal of environmental education is to save lives continuously (starting in preschool and continuing through all official and informal phases). 3. The approach to environmental education should be interdisciplinary. 4. Analyze significant environmental concerns from a local, national, and global perspective. 5. Current and upcoming environmental conditions will be emphasised in environmental education. 6. Encourage local, national, and worldwide cooperation as a necessary component of environmental problem prevention and resolution. 7. Incorporate environmental factors into your development and growth plan. 8. Strengthen students' ability to decide for themselves about their surroundings and take accountability. 9. Provide students the opportunity to study about the signs and possible causes of environmental issues. 10. Help the students' capacity for critical thought and problem-solving growth. 11. Use various learning environments and teaching methods to learn about and teach about the environment, with a focus on first-hand knowledge.

8 1.8 Environmental awareness and education Environmental awareness is skills required to be environmentally responsible are developed through environmental education, which fosters environmental literacy. The initiatives of environmental education can raise public awareness of, concern for, and knowledge about environmental issues as well as the critical thinking, problem-solving, and decision-making abilities necessary to make decisions that are environmentally responsible. So, environmental education ought to be a specialized subject within the sciences in secondary school. It can be regarded as a separate field within education, environmental studies, environmental science, and engineering at the undergraduate and graduate levels. Environmental education is not only taught in the classroom. Children can acquire knowledge about their world in a variety of ways. From classroom sessions to reading environmental wall charts and posters, going on field trips to national parks, and taking part in sustainability projects at the whole school. The topic of environmental education is one that is widely and freely available. It has been determined that this manual and accompanying wall chart are useful teaching resources for environmental education. Adopting sustainable practices in the classroom and public areas is crucial. Parents and children should also be encouraged to incorporate environmental education into their daily lives. 1.8.1 Importance of environmental awareness Because of the effects that humans have on the environment, environmental awareness is essential. We harm forests with our logging operations, pollute rivers and lakes with our waste, and poison the air with pollutants from companies and automobiles every day. All of this has a detrimental effect on the environment and may ultimately result in major issues like climate change. To preserve and protect our planet: The Earth is our home and the only place we have to live, thus it must be preserved and protected. There won't be somewhere else for us to go if we don't take care of it. Our earth must be protected for coming generations. To protect wildlife: Due to habitat loss, pollution, and climate change, wildlife is in danger all around the world. We can assist lessen these dangers and safeguard the animals we care about by increasing our environmental awareness. To Combat and Fight Against Climate Change: One of the most significant environmental problems of our day is climate change. Many factors, including greenhouse gas emissions from companies and automobiles, are to blame. We may contribute to a reduction in the effects of climate change by lowering our own emissions and increasing public awareness of it. 1.9 Green politics A relatively new political movement called "green politics" prioritises protecting the environment and all of its diverse species. When crises are believed to be long-lasting and systemic, new social and political movements start to emerge. The environmental crisis, which is actually a series of connected crises brought on by population growth, air and water pollution,

9 the destruction of tropical and temperate rain forests, the rapid extinction of entire species of plants and animals, the greenhouse effect, acid rain, ozone layer depletion, and other now familiar instances of environmental degradation, is the crisis out of which the broadly based Green movement has emerged. Many are unintended consequences of technology advancements like the internal combustion engine. But, these environmental concerns have a variety of cultural and political roots in addition to scientific ones. They are a result of attitudes and beliefs that elevate or separate humans from nature. All three of the major popular political ideologies—liberalism, socialism, and conservatism—perceive nature as either a hostile force that must be subdued or as a resource that must be used for human ends, notwithstanding their differences. In essence, they all have a bias that is anthropocentric, or human-centered. The contemporary environmental or "Green" movement counterpoints these viewpoints with one of its own. Many Greens prefer to refer to their viewpoint as an environmental ethic rather than a political philosophy. Aldo Leopold and other earlier ecologists discussed a "land ethic." Others, like Hans Jonas, speak of a developing "planetary ethic," while others, like Christopher Stone, speak of an ethic that has the earth as its focal point. Despite variations in accent and emphasis, all are similar in a number of crucial ways. According to them, an environmental or ecological ethics would have a number of essential components. Secondly, such an ethic would underline the web of links and interdependence that all species, including our own, are a part of. A respect for all life, regardless of how small humans may perceive it to be, develops from this realisation of interconnectivity because our species' fate is intertwined with theirs. The third element is that we have a responsibility to respect and care for the environments that foster and support life in all of its varied forms since life depends on particular conditions to survive. Because nature sustains her species inside a complex web of interconnected conditions, harming one component of this web puts the survival of the organisms that depend on it in jeopardy. Green thinkers contend that because of the great influence humans have on nature, our species has a special need to use our influence responsibly. Greens draw attention to the fact that human choices and deeds today have an unparalleled impact on the fate of the planet and all of its inhabitants. For nature depends on our care, discipline, and patience just as much as we do. The population of the planet and the ecosystems that support them may be wiped out by humans using nuclear weapons in a matter of minutes. This leads to the fourth characteristic of a "green" political outlook: Greens must oppose militarism and promote peace. Yet in addition to a thermonuclear war on a global scale, the ecosystem is slowly being destroyed, putting the planet in jeopardy. Such damage is the result of both large-scale policies and small-scale, routine actions. However, since we live in a democracy, everyone of us also bears a portion of the blame for the results of our collective acts and cumulative consequences. Each of us has the power to influence the laws that govern our daily lives. For this reason, Greens place equal emphasis on both our individual and social obligations to safeguard the environment that shields us. Hence, highlighting the significance of educated and engaged democratic citizenship at the local level serves as the fifth characteristic of the Green political perspective. Thus, "Think globally, act locally" is a Green maxim.

10 The majority of Greens concur on this. Yet, there are also a number of unsolved approach, emphasis, and political strategy disagreements. The internal ideological spectrum includes various anarchist ideologies, deep ecology, ecofeminism, social ecology, bioregionalism, New Age Gaia worship, and other groupings, each of which differs from the others in a variety of ways. It also includes "light green" conservationists and "dark green" radicals. Among them are disagreements over the fundamental principles that underpin and drive the green movement. Some New Age Greens desire a spiritual or religious foundation for their environmental ethic. According to them, we ought to view the planet as a kind and compassionate deity—the goddess Gaia, named after the Greek word for "earth"—that deserves to be revered and feared. We can free ourselves from the limiting rationality that defines contemporary science in this way. Some Greens disagree with such a spiritual or religious bent, saying that such convictions are politically harmful and opposed to the logical scientific reasoning needed to identify and address environmental issues. Additional distinctions relate to the political approaches and methods that the environmental movement will use. Some believe that Greens ought to actively participate in electoral politics, perhaps even creating a Green Party in the manner of Greens in Germany. Most have embraced other tactics, such as collaborating with already-established mainstream parties (notably the Democratic Party in the United States) or paying lobbyists to influence legislation, because they are aware of the significant difficulties minority third parties must overcome. The earth and its inhabitants, in the opinion of yet other Greens, hardly represent a special interest and are better served by acting outside of conventional interest group politics. Others, like social ecologists, promote neighborhood-based, grassroots campaigns that include friends, family, and fellow residents in the fight to preserve the environment. Some social ecologists are anarchists who want the state to be eventually replaced by a decentralised system of communes and cooperatives because they view the state and its pro-business and pro-growth policies as the issue, not the solution. According to "bioregionalist" greens, such social and political order should be founded on biological or natural boundaries and areas rather than artificial or political ones. All Greens concur that it is crucial to enlighten and educate the people, but they vary on the most effective way to accomplish this. Other organisations, like Greenpeace, encourage dramatic direct action meant to garner media attention. Even more radical organisations, like the Sea Shepherd Organization and Earth First!, have backed monkey-wrenching as a morally acceptable strategy for drawing attention to and condemning environmental activities. 1.10 Summary Environment, everything that’s surrounds us. it can divide into physical, social and psychological environment. Environmental science is an interdisciplinary field that draws on several facets of the biological, chemical, earth sciences, physical, and economic sciences. Student after educated as environmentalist can work in different fields in industry, education, social science marketing as well as management sector. Environmental education is a prime

11 concerned subject to create environmentalist and safeguard the mother earth. it follows some goals and guiding principles. Four pillars of green politics, namely, social justice, grass-roots democracy, non-violence, and respect for diversity, have become more or less established principles of the Indian political parties. The integration of the environmental dimension of green politics, consisting of the twin pillars of ecological wisdom and sustainability, is in an evolutionary phase. It is likely that increasingly this integration will reflect the views of the growing Indian middle class. The middle class, with a reasonable level of education, information base and income level, has views on environmental issues. These views may be different from those of ecological refugees or empty-belly environmentalists, but may have an edge over other views because of the opinion-maker role that the middle class plays. Parties will get feedback on their environmental policies from the electoral battlegrounds and adapt them suitably. 1.11 Questions/ Self-Assessment questions 1. What is environment? What are the different types of environments? 2. Describe the scope of environmental science. 3. Briefly describe the goals of environmental education. 4. What is the importance of environmental awareness? 5. What do you know about the green politics 1.12 Select Readings/ Suggested Readings • Environmental science by Sovan Roy • Concept of ecology by Kormondy E.J • Environmental science by S.C. Santra • ENVIRONMENTAL SCIENCES: SCOPE AND IMPORTANCE (2015) by Jagadamba Prasad, R.S. Khoiyangbam, and Navindu Gupta In book: Introduction to Environmental Sciences • Chapter: Environmental Sciences-Scope and Importance Publisher: TERI Editors: R S Khoiyangbam and Navindu Gupta • Environmental science by YK singh NEW AGE INTERNATIONAL (P) LIMITED, PUBLISHERS (2006) • “Environmental science education” by Pannerselvam, A and Mohana Ramakrishnan; Sterling publication, New Delhi. (2005). • Environmental Education and Awareness manual by Dr. M. A. Nwachukwu (2014) LAP-LAMBERT publishing house

12 UNIT 2: Components of Environment 2.1 Objectives 2.2 Introduction 2.3 Lithosphere 2.4 Hydrosphere 2.5 Atmosphere 2.6 Biosphere 2.7 Summary 2.8 Questions/ Self-Assessment questions 2.9 Select Readings/ Suggested Readings 2.1 Objectives After reading this unit, you will able to • describe the lithosphere and its importance • elaborate the hydrological cycle and its importance • identify the impacts of human activity which are affecting the hydrological cycle • learn different components of the atmosphere • stratify the atmospheric layers with their characteristics • learn about the biosphere and there characteristics 2.2 Introduction The physical, biological, and cultural components of the environment are believed to form an indivisible whole and to be interconnected in countless ways both individually and collectively. The opportunities and constraints that exist in a given human habitat are largely determined by the physical factors (including space, landforms, waterbodies, climate, soils, rocks, and minerals) that make up that habitat. The biosphere is made up of all living things, including plants, animals, microorganisms, and humans. The majority of what constitutes a society's culture (economic, social, and political factors) is shaped by humans. The four major components of environment include lithosphere, hydrosphere, atmosphere and biosphere, corresponding to rocks, water, air and life respectively.

13 2.3 Lithosphere A lithosphere, from-líthos means 'rocky', and 'sphere' is the rigid, outermost rocky shell of a terrestrial planet or natural satellite. On Earth, it is composed of the crust and the portion of the upper mantle that behaves elastically on time scales of up to thousands of years or more. The crust and upper mantle are distinguished on the basis of chemistry and mineralogy. The crust and topmost mantle are both parts of the lithosphere, which is the planet's firm, unyielding exterior covering. The thinner, cooler, and lower portion of the upper mantle, known as the asthenosphere, lies beneath the lithosphere. A variation in how each lithosphere and asthenosphere respond to tension defines their border. The asthenosphere deforms viscously and accepts strain through plastic deformation, whereas the lithosphere stays solid for very extended geologic time periods during which it deforms elastically and through brittle failure. Thus, it is believed that the lithosphere's thickness corresponds to the distance from the isotherm that marks the change from rigid to fluid behaviour. Due to the fact that olivine is typically the poorest material in the upper mantle, the temperature at which it becomes malleable (roughly 1,000 °C or 1,830 °F) is frequently used to establish this isotherm. The lithosphere is split into geological plates that are separated laterally and frequently contain terranes that have accumulated from other plates. Background concept The English mathematician A. E. H. Love first introduced the idea of the lithosphere—Earth's dense outer layer—in his 1911 monograph "Some Problems of Geodynamics." The idea was later developed by American geologist Joseph Barrell, who coined the term "lithosphere" and wrote a number of papers on the subject. The idea was founded on the observation of large gravitational imbalances over continental bedrock, from which he deduced that there must be a powerful, solid top layer (which he named the lithosphere) above a lighter layer that could move. (Which he called the asthenosphere). The Canadian scientist Reginald Aldworth Daly developed these concepts in his ground-breaking book "Strength and Structure of the Earth", published in 1940.[8] The majority of geologists and geophysicists believe them. The plate tectonics hypothesis depends on these ideas of a powerful lithosphere sitting on a feeble asthenosphere.

14 2.3.1 Oceanic Crust The topmost stratum of the marine geological zone is known as the oceanic crust. It is made up of the lower oceanic crust, which is made up of troctolite, gabbro, and ultramafic cumulates, and the higher oceanic crust, which contains pillow lavas and a dike complex. The hard topmost core stratum is covered by the crust. Oceanic lithosphere is made up of the bedrock and the hard top core stratum. Formation: Mafic minerals, or sima, which are abundant in iron and magnesium, make up the majority of the oceanic bedrock. It is usually less than 10 kilometres thick and lighter than continental crust, or SiAl. However, it is thicker, with a mean mass of about 3.0 grammes per cubic centimetre as opposed to 2.7 grammes for continental crust. The liquid formed from subsurface material below the plate cooled to form the top crust. Magma lenses are created when the magma is inserted into the center of expansion, which is primarily made up of partially formed crystal mush from prior injections. These lenses are the origin of the sheeted dikes that fuel the pillow lavas that are located above. Seawater frequently undergoes chemical modification as the lavas settle. These explosions mostly take place at mid- ocean ridges, but they can also happen at isolated sites and in extremely uncommon but potent events called flood basalt eruptions. However, the majority of lava crystallises at deep in the lower marine bedrock. There, freshly erupted lava can combine with already-existing crystal debris and minerals to interact with them. Life Cycle: • Mid-ocean ridges constantly produce new oceanic bedrock. Magma surges into the upper mantle and rock at these regions where tectonic plates separate. The freshly created boulders chill and begin to disintegrate as the tectonic plates shift away from the crest, and silt slowly begins to accumulate on top of them. The marine peaks are home to the earliest oceanic rocks, and as you move away from the ridges, the rocks get larger and older. The mantle cools and dissolves as it raises, and as the pressure drops, it passes the solidus. Only the rising mantle's temperature affects how much ice is generated. The marine bedrock is therefore uniformly dense (7 km). Thinner crust (4-5 km thick) is produced by very sluggish spreading ridges (1 cm/yr/half-rate), as the mantle has time to chill during upwelling and thus passes the solidus and melts at shallower depths, creating less melt and thinner crust. Lithospher e Oceanic Lithosphere Continental Lithosphere

15 • Known as convergent limits are where the marine lithosphere subducts. Oceanic lithosphere on one plate may be separated from oceanic lithosphere on another, or oceanic lithosphere on one plate may be separated from continental lithosphere on another. Due to the less thick continental lithosphere in the second scenario, the marine lithosphere always subducts. marine lithosphere that is ancient is consumed during the sinking process, so marine bedrock is rarely older than 200 million years. The Wilson pattern is a repetitive pattern of the formation and destruction of marine bedrock that results in the formation and destruction of supercontinents. The west Pacific and northwestern Atlantic have the earliest large-scale continental bedrock, both of which date back 180–200 million years. However, the eastern Mediterranean Sea, which is between 270 and 340 million years old, may contain fragments of the much ancient Tethys Ocean. 2.3.2 Continental Lithosphere The geographic continents and the small littoral regions near their coasts, referred to as continental margins, are formed by a stratum of volcanic, metamorphic, and sedimentary materials known as the continental crust. Because of its overall makeup, which is richer in aluminium silicates (Al-Si) and has a lower density than the marine crust, known as sima, which is richer in magnesium silicate (Mg-Si) rocks, this stratum is occasionally referred to as SiMa. Seismic wave velocity changes have revealed that there is a fairly marked difference between the more felsic higher continental crust and the more mafic lower continental crust at a particular level (the Conrad discontinuity). Formation: The continental crust is made up of numerous strata with a middle mass makeup (SiO2 wt% = 60.6). The mantle's ultramafic substance has a density of about 3.3 g/cm3, which is less dense than the continental crust's typical density of 2.83 g/cm3 (0.102 lb/cu in), according to research. The mass of continental crust is also lower than that of marine crust, which is approximately 2.9 g/cm3 (0.10 lb/cu in). Continental crust has a thickness of 25 to 70 km (16 to 43 mi), which is much denser than marine crust, which has an average thickness of 7 to 10 km. (4.3 to 6.2 mi). Continental crust makes up about 41% of the planet's surface area and 70% of its crustal capacity. Life Cycle: • The size, form, and quantity of continents are continuously shifting throughout natural time, in contrast to the stability of the continental bedrock. As part of a massive supercontinent cycle, various regions split apart, clash, and then recoalesce. • The continental crust is presently estimated to be 7 billion cubic kilometres (1.7 billion cubic miles) in volume, but this number fluctuates due to the character of the factors at play. The relatively brief lifespan of marine crust differs with the relative stability of terrestrial crust. Oceanic crust usually subducts back into the mantle when active edges of the two collide in subduction zones because oceanic crust is less thick than terrestrial crust. Rarely is continental bedrock subducted (this may occur where continental crustal blocks collide and overthicken, causing deep melting under mountain belts such as the Himalayas or the Alps). Because of this, the oldest rocks on Earth are found inside the

16 cratons or cores of the continents rather than in continuously recycled oceanic crust. The oldest intact crustal fragment is the Acasta Gneiss, which dates to 4.01 Ga, whereas the oldest large-scale oceanic crust is from the Jurassic (about 180 Ma), though there may be a few smaller older remnants in the Mediterranean Sea at around 340 Ma. The geological strata on and within the continental bedrock serve as the finest record of Earth's past. • Mountain range heights are frequently correlated with crustal thickness. This is due to the isostasy brought on by orogeny. (Mountain formation). The crushing pressures brought on by subsidence or tectonic impact thicken the rock. Gravity and weathering temper the forces of the collisional tension, which is what propels the rock upward. • Plate tectonic processes, particularly at convergent plate borders, are primarily responsible for producing continental bedrock and (much less frequently) destroying it. Additionally, deposition transfers terrestrial crustal material to marine crust. The partial melting of continental bedrock at subduction zones can add new material to the landmass by causing the lighter material to ascend as magma and create volcanoes. Additionally, when plate tectonic motions cause volcano island arcs, seamounts, or other similar structures to clash with the edge of the landmass, material may accrete laterally. Tectonic weathering of forearcs, delamination, and deep sinking of continental crust in impact zones are other processes that result in the loss of continental crust. Many theories of crustal growth are debatable, such as the rates of crustal growth and recycling, whether the lower and upper crusts recycle in different ways, and how much of Earth's history plate tectonics has been active and thus might have been the primary mode of continental crust formation and destruction. 2.3.3 Subducted Lithosphere According to geophysical research from the early twenty-first century, the lithosphere has been subducted into the mantle at depths of up to 2,900 km (1,800 mi), close to the core- mantle border, while other big chunks of the lithosphere "float" in the upper mantle. Others penetrate the mantle as far as 400 kilometres (250 miles) but stay "attached" to the continental plate above, which is comparable to the scope of the outdated "tectosphere" idea that Jordan reviewed in 1988. Deep tremors along the Wadati-Benioff zone show that subducting lithosphere is still unyielding at a depth of about 600 kilometres. (370 mi). 2.3.4 Importance of Lithosphere • Life requires the lithosphere to survive. The existence of this stony landscape is crucial to the health of Earth's ecosystem. Change is brought about by tectonic plates creating the lithosphere, and this change led to the emergence of modern civilization. • Mountains, volcanoes, and even continents are created as a result of continental plate movement. • In the long run, volcanoes and tremors produce rich soil and territories in addition to causing immediate devastation. These areas aid in the development of fresh life and flora.

17 • Over millions of years, the biotic remnants embedded in this lithosphere gradually transform. These biological substances transform into coal, natural gas, and oil, which fuel contemporary machinery. • Iron, aluminum, copper, calcium, magnesium, and other valuable materials and elements can be found in the lithosphere. These elements have been used by humans to create instruments and machines. • Last but not least, the lithosphere, along with the hydrosphere and atmosphere, is in charge of supplying nutrition to the Earth's animal life. Plants receive nutrition from the stratum, which they then transform into glucose. Higher creatures need this glucose to live. 2.4 Hydrosphere The term "hydrosphere" (derived from the Greek words "hydro" for "water" and "sphaira" for "sphere") The total quantity of water on, beneath, and above a planet, small planet, or natural satellite is. Despite being on Earth for roughly 4 billion years, the hydrosphere is still evolving. The water and ground are rearranged as a result of continental drift and seabed expansion. On Earth, there is 1.386 billion cubic kilometres (333 million cubic miles) of water, according to estimates. This includes water in its gaseous, liquid, and frozen states as soil moisture, groundwater, and permafrost in the Earth's crust (to a depth of 2 km); oceans and seas, lakes, rivers, and streams, wetlands, glaciers, ice, and snow cover on Earth's surface; vapour, droplets, and crystals in the air; as well as a component of living plants, animals, and unicellular organisms that make up the biosphere. Fresh water makes up only 2.5% of this total, while saltwater makes up 97.5%. Only 0.3% of the fresh water on Earth is in readily available lakes, ponds, and river systems. Of this fresh water, 68.9% is in the shape of ice and perpetual snow cover in the Arctic, the Antarctic, and mountain glaciers. 2.4.1 Hydrological Cycle The constant flow of water on, above, and below
the Earth's surface is referred to as the water cycle,
also known as the hydrologic cycle or the hydrological cycle. The amount of water on Earth stays relatively consistent over time, but how it is divided up into the primary sources of ice, pure water, salty water (salt water), and stratospheric water varies based on a variety of weather factors. Evaporation, transpiration, condensation, precipitation, penetration, surface discharge, and subterranean flow are the physical mechanisms by which water flows from one source to another, such as from a waterway to the ocean or from the ocean to the sky. As a result, the water transforms into liquid, solid (ice), and vapour. As the source of 86% of the world's runoff, the ocean is crucial to the water cycle. The energy exchange that takes place during the water cycle causes temperature variations. Water evaporation cools the atmosphere by absorbing energy from its environs. It emits energy and heats the surroundings when it condenses. The environment is affected by these thermal transfers.

18 1. Processes involved in Cycle The energy that the sun emits powers the water cycle. The ocean and oceans' water is heated by this energy. Water dissipates into the air as water vapour. Some snow and ice melts right into water vapour. Water moved by plants and drained from the earth is referred to as evapotranspiration. The chemical mass of the water particle, H_2O, is smaller than that of the two main gases that make up the atmosphere, nitrogen (N_2) and oxygen (O_2), and as a result, it is less thick. Because of the large mass differential, gravity causes damp air to rise. Air pressure declines and temperatures drop as height rises. (Gas laws). Water vapour condenses at the lower temperature into minuscule liquid drops that are heavier than the air and descend unless they are sustained by an updraft. While precipitation near the earth is known as fog, a significant accumulation of these drops over a wide region of the sky becomes visible as cloud. Processes – Advection – the atmospheric water vapour flow. Water that evaporated over the seas could not settle over land without advection. Advection is exemplified by atmospheric rivers, which transport significant amounts of water vapour over considerable distances. Canopy grab – Instead of dropping to the earth, the precipitation that is deflected by plant leaves ultimately dissipates back into the sky. Condensation – the process by which water vapour in the atmosphere changes to liquid water particles, producing clouds and fog. Deposition – This is the process of turning water vapour into ice right away. Evaporation –the process by which water passes from its liquid to gaseous states as it enters the atmosphere from the earth or other sources of water. Solar light is the main energy source for vaporisation. Even though they are collectively referred to as evapotranspiration, evaporation frequently tacitly encompasses plant transpiration. A total of 505,000 km3 (121,000 cu mi) of water is lost through evapotranspiration each year, of which 434,000 km3 (104,000 cu mi) is lost through evaporation from the seas. Over the water, 86% of the world's evaporation takes place. Infiltration –the movement of water into the earth from the top. The water becomes groundwater or soil wetness after it has filtered through.Although, not all soil wetness is similarly accessible for groundwater replenishment or for plant evaporation, new worldwide research using water stable isotopes demonstrates this. Percolation –Gravity causes water to move vertically through the earth and boulders. Precipitation –water vapour that has condensed and fallen to the Earth's surface. Rain makes up the majority of precipitation, but other types include snow, hail, cloud drop, graupel, and ice. Each year, rainwater totals 505,000 km3 (121,000 cu mi), with 398,000 km3 (95,000 cu mi) of that total falling over the seas. The amount of water that falls as rain on land each year is 107,000 km3 (26,000 cu mi), compared to 1,000 km3 for snowfall. (240 cu mi). Over the water, 78% of all precipitation on Earth happens. Runoff –the various methods that water traverses the earth. Both land overflow and canal runoff are included in this. The water that is flowing may percolate into the earth, dissipate into the atmosphere, collect in pools or ponds, or be taken out for use in agriculture or other human endeavours. Ice dissolve –the water generated by snowmelt.

19 Sublimation –Without going through the liquid state, the condition changes from solid water (snow or ice) to water vapour immediately. Underground movement –the movement of water in groundwater, the vadose zone, and subterranean streams. Subsurface water may ultimately percolate into the seas or return to the surface (for example, as a fountain or by being circulated). Under the influence of gravity or gravity-induced forces, water returns to the ground surface at a lower level than where it initially soaked through. Since groundwater moves and replenishes slowly, it can stay in reservoirs for countless ages. Transpiration – The airborne discharge of water vapour from earth and vegetation. On average, 577,000 km3 of water are exchanged annually on Earth. This is water that dissipates from the ground and the ocean's top (502,800 km3). (74,200 km3). 458,000 km3 of water descend on the seas and 119,000 km3 on land, the same quantity as air precipitation. The entire runoff of the waterways on Earth (42,700 km3/year) and the straight groundwater discharge to the ocean (2100 km3/year) are represented by the differential between precipitation and evaporation from the soil area (119,000 – 74,200 = 44,800 km3/year). These are the main sources of pure water for sustaining human needs and commercial activity. Figure 2.1: Hydrological cycle
20 2.4.2 Importance of Hydrosphere A fundamental requirement of existence is water. The Earth is also known as the blue world and the aquatic planet because it is covered by water in two thirds of its surface.The current state of the climate depends significantly on the hydrosphere. Oceans are significant in this context. The Earth's early atmosphere was identical to Mercury's current atmosphere in that it was extremely sparse and abundant in hydrogen and helium. Hydrogen and helium were later ejected from the environment. The Earth's current atmosphere was created from the chemicals and water vapour that were expelled as it chilled. Volcanoes also discharged other chemicals and water vapour into the atmosphere. The water vapour in the atmosphere collected as the Earth chilled and dropped as rain. As air carbon dioxide disintegrated into the rainwater, the atmosphere further chilled. As a result, the water vapour continued to concentrate and transform into rain. The seas were created when the Earth's top depressions were filled with rainwater. This took place, according to estimates, about 4000 million years ago. Oceans were where the first living forms emerged. None of these creatures breathed air. The process of converting carbon dioxide into sustenance and oxygen started later, when cyanobacteria developed. Because of this, Earth's atmosphere is notably different from the atmospheres of other worlds, which made it possible for life to develop there. 1. One of Humanity's Fundamental Needs Water is necessary for drinking, heating, cleansing, bathing, and even the operation of numerous businesses in addition to imbibing. Water is also essential for crops and the hydroelectric industry, which produces energy. A day without water is hard to fathom. 2. A Living Cell's Component Water is the primary constituent of all living things' bodies. It has been discovered that water makes up 75% of the cell. Water is a major factor in the majority of molecular processes that take place in cells. Lack of water makes it difficult for cells to survive. These water molecules are the only ones that plants use to transfer energy. 3. A Variety of Organisms' Habitat Numerous watery vegetation and creatures can be found in the hydrosphere as home. When compared to the amount of living things on earth, there are many more living things in water. Gases that are incorporated in water, like oxygen and carbon dioxide, are used by aquatic plants and creatures to survive. For their survival, they also need minerals like ammonium ions, nitrate, etc. 4. Controls the Temperature The hydrosphere's ability to help control the environment's climate is one of its key characteristics. The primary factor influencing this control is water's particular thermal capacity. Water requires time to warm up and calm down. Therefore, areas near sources of water, such as lakes and seas, prefer to have a regulated temperature. There might not be a great deal of variation in weather along the shore. controls the temperature of the environment while also controlling the temperature of all living things. 5. Existence of Atmosphere The current structure of the atmosphere is significantly influenced by the hydrosphere. Helium and hydrogen were present in the earth's atmosphere over 400 million years ago. The

21 temperature of Earth was around 600°C, and its atmosphere was very sparse, resembling that of Mercury today. Later, as the earth's surface chilled and as a consequence of numerous chemical processes, enormous quantities of water bodies and atmosphere were created. 2.4.3 Impact of Human Activities on Hydrological Cycle The water cycle is being severely impacted by the actions of contemporary civilization. The release of hazardous chemicals, nuclear materials, and other industrial pollutants, as well as the seepage of mineral fertilizers, pesticides, and herbicides into surface and underground water systems, disrupt the dynamic steady state. The condition of the hydrosphere is also being negatively impacted by heat pollution, inappropriate waste dumping, and accidental and intentional hydrocarbon release. 1. Eutrophication Aquatic systems have traditionally been categorised as either oligotrophic or eutrophic. The minerals nitrogen and phosphorus, which have minimal amounts in oligotrophic waterways, are not well nourished. Thus, photosynthesis in such waterways produces little organic matter. In comparison, eutrophic waterways are rich in nutrients, typically contain high concentrations of nitrogen and phosphate, and as a result of high biological output, also contain large concentrations of algae. Such watery environments typically have turbid waterways, and lakes and shoreline oceanic environments may have oxygen depletion at deep. Eutrophication is the process of high biotic output in watery environments as a consequence of increased fertiliser or organic matter intake. Because of the buildup of organic debris, this enhanced biological output for lakes typically results in a reduction in lake capacity. Natural eutrophication, as opposed to cultural eutrophication, which results from human involvement, happens as water systems fill in with organic matter. The latter is common in marine ecosystems that have been enhanced intentionally using extra fertilisers and organic matter from waste, farmland, and industry. 2. Acid Rain Acidification of rain and watery marine systems is a result of human actions, mainly the combustion of fossil fuels, which release sulphur dioxide and nitrogen compounds into the atmosphere. For the nations of western Europe and eastern North America, the issue of acid rain is well known on a global scale. Precipitation with a pH of less than 5.2 that comes from interactions involving gases other than carbon dioxide is referred to as acid rain. The formulae' general responses are what lead to this downpour. 3. Greenhouse Gas Formation The greenhouse gases, so named for their ability to capture heat in the atmosphere, are one issue that was caused by human activity and is unquestionably having an impact on the hydrosphere worldwide. Carbon dioxide has drawn a lot of notice among the atmospheric gases produced by human activity. According to measurements of carbon dioxide in air bubbles trapped in ice and the ongoing analysis of air samples taken at Mauna Loa, Hawaii, since 1958, the atmospheric concentration of more than 400 ppmv is roughly 45 percent higher than its 22 value of 275 ppmv from the late 1700s. (see also Keeling curve). The combustion of timber, coal, oil, and gas, as well as the slash-and-burn practises that go along with forestry practices, are the main causes of this rise. (as, for example, those adopted in the Amazon River basin). The ocean is the part of the hydrosphere that has been most significantly impacted by this carbon dioxide release. 4. Global Warming The hydrologic cycle may be further impacted by global warming due to the thawing of ice and snow in mountain glaciers, the Greenland and Antarctic ice sheets, and other frozen bodies of water, which would release water into the seas. During the 20th century, this process led to a gradual increase in sea level; it is anticipated that this process will continue throughout the 21st century, along with the heat growth of the seas brought on by global warming. Over the following several hundred years, the water level could increase by more than 3 metres (nearly 10 feet) if the West Antarctic Ice Sheet were to collapse. If all glacier ice melted, the water level would rise by more than 66 metres. (about 216 feet). 2.5 Atmosphere An atmosphere is a coating of gas or strata of gas that surround a planet and are kept in place by the gravity of the celestial body (from Ancient Greek: atmos, means "vapour, steam," and "sphaîra," "sphere"). When the gravitation is strong and the temperature of the atmosphere is low, a world maintains its atmosphere. The exterior area of a star, which contains the layers above the dark photosphere, is known as the stellar atmosphere; low-temperature stars may have outer atmospheres with complex molecules. Nitrogen makes up 78% of the atmosphere of Earth, along with oxygen (21%), argon (0.9%), carbon dioxide (0.04%), and minor elements. The majority of creatures use oxygen for breathing, while plants, algae, and cyanobacteria use carbon dioxide for photosynthesis. Lightning and bacteria bind nitrogen to create ammonia, which is then used to make DNA and amino acids. The atmosphere's stratified structure reduces the negative impacts of sunshine, UV radiation, the solar wind, and cosmic particles to shield living things from DNA deterioration. The biological alteration of the paleo-atmosphere by living creatures over billions of years is what led to the makeup of the Earth's environment as it is today. 2.5.1 Origin and Composition The local solar nebula from which a planet is created, as well as the later departure of some gases from the atmosphere's actual core, decide the original atmospheric makeup of an atmosphere. A spinning cylinder of gases that compressed onto itself and split into a number of separated bands of gas and matter, which subsequently compacted to create the planets of the Solar System, is thought to be the source of the planets' initial atmosphere. The main gases that make up the atmospheres of Venus and Mars are carbon dioxide, nitrogen, argon, and oxygen. The by-products of the species that the Earth supports decide the makeup of the atmosphere. Generally speaking, a varying quantity of water vapour is also present, with an

23 average concentration of about 1% at sea level. Dry air (a combination of gases) from Earth's atmosphere includes 78.08% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and remnants of hydrogen, helium, and other "noble" gases. The largest planets of the Solar System—Jupiter, Saturn, Uranus, and Neptune—have low temps and greater gravitation, which make it easier for them to keep gases with low molecule weights. These worlds have atmospheres made primarily of hydrogen and helium, with traces of other more complicated substances. 2.5.2 Layering System of Atmosphere Each stratum in the Earth's atmosphere has unique characteristics. These levels, which rise from the surface of the earth, are known as the troposphere, stratosphere, mesosphere, thermosphere, and exosphere. Over time, the exosphere progressively disappears into outer space. A. Troposphere The lowest part of the atmosphere on Earth is called the troposphere. It rises from the surface of the Earth to an average height of 12 km (7.5 mi; 39,000 ft), though this height fluctuates depending on the weather, from about 9 km (5.6 mi; 30,000 ft) at the geographic extremes to 17 km (11 mi; 56,000 ft) at the Equator. The tropopause, or layer of comparatively warm air above a layer of cooler air, is the border above the troposphere. In some locations, a temperature gradient marks this boundary, while in others it is indicated by an area that is uniform with height. Characteristics: (i) This is the atmosphere's base-most stratum. (ii) This stratum is about 8 km tall at the poles and 18 km high at the tropics. Hot convection currents that force the vapours upward are the primary cause of the equator's greater height. (iii) Because all types of meteorological shifts only occur in this layer, it is the most significant stratum of the atmosphere. These shifts have caused the evolution of the living world on earth. In this stratum, the air is never steady. As a result, this stratum is also known as the atmosphere or shifting sphere.

24 (iv) As the height of the troposphere rises, the ambient temperature falls. At a height of 165 meters, it drops by 10C per minute. The term for this is normal slip rate. (v) The tropopause is the term for the troposphere's higher boundary. This area is in change. This zone exhibits tropospheric and ionospheric features. Tropopause: The lowest two of the Earth's five atmospheric levels, the troposphere and stratosphere, are separated by the tropopause, an atmospheric barrier. The top of the troposphere, or tropopause, is a thermal gradient-stratification layer that is roughly 17 km (11 mi) above the tropical areas and 9 km (5.6 mi) above the pole regions. The limit of the tropopause is movable. A strong rainstorm will overflow into the lower atmosphere and experience a short (hour-order or less) low-frequency vertical oscillation, for instance, especially if it is equatorial in origin. This fluctuation generates a low-frequency atmospheric gravitational pulse that can influence the local ocean and air currents.During the transit portion of their journeys, the majority of commercial aeroplanes fly in the lower stratosphere, just above the tropopause; in this area, the clouds and substantial weather disturbances typical of the troposphere are typically missing. B. Stratosphere The second-lowest part of the atmosphere on Earth is the stratosphere. It is located above and apart from the atmosphere by the tropopause. This layer reaches the stratopause at a height of approximately 50 to 55 km, which is located between the summit of the troposphere at an altitude of 12 km (7.5 mi; 39,000 feet) above Earth's surface. (31 to 34 mi; 164,000 to 180,000 ft). About 1/1000 of the air pressure at sea level exists at the summit of the atmosphere. The region of the Earth's atmosphere that has comparatively high amounts of that gas is called the ozone layer, and it is found there. A stratum in which temps increase with elevation is known as the troposphere. Because the ozone layer prevents disturbance and mingling by absorbing ultraviolet (UV) energy from the Sun, this temperature increase is the result. The summit of the stratosphere is much warmer and may be close to 0 °C, even though the temperature at the tropopause may be 60 °C (76 °F; 210 K). Characteristics: (i) The atmosphere is above this stratum. (ii) This layer extends 50 kilometres above the Earth's surface. Its 40 km typical range. (iii) Up to a height of 20 km, the temperature in the lowest portion of this stratum stays essentially constant. After that, as the height rises, the temperature gradually rises. Ozone vapour is present in the top portion of this stratum, which raises temperature. (iv) There are no weather-related events in this stratum. Here, the wind is straight. As a result, this stratum is thought to be perfect for aeroplane flight. Stratopause: The stratopause, formerly known as mesopeak, is the point in the atmosphere where the stratosphere and mesosphere meet. The stratopause is the area where the temperature reaches its highest in the atmosphere, where temperature rises with height. This weather phenomenon can be found on any planet or asteroid with an atmosphere, not just Earth.

25 The stratopause is located 48–55 km (30–34 mi) above sea level on Earth. Around 11000 of the pressure at sea level exists in the atmosphere. The stratopause has a temperature of 2.5 °C (27.5 °F). C. Mesosphere The mesosphere, which lies beyond the stratosphere beneath the thermosphere, is the third-highest stratum of the Earth's atmosphere. It stretches from the mesopause at 80–85 km (50–53 mi; 260,000–280,000 feet) above sea level to the stratopause at a height of about 50 km (31 mi; 160,000 ft). As one ascends to the mesopause, the summit of this intermediate stratum of the atmosphere, temperatures decrease. With a typical temperature of about 85 °C (120 °F; 190 K), it is the lowest location on Earth. Characteristics: (i) The troposphere is covered by the third stratum of the atmosphere. (ii) It extends up to an altitude of 80 kilometres above the earth's surface. It spans 30 kilometres. (iii) The temperature continues to decline and reaches -1000C. (iv) In this stratum, "meteors" or descending stars can be seen. Mesopause: The border between the mesosphere and thermosphere air areas is marked by the mesopause, which is a spot of lowest temperature. The mesosphere is the lowest place on Earth, with temps as low as -100 °C (-148 °F or 173 K). This is because it receives no sun energy and experiences very intense atmospheric chilling from carbon dioxide. For many years, it was believed that the mesopause occurred at a height of about 85 km (53 mi). However, measurements at higher elevations and modelling studies conducted in the past 10 years have revealed that the mesopause actually consists of two minima, one at about 85 km and a larger one at about 100 km. (62 mi). The fact that the summer mesopause is colder than the winter is another characteristic. (Sometimes referred to as the mesopause anomaly). It results from a movement from summer to winter that causes upwelling at the summer pole and downwelling at the winter pole. D. Thermosphere The thermosphere is the Earth's atmosphere's second-highest stratum. It reaches the thermopause at a height between 500 and 1000 km, extending from the mesopause (which divides it from the mesosphere) at an altitude of about 80 km (50 mi; 260,000 feet). (310– 620 mi; 1,600,000–3,300,000 ft). Changes in sun energy cause the height of the thermopause to vary greatly. The thermopause is also known as the exobase because it is located at the exosphere's lowest limit. The ionosphere is located between 50 and 342 miles (80 and 550 kilometres) above Earth's surface in the lower thermosphere. Although the gas molecules in the thermosphere are so far apart that measuring its temperature in the conventional sense is not very useful, it can reach temperatures of up to 1500 °C (2700 °F) as it steadily rises in altitude. Due to the extreme rarification of the air, an individual molecule (such as an oxygen molecule) moves an average distance of 1 kilometre (0.62 mi; 3300 feet) before colliding with another molecule. Characteristics:

26 (i) This is the fourth layer of the atmosphere. It is located above the mesosphere. (ii) This layer spreads upto the height of 400
kms. from the surface of the earth. The width of this layer
is about 300 kms. (iii) The temperature starts increasing again with increasing height in this layer. (iv) Electrically charged currents flows in the air in this sphere. Radio waves are reflected back on the earth from this sphere and due to this radio broadcasting has become possible. Thermopause: The thermopause, which is situated at the summit of the thermosphere, is the air limit of the Earth's energy system. The thermopause could be anywhere between almost absolute 0 o F and 1,810 o F (987.547 o C). Due to the greater abundance of heavy gases, such as monatomic oxygen, below this point, the atmosphere is characterised as being active[clarification required] on the insolation received. At the thermopause, the solar constant is thus represented. The narrowest remaining portion of the atmosphere with a high mean free path, primarily hydrogen and helium, is referred to as the exosphere above (beyond) this. Exobase is another name for this barrier, which serves as the exosphere's bottom limit. E. Exosphere The topmost part of Earth's atmosphere is called the exosphere. (i.e., the upper limit of the atmosphere). It stretches from the thermopause, located at the highest point of the thermosphere at a height of roughly 700 km above sea level, to a distance of about 10,000 km (6,200 mi; 33,000,000 feet), where it joins the solar wind. Closer to the exobase, this layer is primarily made up of heavy compounds like nitrogen, oxygen, and carbon dioxide as well as hydrogen and helium, both of which have extremely low concentrations. Because of how far apart the atoms and molecules are from one another, they can move hundreds of kilometres without running into one another. The exosphere no longer functions as a vapour as a result, and fragments are continuously ejected into space. These free-moving particles may move into and out of the magnetosphere or the solar wind and follow ballistic paths. There is insufficient space between Earth and the exosphere for weather events to exist. The northern and southern lights of Earth, the aurora borealis and aurora australis, do, however, occasionally appear in the lower exosphere, where they merge into the thermosphere. Many of the manmade spacecraft that circle the Earth are found in the exosphere. Characteristics: (i) The uppermost stratum of the atmosphere, which reaches more than 400 km above the surface of the planet, is this one. (ii) Because there is no gravity pull on the gases in this cylinder, they are very scarce. As a result, the air's density is very low here. (iii) Aurora australis and Borealis are the phenomenon which occur in this layer. (v) Atoms of Oxygen, Hydrogen, Helium with a concentration of less than 1%, form the tenuous of this layer.

27 Figure 2.2: Layers of the atmosphere

28 2.5.3 Importance of Earth Atmosphere Without Earth's atmosphere to shield it from the brutal elements of the solar system, the world would become a dead, arid wasteland similar to the moon. The Earth's atmosphere provides warming and absorbs dangerous sun radiation to shield and support the planet's people. The atmosphere holds the oxygen and carbon dioxide that are necessary for life to exist, as well as the sun's radiation and many of space's perils. A. Temperature: The atmosphere's ability to keep the Earth's climate constant is among its most significant advantages. Temperatures on the moon, which lacks a shielding atmosphere, can vary from minus 157 degrees Celsius in the darkness to 121 degrees Celsius in the daylight. (Negative 250 degrees Fahrenheit). On Earth, however, atmospheric molecules capture the sun's energy as it approaches, warming the entire globe. Additionally, the molecules capture surface reflection energy, which keeps the planet's night side from getting too frigid. B. Radiation: Radiation and cosmic particles are shielded from us by the atmosphere. Without protection, UV light from the sun, which bombards the solar system, can seriously harm skin and eyes. Many of these rays are prevented from reaching the surface by the ozone layer, which is located aloft in the Earth's atmosphere. Cosmic, gamma, and x-ray radiation are also absorbed by dense layers of molecular vapors, stopping these powerful particles from hitting living things and causing mutants and other types of genetic harm. Even in the midst of a solar outburst, which can significantly increase the sun's destructive production, the atmosphere is able to prevent the majority of the negative impacts. C. Physical Shield: Although the solar system may appear to be expansive and vacant, it is actually filled with waste materials and tiny fragments left over from the formation of planets or impacts in the asteroid belt. According to NASA, more than 100 tonnes of space junk, mostly in the form of dust and minute particles, impact Earth every single day. However, the ensuing friction kills them long before they reach the earth when they come into contact with the molecules that make up Earth's atmosphere. The pressures of atmospheric re-entry can cause even bigger meteorites to fragment, rendering disastrous meteor impacts extremely uncommon. Without the atmosphere's physical support, the Earth's surface would be covered in impact scars, making it mimic the moon. D. Weather and Water Cycle: The weather also plays a significant role in the flow of water. Oceans release vapour that condenses as it cools and descends as rain, giving otherwise arid parts of the continents the wetness, they need to support life. The Earth's atmosphere can contain about 12,900 cubic kilometres (3,100 cubic miles) of water at any particular moment, according to the U.S. Geological Survey. It would either vaporise away into space or stay trapped in places beneath the planet's surface in the absence of an atmosphere.

29 2.6 Biosphere The biosphere is the region where life exists along with the air and the land. It is the combination of all types of ecosystems on Earth which integrates all the biological communities and their interactions or relationships with the environment. The living communities comprise animals, microbes, plants, fungi, and human beings. The term 'biosphere' is derived from the Greek term "bios" and "sphaira" which means "Life" and "Earth's shape" respectively. The term was coined by Eduard Suess, an English-Austrian scientist, in his work titled "The Face of Earth" in which he described the relationships between living things and how the Earth supports them. From the darkest depths of the ocean to the densest rainforests and highest peaks, everything is included in the biosphere. The ecosphere is another name for it. The biosphere ranges from at least 8,000 metres deep in the ocean, and up to 12500 metres above ground. Biosphere-2, arguably the largest closed habitat ever constructed by mankind, is an example of an artificial biosphere. 2.6.1 Origin and evolution of Biosphere About 3.8 billion years ago, the first prokaryotes flourished in an oxygen-free world. These prehistoric primordial prokaryotes contained single-celled organisms like bacteria and archaea. Certain prokaryotes evolved a unique chemical mechanism known as photosynthesis and, with the aid of sunlight, transformed water and carbon dioxide into simple sugars and oxygen. Autotrophy is the organism's ability to perform photosynthesis. Hence, more species were able to utilise the carbon dioxide in the atmosphere and finally provided oxygen to the atmosphere. From single-celled algae to multicellular autotrophs such as vascular plants, these organisms ranged in complexity. The atmosphere gradually transformed into a mixture of gases that could support new forms of life. As a result of the biosphere acquiring more oxygen, more complex life forms were able to evolve and gain distinct ecological niches. Many species of plants and other photosynthetic organisms, which constituted the autotrophs of the food chain, multiplied. Similarly, animals that consume plants or other heterotrophic animals also evolved. Likewise, bacteria and fungi (decomposers) evolved to breakdown dead plants and animals. 2.6.2 Components of Biosphere The biosphere comprised of three basic components i.e., abiotic components (physical and inorganic); biotic components (organic) and energy components. i. Abiotic components: These components composed of all non-living elements, which are essential for the survival of all living organisms e.g., mineral nutrients, gases, water, sunlight, etc. Broadly the abiotic components of biosphere are categorized into Lithosphere, hydropspher and atmosphere. a) Lithosphere (Geosphere)

30 • It forms the terrestrial portion of the biosphere. • It is the stiff, rocky outer layer of the Earth which is made up of the crust (the rocks that make up the continents and the ocean floor) and the upper mantle's solid outer layer. These layers support life by giving shelter and sustenance from tiny bacteria to big mammals and lofty trees. • It also stretches to a depth of almost 60 kilometers, and its lower mantle and core are the only parts that do not support life and are not a part of the biosphere. b) Atmosphere • It is the region that contains different gases like oxygen, carbon dioxide, and other gases. • This gaseous envelope makes it possible to see insects, birds, and other creatures soar high or fly above 2000 meters in the sky. • With the increase in height, the concentration of oxygen level goes on decreasing, which limits the availability of organisms in the atmosphere. The region in the atmosphere up to which animals or other forms survive or sustain makes up the biosphere. • Besides providing oxygen for respiration, the ozone layer of the atmosphere plays a crucial role in protecting living forms from the sun's harmful ultraviolet rays. c) Hydrosphere • It forms the aquatic portion of the biosphere as all the water components of the Earth, such as waterways, ponds, oceans, etc., are included in it. • However, several solid forms, such as glaciers, are also included under the hydrosphere. • It maintains the ecosystem by temperature regulation on Earth and supplying water to all living things. • Every component of the hydrosphere is responsible for the existence of living forms. ii. Biotic components of Biosphere Plants, animals and human beings including microorganisms constitute the biotic components of biosphere. i. Plants: These are autotrophic organisms that manufacture their food themselves through a process called photosynthesis. These are the primary producers, becoming the only primary source for all living organisms. ii. Animals: These are heterotrophic organisms that depend on primary producers or other animals for their food, release energy and reserve it for future purposes. Thus, they are known as consumers. iii. Microorganisms: They serve as decomposers that obtain their nutrition through the breakdown of waste or dead and decayed bodies. Fungi, bacteria, algae, viruses, etc., are under this category. iii. Energy components of biosphere It's the third and final component of the biosphere, and without it, life on Earth would be impossible. It's a necessity for the survival and procreation of all life on Earth. Every living creature is essentially a machine that can take in one source of energy and use it to accomplish

31 other tasks. The sun provides the energy necessary for the survival of all species in the biosphere. 2.6.3 Factors affecting the Biosphere a) Earth tilting: Tilting of the earth causes seasons and seasonal fluctuations. Seasons are crucial to the continuation of life on Earth as it determines the type of species that will survive in an area. b) Distance between the Earth and the Sun: Lesser the distance from the Sun, the warmer the place, and the greater the distance between the Sun and the Earth, the cooler the place will be. c) Natural disasters: Catastrophes such as landslides, floods, volcanic eruptions, earthquakes, etc. ruin life and property, thereby creating an imbalance in the ecosystem. d) Some smaller factors: Several minor factors, such as changes in climate, humidity, temperature, precipitation, etc., carry the potential to alter the land and living conditions. These factors are responsible for the changes at the molecular level. 2.6.4 Importance of Biosphere 1. The biosphere of the Earth is made up of things like the suitable temperature, moisture, food and energy, and minerals that are important for the survival of species. 2. The biosphere is essential in producing organic material since the oxygen and nitrogen produced through oxygen synthesis are the molecules that produce organic matter. 3. Plants in biotic communities give us things we need to live, like oxygen, food, fuel, and fibers. 4. The decomposers of the biosphere are in charge of breaking down toxins and other harmful substances and changing them biologically. 5. Compounds that occur naturally in the terrestrial biosphere help the pharmaceutical industries make pharmaceutical compounds. 6. The composition of the biosphere can be studied and controlled to help control the amount of pollution on land. 2.7 Summary Environment means the surroundings consisting of physical and living system in which man and other organisms live. The environment is influenced by biological, physical, chemical, social, political and economic factors. The important components of environment are abiotic (i.e., non-living), biotic (i.e., living) and energy components. So, the abiotic components are constituted by atmosphere, hydrosphere and lithosphere. Thus, abiotic environment includes

32 medium (e.g., air, soil, water) and climate (temperature, rainfall, humidity, light etc). The biotic environment consists of flora and fauna including human beings. Biosphere is the interface of interaction between the biotic and abiotic components of the environment. The energy components are involved in both biotic and abiotic components and the interaction between biotic and abiotic world. 2.8 Questions/ Self-Assessment questions 1 . What is lithosphere? How does the oceanic crust do form? 2 . Describe the importance of the lithosphere. 3 . Briefly describe the hydrological cycle. 4 . Point down the human activities affecting the hydrological cycle. 5 . Describe the components of the biosphere. 6 . Describe the factors affecting the biosphere. 2.9 Select Readings/ Suggested Readings 1 . Environmental science for UGC NET/SET/JRF by arihant publication 2 . Environmental science by Sovan Roy 3 . Environmental science by G. tyler Miller Jr by Thompson Brooks 4 . Skinner, B. J.; Porter, S. C. (1987). "The Earth: Inside and Out". Physical Geology. John Wiley & Sons. p. 17. ISBN 0-471-05668-5 5 . Barrell, J. (1914). "The strength of the Earth's crust". Journal of Geology. 22 (4): 289– 314. 6 . Barry, R.G.; Chorley, R.J. (1971). Atmosphere, Weather and Climate. London: Menthuen& Co Ltd. p. 65. ISBN 9780416079401. 7 . Ahrens, C. Donald. Essentials of Meteorology. Published by Thomson Brooks/Cole, 2005. 8 . States, Robert J.; Gardner, Chester S. (January 2000). "Thermal Structure of the Mesopause Region (80–105 km) at 40°N Latitude. Part I: Seasonal Variations". Journal of the Atmospheric Sciences. 57 (1): 66–77. 9 . • Encyclopedia Britannica,'Hydrosphere': https://www.britannica.com/science/hydrosphere/Origin-and-evolution-of-the- hydrosphere 10 .• Western, David (2001). "Human-Modified Ecosystems and Future Evolution". Proceedings of the National Academy of Sciences of the United States of America. 98 (10):doi:10.1073/pnas.101093598 11 .• James C.I. Dodge. Concepts of the hydrological Cycle. Ancient and modern (PDF). International Symposium OH'Origins and History of Hydrology', Dijon, May 9–11, 2001.

33 UNIT 3: Man, society, and environment 3.1 Objectives 3.2 Introduction 3.3 Philosophical Thoughts of Human Civilization Process 3.4 Human settlement 3.5 Biogeographical provinces of the world 3.6 Ecofeminism 3.7 Summary 3.8 Questions/ Self-Assessment questions 3.9 Select Readings/ Suggested Readings 3.1 Objectives After completing this unit, you will be able to • know different philosophical thoughts of human civilization process • describe the structure of the human settlement • distinguish the biogeographical provinces of the world • define the ecofeminism, its perspectives and importance. 3.2 Introduction The term "man-environment relationships" is used to describe the connections between the social and geophysical systems as a result of the interactions and feedbacks between human and natural components. The term ‘man-environment relationship’ includes different Concepts and ideas, thoughts which make the study of the human environment relationship possible. The study of ‘Man and environment relationship’ encompasses the causes of environmental changes; community responses, environmental policy making, and other aspects. The study of the man-environment relationship has been approached from a number of different philosophical perspectives, some of which are included here. 3.3 Philosophical Thoughts of Human Civilization Process 3.3.1 Determinism: There have been many different ways of thinking about the man-environment relationship throughout the development of geographical ideas. In the beginning, geographers used a

34 deterministic method to analyze the global distribution of human settlements. The determinist view holds that all human acts and choices are merely causal events subject to random laws. According to this theory, every human behavior can be traced back to a single underlying cause. This concept of the interaction between humans and their environments is typically seen as incompatible with free choice, although there are many who argue that determinism is consistent with or even required for free will to exist. Primitive human society's interplay with powerful natural forces is the basis of Determinism's philosophical stance. One of the most influential ideas that survived in some form until World War II is determinism. It asserts that a person's behavior is determined by the environment in which they are immersed. 3.3.2 Environmental determinism: Environmental determinism holds that all human behaviour may be traced back to the conditions of the natural world. The environment, in this view, determines the actions people take. The central tenet of this philosophy of the man-environment relationship is, in other words, the assumption that disparities in human behaviour around the world may be explained by differences in the natural environment. Those who subscribe to the deterministic school of thought believe that environmental elements, such as climate and geography, have a disproportionately large impact on a society's or nation's past, present, and future. According to proponents of this theory, a society's behaviour and culture are shaped by its members' shared experiences of the physical environment, particularly its temperature. It was once thought that people living in tropical climes were more prone to sloth, a carefree attitude, and promiscuity, whereas those living in the middle latitudes, where weather changes more frequently, had stronger work ethics. According to this school of thought, the collapse of advanced societies like the Egyptians, Mesopotamians, and Indus Valley people was precipitated by a shift in the climate. Because climate change caused their pastures to dry up and force them to relocate throughout the 13th century, it is widely thought that this is what motivated the Central Asian nomads to attack neighbouring civilizations. Greek and Roman scholars were the first to try to explain how climate and geography shape societies and cultures. Aristotle says that despite their bravery, the people of frigid places lack the political organisation necessary to control their neighbours. The Asian people are also enslaved because they lack courage. But, the Greeks in the middle are endowed with the best qualities and can therefore govern the globe. Like other ancient geographers, Roman Strabo attempted to justify the influence of natural phenomena on human culture by arguing that slope, relief, and climate were all divine creations. The writings of Arab geographers were preoccupied with the idea of geographical determinism. According to Al-Masudi, those who live in regions with an abundance of water are jovial, whereas those who live in arid regions are quick to anger. Those who confine themselves to urban settings lack the power, physical health, and wisdom of nomadic peoples who live in the open. He went on to say that northern quarter residents who avoid the sun in chilly climates have good physiques, rude personalities, thick flesh, thin skin, blue eyes, and curling and red hairs. All of these characteristics flourish in them since the cold and wet climate of their area inhibits religious practise. According to Ibn Khaldun, population density rises as one moves away from the equator up to the 64th parallel and then falls once again beyond that line. Because of the extreme heat and humidity found in the equator, population density is low

35 there, but it is quite high in the temperate zones. Due to the severe cold, population density drops off significantly beyond the 64th parallel. Even during the time that most geographers still consider geography to be primarily a natural study (the 19th century), environmental causation persisted. German geographer Carl Ritter, a prominent figure in the field, took an anthropocentric perspective and established geographical determinism in the early nineteenth century. Ritter investigated the reasons why men in different climates and environments have such varied body types and health profiles. Even Ritter's contemporaries, like Alexander von Humboldt, one of the architects of so-called "modern geography," agree that people who live in hilly regions have a different way of life than those who live in flatter regions. He included humans and their efforts in his discussions of the nature-human interface, but he downplayed the role of humans as decisive factors. Friedrich Ratzel is often credited as the creator of "new" determinism. He combined 'classical' geographical determinism with 'Social Darwinism,' coming up with a notion of the state as an organism that lived off the land and always sought to expand its area. A person's lifestyle tends to be consistent with their surrounding community, according to Ratzel. He used Britain and Japan as an example of countries whose insular locations make them well-protected against invasion. This has allowed the people of these nations to make great strides forward. The study of "the evolving link between the unresting man and unstable earth," as defined by Miss Semple. She also believes that man was born from the soil of the earth and that the elements of the natural world permeate his own being. Further bolstering human geography's authority, she also accorded "environmentalism" or "determinism" its due attention. American geographer Elseworth Huntington (who published The Principles of Human Geography in 1945) was a staunch advocate of ecological determinism. The racial stereotyping and ecological explanatory preferences that permeate Huntington's works on climate and civilization are obvious. Huntington's central thesis was that climatic change caused cultural "pulsations" and that the highest points of civilization in any given area were inextricably linked to a specific weather pattern. Later geographers took a deterministic view of societal development, including Mackinder, Chisholm, Davies, Bowman, Robert Mill, Geddes, Sauer, Herbertson, Taylor, etc. 3.3.3 Shifting from determinism to possibilism: Rather Than Goals There's no denying the reciprocal nature of environmental and human influences. The complexity of the relationship between humans and their environments makes it nearly hard to determine where one factor's influence ends and another begins. A much of the scenery we see around us is actually man-made, even though it looks totally natural. The Mediterranean countries rely almost totally on the fruits of human labour: wheat, barley, olive, and vine. Humans are responsible for the apple and almond orchards in Kashmir, Himachal Pradesh, and the Kumaon region of Uttarakhand. Equally impressive is the fact that farmers in the Punjab and Haryana have been able to successfully grow basmati rice while receiving only 50 centimetres of precipitation every year. Wheat is now grown in West Bengal, Odisha, and Dimapur, Nagaland, all thanks to HYV seed varieties developed by humans. There are countless examples of this, both in developed and developing nations. As man and his environment are inextricably linked, determining the relative importance of the two is a tricky business. The environmentalist worldview came under fire after WWII. Geographers from the

36 United States, UK, Canada, and elsewhere have pointed out the environmental movement's bias in their interpretation of history, highlighting the environmentalists' tendency to overemphasise nature's active involvement and understate humanity's ability to adapt. Human activity reveals numerous facts for which natural processes provide an inadequate explanation. Spate argued that environmental determinists take an overly dogmatic stance. The expression "environment taken by it" is a meaningless oxymoron in his view, because "environment does not exist without man." His suggestion that we ought to think about how the physical location influences us psychologically and physiologically is also crucial. Spate stated that "it functions through society; cultural heritage has a certain autonomous influence" and that this makes up only one of the determinants of territorial differentiation. It's hard to conceive the extreme weather circumstances not playing a direct impact in any human activity which occurs in the Desert, as recently highlighted by Australian writer Wolfgang Hartake. Hartshorne essentially makes the same case. He was against environmentalism for the simple reason that it divides nature and humanity, which he argued ran counter to the idea of geography as a unified discipline. But, the environmentalist movement that began in the 1960s has made it abundantly clear that the biophysical persistence and resilience of the planet's systems have an overall limit to certain types of human economic activity. In a nutshell, we can be determinists on the largest sizes, but we can see the value of possibilism or cultural and social determinism on the smaller scales. 3.3.4 Possibilism The theory of Possibilism emerged at the turn of the twentieth century. Conservative ideas like determinism have no place in today's more civilised and progressive societies. This is because, with the help of technology, man has altered nature to make it more hospitable for human habitation, building canals to bring water to formerly inhospitable regions like the middle of a desert. According to the theory of possibilism, man has a wide range of options available to him in the world. According to this school of thought, man may alter the effects of nature by using his intellect and willpower. Seeing man as an active agent, the philosophy of possibilism seeks alternative explanations for the link between man and environment. According to this idea, as a culture develops in terms of both knowledge and technology, so too does the number of options available to its members. Lucian Febvre, who proposed the possibilism hypothesis, thinks that humans are the single most influential factor in shaping Earth's surface. According to Lucian, "there are no necessities but everywhere options," therefore the use that man takes of, say, iron, is entirely up to him. Based on his level of technological advancement, he may fashion the iron into a hammer, a bicycle, a car, a ship, or a plane. That there are opportunities but no requirements is demonstrated by this example. Even if there was no need for a flying ship or an automobile before iron was invented, the possibility still there. Vidal de Lablache was a strong proponent of the possibilist philosophy. He has minimised the impact of nature on humans in his work. He explains how different people can be despite sharing the same surroundings. He claimed that human values and lifestyle choices, rather than climatic variance, were to blame for the variations. It is not just nature that brings about changes or differences in human society, as the possibility school of thinking would have us believe; man is also responsible for bringing about these changes and affecting the environment. Jean

37 Brunhes, a French philosopher, took the mantle of possibilism from Vidal de Lablache. Another possibilist, Sauer, argued that it is the geographer's responsibility to learn about and comprehend the processes by which a natural landscape is transformed into a cultural one. The geographer will learn how the land has changed as a result of successive human groups by conducting such research. Wheat, for instance, does not produce particularly well in the region where it was first domesticated (southwest Asia), but it does in North America, Europe, and even some Asian countries. As a result, environmental thought was criticised in the decades following World War II. It has been argued by several geographers in the United Kingdom, Canada, and the United States that an explanation of events based solely on nature and its forces is insufficient and unsatisfying. 3.3.5 Neo-determinism: Griffith Taylor proposed neo-determinism, an approach that strikes a balance between environmental determinism and possibilism. To him, it is the responsibility of a geographer to interpret the optimum economic programme for a country, which is largely influenced by nature. Stop-and-go determinism is another name for his theory, in which man is like a traffic controller who can speed up, slow down, or stop the flow of an event, but not alter its course. The idea demonstrates that neither a situation of absolute necessity (environmental determinism) nor a condition of absolute freedom (possibilism) exists. Alternatively put, the concept demonstrates that neither a situation fully dominated by nature (determinism) nor a situation fully controlled by man (controllism) exists (Possibilism). That by doing so, humans can achieve dominion over the natural world. Unless nature allows for a change, men must heed the warning signs and stop any forward progress. This means that new opportunities can be crafted without causing irreparable harm to the natural world, and that there is no such thing as a risk-free run without the corresponding increase in the likelihood of unfortunate events. In the case of the developed nations of the world, for instance, the problem of greenhouse gas emissions, ozone layer depletion, melting glaciers, and deteriorating land and overall environment has arisen because these nations have chosen the path of free run rather than obeying nature or wisely selecting the path offered or as planned by nature. In a nutshell, neo- determinism is an attempt to strike a middle ground between environmental determinism and possibilism. Taylor argues that geographers should focus on studying nature and how it affects humans, rather than tackling a wide range of issues related to people and their cultural surroundings. The anthropocentrism of geographers is emphasised more by the positivist worldview than by the scientific study of natural environments. 3.3.6 Cultural ecology The third and most recent perspective, cultural ecology, takes into account the possibility of a culture changing in reaction to its surroundings. Unlike the other two methods, this one aims to spell out which specific environmental factors actually play a role in shaping a society's norms and mores. According to Steward, who made a seminal contribution to the cultural ecology notion in 1955, the point of this method is to find out if comparable social and cultural adaptations take place in analogous settings. Significant benefits of the cultural ecological approach over its predecessors include the specification of cause and effect, the treatment of

38 cultures as unique instances rather than stages in the development of civilization, and the recognition that cultures are constantly evolving and changing in response to their environments (Abbott, NA). Culture is not determined by nature, although nature does offer or limit some options, as Carl Sauer emphasised. His argument was that cultural norms, rather than natural restrictions or logical necessity, determine how people act (Koszegi, 2015). Anthropologists at the time devised a new approach because they were unhappy with the strict conceptions of cultural change exemplified by environmental determinism. As the American anthropologist Julian Steward put it, "the study of processes by which a culture adapts to its environment" is the essence of cultural ecology. Unlike environmental determinism and historical possibilism, which view the environment and culture as distinct entities that have external effects on each other, cultural ecology introduces the concept of an integrated system in which cultural and environmental factors interact, thereby representing a significant innovation in the way the relationship between culture and the environment was conceptualised. Several parts of cultural ecology have been challenged, despite the clear progress in our understanding of human-environment relations. Steward argued that the environment determinist paradigm was too simplistic to provide insight into the ways in which individual cultures engaged with their physical surroundings. 3.3.7 Structuralist's Deterministic approach Within the framework of the geographical approach, the writings of the'realist' philosophers or the structuralisms analysed the human-environment system with the goal of identifying how political and economic structure determines or influences individual adjustment to the environment, especially in Third World settings. Wisner stresses the importance of accounting for political and economic structure in economic vulnerability. He claims that the poorest people in capitalist economies in the developing world are forced by market pressures to reside in the most dangerous neighbourhoods. As a result of the underdevelopment process, the peasants is placed in a more precarious position, compelling them to either seek other means of subsistence in places of higher security and risk, or to alter their resources in ways that further expose them to danger. The term "marginality" originated from this perspective. This theory explains why poor individuals are especially susceptible to harm after a natural disaster. The poor continue to bear the brunt of disaster's aftermath since the wealthy keep much of the humanitarian money and 'normal' development for themselves. The ability to defend oneself and one's possessions, as well as to rebuild after a tragedy, is directly proportional to one's level of income. However, structural determinism was criticised on the grounds that it cannot be proven because no specific events have been predicted in advance by structuralisms. 3.3.8 Radicalism In response to widespread criticism of quantitative geography, positivism, and conventional regional geographies, the radical approach to the discipline evolved. The radical geography movement of the 1960s in the United States might be seen as the genesis of the field of radical geography. The Vietnam War, the Black Civil Rights Movement, and the ubiquitous phenomena of poverty in urban ghettos all contributed to the rise in social tension that fueled the movement. The radicals have stressed the importance of a change in geographical thought

39 and practise. So, in contrast to the purportedly value-free techniques, the radical approach is value-based, in particular the idea of labour value. According to radicals, the harmonious connection between humans and their natural surroundings is constantly evolving alongside the development of new manufacturing methods. In the realm of historical and structural determinism, radicalism limits humans to passive existence. People stop being the result of the past and start making it themselves. The radicals, trapped in Marxist ideology, prioritise time over location. In a rapidly evolving knowledge landscape, the radicals are unable to adapt. The radical interpretation of geography, then, is hampered by a too-dogmatic examination of space. 3.3.9 Quantitative approach Following WWII, academic geographers in advanced countries began to see the value of expressing concepts in mathematical terms rather than literary ones. The start of the Quantitative Revolution in geography marked a shift away from focusing just on describing the varying features of Earth's surface in favour of constructing models instead. Hence, the quantitative revolution was described as the spread of statistical methods into geography to improve the quality of research and geographic theory. Quantitative methods were first put to use in fields including meteorology, geography, and crop productivity. Christaller's study, Central Places in, made significant contributions to location theory through extensive use of quantitative techniques. The obtained data was whittled down to a more manageable size, and the conclusions drawn from that data were validated and verified using statistical methods. The main problem with this strategy was that theories and models based on empirical data didn't account for normative problems like beliefs, emotions, attitudes, desires, hopes, and fears, therefore they couldn't be used to describe the real connection between people and their surroundings. 3.3.10 Positivism That "human social world phenomena are no different from those of the natural inorganic and organic world" is a central tenet of positivism, a philosophical school of thought. The philosophical system known as positivism rejects metaphysics in favour of what can be shown either through empirical scientific study or through rigorous logical or mathematical analysis. Hence, Auguste Comte, the creator of positivism, believed that social phenomena deserved a more scientific approach to their study. The term "positivism" was first used because its proponents sought to give greater weight to verifiable facts. Comte was contemptuous of metaphysical and normative concerns because he believed they were unanswerable from a scientific perspective and needed objective studies utilising replicable procedures in order to produce common laws. 3.3.11 Behavioralism The growth of this school of thought can be traced back to growing criticism and dissatisfaction with positivist models and theories developed through the application of statistical techniques (the quantitative revolution), which were founded on the idea that people act economically rationally. The concept of man in behavioural geography is that of a stimulus-response system.

40 Its goal is to determine the variation in responses to certain stimuli across persons (and within the same individual across situations) and to separate the correlates of those differences in order to construct models that can forecast the likely impact of specific stimuli. Geographers have come to know that the models and theories proposed and tested using quantitative methods offer an inadequate account of geographic reality and the man-environment relationship as time has progressed. Inadequacy in explaining society's spatial arrangement was found, for instance, in theories like the Central Place Theory, which relied on statistical and mathematical methods. Since a floodplain resident continues to live there despite the threat of flooding, the idea of economic rationality, which states that all men are economic and solely care about getting money, appears to be untrue. Hence, this method of studying the connection between humans and their surroundings has also been questioned. 3.3.12 Humanism In the 1960s, as a backlash against positivism, the humanistic approach to environmental studies gained traction. The quantitative revolution gave rise to a mechanistic model of spatial science, which led to the rise of the humanistic approach. The adherents of the positivistic method and spatial science viewed individuals as nothing more than points on a map, pieces of information on a graph, or a variable in an equation. Kirk (1951), who emphasised the complexities and ambiguities of the link between man and environment, lent his support to the humanistic approach because of its emphasis on the role of human awareness, human agency, human consciousness, and human creativity. The primary notion of this topic was that the methods and assumptions of the quantitative revolution could not adequately explain the human world or the problems that plague it, especially those problems that had to do with social institutions, attitudes, morality, traditions, and aesthetics. Space and location are not to be reduced to geometrical abstractions, according to this theory of the relationship between man and his environment. 3.4 Human settlement A human settlement can be anything from a small farm to a sprawling metropolis. The meaning is that, the people are moving into and settling a previously deserted region. A cluster of homes, be it a village, town, or city, is where most people make their permanent homes. Human geography begins and ends with the study of human settlements, as the type of settlement in a given place reveals how people there interact with their natural surroundings. A human settlement is any location that is home to people on a regular basis. No matter how many times a home is remodelled or rebuilt or how many times a building's purpose is transformed, human habitation persists across both space and time. Some communities are seasonal in nature, with residents staying for only a few months at a time.

41 3.4.1 The rural and urban settlement dichotomy The term settlement is accepted, although its existence might be defined as rural or urban, and there is no consensus on what precisely defines a village or a city. In heavily populated nations like India and China, many little villages have more residents than entire towns in Western Europe and the United States. This highlights the fact that population size is not a universal criterion. Villagers may have worked in agriculture or other main industries in the past, but many people in industrialized nations now choose to commute to the city for their jobs, but still make their home in a rural setting. In urban areas, most people work in the service or retail sector, whereas in rural areas, the majority of the population is involved in primary industries like farming, fishing, logging, mining, and animal husbandry. Even if there is no standard hierarchy of the functions given by rural and urban communities, distinctions based on functions are more important. In the United States, filling up at the petrol station is seen as a low priority, while in India, it is a necessary part of city life. It's possible for ratings of functions to fluctuate even within a country based on the economic climate of different regions. In less developed and developing countries, village life sometimes lacks the modern conveniences taken for granted in more affluent countries. 3.4.2 Types of Human settlement Broadly the human settlement can be differentiated into rural and urban settlement, but there is no consensus on what exactly defines a village or a town. Although population size is an important criterion, it is not a universal criterion since many villages in densely populated countries of India and China have population exceeding that of some towns of Western Europe and United States. 1. Rural settlements The sparsely located small settlements are called villages, specialising in agriculture or other primary activities. 3.4.2.1.1 Classification of rural settlements Rural settlements in India can broadly be put into four types i. Clustered Settlements (agglomerated or nucleated) • The clustered rural settlement is a compact or closely built up area of houses. • In this type of village, the general living area is distinct and separated from the surrounding farms, barns and pastures. • The closely built-up area and its intervening streets present some recognisable pattern or geometric shape • Such settlements are generally found in fertile alluvial plains and in the north eastern states. Sometimes develop along river valleys. • Communities are closely knit and share common occupations.

42 ii. Semi-Clustered (or fragmented) Settlements • Semi-clustered or fragmented settlements may • result from tendency of clustering in a • restricted area of dispersed settlement. • More often such a pattern may also result from • segregation or fragmentation of a large compact village • Such settlements are widespread in the Gujarat plain and some parts of Rajasthan. iii. Hamleted Settlements • These units are locally called panna, para, palli, nagla, dhani, in various parts of the country. • This segmentation of a large village is often motivated by social and ethnic factors. iv. Dispersed (or isolated) Settlements • Dispersed or isolated settlement pattern in India appears in the form of isolated huts or hamlets of few huts in remote jungles or on small hills with farms or pasture on the slopes. • Many areas of Meghalaya, Uttarakhand, Himachal Pradesh and Kerala have this type of settlement. • A cultural feature such as a place of worship or a market, binds the settlement together. 3.4.2.1.2 Factors affecting rural settlements: • Land: People choose to settle near fertile lands suitable for agriculture. • Upland: Upland which is not prone to flooding was chosen to prevent damage to houses and loss of life. • Defense: During the times of political instability, war, hostility of neighboring groups villages was built on defensive hills and islands. • Planned Settlements: Sites that are not spontaneously chosen by villagers themselves, planned settlements are constructed by governments by providing shelter, water and other infrastructures on acquired lands. The scheme of villagization in Ethiopia and the canal colonies in Indira Gandhi canal command area in India are some of good examples. • Water Supply: Usually rural settlements are located near water bodies such as rivers, lakes, and springs where water can be easily obtained. Sometimes the need for water drives people to settle in otherwise disadvantaged sites such as islands surrounded by swamps or low-lying river banks. Most water based 'wet point' settlements have many advantages such as water for drinking, cooking and washing. Rivers and lakes can be used to irrigate farm land. Water bodies also have fish which can be caught for diet and navigable rivers and lakes can be used for transportation.

43 • Building Material: The availability of building materials- wood, stone near settlements is another advantage. Early villages were built in forest clearings where wood was plentiful. 3.4.2.1.3 Pattern of rural settlements: 1. Linear pattern: In such settlement's houses are located along a road, railway line, river, canal edge of a valley or along a levee. 2. Rectangular pattern: Such patterns of rural settlements are found in plain areas or wide inter montane valleys. The roads are rectangular and cut each other at right angles. 3. Circular pattern: Circular villages develop around lakes, tanks and sometimes the village is planned in such a way that the central part remains open and is used for keeping the animals to protect them from wild animals. 4. Star like pattern: Where several roads converge, star shaped settlements develop by the houses built along the roads. 5. T-shaped, Y-shaped, Cross-shaped or cruciform settlements: T-shaped settlements develop at tri-junctions of the roads. While Y-shaped settlements emerge as the places where two roads converge on the third one and houses are built along these roads. Cruciform settlements develop on the cross-roads and houses extend in all the four directions. 6. Double village: These settlements extend on both sides of a river where there is a bridge or a ferry. 3.4.2.1.4 Problems of rural settlements: • Rural settlements in the developing countries are large in number and poorly equipped with infrastructure. They represent a great challenge and opportunity for planners. • Supply of water to rural settlements in developing countries is not adequate. People in villages, particularly in mountainous and arid areas have to walk long distances to fetch drinking water. Water borne diseases such as cholera and jaundice tend to be a common problem. • The countries of South Asia face conditions of drought and flood very often. • Crop cultivation sequences, in the absence of irrigation, also suffer. • The general absence of toilet and garbage disposal facilities cause health related problems. • The houses made up of mud, wood and thatch, remain susceptible to damage during heavy rains and floods, and require proper maintenance every year. Most house designs are typically deficient in proper ventilation. • Unmetalled roads and lack of modern communication network creates a unique problem. During rainy season, the settlements remain cut off and pose serious difficulties in providing emergency services. • It is also difficult to provide adequate health and educational infrastructure for their large rural population.

44 2. Urban settlements • The definition of urban areas varies from one country to another. • Urban settlements are generally compact and larger in size than rural settlements. • They are engaged in a variety of non- agricultural, economic and administrative functions. Definition of Urban area as per census 2011 of India As per census 2011 of India Urban area can be defined as 1. All places with a municipality, corporation, cantonment board or notified town area committee, etc. 2. All other places which satisfied the following criteria: 1. A minimum population of 5,000; 2. At least 75 per cent of the male main working population engaged in non- agricultural pursuits; and 3. A density of population of at least 400 persons per sq. km 3.4.2.2.1 Classification of Urban settlements 1. On Basis of Age i. Ancient Towns: ii. Medieval Towns iii. Modern Towns 2. On Basis of Population i. Class I towns – <1,00,000 population ii. Class II towns – 50,000 – 99,999 iii. Class III towns – 20,000 – 49,999 iv. Class IV towns – 10,000 – 19,999 v. Class V towns – 5000 – 9,999 vi. Class VI towns – > 5,000 3. On Basis of Functions i. Administrative Towns: Towns supporting administrative headquarters of higher order are administrative towns, such as Chandigarh, New Delhi, Bhopal, Shillong, Guwahati, Imphal, Srinagar, Gandhinagar, Jaipur, Chennai, etc ii. Industrial Towns: Industries constitute prime motive force of these cities, such as Mumbai, Salem, Coimbatore, Modinagar, Jamshedpur, Hugli, Bhilai, etc. iii. Transport Cities: They may be ports primarily engaged in export and import activities such as Kandla, Kochchi, Kozhikode, Vishakhapatnam, etc., or hubs of inland transport, such as Agra, Dhulia, Mughalsarai, Itarsi, Katni, etc. iv. Mining Towns: These towns have developed in mineral rich areas such as Raniganj, Jharia, Digboi, Ankaleshwar, Singrauli, etc. v. Cantonment Towns: These towns emerged as garrisson towns such as Ambala, Mhow, Babina, Jalandhar, Udhampur, etc.

45 4. Educational Towns: Starting as centres of education, some of the towns have grown into major campus towns, such as Roorki, Varanasi, Aligarh, Pilani, Allahabad, etc. i. Religious & Cultural Towns: Varanasi, Mathura, Amritsar, Madurai, Puri, Ajmer, Pushkar, Tirupati, Kurukshetra, Haridwar, Ujjain came to prominence due to their religious/cultural significance. 5. Tourist Towns: Nainital, Mussoorie, Shimla, Pachmarhi, Jodhpur, Jaisalmer, Udagamandalam (Ooty), Mount Abu are some of the tourist destinations. 6. On Basis of Forms ii. An urban settlement may be linear, square, star or crescent shaped. In fact, the form of the settlement, architecture and style of buildings and other structures are an outcome of its historical and cultural traditions. iii. Towns and cities of developed and developing countries reflect marked differences in planning and development. While most cities in developed countries are planned, most urban settlements of developing countries have evolved historically with irregular shapes. For example, Chandigarh and Canberra are planned cities, while smaller town in India have evolved historically from walled cities to large urban sprawls. 3.5 Biogeographical provinces of the world The biogeographic realm or provinces are the area of land that contains similar living organisms. Biogeographic regions are further subdivided into eco-regions, which are further divided into biomes. Types: The widely accepted modern classification of land masses into regions is given below, which are based on Wallace (1876) and Darlington (1957). 1. Realm Megagea a) Region Palaeartic (Europe, Russia, Mediterraean) b) Region Nearctic (North America upto the middle of the Mexico) c) Region Ethiopian/African (Africa, South Sahara) d) Oriental (Tropical Asia South of 30 0 latitude) 2. Realm Neogea e) Region Neotropical (South America, tropical Mexico, Caribbean islands) 3. Realm Notogea f) Region Australian (Australia, Tasmania, New Guinea and New Zealand) a) Palaearctic region: The areas of this region extend to whole of the Europe, China, Japan, Africa, North Sahara, Siberia, Mediterranian, Manchuria, Asia north of Himalaya and north of Arabia. The region is surrounded by sea from three sides viz. West, North and East; and on the southern side by Sahara and Himalayas. It has got a continuous connecting-link with its two neighbouring regions of Ethiopian

46 and Oriental. The climate is chiefly temperate having arctic tinge in it. It includes both wet forest lands and dry open steppe land, large area of coniferous forest and some tundra. Thus, great degree of climatic-variability is exhibited and variations in the fauna are also found as the natural rule. Fauna: The fauna is dominant and rich in warmer areas; diminishes northward and ultimately in arctic area only some fresh water fishes or Rana species (frog) are found. The fauna of Palaearctic region exhibits similarity with fauna of Neoarctic region and a number of genera and families are common to both the regions, it clearly supports that there might have existed some land-bridges in between the two regions during earlier times. Palaearctic region possesses 33 families of mammals, 68 of birds, 24 of reptiles, 10 of amphibians and 13 families of freshwater fishes. i. Fishes: The freshwater fishes include many species of Cyprinids, a few localized catfishes, cobitridis choundis etc. ii. Amphibians: They are varied and rich and include Rana, Toad, Hyla, Necturus, Proteus, Siren etc. The Giant Salamanders are found both in Palaearctic as well as Neoarctic regions. iii. Reptiles: The region is poor in reptilian stock and there are a few species of snakes. True Vipers, Asian Pit-vipers and Colubirds are the only snakes found in this region. In northern portion however, Trionyx and Tertudo, Alligator of China, Naranus, Chamdan and Sand Boas etc. are found. iv. Birds: About 53 families of birds are presented by the region and about 17 families are widely distributed and are also met in other regions of the world. The bird species found include Hawks, Herons, Storks, Bucks, Loons, Rails, Grebes, Wrenks, Cuckoos, King-fishers, Wood-peckers, Shallows, Crows, Finches, Warblets, Old world flycatchers. Hedge- sparrows are exclusively confined to this region, whereas Parrots are absent. v. Mammals: Out of 33 families of mammals found, only two are endemic. The important mammalian fauna include Moles, Shrews, Pandas, Pigs, Rabbits, Squirrels, Deer, number of Dog and Cat families. Palaearctic region has further been sub-divided into: (i) European sub-region (ii) Mediterranean sub-region (iii) Siberian Sub-Region: The families of Yak, Musk deer and Moles are exclusively confined to this sub-region. (iv) Manchurian Sub-Region: Great Panda, Tibetan Langurs, Chinese Water- deer are confined in this sub-region only. b) Neoarctic region: The geographical limits of Neoarctic region comprises of North America above tropics, New Found land and Mexican plateau, and Greenland. It is connected by a narrow strip with Central America and from all other sides is surrounded by the sea. The climatic conditions are varied and extreme, and similar to Palaearctic region. It has extensive mountain ranges in the west running to north to south. There are coniferous belt, deciduous forests in the eastern part of North America and grasslands in the central part and also the arid zone in the south-west part of North America.

47 Fauna: Fauna of this region are transitional and represent the mixture of Palaearctic and Neo-tropical regions. There are about 26 families of mammals, 49 of birds, 21 of reptiles, 14 of amphibians and 24 of fishes. i. Fishes: 13 genera of Cyprinidae, Cat fishes, Sturgean etc. ii. Amphibians: Tailed amphibian such as Axolotal, Ambystoma and Siren are notable. Among tailless are Rana, Bufo and Hyla. Reptiles Quite varied are found in abundance having a mixture of Tropical American groups and Palaearctic. The common reptiles are Musk Turtle, Crocodiles and Alligators. Lizards include Geekas, Ophisaurus. Heloderma is found only in south-west Central America. Snake includes the Pit-vipers, Cesal snakes and Rattle snake. Snapping-turtle, Heloderma and Musk-turtle are endemic to this region. iii. Birds: There are 49 families of birds, of which 32 are widely distributed and present mixture of Neotropical and Palaearctic regions. The common birds are Pelicans, Grebes, Vultures, Rails, Cranes, Cuckoos, Gulls, Pigeons, Owls, Herons, Hawks, King-fishers, Humming-birds, Woodpeckers, Wax-wings flycatchers. iv. Mammals: Most commonly found mammals are Rabbits, Shrews, Moles, Squirrels, Beavers, Cats, Bats, Bears, Deer, Flying squirrels, Tree porcupines, Star- nosed moles, Canadian porcupines, Longlegged bats and American badger which are the exclusive form of mammals found in Neo-arctic region c) Ethiopian region: It includes Africa, South of Sahara, Madagascar and South Arabia. All other sides are surrounded by sea except the land link with northern Palaearctic region. The climatic condition is tropical and due to this there is lush growth of evergreen tropical rain forests. Fauna: This region is very rich and colourful in its fauna. The birds and mammals present great degree of affinity with the Oriental region; while the fish, amphibian and reptile resemble with Neotropical and Oriental regions. There are about 161 families of terrestrial vertebrates in this region. i. Fishes: Carps, Cat fishes, Cyprinodants and Cichlids, Protopterus of lung- fishes, Archaic Bichris and a few Cat-fishes are exclusive of this region. ii. Amphibians: Only tailless amphiba are represented by the families Bufonids, Ranids, Rhaephonids and Caecilians. Rana and Bufo are absent. Tailed amphibia are also absent. iii. Reptiles: It includes Crocodiles, Turtles, Lacertid and Agamid lizards. Chandeon is almost exclusive. Pythons, Colubirds, Typhlops, Viperids and Leptotyphons represent snakes of this region. iv. Birds: The most exclusive birds of the region are Ostriches, Helmet birds, Hammer-headed birds, Pitta and Mouse-birds. The common birds are Herons, Hornbills, Cuckoos, Weavers, Storks, Goatsuckers, Parrots, Larks, Pigeons, Bee-eaters, Finches, and Bustards etc. There are 67 families of the birds found in this region and out of which 53 are worldwide. v. Mammals: There are about 38 families of mammals in this region, out of which about 10 families are exclusive and the rest are shared with Palaearctic or Oriental region. Most widely distributed mammals are Bats,
48 Shrews, Rabbits, Squirrels, Dogs and Cats. The Oriental mammals present here are quite different from that of Oriental one and include Lemurs, Loris, Apes, Elephants, Rhinoceros etc. The exclusive families include Hippopotamus, Giraffes and Rodents. In addition, species of Zebra and other large number of Antelopes are unique to this region. The species of Bear, Deer, Goat and Sheep are entirely absent in this region. d) Oriental region: It includes the entire Indian sub-continent, Indochina, Philippines and South China. The region abounds varied climatic conditions. The region is represented by tropical rain forests in Burma, Indochina, Northeast Asia and Southern parts of India. Temperate climate includes northern part of India. Fauna: The fauna of Oriental region exhibits considerable affinity with Ethiopian region and the resemblance is so great that some zoogeographers have preferred to put both these regions into one region under the name Palaeotropical region. The families of the region are widely distributed. i. Fishes: Dominated by, Carps and Cat-fishes. Other fish families include Cobitidae, Osteoglossid, Notopteridae, Cypriniformis and Anabantidae. ii. Amphibians: Dominated by, Carps and Cat-fishes. Other fish families include Cobitidae, Osteoglossid, Notopteridae, Cypriniformis and Anabantidae. iii. Reptiles: All the important genera of snakes like Python, Vipers and Pit-vipers, Colubirds, Typhlops and Leptotyphops are widely present. Among lizards; Chanebons, Varanus, Agamids are present. Crocodilus polustris and Gavialis gangeticus are found in India. Turtles are represented by Trionychids, Testudinius and Eumydine turtles. iv. Birds: Pigeons and Pheasants are very numerous. There are 66 families, out of which 52 are widely distributed. Eurylaemidae (Peacock) is the only one exclusive bird family. Other birds found are Peacock (the National Bird of India), Woodpeckers, Hornbills, Parrots, Honey guids, Sunbirds and Finches. v. Mammals: Mammals include four exclusive families of Hylobatiodae (Gibbons), Tarsidae (Tarsiers), Galeopithecidae (Flyling-lemurs) and Tupaiidae (Tree-shrew). There are 30 mammalian families in this region. The most common mammals are Shrews, Rabbits, Squirrels, Dogs, Mustelids, Cats, Bovids, Civets, Hyaenas, Pigs, Porcupines, Apes, Pangolins, Elephants, Rhinoceros, Old World Monkeys, Moles, Bears and Deer are found widely distributed; though interestingly enough, these animals are absent in Ethiopian region. In the perspective of earth's history, the present position of India is of recent origin and it forms a part of the Oriental region in Zoogeographic classification. Tens of millions of years ago, India was not even part of Asia. It was an island-continent, edging slowly northwards towards Asia across a vanished ocean which also isolated Africa from Eurasia. All that remains of the vanished ocean, referred to as the Tethys, are the Mediterranean, Black and Caspian seas. Geological movements, about 15 million years ago, joined the landmasses of India and Africa with Asia and Europe resulting in the formations of the Himalayan massif in Asia and the Alps and the Caucasus mountains in Europe. Land-bridges were also established between Africa, Europe and Asia.

49 Faunal changes apparently took place over the three continents during the Caenozoic period, wherever climatic and ecological limitations favoured such exchanges. Though the exact nature of such exchanges is not clear, fossil remains in the "Siwalik" throw a great deal of light on the North Indian fauna during the Tertiary period. Amongst the giant creatures existing, were the Mastodons, and some eleven species of Elephants. Along with them lived the Siwalik Bison, Buffalo, Ox, Tamarau as well as the recent African elements such as Hippopotamus, Giraffe, and Chimpanzee etc. Rhinoceros of varied kinds and the magnificent four-horned ruminant, Siva therium also lived there. The presence of these animals indicates that the area was covered with savannah and woodlands and had African links. There was a total eclipse of some forms which left no descendants while some forms evolved into others, and some escaped by chance and are still thriving today. The Asiatic Lion, Striped-hyaena and the Antelopes can be said to be the relics of the past. Most exciting of all Siwalik discoveries, are a few jaw-fragments of Ramapithecus, a very primitive Hominid Ape belonging to Man's own family. For some years, archaeologists have thought that Ramapithecus may have been directly ancestral to man, but more complete remains of the animal from East Africa suggest that it may be only another curious sideline of ape-evolution. e) Neotropical region: This regions consists South America, Central America, tropical low land of South Mexico and West Indies. The general climatic condition is tropical; the southern part of South America has temperate zone. Due to the tropical climate, extensive evergreen forests are found in the Amazon Valley while in Argentina and Saveinna tracts have drier patches and in the Western South America sub-desert conditions are found. Fauna: In this region; out of 155 families of the terrestrial vertebrates, about 39 are absolutely endemic. The region has both distinctive and varied fauna. i. Fishes: There is complete absence of Cyprinidae in this region. The region is dominated by Cat-fishes, Gymnoitids and Electic-fishes. One genera of Lung-fishes (Lepidosiren) showing discontinuous distribution is present. ii. Amphibians: The most common in tailless amphibians are Hyla, Rana, Bufo and Pipa. There are 14 families of amphibian. iii. Reptiles: Varieties of reptilian fauna are present in this region and include Crocodiles, Alligators, Turtles and Tortoises. There are 15 families of Lizards in which Helodermidae, Anadiadae, Chircocolidae, Cercosauridae and Iphisiadae are peculiar. But the families Varanidae and Agamidae are absent. iv. Birds: South America is called as "Bird Continent" on account of the diverse presence of birds. There are about 67 families of birds of which about 23 families are restricted and two others are confined to this region only. American Ostrich (Rhea) and Tinamus are endemic to this region. The common birds are Storks, Barets, King-fishers, Herons, Wood-peckers, Ducks, Pigeons and Plovers.

50 v. Mammals: There are about 32 families of mammals in this region. The Opossum marsupials are present and Sloths, Armidallos, New World Monkeys, Rabbits, Deer, Squirrels and New World Porcupines as well as 11 families of rodents are commonly found in this region. Moles, Hyaenas and Hedgehogs are absent in this region. f. Australian region: This region contains Australia, New Zealand, Tasmania, New Guinea and other islands. This region is completely isolated and has no link with any other region of the world. In this region, both tropical and temperate climatic-conditions are found. The northern part of Australia and New Guinea are tropical while Tasmania is temperate; the interior areas of North Australia are arid. Fauna: This region has unique faunal significance but the region is very poor in animal population and the most interesting thing is the absence of higher mammals. Marsupials and Monotremes are found only in this part of the world. i. Fishes: Osteoglossids and Neoceratodus are found. ii. Amphibians: Hyla and Rana are found in this region while tailed amphiba are absent. iii. Reptiles: Among snakes, Python and Biting tiger-snake are found in abundance. Other reptiles include Crocodile, Turtle, Geekos, Varanus, Typhops and Colubrids iv. Birds: About 58 families of the birds are found in this region, out of them 44 are widely distributed. Of these 12 families are exclusive of this region. The common- birds are Trogan, King-fishers, Hawks, Pigeons, Cuckoos, Parrots etc. The families of parrots, cuckoos, loris and pigmy-parrots, wood-swallows, flower-peckers and megapodes are shared with Oriental region. The exclusive families include Cassowaries, Enius, Megapodes, Honey-suckers, Scrub-birds, Flower-peckers, Bell-magpies, Owlet frog marth, Bower birds, Legendary birds of paradise. The most important bird of New Zealand is the flightless Kiwi. v. Mammals: In the Australian region, there is complete absence of higher placental mammals and sole representation of Monotremes and Marsupials constitute the peculiarity and uniqueness of the region. Among monotremes are Echidna and Ornithorhynchus. Among marsupials are Dasyurus, Perameles, Bandicoot, Opossum, Wombat and Phascolomys. In addition, there are Mice, Australian Dogs and Squirrel.

51 Figure 3.1: Zoogeographical regions of world (Source: http://www.mbbcollege.in/db/notes/96.pdf) 3.6 Ecofeminism Ecofeminism is a subset of feminism that bases its analysis and practise on environmentalism and the relationship between women and the nature. Ecofeminists analyse the relationships between humans and the natural world through the lens of gender. French author Francoise d'Eaubonne coined the word in her work La Féminisme ou la Mort (1974). Ecofeminist theory states that a feminist view on ecology does not place women in a position of power dominance, but rather calls for an egalitarian, collaborative society in which no one group is dominant. Several ecofeminisms exist now, with diverse perspectives and interpretations, such as liberal ecofeminism, spiritual/cultural ecofeminism, and social/socialist ecofeminism (or materialist ecofeminism). 3.6.1 Nature of Ecofeminism: The core concept of ecofeminism reveals major links between women's oppression and environmental deterioration. Lastly, every feminist theory must incorporate an ecological viewpoint, and vice versa, because of the need of understanding the nature of these relationships in order to understand the oppression of women and environment. Political research that analyses the linkages between androcentrism and environmental degradation is also part of the ecofeminist term. This "knowledge" begins with the awareness that "Western Man's attitude towards women and indigenous cultures is intimately related to the pillage of nature." This means that ecofeminists ascribe the supremacy of women and nature mostly to ideology. To move past this, people need to support equality, nonviolence, and nonhierarchical modes of organisation in addition to reconstructing and reconceiving their culture's underlying patriarchal values and structural relations. Ecofeminists say that respect for nature and other

52 forms of life derives from realising our natural connection. Humans need to stop attempting to rule nature and start working with it, and they also need to stop relying on hierarchical ties to get things done. This would entail reconciling the gender-based dichotomies that characterise traditional worldviews. The ecofeminists contend that the journey itself is just as important as the destination. Since the private is the public, women's personal lives have equal value and impact on men's public worlds. To modify the patriarchal nature of the system, one must deny patriarchy of its resources. 3.6.2 Perspectives of Ecofeminism The different configurations of ecofeminism reflect the different ways of analyzing the connections between women and nature, as well as the differences in the nature of women's oppression and solutions to them. (Rao 2012). (a) Liberal views: Liberal feminism formed a prominent part of the history of feminism since its beginnings in the seventeenth century until the 1960s. When each individual maximizes her/his own productive potential an optimal society can be made. Thus what is good for each individual is good for society as a whole. Historically, liberal feminists have argued that women do not differ from men as rational agents and that exclusion from educational and economic opportunities have prevented them from realizing their own potential for creativity in all spheres of human life. (Merchant, 2005:200). Twentieth-century liberal feminism was inspired by Simone de Beauvoir's The Second Sex (1949) and by Betty Friedan's The Feminine Mystique (1963). De Beauvoir argued that women and men were biologically different, but that women could transcend their biology, freeing themselves from their destiny as biological reproducers to assume masculine values. Friedan challenged

the "I'm just a housewife" mystique resulting from post-World War II production forces that

made way for soldiers to reassume jobs in the public sphere, pushing

the "reserve army" of women labourers back into the private sphere of the home.

The liberal phase of the women's movement that exploded in the 1960s demanded equity for women in the workplace and in education as the means of bringing about a fulfilling life. Simultaneously, Rachel Carson made the question of life on earth a public issue. Her Silent Spring (1962) focused attention on the death-producing effects of chemical insecticides accumulating in the soil and tissues of living organisms—deadly elixirs that bombarded human and nonhuman beings from the moment of conception until the moment of death. (Merchant, 2005:200). For liberal ecofeminists (as for liberalism generally), environmental problems result from the overly rapid development of natural resources and the failure to regulate pesticides and other environmental pollutants. Given equal educational opportunities to become scientists, natural resource managers, regulators, lawyers and, legislators,

women, like men, can contribute to the improvement of the environment, the conservation of natural resources, and the higher quality of human life.

Women, therefore, can transcend the social stigma of their biology and join men in the cultural project of environmental conservation. (Merchant, 2005:200-201). (b) Radical view: Cultural feminism developed in the late 1960s and 1970s. Cultural ecofeminism is a response to the perception that women and nature have been mutually associated and devalued in western culture. Sherry

Ortner's 1974 article, "Is Female to Male

53 as Nature is to Culture?"

posed the problem that motivates many ecofeminists. Ortner argued that, cross-culturally and historically women, as opposed to men, have been seen as closer to nature because of their physiology, social roles and, psychology. Physiologically, women bring forth life from their bodies, undergoing the pleasures, pain, and, stigmas attached to, menstruation, pregnancy, childbirth and, nursing, while men's physiology leaves them freer to travel, hunt, conduct warfare and, engage in public affairs. Socially, childrearing and domestic caretaking have kept married women close to the hearth and out of the workplace. Psychologically, women have been have assigned greater emotional capacities with greater ties to the particular, personal and, present than men who are viewed as more rational and objective with a greater capacity for abstract thinking. (c) Cultural view: To cultural ecofeminists, the way out of this dilemma is to elevate and liberate women and nature through direct political action. Many cultural feminists celebrate an era in prehistory when nature was symbolized by pregnant female figures, trees, butterflies, and snakes and in which women were held in high esteem as bringers forth of life. An emerging patriarchal culture, however, dethroned the mother goddesses and replaced them with male gods to whom the female deities became subservient. The scientific revolution of the seventeenth century further degraded nature by replacing Renaissance organicism and a nurturing earth with the metaphor of a machine to be controlled and repaired from the outside. Their ontology and epistemology are viewed by cultural feminists as deeply masculinist and exploitative of a nature historically depicted in the female gender. The earth is dominated by 8 male-developed and male-controlled technology, science and, industry. Often stemming from an anti-science, anti-technology standpoint, cultural ecofeminism celebrates the relationship between women and nature through the revival of ancient rituals centred on goddess worship, the moon, animals and, the female reproductive system. A vision in which nature is held in esteem as mother and goddess is a source of inspiration and empowerment for many ecofeminists. Goddess worship and rituals centred around the lunar and female menstrual cycles, lectures, concerts, art exhibitions, street and theatre productions, and direct political action are all examples of the re-visioning of nature and women as powerful forces. Cultural ecofeminist philosophy embraces intuition, an ethic of caring and, web-like human-nature relationships. Women's biology and nature are celebrated as sources of female power. (d) Socialist / Marxist Socialist ecofeminism: It is a feminist transformation of socialist ecology that makes the category of reproduction, rather than production, central to the concept of a just, sustainable world. Like Marxist feminism, it assumes that nonhuman nature is the material basis of all of life and that food, clothing, shelter and, energy are essential to the maintenance of human life. Nature and human nature are socially and historically constructed over time and transformed through human praxis. Nature is an active subject, not a passive object to be dominated, and humans must develop sustainable relations with it. It goes beyond cultural ecofeminism in offering a critique of capitalist patriarchy that focuses on the dialectical relationships between production and reproduction and, between production and ecology.
54 3.6.3 Prakiti and Shakti: The connection between women and the natural world in ancient Indian philosophy runs even deeper than in Western ideas. However, in Indian philosophical thought, there is no opposition between the male and the female, or between nature and culture. According to Vandana Shiva (1988), this is indicative of a society in which men and women are seen as equals rather than opposites. The world, according to Indian cosmology, is the result of a struggle between the forces of dissolution and formation, of unity and division (Shiva, 1988). The creative energy that emerges from this transformation is known as Shakti, and it is the very essence of all things. Prakriti, also known as nature, is the physical expression of Shakti, the feminine principle, in the form of energy or power. Together with the masculine principle (Purusha), Prakriti creates the world as an expression of Shakti, the feminine and creative principle of the cosmos, in all of nature, living and nonliving alike (Shiva, 1988, p.38). Purusha and Prakriti, the individual and the natural world, are thus two aspects of the same whole. In fact, they are "...inseparable complements of one another in nature, in woman, in man" and should be seen as such rather than as competing forces (Shiva, 1988, p.40). According to Shiva, the revolutionary idea that women belong only in nature is what leads to their subjugation and exploitation. According to her, Beauvoir's formulation is typical of Western feminist thought, which recognises the male and female as diametrically opposed and thus further positions women as weak and oppressed. In fact, Beauvoir believes that masculinizing women is the solution to the issue of women. In a world where women can freely adopt masculine norms and roles, liberation will prevail. Given that the distinctions between male and female are also culturally constructed, Shiva has issues with this formulation. The Western view of gender categorises them as essentialists based on biology. On the other hand, Shiva is a proponent of a transgender ideology that recognises the feminine spirit in both sexes. "One cannot really differentiate the masculine from the feminine, person from nature, Purusha from Prakriti," which translates to "one cannot really distinguish the principle of activity and creativity in nature as the principle of the feminine." As one scholar puts it, "Woman
and nature are related not in passivity but in innovation and in the maintenance of life"

in ancient ideologies, especially those from the Third World. Despite the fact that men and women share a similar perspective on nature, Shiva stresses that women have a unique bond with the natural world. The following examples show this to be true. First, in the symbiotic nature of women's relationships with the natural world, wherein both parties contributed to the growth and renewal of the planet and human civilization. Second, women are partners with the natural world since they not only benefit from but also contribute to it. Those who insist
on being a part of the process of "to allow grow and to make grow"
do not view nature as property. At the end of the day, women in nature are producers who help keep communities and relationships afloat. A subsistence economy has its supporters, and the first productive economy had its creators. In this context, colonisation is always to blame for the separation of nature and the subjugation of women. Shiva blames colonialism for ruining the planet and devaluing women's labour. Science and technology have ushered in a new era of inequality and hierarchy, severing the bonds between nature and masculine and feminine ideals. Women and the environment suffer as a result of development, which is seen as harmful because it strengthens patriarchy and centralization. Consider the decimation of India's forests at the hands of colonial powers. In
55 India, the forest represents life and fertility, as pointed out by Shiva. In some places she is worshipped as Aranyani, in others as the Goddess of the Forest. Forests have traditionally been seen as the pinnacle of communal harmony and have been revered and protected as sacred groves. This represents the group's in-depth familiarity with environmental issues. The decimation of India's forests and other natural resources paved the way for colonial rule. The displacement of traditional indigenous knowledge and women's subsistence economy began with the colonial practise of commercial forestry and scientific management of forests, which included marking out forest area as'reserved' and protected. Forests and the rights of indigenous people to their products were harmed as a result of the aforementioned practise. Because they are experiencing the negative effects of progress firsthand, and because they have the ecological and holistic understanding of what Eco-Feminism, the protection and production of life, entails, Shiva argues that the role of marginalised women and communities becomes especially important. The most exemplary members of this group are women from the Third World. According to Bina Agarwal, Shiva's theory differs from the Western feminist perspective because it considers factors such as people's reliance on the natural world for survival and the links between development and developmental change that have been neglected by the latter in their formulation. However, there are flaws in the theory that must be considered. First, according to Shiva's theory, all women in the Third World are the same. Agarwal argues that essentialism includes this type of oversimplification, which ignores or dismisses important differences across cultural, economic, and social contexts. All women in the Third World are stereotyped as being extremely eco-literate and reliant. Two, the theory overlooks other social, cultural, and historical processes and ideas that may have influenced the human-nature relationship even within India. Other Indian philosophies and practises are not affected by the reliance on Hinduism. Even among Hindus themselves, there are many schools of thought that might disagree with Shiva's theory. Third, Agarwal claims that the effects of precolonial structures and practises on the environment and on women are not accounted for in Shiva's teachings. Shiva dismisses the long history of caste and class inequality within the Indian social framework, blaming instead the arrival of colonial power and modern scientific thought for the devastation of the environment and the subjugation of women. The aforementioned objections show that ecofeminism can be refined and improved. As Salleh points out, the movement's vitality stems from its theoretical stance, which responds to global shifts and gives credence to alternative theories that take a more comprehensive approach to environmental and gender equality concerns. To better understand these debates and how they might be resolved, the following section will introduce you to some ecofeminism alternatives. Ecofeminism in India: In India, ecofeminist Vandana Shiva is the pioneer who prepared the ground for ecofeminism with a strong belief that women have always been the key to solve various societal problems and environmental problems are one of them. Literature in which the concept of ecofeminism has been taken into account ranges from early ecofeminism to the recent or the urbanized one such as ‘Nectar in a Sieve’ (1954) by Kamala Markandya, ‘Fire on the Mountain’ (1977) by Anita Desai, ‘A Riversutra’ (1993) by Gita Mehta, ‘The God of Small Things’ (1997) and ‘An Atlas of Impossible Longing’ (2008) by Arundhati Roy and ‘Monkey- Man’ (2010) by Usha K.R. Various environmental movements like Bishnoi movement, Chipko

56 Movement, Aapiko movement, Silent valley movement and Narmada Bachao Andolan are the significant environmental movement of India that reflect the integral leadership of women. 3.6.4 Importance of Ecofeminism: There are three main reasons why ecofeminism is important in today's society. 1. Helping the environment: It brings the environment to the forefront of discussions surrounding feminism. This is important because of the continuing environmental degradation happening to the planet. 2. Connecting social and environmental issues: Bringing together social and environmental issues is at the core of ecofeminism. This is important as it provides a new and unique perspective in looking at how the problems surrounding social and environmental issues are in fact connected. 3. Core aim of equality: Finally, it is important to remember that ecofeminism is a type of feminism. At its core, the aim of ecofeminism is equality in society and eliminating the patriarchy. As such, when viewing ecofeminism in the context of its original aims it is important because any contribution to equality in society can trigger positive change. 3.6.5 Criticism on Ecofeminism: Some people say ecofeminism is essentialist because it assumes all things have fixed qualities. Feminists should not, according to these critics, highlight the importance of women's relationships with animals and the environment. Furthermore, the patriarchy's control over women's views of their bodies may be reflected in the overemphasis of the relevance of women's biology in terms of sex and reproduction. This outdated viewpoint holds that gender differences in society are grounded in biological differences between the sexes. 3.7 Summary "Man, and environment relationship" studies environmental changes, community responses, environmental policymaking, and other topics. There are different philosophical ideas on the man-environment relationship which include determinism, environmental determinism, possibilism, cultural ecology, radicalism, positivism, humanism etc. A human settlement can range in size from a single farm to an enormous city. The implication is that the population is increasing in an otherwise uninhabited area. Human settlement can be categorized broadly categorized into rural and urban settlements. The biogeographic realm or province is the area of land where similar living things are found. Biogeographic regions are further subdivided into eco-regions i.e., Palaearctic, Nearctic, Ethiopian, Oriental, Neotropical and Australian which are then subcategorized into biomes.

57 Ecofeminism is a branch of feminism that focuses on environmental issues and the relationship of women with the natural world. 3.8 Questions/ Self-Assessment questions 1 . What do you know about the possibilism and positivism thought of human civilization process? 2 . What are the class of the rural settlements? 3 . List down the factors affecting rural settlements. 4 . Elaborate the patterns of the rural settlements. 5 . Define the urban settlement. What are the class of the urban settlements? 6 . Describe the faunal structure of neotropical region. 7 . What do you mean by ecofeminism? 8 . Briefly describe the importance and criticisms of ecofeminism. 3.9 Select Readings/ Suggested Readings 1. General Overview of Ecofeminism by Laila Fariha Zein & Adib Rifqi Setiawan, LΛ×ΛRS, 28 August 2017. 2. Agarwal, Bina (2007). 'The gender and environment debate: Lessons from India.' In Mahesh Rangarajan (Eds.). Environmental Issues in India: A Reader. New Delhi: Pearson India. 3.

Shiva, Vandana (1988). Staying Alive: Women, Ecology and Survival in India. New Delhi: Kali for Women. 4. A Classification of the Biogeographical provinces of the world by Miklos D.F Udvardy, IUCN 5. Environment and Ecology by PD Sharma

58 UNIT 4: Current Environmental issues 4.1 Objectives 4.2 Introduction 4.3 The major global environmental issues 4.4 Indian Environmental issues 4.5 Big dam movements 4.6 Namami Ganga 4.7 Yamuna Action Plan 4.8 Rivers Interlinking Project in India 4.9 Conservation of Wetlands 4.10 Ramsar Convention on Wetlands 4.11 Desertification 4.12 Summary 4.13 Questions/ Self-Assessment questions 4.14 Select Readings/ Suggested Readings 4.1 Objectives After studying this module, you will be able to • explain the cause and effects of ozone-layer depletion • comment on the major causes of desertification • explain the cause of biodiversity loss • describe the harmful effects of acid rain on living organisms, buildings, and monuments • define and connect global warming with the greenhouse effect • list the major effects of global warming on living and non-living components of the environment • explain the issues of oil spills and their impact on aquatic ecosystem • address the issues of hazardous waste dumping 4.2 Introduction We have a lot to be thankful for and happy about in this world. It incorporates the natural world around us. But the very ecosystem that nourishes us is being changed mostly owing to our

59 actions. A hostile environment would make life very challenging for us. This unit describes different environmental problems, which are plaguing the world today and the solutions that have been proposed to address them. 4.3 The major global environmental issues This rapid decline in environmental quality can be directly attributed to the exponential growth of human population, rapid urbanization, and industrial growth. The life support system has been seriously impacted by different types of anthropogenic activities. The differences in economic development between countries and regions are a major threat to the planet as a whole. This can be resulted into complicated environmental problems which are needed to be solved. Some important global environmental issues are • The greenhouse effect and global warming • Loss of biodiversity includes • Desertification • Ozone depletion • Issues of acid rain • Oil spills • Dumping of hazardous wastes and so on. 4.3.1 Greenhouse effect and global warming The surface of the earth is heating up at a rapid pace. The increase of average global temperature is known as global warming. Till date sixteen out of total seventeen warmest years have been recorded after the year 2000. Melting of glaciers, rising of sea levels, decrease in the forests, danger, and scrambling of wildlife are the most common effect of this global temperature rising. This is also known as greenhouse effect. What is greenhouse effect? The term "green house" refers to a glass enclosure used to grow plants in order to warm them up by capturing solar energy. In contrast to sunlight, heat radiation cannot escape through glass; hence the heat it produces cannot escape the glass chamber. Sunlight (a source of energy) flows through the glass and is absorbed within, releasing heat radiations. Consequently, the inside of a greenhouse can get warmer to encourage plant development even on a chilly winter day. The greenhouse effect is the term used to describe the phenomena of heat building up inside a glass chamber due to solar radiation absorption. 1. Global warming and Green-house effect On earth, the green-house effect has been a natural occurrence for millions of years. This natural greenhouse effect, which is caused by water vapour and tiny water particles in the atmosphere, has made life on earth possible. These factors account for more than 95% of all greenhouse gas emissions. Because of the natural greenhouse effect, average global

60 temperatures are kept at roughly 15°C. Without this phenomenon, the world's average temperature may have been roughly -17°C, a temperature too low for life to exist. Simple human activities did not significantly raise the air temperature prior to industrialization. The rise in greenhouse gas emissions brought on by rapid industrialization and urbanization, which is very alarming. In recent years, the atmospheric concentration of these greenhouse gases (e.g., CO 2 , CH 4 , N 2 O, CFCs, tropospheric ozone, SF 6) has considerably increased. Table 4.1: Some important greenhouse gases Name of the greenhouse gases Sources Carbon dioxide (CO 2) Burning of fossil fuels, deforestation Methane (CH 4) Growing paddy, excreta of cattle and other livestock, termites, burning of fossil fuel, wood, landfills. Nitrogen oxides (N 2 O) Burning of fossil fuels, fertilizers; burning of wood and crop residue. Chlorofluorocarbons (CFCs) Refrigeration, solvents, insulation foams, aero propellants, industrial and commercial uses Tropospheric ozone Vehicular pollution Sulphur hexa fluoride (SF 6) Electrical transmission and distribution equipment, manufacture of electronics / semiconductors 2. Mechanism of global warming/greenhouse effect Sunlight rays hit the earth. Some of these radiations penetrate through the atmosphere towards earth while others are reflected back into space by the atmosphere. The atmosphere absorbs around half of photons and warms the air. The earth's surface receives the remainder. The earth's surface now emits longer wavelength, lower energy (heat or infrared) radiations as it warms up. These infrared rays are reflected and return to the atmosphere. Most of it is absorbed by the greenhouse gases of the atmosphere e.g., CO 2 , CH 4 , N 2 O etc. and reradiated back to the earth's surface rather than being completely radiated out into space. The temperature of the atmosphere and the area around the earth's surface then increases.

61 Figure 4.1: Greenhouse effect. [Source: shutterstock.com] 3. Causes of Global warming/Greenhouse Effect The causes of global warming are mainly anthropogenic as well as natural. Anthropogenic or manmade causes: i. Deforestation: Oxygen, which humans need to breathe, comes primarily from plants. Through the process of photosynthesis, plants absorb carbon dioxide and give off oxygen. Several human activities, both at home and in business, contribute to forest depletion. This has caused an environmental imbalance, which has contributed to the escalation of global warming. ii. Using Automobiles: Even for short distances, driving a car produces a variety of harmful gases. Carbon dioxide and other pollutants released into the atmosphere as vehicles consume fossil fuels raise global temperatures. iii. Chlorofluorocarbon:

Humans have been contributing CFCs into the environment, which harm the atmospheric ozone layer, through the excessive use of air conditioners and refrigerators. The ozone layer serves as a barrier between the surface of Earth and the sun's potentially dangerous ultraviolet radiation. CFCs have caused the ozone layer to thin, allowing more heat-trapping UV light to reach the surface. CFCs also have very high global warming potential. iv. Engineering Progress: The rise in global average temperature can be directly attributed to the widespread adoption of industrial practises. Pollutants released by factories contribute to global warming. The worldwide average temperature rose by 0.9 degrees Celsius between 1880 and 2012, according to the Intergovernmental Panel on Climate Change's (IPCC) 2013 report. When compared to the average temperature before industrialization, this is an increase of 1.1 degrees Celsius.

62 v. Agricultural practices: Carbon dioxide and methane gas are byproducts of many farming processes. These contribute to the already high levels of greenhouse gases in the atmosphere, which in turn raises global temperatures. vi. Overpopulation: Simply put, more people requiring oxygen indicates a rise in the population. Because of this, atmospheric concentrations of carbon dioxide rise, the principal greenhouse gas. Natural causes i.
Volcanoes: Volcanoes are one of the largest natural contributors to global warming. The ash and smoke emitted during volcanic eruptions goes out into the atmosphere and affects the climate. ii.
Water
Vapour: Water vapour is a kind of greenhouse gas. Due to the increase in the earth's temperature, more water gets evaporated from the water bodies and stays in the atmosphere adding to global warming. iii. Melting Permafrost: Permafrost is frozen soil that has environmental gases trapped in it for several years and is present below Earth's surface. It is present in glaciers. As the permafrost melts, it releases the gases back into the atmosphere, increasing Earth's temperature. iv. Forest Blazes/Forest fires:
Forest blazes or forest fires emit a large amount of carbon-containing smoke. These gases are released into the atmosphere and increase the earth's temperature resulting in global warming. 4. Effects of Global warming/ Greenhouse effects a. Hotter temperatures: As greenhouse gas concentrations rise, so does the global surface temperature. The last decade, 2011-2020, is the warmest on record. Since the 1980s, each decade has been warmer than the previous one. Nearly all land areas are seeing more hot days and heat waves. Higher temperatures increase heat-related illnesses and make working outdoors more difficult. Wildfires start more easily and spread more rapidly when conditions are hotter. Temperatures in the Arctic have warmed at least twice as fast as the global average. b. More severe storms: Destructive storms have become more intense and more frequent in many regions. As temperatures rise, more moisture evaporates, which exacerbates extreme rainfall and flooding, causing more destructive storms. The frequency and extent of tropical storms is also affected by the warming ocean. Cyclones, hurricanes, and typhoons feed on warm waters at the ocean surface. Such storms often destroy homes and communities, causing deaths and huge economic losses. c. Increased drought: Climate change is changing water availability, making it scarcer in more regions. Global warming exacerbates water shortages in already water-stressed regions and is leading to an increased risk of agricultural droughts affecting crops, and ecological droughts increasing the vulnerability of ecosystems. Droughts can also stir destructive sand and dust storms that can move billions of tons of sand across continents. Deserts are expanding, reducing land for growing food. Many people now face the threat of not having enough water on a regular basis.

63 d. A warming, rising ocean: The ocean soaks up most of the heat from global warming. The rate at which the ocean is warming strongly increased over the past two decades, across all depths of the ocean. As the ocean warms, its volume increases since water expands as it gets warmer. Melting ice sheets also cause sea levels to rise, threatening coastal and island communities. In addition, the ocean absorbs carbon dioxide, keeping it from the atmosphere. But more carbon dioxide makes the ocean more acidic, which endangers marine life and coral reefs. e. Loss of species: Climate change poses risks to the survival of species on land and in the ocean. These risks increase as temperatures climb. Exacerbated by climate change, the world is losing species at a rate 1,000 times greater than at any other time in recorded human history. One million species are at risk of becoming extinct within the next few decades. Forest fires, extreme weather, and invasive pests and diseases are among many threats related to climate change. Some species will be able to relocate and survive, but others will not. f. Not enough food: Changes in the climate and increases in extreme weather events are among the reasons behind a global rise in hunger and poor nutrition. Fisheries, crops, and livestock may be destroyed or become less productive. With the ocean becoming more acidic, marine resources that feed billions of people are at risk. Changes in snow and ice cover in many Arctic regions have disrupted food supplies from herding, hunting, and fishing. Heat stress can diminish water and grasslands for grazing, causing declining crop yields and affecting livestock. g. More health risks: Climate change is the single biggest health threat facing humanity. Climate impacts are already harming health, through air pollution, disease, extreme weather events, forced displacement, pressures on mental health, and increased hunger and poor nutrition in places where people cannot grow or find sufficient food. Every year, environmental factors take the lives of around 13 million people. Changing weather patterns are expanding diseases, and extreme weather events increase deaths and make it difficult for health care systems to keep up. h. Poverty and displacement: Climate change increases the factors that put and keep people in poverty. Floods may sweep away urban slums, destroying homes and livelihoods. Heat can make it difficult to work in outdoor jobs. Water scarcity may affect crops. Over the past decade (2010–2019), weather-related events displaced an estimated 23.1 million people on average each year, leaving many more vulnerable to poverty. Most refugees come from countries that are most vulnerable and least ready to adapt to the impacts of climate change. 4.3.2 Biodiversity loss Biodiversity refers to the variety of living organisms within a given area.The term "biodiversity" describes all the various species of living things found in a specific location. Plants, animals, fungi, and other living things are all included in biodiversity. Tall redwood trees and microscopic, unicellular algae that cannot be seen without a microscope are both examples of biodiversity. Over 1.75 million unique species have been recognised by scientists. This comprises 950 000 bug species, 270,000 plant species, 19,000 fish species, 9,000 bird species, and 4,000 animal species. The number of species on Earth is much larger than this. Millions more species still to be found and given names.

64 Global biodiversity has drastically diminished during the last century. There are many extinct species. Extinction is a natural process in which some species pass away and others develop. Yet, the natural processes of extinction and evolution have been altered by human activities. According to scientists, species are vanishing at a rate that is hundreds of times faster than natural.With the current rate of development, population growth and migration communities are increasingly unable to meet their sustained needs. However, the present-day drastic changes in the environment and habitat due to population explosion and unmanaged developmental activities are so unnatural that the species are not getting full liberty of time and space for their survival and adaptive radiation, therefore, resulting in loss of biodiversity, which is a global crisis. It is high time that our natural wealth be preserved from loss. 1. Causal factors for loss of biodiversity Causal factors of threat may be natural or anthropogenic. They are as follows 1. Development pressure • Construction • Forest based industries • Hydel/ Irrigation projects • Mining • Oil drilling • Pollution • Resource extraction • Road & Transport 2. Encroachment • Agriculture • Expansion of forest villages • Fishery d. Grazing / increased domestic animals • Habitat depletion / change • New settlements • Shifting cultivation 3. Exploitation • Collection made by scientific/educational institutions • Exploitation by local authorities as revenue resources • Firewood collection • Food gathering and hunting • Poaching 4. Human induced disasters • Floods • Major oil spills/leakage • Epidemics • Forest fires 5. Management of Natural resources • Genetic uniformity

65 • Inadequate water/ food for wildlife • Increased competition • Introduction of exotic species • Predation 6. Management of Human Resource • Change in people’s lifestyle • Increasing demands • Dilution of traditional values • Human harassment • Inadequate trained human resources • Lack of effective management • In appropriate land use 7. Political and policy issues • Change in use / legal status • Civil unrest • Intercommunity conflict • Military activities 2. The major drivers of global biodiversity loss 1. Changes in land and sea use The biggest driver of biodiversity loss is how people use the land and sea. This includes the conversion of land covers such as forests, wetlands and other natural habitats for agricultural and urban uses. Since 1990, around 420 million hectares of forest have been lost through conversion to other land uses. Agricultural expansion continues to be the main driver of deforestation, forest degradation and forest biodiversity loss. The global food system is the primary driver of biodiversity loss, with agriculture alone being the identified threat of more than 85 per cent of the 28,000 species at risk of extinction. Harvesting materials such as minerals from the ocean floor and the building of towns and cities also impact the natural environment and biodiversity. Reconsidering the way people grow and consume food is one way of reducing the pressure on ecosystems. Degraded and disused farmland can be ideal for restoration, which can support protecting and restoring critical ecosystems such as forests, peatlands and wetlands. 2. Climate change Due to a doubling in greenhouse gas emissions since 1980, the average global temperature has increased by at least 0.7 degrees Celsius. Global warming is already having an impact on species and ecosystems, especially the most delicate ones like coral reefs, mountains, and polar ecosystems. There are signs that global temperature rises brought on by climate change may endanger as many as one in six species. Ecosystems including wetlands, peatlands, and forests serve as important global carbon sinks. The
66 Paris Agreement's goals cannot be attained without their conservation, restoration, and sustainability. By 2030, emissions can be cut by up to 11.7 gigatons of carbon dioxide equivalent annually by cooperating with nature, which is more than 40% of what is required to stop global warming. 3. Pollution Water and marine ecosystems are particularly vulnerable to the catastrophic direct consequences of pollution, which is a significant driver of biodiversity loss and ecosystem change. The continued use of extremely harmful, non-selective insecticides has resulted in a decline in plant and insect populations. Since 1980, there has been a tenfold rise in marine plastic pollution, affecting at least 267 animal species. Eighty-six percent of marine turtles, forty-four percent of seabirds, and forty-three percent of marine mammals are all affected by this problem. Increases in both air and soil pollution are also being observed. Atmospheric nitrogen deposition is a major factor in the decline of biodiversity around the world. The deposition of nitrogen on terrestrial ecosystems can have a domino effect, typically leading to a loss of species diversity. In order to solve the nature disaster, it is essential to lessen the amount of pollution in the air and water and to properly store and dispose of chemicals and garbage. 4. Invasive species/Invasive alien species Animals, plants, fungi, and even microorganisms that have spread outside of their native range are considered invasive alien species (IAS). Devastating effects of IAS on native plant and animal life are well documented, with many native species suffering severe declines or going extinct as a result of these pests' introduction. The increased mobility of people and goods brought about by the development of a global economy has paved the way for the spread of invasive species across great distances and across traditional barriers to their spread. Climate change, habitat loss, and pollution can all compound the damage that these animals do to biodiversity. Almost 40% of all documented animal extinctions since the 17th century have been caused by IAS. Meanwhile, it's estimated that introduced pests cost the environment over US$100 billion annually in Australia, Brazil, India, South Africa, the United Kingdom, and the United States. Invasive alien species (IAS) is a worldwide problem that calls for global solutions. It is more cost-effective to prevent the spread of these species internationally and to detect them quickly at borders than to try to control or eradicate them. 4.3.3 Ozone layer depletion Ozone, or O 3 , is a triatomic oxygen molecule that is extremely reactive. A thin layer of ozone can be found in the stratosphere region of Earth's atmosphere, which is located between 10 and 50 kilometres above the surface. This layer acts as a natural barrier to the potentially lethal ultraviolet (UV) radiation coming from the Sun. So, the ozone layer is an essential component of Earth's environmental defence system. Stratospheric ozone (O 3) blocks 95-99% of UV

67 radiation from reaching earth's surface. Allows life to exist on the land. Since the 1960s, ozone levels have fallen by 10-50%, depending on latitude. More UV striking earth's surface, causing long-term health problems for humans, and threatening the existence of some plants and animals. Ozone depletion or "Ozone hole" refers to the depletion of stratospheric ozone layer. 1. Causes of Ozone Depletion i. Problem stems from the use of a wide variety of chlorofluorocarbons (CFC) used as propellants, coolants, solvents, sterilant, fumigants, and in foam bubbles. Widely used because they are stable, insoluble in water, non-corrosive, nontoxic, and inflammable. They seemed like the perfect molecules. However, once emitted into the atmosphere, CFC molecules rise to the stratosphere and remain there for decades. They react with UV radiation, losing a chlorine atom. Chlorine then reacts with ozone, converting it to an O 2 molecule and O ion. Each CFC molecule does this to tens of thousands of ozone molecules so that ozone is destroyed faster than it can be created. ii. Other chlorine and bromine bearing molecules used in industry can do the same thing. Natural sources of chlorine and bromine (volcanic gases and sea spray) are typically soluble in water and are quickly washed out of the atmosphere. iii. Ozone depletion is greatest over the poles (50+%), particularly Antarctica. This is due to the build-up of Cl 2 O 2 on ice crystals (also act as a catalyst for ozone depleting reactions) during the frigid winters. When sunlight returns in the spring, the Cl 2 O 2 is rapidly destroyed releasing a burst of chlorine and causing a rapid reduction in ozone. Eventually, by the end of the polar summer, ozone levels rebound. Each spring large amounts of ozone-depleted air is released from the poles and spreads over the higher southern (Australia, New Zealand, South Africa, Argentina, Chile) and northern (Europe, North America, Asia) latitudes. UV levels rise by as much as 15% in these regions. Table 4.2: Some Important ozone depleting substances Name of the substances Sources Chlorofluoro carbons (CFCs) e.g., CFC11, CFC 12 etc. Refrigeration, aerosol, foam, food freezing, warming devices, cosmetics, heat detectors solvents, cosmetics, refrigerants, firefighting Halons Fire fighting HCFCs Refrigeration, aerosol, foam, fire fighting Methyl chloroform Solvent Carbon tetrachloride (CCl 4) Solvent 2. Effects of Ozone Depletion i. Effects on humans: For humans, the most important health impacts from lower ozone and higher UV levels are more cataracts, premature aging of the skin, more severe

68 sunburns, and more skin cancers. Present loss of ozone estimated to produce over 300,000 additional skin cancers worldwide each year. Three types: squamous cell, basal cell, and malignant melanoma. The first two are very curable if caught early, whereas the latter is often fatal. Present ozone loss also estimated to produce 1.5 million additional cataracts. Estimated that in the U.S., 12 million additional skin cancers will occur with about 200,000 deaths occurring over the next 50 years. Other human health impacts include suppression of the immune system and the increase in tropospheric ozone, which will increase respiratory diseases. ii. Effects on plants: Increased UV also will lower crop yields ($2.5 billion/year in U.S.), decrease forest and phytoplankton productivity (increasing global warming and destroying ecosystems). iii. Effects on materials: Increased UV radiation may increase the degradation and destruction of many materials, including plastics (become brittle) and paints (fade). iv. Effects on other organisms: Marine freshwater organisms are very sensitive to UV- rays. Larvae of fish, shrims, crabs are affected due to UV radiation. Corals can be bleached due to UV radiation. 3. Ways to Reduce Ozone Loss • Best way is to stop producing all ozone-depleting chemicals. Still will take decades to return to normal levels (prior to 1950). • A number of substitute compounds already exist to replace CFCs, including HCFC, HFC, HC, ammonia, H 2 O, terpenes, and helium. Some deplete ozone at a greatly reduced rate and some also are greenhouse gases. There is no single answer. • Recent agreements have led to the international phasing out of CFCs. Worldwide production is down over 80% since 1988. This should result in a stabilization of ozone levels 10-30% lower than present by 2080 in the northern hemisphere. • Unfortunately, China and India have not signed these agreements, other countries are not meeting their obligations, and there is a black market for CFCs in the U.S. where they are now illegal. May prolong ozone depletion into the 22nd century. • Much progress has been made in this area thanks to the international community's recognition of the issue and its subsequent action in the form of the Helsinki (1989) and Montreal (1990s) conventions and protocol. CFCs and other ozone-depleting chemicals should be outlawed entirely. Hydrochlorofluorocarbons (HCFCs) are being recommended as a temporary replacement for CFCs because they cause less damage to the ozone layer than CFCs do, but they still aren't completely ozone safe. 4.3.4 Acid rain Acid rain is an environmental problem that knows no boundaries. Increasing acidity in natural waters and soil has become a global concern. Acidification and climate change are interrelated as the sources responsible for acidification of environment and greenhouse gases are to some extent similar.

69 What is acid rain? The term acid rain was first used by Robert angus in 1872. Literally it mans presence of excessive acids in rain water. Normally unpolluted rainwater is always slightly acidic as CO_2 in the atmosphere dissolve in it and carbonic acid (H_2CO_3) is formed. The pH of unpolluted rainwater is about 5.5-5.7. But due to presence of SOx and NOx gases in the atmosphere as pollutants in the atmosphere, the pH of the rain is further lowered. Often as low as 2.4 and this type of precipitation is known as acid rain. So, when the pH of the rain water is below 5.5, then it is known as acid rain. Acid rain is in fact mixture of primarily H_2SO_4, HNO_3 and HCl. H_2SO_4 is the major contributor (60-70%), HNO_3 (30-40%), and HCl is the third contributor. These oxides may travel long distance in the atmosphere and undergo several physical and chemical transformations to produce more hazardous substances, which may fall on the earth with rain. Once these fallen on the earth it is very difficult to remove. Types of acid rain i. Wet acid rain: Acid rain in the form of snow, dew, fog, mist, frost, rain represent wet acid rain. ii. Dry acid rain: Dust particles containing sulphates and nitrates settled on the earth is called dry deposition. However, the wet form of acid rain is most common. 1. Mechanism of formation of acid rain i. The molecule of nitric oxide (NO), which is generated during lightning storms by the reaction of nitrogen and oxygen, two prevalent atmospheric gases, contributes to the natural decrease of pH (acidity) of precipitation. Nitric oxide (NO) is oxidized to nitrogen dioxide (NO_2) in the air, which then reacts with water to form nitric acid (HNO_3). In a reaction similar to the dissociation of carbonic acid indicated in the equation below, this acid dissociates in water to produce hydrogen ions (H^+) and nitrate ions (NO_3^-), reducing the pH of the solution once more. $NO + \frac{1}{2} O_2 (g) \rightarrow NO_2 (g)$ $N_2 (g) + O_2 (g) \rightarrow 2NO$ (when lightning strikes in the atmosphere, a reaction occurs.) $3NO_2 (g) + H_2O \rightarrow 2HNO_3 (aq) + NO (g)$ Nitric acid is responsible for around one-fourth of the pH drop in rain (HNO_3). ii. The presence of sulphuric acid (H_2SO_4) in rainwater accounts for the reduction of pH in most water bodies. Despite the fact that sulphuric acid is produced naturally. Sulphuric acid is produced nearly completely by human activity, particularly the combustion of sulphur-containing fossil fuels in power plants. It is produced naturally

70 in trace amounts through biological decomposition and volcanic activity. Sulphur in these fossil fuels reacts with water to generate sulphuric acid when they are burned. $SO_2 (g) + O_2 \rightarrow SO_3 (g) + H_2O \rightarrow H_2SO_4$ Sulphuric acid is an extremely powerful acid. As a result, it is regarded as a strong electrolyte that easily dissociates in water to produce H^+ and HSO_4^- ions. The hydronium ion (H^+) and sulphate ion may dissociate further from the HSO_4^- ion (SO_4^{2-}) As a result of the presence of H_2SO_4, the concentration of H^+ ions in the rainwater rises substantially, and the pH decreases to a dangerous level. $H_2SO_4 \rightarrow HSO_4^- + H^+$ $HSO_4^- \rightarrow SO_4^{2-} + H^+$ 2. Environmental Effects of Acid Rain Acid rain increases the number of inorganic and biological reactions that have negative environmental consequences, resulting in a global environmental disaster. 1. Many huge lakes have become so acidic (low pH lake) that fish can no longer survive in them. 2. The breakdown of many naturally occurring soil minerals produces metal ions. These metal ions are then swept away in the runoff, resulting in a variety of consequences: a) The mobility of harmful ions such as Al^{3+} in the water supply increases due to the acidic situation. b) The loss of essential minerals, such as Ca^{2+}, from the soil in the process of neutralizing sulphuric acid, which generates a Ca^{2+} deficit, kills trees and damages crops. 3. It affects both animals and people' respiratory systems. 4. Acid rain has an impact on the aquatic ecosystem when it falls and runs into rivers and ponds. It creates water pollution by changing the chemical composition of the water to a state that is damaging to the aquatic ecosystem's ability to exist. 5. Corrosion of water pipes is also a result of acid rain. As a result, heavy metals such as iron, lead, and copper are leached into drinking water. 6. It causes damage to stone and metal structures and monuments. 3. Control of Acid rain 1. We have to adopt and enforce some strict measures to reduce vehicular emissions containing nitrogen oxide and emissions from power stations containing SO_2.

71 2. Short term control of acid deposition problem can be achieved by using lime, New York has been liming its lakes, ponds since 1959 but liming is possible for only few lakes by observing that whether it is economically feasible to lime the whole lake. 3. People should be made more aware about the harmful effects causes and preventive measures of controlling acid rain. 4.4 Indian Environmental issues 4.4.1 Bishnoi movement Year: 1700s Place: Khejarli, Marwar region, Rajasthan state. Leaders: Amrita Devi along with Bishnoi villagers in Khejarli and surrounding villages. Aim: Save sacred trees from being cut down by the king's soldiers for a new palace. The Maharaja Abhay Singh of Jodhpur wanted to build a new palace and required wood for it. To procure this his men went to the area around the village of Jalnadi to fell the trees. Amrita Devi, a country woman, was unable to tolerate seeing the destruction of her sacred trees (Khejri trees) and her religion. She hugged the trees and encouraged others to do the same. 363 Bishnoi villagers were killed in this movement

by me sent by the king. After hearing the news, the King felt regret and sent a representative to the community to offer his apologies. He assured them that no khejri tree would be taken down, and hunting would be prohibited in the area around the Bishnoi settlements. That's how the previously known Jalnadi became known as Khejarli. The Bishnoi people will stop at nothing to safeguard the local fauna and flora. Guru Maharaj Jambaji, the founder of the Bishnoi faith in 1485, forbade harm to trees and animals in his teachings, which may have influenced the Bishnoi tree martyrs. This regulation is still in effect in the area today. 4.4.2 Silent Valley Movement A social campaign called Save Silent Valley aimed to preserve Silent Valley, an evergreen subtropical forest in Kerala, India's Palakkad district. An organization under the direction of Kerala Sasthra Sahithya Parishad (KSSP) began it in 1966 to prevent a hydroelectric project from flooding the Silent Valley. The project, which had a budget of about Rs. 25 crores, was authorized by the Planning Commission in February 1973. In 1985, Silent Valley National Monument was established within the valley.
72 1. Story behind Movement The Save Silent Valley Movement, India's most acrimonious environmental discussion of the decade, focused on the valley after it was announced that a dam would soon be built there. The topic was made public because of worries about the lion-tailed macaque, a vulnerable species. Romulus Whitaker, the man behind the Madras Snake Park and the Madras Crocodile Bank, was probably the first to
bring the tiny, inaccessible region to the notice of the general public. The Silent Valley area was the subject of an ecological effect study conducted in 1977 by the Kerala Forest Research Institute, which recommended that the region be designated as a biosphere reserve. The project was given the go-ahead by Indian Prime Minister Indira Gandhi in 1978 on the condition that the state
legislature passes legislation ensuring the necessary safeguards. The controversy grew that year, and
the IUCN (International Union for Conservation of Nature) approved a resolution endorsing the preservation of lion-tailed macaques in Silent Valley and Kalakkad. The Keralan government approved the Protection of Ecological Balance Act of 1979, establishing the Silent Valley Protection Area. It announced that the proposed national park
would not include the hydroelectric project area. 2. Participants The public's view on the need to save Silent Valley was successfully sparked by Kerala Sasthra Sahithya Parishad (KSSP). A study on the hydropower project in Silent Valley's techno-economic and socio-political evaluation was also released. Sugatha kumari, a poet and activist, was a key figure in the Silent Valley protest. Her poetry "Marathinu Stuthi" ("Ode to a Tree"), which served as the introductory hymn or prayer at the majority of "save the Quiet Valley" campaign gatherings, became an emblem of the academic community's opposition. A leading naturalist from the Mumbai Natural History Society, Dr. Salim Ali, toured the valley and pleaded for the hydropower project's termination. The High Court of Kerala received a writ appeal protesting the clearing of woods for the hydropower project, and it put an end to the clearing.A national rainforest biosphere reserve should be established on 389.52 km 2 , which includes the
Silent Valley region (89.52 km 2), New Amarambalam (80 km 2), Attappadi (120 km 2) in Kerala, and Kunda (100 km 2) in Tamil Nadu.
This will help to "prevent erosion of valuable genes from the area," according to Dr. M. S. Swaminathan, a
renowned agricultural scientist and the former secretary of the Department of Agriculture.
Hear Dr. M. S. Swaminathan discuss sustainable development at 8:46 in his August 27, 2002, speech on page 83. The prohibition on clear-cutting was removed by
the High Court of Kerala in January 1980, but the Indian Prime Minister later asked the Keralan government to halt further construction until all relevant issues had been thoroughly considered. The Silent Valley region, excluding the territory designated for
the hydropower project, was designated a national park by the Keralan government in December.
To determine whether the hydropower project could be completed without causing major natural harm, an interdisciplinary group was established in 1982 with Prof. M. G. K. Menon serving as its head and Madhav Gadgil, Dilip K. Biswas, and other members as its members. Prof. Menon's Commission turned in its findings at the beginning of 1983. The Indian Prime Minister chose to give up on the Initiative after carefully considering the Menon report.

73 Indira Gandhi was murdered on October 31, 1984, and the Silent Valley woods were later designated as a national park on November 15. Despite suggestions from expert groups and scientists, Silent Valley Park's limits were constrained and no buffer zone was established. 3. Government Initiative The Silent Valley National Park was officially opened ten years later, on September 7, 1985, and Rajiv Gandhi, the new Indian Prime Minister, presented an Indira Gandhi monument at Sairandhri. The Nilgiri Biosphere's main region, Quiet Valley National Park, was established on September 1st, 1986. Since then, a sustained protection effort has been made to protect the ecology of Quiet Valley. The "man vs. chimpanzee argument" was brought back to life in 2001 when a new power project was suggested. The new dam's (64.5 m high and 275 m long) planned location is only 500 m outside the national park's boundaries and is located just 3.5 km downstream of the previous dam site at Sairandhiri. The project's 84 km 2 watershed included 79 km 2 of Silent Valley National Park. However, if the planned Pathrakkadavu hydro-electric project is enacted, the magnificent cascade that flows between the Neelikkal and Pathrakkadavu hills and borders the Silent Valley will vanish. The Environmental Resources Research Centre in Thiruvananthapuram conducted a rapid Environmental Impact Assessment (EIA) from January to May 2003; its report, which was published in December, stated that the project would only result in a loss of forest covering 2216 km 2 , excluding the 7.4 km approach road and the land that must be acquired for the Karapadam powerhouse. 4. Current Scenario There was only so much more information until November 15, 2006, when Kerala's Minister of Forests, Binoy Viswam, announced that Silent Valley's planned buffer zone would shortly be announced. After a cabinet conference, Chief Minister A. K. Antony stated to media on February 21, 2007 that "The centre had pledged to approve the Pooyamkutty project after the Silent Valley plan was rejected. However, this pledge had not been kept. Concerning restarting the Silent Valley Hydel Project, the Keralan administration has not made any decisions ". Sugathakumari, a political artist, pleaded with the Kerala Chief minister on March 22, 2007, not to allow the electricity minister to revive the plan for a hydropower project at Pathrakkadavu. The Pathrakkadavu Hydroelectric Project was authorised by Kerala Chief Minister V. S. Achuthanandan and his government on April 18, 2007, and it was then sent to the Union Government for environmental clearance. The Kerala Government officially authorised the 147.22 km 2 Silent Valley Buffer Zone on June 6, 2007. Additionally, the government approved 35 employees and two additional forest posts at Anavai and Thudukki in the Bhavani Range. The zone aims to prevent illegal ganja farming, hunting, and unlawful distilling in regions close to Quiet Valley and contribute to the protected area's long-term viability.

74 The battle to protect the Quiet Valley is the subject of the well-researched video “Only An Axe Away” (2003), which is 40 minutes long. The movie depicts Keralans’ worry about the Silent Valley's future. P. Baburaj and C. Saratchandran are the creators. 4.4.3 Chipko Movement In essence, the Chipko movement is a women's organisation. Floods and flooding brought on by an increase in vegetation in response to urbanisation led women, who were exclusively responsible for farming, raising animals, and caring for children, to lose everything they owned. The 1973 non-violent protest known as the Chipko movement sought to protect and conserve trees. Still, it is perhaps best known for the collaborative mobilisation of women for the cause of protecting woodlands, which also led to a shift in attitudes towards their own standing in society. The protests against logging and preserving the natural equilibrium began in Uttar Pradesh's Chamoli region (currently Uttarakhand) in 1973, and they quickly spread to other north Indian states. The name of the movement, "Chipko," is derived from the word "embrace," as the people surrounded and embraced the trees to stop them from being cut down. However, few people are aware that the Bishnoi group of Rajasthan founded the initial Chipko andolan in the 18th century. The event is remembered in history for the sacrifice of a group of peasants, headed by a woman by the name of Amrita Devi, who gave their lives to stop trees from being cut down on the king of Jodhpur's commands. Following this event, the monarch issued an imperial proclamation forbidding tree chopping in all Bishnoi communities. 1. Historical Background The Indian state of Uttar Pradesh saw growth in development after the Sino-Indian boundary dispute was resolved in 1963, particularly in the remote Mountainous areas. Many international forestry firms looking for access to the region's abundant forest resources were drawn to the inner roadways constructed for the war. The government's policy prevented the villagers from managing the lands and denied them access to the lumber, despite the fact that the rural villagers relied heavily on the forests for subsistence—directly, for food and fuel, and indirectly, for services like water purification and soil stabilisation. Commercial forestry operations were frequently poorly managed, and the clear-cutting of woods reduced farming harvests, caused erosion, drained water supplies, and raised inundation in a large portion of the neighbouring regions. 2. About the Movement In order to promote minor businesses for rural people using local resources, conservationist and Gandhian social worker Chandi Prasad Bhatt established a communal group called Dasholi Gram Swarajya Sangh (later changed Dasholi Gram Swarajya Mandal [DGSM]). When industrial forestry was found to have contributed to the devastating spring rains that killed more than 200 people in the area in 1970, DGSM grew into a powerful opponent of the big business. In the upper Alaknanda valley, close to the hamlet of Mandal,

75 the first Chipko demonstration took place in April 1973. The peasants were furious when the government gave a sporting goods maker a much bigger tract after denying them access to a small number of trees to make farming implements. Chandi Prasad Bhatt took the locals into the jungle where they hugged the trees to stop cutting after their pleas were rejected. After those demonstrations lasted for several days, the government revoked the company's forestry permission and gave DGSM the initial allocation it had asked. Following Mandal's success, DGSM staff members and a local conservationist named Sunderlal Bahuguna started to explain Chipko's strategies to residents of other communities throughout the area. The next significant demonstration took place in 1974 close to the hamlet of Reni, where more than 2,000 trees were expected to be cut down. The government called the males of the neighbouring communities to a nearby city for recompense after a sizable student-led protest, purportedly to enable the loggers to continue without conflict. The villagers' women, headed by Gaura Devi, confronted the hunters and ultimately compelled them to leave the woodland by refusing to leave. The incident in Reni spurred the state government to form a commission to look into the Alaknanda valley's destruction, which eventually resulted in a 10-year moratorium on commercial forestry in the region. Thus, despite the fact that the different demonstrations were mainly dispersed and independent, the Chipko movement started to take shape as a farmer and women's campaign for forest rights. In addition to the well-known "tree embracing," Chipko demonstrators also used a variety of other methods based on the satyagraha philosophy of Mahatma Gandhi (nonviolent resistance). For instance, Bahuguna is renowned for his two-week fast against forest policy in 1974. Dhoom Singh Negi, a Chipko activist, fasted in 1978 in the Advani forest in the Tehri Garhwal region in opposition to the forest's sale, while local women adorned the trees with holy threads and recited passages from the Bhagavadgita. In some places, chir pines (Pinus roxburghii) that had been harvested for their resin were bound as a form of protest. In 1978, the women took the loggers' tools from Pulna hamlet in the Bhyundar valley and left invoices for them to be recovered if they departed the jungle. According to estimates, more than 150 communities participated in the Chipko movement between 1972 and 1979, which led to 12 significant demonstrations and numerous smaller clashes in Uttarakhand. A 15-year prohibition on business cutting in the Uttarakhand Mountains was enacted in response to a plea made by Bahuguna to Indian Prime Minister Indira Gandhi in 1980, which was the movement's pinnacle achievement. Himachal State and the old Uttaranchal both passed similar restrictions. 3. Impacts With time, the demonstrations evolved into the "Save Himalaya" campaign as they became more project-focused and covered the entire region's ecosystem. In order to popularise the cause, Bahuguna marched 5,000 km (3,100 miles) across the Mountains between 1981 and 1983. The Tehri dam on the Bhagirathi River and different mining activities were the targets of numerous demonstrations throughout the 1980s, which led to the closing of at least one limestone mine. Parallel to this, a significant replanting endeavour resulted in the cultivation of over a million plants in the area. In reaction to the easing of the forestry prohibition in Himachal Pradesh in 2004, Chipko demonstrations were restarted, but they failed to recreate the original incident.

76 4. Legacy As the movement expanded through the Dehradun district, which had previously experienced significant loss of flora and wildlife due to the destruction of its forest cover, Chipko activists in Tehri District would later oppose limestone extraction in the Doon Valley in the 1980s. After years of protest by Chipko activists, mining was finally outlawed. This was swiftly followed by a massive public reforestation campaign that, just in time, turned the valley around. Activists like Bahuguna opposed the Tehri dam's building on the Bhagirathi River throughout the 1980s and for the next 20 years before establishing the Beej BachaoAndolan, or Save the Seeds movement, which is still active today. Over time, Chipko activists began "working a socio-economic revolution by taking control of their forest resources from the hands of a distant bureaucracy which is only concerned with the selling of forestland for making urban-oriented products," as mentioned in a United Nations Environment Programme report. The Chipko movement set the bar for socio- ecological movements in other Himachal Pradesh, Rajasthan, and Bihar Forest regions. In September 1983, the Chipko movement sparked the Appiko movement in India's Karnataka state, which resulted in the cessation of tree-cutting in the Western Ghats and Vindhyas. Chipko adopted a more extreme stance in the Kumaon area, joining the larger campaign for a distinct Uttarakhand state, which was finally realised in 2001. In recent years, the movement has motivated many people to work on practical projects involving recycling, afforestation, energy conservation, and water management. It has also encouraged academics to begin researching environmental issues and conservation strategies in the Himalayas and across India. On March 26, 2004, the Niti Valley's Reni, Laata, and other communities commemorated the 30th anniversary of the Chipko movement, which brought together all the remaining initial members. The festivities began at Laata, the family residence of Gaura Devi, where Pushpa Devi, the late Chipko Leader Govind Singh Rawat's wife, Dhoom Singh Negi, the late Chipko Leader of Henwalghati, Tehri Garhwal, and other Chipko leaders were honoured. A parade left from here and travelled to Reni, a nearby hamlet where the real Chipko incident occurred on March 26, 1974. This was the first step in a global effort to make the current situation better. Following in the footsteps of the Chipko movement, rapid deforestation in 2017 over the century-old trees that formed almost a canopy in Jessore Road of the district of North 24 Parganas, West Bengal, also sparked a massive movement that resulted in a campaign by the local populace to save 4000 trees. A Google Doodle commemorated a Chipko movement environmental effort on March 26, 2018, the 45th anniversary of the movement.

77 4.4.4 Appiko Movement The farmers of the Uttara Kannada region of Karnataka Province in southern India launched a similar campaign to save their woods after being influenced by the well-known Chipko Andolan (Hug the Trees campaign) of Uttarakhand in the Himalayas. In Kalase woodland in September 1983, Salkani men, women, and kids "hugged the trees." (The local term for "hugging" in Kannada is appiko.) Southern India as a whole experienced a new consciousness thanks to the AppikoAndolan. More than 81 percent of the land in the Uttara Kannada region was covered in woodland in 1950. The government started the " development " process after designating this woodland region as a "backward" location. A plywood plant, a pulp and paper mill, and a series of hydropower structures built to control the waterways all sprang up in the region. These businesses have overused the forest resource, and the dams have flooded vast tracts of arable land and woodland. By 1980, the woodland no longer covered roughly 25% of the district's surface. The structures uprooted the local people, particularly the poorer sections. The water sources were dried up due to the change of the native mixed woods into teak and eucalyptus farms, directly impacting the forest inhabitants. In summary, the three main p's—paper, plywood, and power—which were meant to promote human growth have produced a fourth p: destitution. Appiko Andolan gave birth to a new awareness all over southern India. The Sahyadri Range, or the Western Ghats, in southern India is the home of a tropical forest ecosystem.

Although this tropical forest constitutes a potentially renewable resource, it is also
a fragile ecosystem and merits special attention. The past 30 years have seen the onslaught of "development" activities and an increase in population, both of which have exhausted this fragile resource system. In the case of Kerala, which comprises 42% of the entire Western Ghat area, the forest cover fell from 44% in 1905 to a meagre 9% in 1984. Such deforestation in the Western Ghats has caused severe problems for all of southern India. The recurring drought in Karnataka, Maharashtra, Kerala and Tamil Nadu provinces clearly indicates watershed degradation. The power generation, water supply and ultimately the whole economy of southern India is adversely affected. The ongoing "development" policy of exploiting the "resources - mainly forest and mineral resources - in the Western Ghats for the benefit of the elite has deprived the poor of their self-supporting systems. 1. Background In 1950: the Uttara Kannada district forest covered more than 81% of its geographical area. The government, declaring this forest district a "backward" area, then initiated the “ development “ process. There major industries - a pulp and paper mill, a plywood factory and a chain of hydroelectric dams constructed to harness the rivers - sprouted in the area. These industries have overexploited the forest resource, and the dams have submerged huge forest and agricultural areas. The forest had shrunk to nearly 25% of the district's area by 1980. The local population, especially the poorest groups, were displaced by the dams. The conversion of the natural mixed forests into teak and eucalyptus plantations dried up the water sources, directly affecting forest dwellers. In a nutshell, the three major p's - paper, plywood and power

78 - which were intended for the development of the people, have resulted in a fourth p: poverty. The Movement With the felling and commercialization of the natural forest, the Appiko movement rose: a popular people’s response against deforestation and the ruin of ancient livelihoods. At the same time, the forest department was involved in the clearing of natural ever green forest and plantation of monoculture of Teak and Eucalyptus. This destruction of tropical natural forests and the raising of monoculture plantations of Teak and Eucalyptus caused irreversible changes in the forest ecosystem. The destruction of mixed species denied people access to biomass for fodder, fertiliser, etc. The clear felling of natural forests has led to severe soil erosion and drying up of perennial water resources. 2. Movement Procedure: The Appiko Movement raises consciousness using a variety of methods, including slide presentations, traditional performances, street dramas, and foot marches through the inner woods. The state government has prohibited the cutting of verdant trees in some woodland regions, and only deceased, failing, and desiccated trees are now razed to satisfy local needs. This indicates that the movement has had some success. The campaign has reached the four hill districts of the province of Karnataka and has the capacity to reach the Eastern Ghats of the provinces of Tamil Nadu and Goa. The promotion of afforestation on barren territory is the second field of the Appiko Movement's activity. To plant seedlings among the locals. The development of dispersed childcare has attracted the active attention of both individual families and community youth groups. People in the Sirsi region raised an all-time high of 1.2 million seedlings in the years 1984–1985. Without a question, the collaboration of the forest department, which provided the plastic sacks for developing seedlings, made this feasible. The advocates who were creating the autonomous nursery soon discovered that the forest department profits more than usual from maintaining a nursery. Villagers paid 20 paise (US 2 cents) for each seedling they planted, but the forest agency charged at least Rs 2 for each tree they grew. (US 15c). The timber service also applied manure and provided pills to young trees. The woodland nursery now uses excessive amounts of chemical nutrients due to the Appiko Movement's experience, making it a costly and lucrative initiative. The seedling initiative promoted by the timber department is actually a way to use low-cost labor from the villages. Following their teachings from this encounter, Appiko advocates are now only producing seedlings for their own purposes and not for the benefit of the forest department. In arid common ground, the people have started a restoration process. The Youth Club has taken on the project's management duties, and the entire community has banded together to safeguard this territory from livestock, lopping, and fire. The experience demonstrates that natural regrowth is the most effective and affordable way of putting bare ground under open cover in those places where dirt is available. Tree planting is done in places where dirt is swept away, particularly of native, quick-growing species. Ironically, the forest department uses massive quantities of fertilizer on these foreign, homogenous farms in addition to automating the sowing of alien species. The area's earth and ultimately its forest growth will suffer as a result of this activity. There are two clear methods of greening that are used: one is the Forest

79 Department's method, which requires a lot of money, and the other is the people's method of developing through renewal, which uses a natural process for the soil's sustainable growth. The Appiko Movement's third main focus is on bringing different energy sources to lessen the strain on the woodland and promote eco-friendly use of the environment. The campaigners built 2,000 fuel-efficient chulhas ("hearths") in the region, which reduces the need for fuelwood by nearly 40%. Since there is a natural demand from the public, advocates do not wait for government funding or help. These chulhas are put in motels even in Sizsi village and other populated regions, lowering the need for fuel. The construction of gobar is a different strategy for lessening strain on the woodland. (gasplants). Biogas facilities are being constructed by a growing number of individuals. However, the Appiko advocates place more emphasis on chulhas because they are more concerned with those from lower socioeconomic classes who cannot buy gas plants. 4.5 Big dam movements 4.5.1 Narmada Dam The biggest waterway improvement project in India is the Narmada River Development Project. The Sardar Sarovar Dam is a concrete gravity dam situated on the Narmada River in Navagam, Narmada District, Gujarat, India, not far from the village of Kevadiya. Gujarat, Madhya Pradesh, Maharashtra, and Rajasthan are the four Indian regions that will receive water and power from the dam. 1. Historical Background First Deputy Prime Minister of India Sardar Vallabhbhai Patel, also known as Sardar Patel, had the idea for the project, and Jawaharlal Nehru placed the cornerstone. The project began in 1979 as a $200 million debt was used to boost irrigation and generate hydroelectricity as part of a development plan financed by the World Bank through its International Bank for Reconstruction and Development. The building of the dam started in 1987. Still, due to worries about population relocation during the Narmada BachaoAndolan in 1995, the Supreme Court of India stopped the project. According to instructions from SC, the project was restarted in 2000–2001 but with a reduced height of 111 metres. This height was subsequently raised to 123 metres in 2006 and 139 metres in 2017. The length of the Sardar Sarovar Dam is 1210 metres. Narendra Modi, the prime minister, opened the dam in 2017. On September 15, 2019, the Sardar Sarovar Dam's water level finally rose to its maximum capacity of 138.7 metres. The Sardar Sarovar Dam is the biggest building that will be constructed out of the 30 structures that are anticipated for the Narmada River. After the Grand Coulee Dam across the Columbia River in the United States, it is the second biggest concrete dam in the world in terms of the quantity of concrete used in its building. It is a component of the Narmada Valley Project, a sizable hydraulic engineering undertaking that calls for the building of numerous sizable irrigation and hydroelectricity multi-purpose structures on the Narmada River. By 2014, the

80 Narmada Control Authority had approved a number of changes in the final height and the associated displacement caused by the increased reservoir, from the original 80 m (260 ft) to a final 163 m (535 ft) from foundation, following several cases before the Supreme Court of India (1999, 2000, 2003). The initiative will water 1.9 million hectares of land, the majority of it in Kutch and Saurashtra's drought-prone regions. Six Francis pump-turbines with a combined output of 200 megawatts (MW) are housed in the primary power facility of the dam, which also has pumped storage capacity. A power facility on the major canal's entrance also has five 50MW Kaplan turbine-generators. The electricity plants combined operating output is 1,450 Megawatts. 2. Geographical Dimension On the intersection of Gujarat and Maharashtra, in the Narmada region of Gujarat, is where the dam is situated in the hamlet of Kevadia. The Malwa region in Madhya Pradesh, where the Narmada River divides the hill ranges and reaches its peak in the Mathwar hills, is to the west of the dam. The barrier is 163 metres tall and 1,210 metres long. The Sardar Sarovar reservoir can hold 0.586 million hectares of water in active storage and 0.95 million hectares of water in total. Its average length is 214 km, and its average breadth is 1.7 km. It covers an area of 37,000 hectares. The 88,000 square kilometre river drainage region is located above the dam location. Its overflow can discharge 87,000 cubic metres of water per second. One case study for Combined River Basin Planning, Growth, and Administration is this barrier. 3. Management Strategy The rainy season, which lasts from July to October, is when the watershed area's reservoirs are operational. The River Bed Power House (RPBH) is in charge of carefully increasing the yearly water share allotment. It makes sure the least amount of water is used in the dam overflow time and the least amount of water is sent downward (generally in Monsoons). By avoiding water storage, limiting water-intensive annual crops, adopting subsurface pipes, keeping canals, associated buildings, and operating canals on a rolling basis, RPBH minimises traditional and practical losses during non-monsoon months. 4. Importance Gujarat's "lifeline" is referred to as this dam. Since 75% of Gujarat's command area is thought to be prone to drought, this dam will give household water to the Kutch and Saurashtra areas. For the first time in 2021, the Sardar Sarovar Dam supplied water for summertime cultivation. Irrigation: In Gujarat, the dam irrigates 17,920 km2 (6,920 sq mi) of territory across 12 districts, 62 talukas, 3,393 communities, and 730 km2 (280 sq mi) of barren land in the Barmer and Jalore regions of Rajasthan. The dam supplies potable water to 1336 villages and 3 cities in Rajasthan, 9490 communities and 173 metropolitan areas in Gujarat. Additionally, the dam offers storm protection to riverine areas in Gujarat totaling 30,000 hectares (74,000 acres), which include 210 communities, the metropolis of Bharuch, and a population of 400,000. [20]

81 A significant initiative to use the water from the waterway to cultivate many areas is Saurashtra Narmada Avtaran Irrigation. Drinking Water: For Gujarat's current population of 28 million people and anticipated population of more than 40 million by the year 2021, a specific allotment of 0.86 MAF of water has been made to provide potable water to 173 urban centres and 9490 communities both inside and outside command. All the towns and cities in the desert regions of Saurashtra and Kachchh, as well as all "no source" communities and villages in North Gujarat impacted by salt and fluorine, will gain. The initiative will also meet the water supply needs of several businesses, boosting overall output. Hydroelectricity: This year, Gujarat's Narmada region has produced 2,142 million units (MUs) of electricity, nearly twice as much as it did during the same time last year, thanks to good rains in the Sardar Sarovar dam's watershed area. According to the published statistics, August was the month that made the biggest contribution. The neighbouring states of Gujarat and Madhya Pradesh have both experienced above- average rainfall this monsoon season, according to the India Meteorological Department (IMD). 85,858 sq km and 9,894 sq km, respectively, of the 97,410 sq km overall territory of the Narmada River watershed are located in Madhya Pradesh. Solar Power: River Bed Power House and Canal Head Power House, with total capacities of 1200 MW and 250 MW, respectively, are the two power plants. Madhya Pradesh would hold 57% of the authority, followed by Maharashtra with 27% and Gujarat with 16%. This will give the western infrastructure of the nation, which currently has very little hydel power output, some usable maximum power. On the offshoot waterways where there are handy falls, a number of mini hydel power plants are also proposed. Flood & Wildlife: Additionally, it will offer storm protection to riverine areas in Gujarat totaling 30,000 hectares, which include 210 communities, the metropolis of Bharuch, and an inhabitant of 4.0 lakh. The "Shoolpaneshewar wild life refuge" on the left Bank, the "Wild Ass Sanctuary" in the "Little Rann of Kachchh," the "Great Indian Bustard Sanctuary" in Kachchh, the "Nal Sarovar Bird Sanctuary," and the "Alia Bet" at the end of the River will all be benefited. 5. Narmada Bachao Movement The Narmada BachaoAndolan started organising major marches and demonstrations against the Narmada Valley Development Project, particularly the main one, the Sardar Sarovar, in 1985 under the leadership of agitator Medha Patkar. Despite the nonviolent demonstrations, Patkar and others frequently encountered police beatings and arrests. After the NBA was established in 1986, 50,000 people from all over India congregated in the valley to make a commitment to halt harmful growth in 1989. In 1990, thousands of farmers travelled to a tiny town in Madhya Pradesh on foot and by canoe to defend their vow to perish in the reservoir waters rather than leave their homes. Later that year, on Christmas Day, a seven- person sacrifice team walked more than 100 kilometres with the assistance of an army of 6,000 men and women. The sacrifice team made the decision to give their lives in order to save the
82 waterway. After a little more than a week, the team declared an ongoing hunger strike. This first fast, which spanned 22 days, was the first of three. Along with many others, Ms. Patkar was in danger. Additionally, the NBA has adopted a more polite strategy to influence the government. They have sent written grievances to representatives of the government, including the President, the Minister of Social Justice and the Environment Maneka Gandhi, the Complaints Redressal Commission, and the Sardar Sarovar Narmada Nigam. Most of the time, their opinion is ignored and disregarded. The campaign to halt the construction of both large and minor structures along the Narmada has changed course as a result of the marches, gatherings, hunger strikes, blockades, and written statements made by the Narmada BachaoAndolan. These incidents have brought the problems from a local to a more national level thanks to media coverage. By applying pressure on the World Bank with unfavourable public coverage, the NBA played a crucial role in getting the Bank to cancel its loan from the projects. Recommendations: The Indian government should start by reevaluating the social and environmental effects of the more than 3,000 dams planned for building. This will help the nation's water management issues. Then, instead of disobeying the recommendations made by those assessments, it should follow them. The nation and the various states could also take into account already-existing, more affordable and efficient energy options. In reality, a task group formed by the state government of Madhya Pradesh proposed options like demand control strategies, biomass production, optimal use of current dams and oil-based plants, and micro-hydro plants. According to noted irrigation expert K. R. Datye, a thorough analysis of the output of the field is necessary, taking into consideration the supply of water, energy, and waste. Datye emphasises the need for native water supplies and renewable water use in cultivation. To return vegetation to damaged land and to replenish severely diminished ground water reservoirs, water from outside sources (such as dams) is used. This allows for the maintenance of a water and energy equilibrium. 4.5.2 Tehri Dam The astounding Tehri Dam is one of the highest dams in the world and the biggest in India. The Tehri Dam is 260.5 metres (855 feet) tall. Along with being a dam, the bridge was constructed on the Bhagirathi River close to the Uttarakhand region of Tehri Garhwal for multiple purposes. The dam is a component of the multifunctional Tehri Dam & Hydro Project Electricity for the river basin. Large tracts of territory can now access water for hydropower and agricultural reasons thanks to the building of the Bhagirathi River dam. Both the Tehri and the

83 earth pack dams are structures. The Chute spillway (a spillway with three peripheral gates of the spillway) and the four-shaft spillway make up the construction's spillway system. This is built to withstand a descent of roughly 220 metres and an Expected Maximum Flood (PMF) of approximately 15540 cusecs. The approximate length of this dam is 575 metres, or 1,886 feet. The dam has a base breadth of approximately 1,128 metres and a peak width of approximately 20 metres (66 feet) (3,710 feet). A pond with a surface area of 52 square kilometres and a volume of 4.0 cubic kilometres (roughly 3,200,000 acres feet) was created by this dam. The local community that is closest to this impoundment is Pratapnagar. 1. History of Dam In 1961, a strategy was developed to build this dam in Uttarakhand. The dam's building started in 1978 but was shortly delayed due to both financial and societal issues. Leading environmental advocates opposed the dam's building because they thought it would harm the delicate ecology and environment of the Mountains. After conquering a number of obstacles, such as money problems and societal problems, the building of the Tehri Dam was finally finished in 2006. The Soviet Union (USSR), also known as the Union of Soviet Socialist Republics (USSR), provided technological and financial assistance that enabled the building of the dam despite obstacles. In the Uttarakhand region's Tehri subdivision is the rock-filled Tehri Dam. The idea for this dam project was developed, and a thorough viability analysis was produced using the best tools and knowledge at hand. Useful secondary and source statistics on terrain, geology, drainage, seismology, and the environment were incorporated into the project's technological architecture. Although it complies with municipal laws, this is far from meeting worldwide standards. There were no major changes made to the Tehri Dam building plan. For safety reasons, only a few small changes were made. These changes in no way resulted in delays. The basic plans were made using readily available information and modern technology. One ought to benefit from the fact that both have advanced over time. Geological information that was available at the time of project planning is improved during project implementation. Additional reinforcing, filling, and concreting were performed in view of the bedrock revealed during the construction process. 2. The overall process of construction Under the direction of the Technical Advisory Committee, work on this dam in Uttarakhand started in 1978 and was finished in 2006. The group also assisted in solving problems by offering suggestions to the building experts. The project's R&R and property purchase were handled by a separate department. The main challenges encountered during the building of the Tehri Dam in India were the societal, municipal, and governmental constraints. R&R emerged as a significant problem for the project's expense, further compounding the challenges. R&R is still a procedure that is 84 ongoing. Due to the time delay brought on by the R&R restrictions, the original allocation for the Tehri Dam project in 1994, which was 13%, or 2,851 crores, increased to 15% in 2005, or 6,896 crores. After the Ministry of Electricity guaranteed funding for the project through the joint venture with THDC India Limited and the state government of Uttarakhand, the financial restrictions were lifted. 3. Benefits of the project ❖ The area of northern India saw a rise in total power of 1000 megawatts (2400 megawatts delivered on completion of the entire complex). ❖ The peak annual energy supply was 3,568 Million Units (MU) (6,200 Million Units delivered on completion of the entire complex). ❖ The irrigation grew to 2.7 lakh hectares of the region, along with maintaining the current 6.04 lakh hectares of land. ❖ Around 300 cusecs (162 million gallons) of potable water is provided to Delhi to accommodate for the water requirements of the 40 lakhs people of the state. ❖ Every 200 cusecs (108 million litres), potable water is delivered to Uttar Pradesh's cities and communities. ❖ aided in the Garhwal region's unification of growth. It involves the building of the new hill station for the New Tehri Town (NTT) (NTT). ❖ All the feasible amenities, such as improved connectivity, health, education, non-pollution businesses, luring tourism, gardening development, forestation, fishing, etc were also given to NTT for the benefit of the people residing in this area. 4. Ecotourism The Bhagirathi River was diverted to fill the Tehri Dam reservoir, resulting in the emerald-green Tehri Lake or Tehri Dam reservoir in Uttarakhand. The Tehri Lake is tucked away among the lush hills, making it the ideal location for a weekend entry and popular tourist destination for the Tehri Dam. The Tehri dam reservoir is the location for sailing in the Tehri dam reservoir, Tehri Lake. The Tehri Dam site has been targeted as one of the top tourism activity destinations by the Uttarakhand government. This Dam Pond will become an adventure destination when they introduce thrilling water sports and other flying activities. Houseboats and floating cabins have also been introduced to meet the requirements of visitors seeking lodging. The following list of outdoor activities is available on this dam reservoir – Paragliding: Tourists participating in this daring activity will never forget what it's like to fly like a bird. Jet skiing is an aquatic recreation that can be enjoyed by tourists and guests to make their trip to the dam unforgettable. The ability of the passenger on the yellow boat to go overboard and into the Tehri dam pond water makes the banana boat trip one of the finest things about this dam site and its activities.

85 5. Environmental Issues and Movement Environmentalist groups and regional residents have protested the Tehri Dam. The Anti-Tehri Dam Struggle Committee's creator and attorney Virendra Dutt Saklani was fast to draw attention to the negative effects of the massive undertaking.

From the 1980s to 2004, Sunderlal Bahuguna, an environmental campaigner, headed the anti-Tehri Dam effort. The demonstration was in opposition to the eviction of town residents and the environmental effects of the fragile ecology.

Along with issues with human rights, the project has raised issues with the environmental impact of building such a sizable dam in the delicate ecology of the Himalayas mountains. Regarding the physical safety of the barrier, there are additional worries. The Central Himalayan Seismic Gap, a significant natural fissure zone, contains the Tehri dam. A 6.8 magnitude earthquake struck this area in October 1991, with the location 53 km (33 mile) from the dam. While supporters of the dam assert that the complex is built to endure earthquakes with a magnitude of 8.4, some seismologists believe that earthquakes with a magnitude of 8.5 or higher may happen in this area. The possible dam breach that would come from such a disaster would drown many communities downstream, which have a combined population of close to 500,000 people. More than 100,000 people have been relocated from the region, which has resulted in lengthy judicial disputes over transfer rights and, eventually, postponed the project's conclusion. The discharge of Bhagirathi water has been decreased from its usual 1,000 cu ft/s (28 m3/s) flow to just 200 cu ft/s (5.7 m3/s) since the reservoir began to fill in 2005. Since the Bhagirathi is regarded as a portion of the holy Ganga, whose waters are essential to Hindu beliefs, this decrease has been at the centre of local opposition to the dam. Because Bhagirathi waters are tampered with, this stream occasionally ceases running throughout the year. Many Muslims feel offended by this because they believe the Ganges' sacredness has been violated in order to produce energy. According to the authorities, once the pond is full to capacity, the river's movement will return to usual. The Tehri Dam is still in use despite objections and worries. 4.5.3 Almatti Dam The Krishna After the Ganges and the Godavari, the Krishna waterway is a waterway in the Deccan region and is the third-longest river in India. In terms of water sources and river catchment size, it ranks fourth in India, behind the Ganges, Indus, and Godavari. The river, also known as Krishnaveni, is 1,400 kilometers, long, with 282 kilometers of that length located in Maharashtra. The Krishna Basin covers an area of 258,948 km 2 , or just under 8% of the entire country's landmass. This vast region is located in the provinces of Maharashtra (76,252 km 2), Telangana (113,271 km 2), and Karnataka (69,425 km 2). Krishna basin is India's fifth-largest river basin. In this region, it has been estimated that there is a 78.1 km 3 average yearly surface water capacity. 58.0 km 3 of it can be used for water.In the Indian regions of Maharashtra, Karnataka, Telangana, and Andhra Pradesh, it is a
86 significant supply of irrigation.13 main streams make up the Krishna River. The Ghataprabha River, Malaprabha River, Bhima River, Tungabhadra River, and Musi River are some of its major sources. The drainage region of the Tungabhadra River is 71,417 km 2 , and its length is 531 km. The Bhima River is the Krishna River's largest branch. Its length is 861 km in total, and its drainage region is 70,614 km 2 . 1. Overview of Almatti The Lal Bahadur Shastri Dam, also known as the Almatti Dam, was finished in July 2005 and is a hydropower facility on the Krishna River in North Karnataka, India. The dam's intended yearly energy production is 560 MU (or GWh). The Upper Krishna Irrigation Project's Almatti Dam serves as its primary reservoir, and its 290 MW power plant is situated on its right bank. Five 55MW and one 15MW vertical Kaplan turbines are used at the site. After being used to generate electricity, water is discharged into the Narayanpur pond to meet the requirements of agriculture further downstream. Almatti-I Powerhouse and Almatti-II Powerhouse are two distinct buildings that each have the ability to generate electricity. The project's expected expenses were initially predicted to be Rs. 14.70 billion, but after project administration was turned over to the Karnataka Power Corporation Limited (KPCL), they were cut by more than half, to Rs. 6.74 billion. The project was ultimately finished by KPCL for an even cheaper price of Rs. 5.20 billion. Construction on the dam was completed in less than 40 months, in July 2005. The dam is situated on the border of the municipalities of Bijapur and Bagalkot. Geographically, it is in the Bijapur district, but the reservoir's filling has also flooded a significant portion of the Bagalkot district. At 519 meters MSL, the dam has a total water holding capacity of 123.08 TMC. Several migrating species are hosted by the dam's backwaters in the summer. 4.6 Namami Ganga The Namami Gange Program is an Integrated Conservation Mission that the Union Government of India approved as a Flagship Program in June 2014 with a budget outlay of Rs. 20,000 crore to achieve the twin goals of effective pollution abatement and conservation and rejuvenation of the National River Ganga. It was intended to interact with the UK population, bringing together a variety of interest groups such as scientists, technology firms, investors, and locals. According to a press release from the Ministry of Jal Shakti, NMCG (National Mission For Clean Ganga) has chosen to make Chacha Chaudhary, a well-known comic book figure, the program's emblem. All of the sewers in the holy and historic city of Ayodhya that empty into the river Saryu are being drained as part of the Namami Gange Program, which then transports polluted water to a wastewater treatment facility. Four branches were established in Scotland, Wales, the Midlands, and London as a consequence of the Clean Ganga Roadshow, which was launched in Glasgow on the margins of COP26 and aimed to link different interest groups with the Namami Gange Program. At the junction of the Ganga and the Yamuna in Prayagraj Sangam, more than 30,000 embryos of

87 India's main carps, including catla, rohu, and mrigal minnows, which are decreasing throughout the Ganga River, were unleashed. According to data from the National Mission for Clean Ganga (NMCG), 61 out of 157 sewer projects (or 39%) have been finished, out of a total of 341 projects. The bulk of these projects are connected to waste infrastructure. Prime Minister Narendra Modi said, "Ganga ji is not just a river and we are taking a twin approach through Namami Gange and Arth Ganga to serve this holy river," during the flag-off of the MV Ganga Vilas voyage. 4.6.1 Necessity of such Action Plan In verses 5 to 6 of Siddhanta Muktavali, philosopher and reformer Vallabh Acharya (1478–1530) and Vyasa describe three different ways of seeing the Ganga River: (A) as a stream of material water, (B) as a stream of material water with some degree of spiritual ability, and (C) as a stream of water that is the manifestation of the divine Ganga Ma. With the construction of the upper Ganga Canal by Cutley in 1855, the East India Company launched river development. Since then, the development strategy has focused mainly on handling the Ganga as a trickle of raw water. Pollution from businesses and governments has been released into rivers as a result of the growing population and urban areas. People protested against the dam's construction in Haridwar because it blocked the Ganges Aviralta, including the kings of Mysore, Travancore, and Jaipur. The Ganga has been viewed as a mystical force for the past 170 years, but today it is handled like ordinary water, which makes it extremely difficult to revitalize the river. Programs like GAP I and GAP II were started between 1985 and 2015, but their attempts to reduce pollution were unsuccessful. Given the extent and intricacy of the Ganga region, the allotment of a total of Rs. 4000 crores for 30 years was very low due to the piecemeal strategy and dearth of resources. Taking lessons from the past, the NamamiGange Programme was created in a unique way that treats the region as a whole rather than the Ganga as a distinct waterway. NamamiGange, which translates to "bowing to the Ganga river," refers to the mission's act of acknowledging the Ganga as more than just a body of water but as a source of life for millions of people as well as a spiritual, cultural, and environmental ecology. The river Ganga is essential to India's heritage and culture. India cannot honor Ganga without it. The biological and molecular characteristics of the Ganga make it distinct from other rivers, and it would not be incorrect to state that it is the most living river in the world. On the Ganga major length, 4457 villages and 97 metropolitan areas were located. The capability of the city's sewage production and disposal systems was analytically assessed once we knew the number of main cities. According to the research, only about 900 MLD of capacity for waste production over 2900 MLD was built over a long period of time, and of these, nearly 60% of STPs were either not working or did not satisfy design standards, necessitating expenditures in repair.Since the Ganga Rejuvenation challenge is multi-sectoral, multi- dimensional, and multi-stakeholder in nature, efforts have been made to improve the inter- ministerial and center-state coordination through increased participation in action plan preparation and increased monitoring at the central and state levels.

88 Entry-level activities (for an instant noticeable effect), medium-term activities (to be done within a 5-year time period), and long-term activities have been split into the program's execution. (To be implemented within 10 years) – Entry Level: The first steps include cleaning the river's surface to deal with floating solid wastes, improving rural sanitation to stop pollution (both solid and liquid) entering through rural sewage drains, and building toilets. They also include renovating, modernizing, and building crematoria to stop the disposal of unburnt or partially burned bodies in rivers as well as repairing, modernizing, and building ghats to improve the human-river connection. Medium Term: The medium-term actions will concentrate on stopping the commercial and local waste from joining the waterway. In the next five years, an extra 2500 MLD of purification capability will be built in order to handle the contamination caused by local waste. In order to make the program effective, responsible, and long-lasting, significant funding changes are currently being implemented. The Cabinet is presently considering a hybrid annuity-based public-private partnership strategy for project execution. If authorized, a Special Purpose Vehicle will oversee concessionaires in all significant towns, create a market for purified water, and guarantee the long-term viability of assets. Improved regulation has been attempted to increase cooperation in order to manage industrial waste. Grossly polluting industries along the Ganga have been told to lower wastewater quality and amount or switch to zero-liquid release. Pollution Control Boards already have an action plan for implementing these directives, and each business group has a timetable with extensive discussions. Real-time online tracking systems for wastewater are required for all businesses. In addition to these initiatives, the program is also pursuing wildlife preservation, reforestation, and water quality tracking. There are already programs in place to protect important emblematic species like the Golden Mahaseer, Dolphins, Ghariyals, Turtles, and Otters. Similar to this, 30,000 hectares of land will be planted as part of "NamamiGange" to increase groundwater replenishment, lessen runoff, and enhance the health of the river ecology. The planting campaign is scheduled to start in 2016. The construction of 113 real-time water quality tracking sites will also enable complete water quality surveillance. Long Term: In the long run, it is intended to determine e-flow, boost water use efficiency, and enhance surface irrigation efficiency in order to provide the river with a sufficient flow. It is important to note that due to the Ganga's socioeconomic and cultural significance and continued abuse for a variety of purposes, cleansing it is a very complicated process. A complicated program that has never been enacted before will call for involvement from all industries and every single resident of the nation. There are many methods that each of us can support the effort to clear up the Ganga: • Financial contribution: Restoring the character of a waterway with the length and size of the Ganga necessitates sizable expenditures. Even though the funding has already been multiplied by four, it might not be enough to meet the demands. There is now a clear Ganga Fund that offers everyone a way to donate money to help keep the Ganga clear.

89 • Reduce, Reuse, and Recovery: Most of us are unaware that, if improperly disposed of, used water and household waste can wind up in waterways. The government is already building sewage infrastructure, but individuals can cut back on their water use and garbage production. The initiative can gain a lot by recycling used water, biological refuse, and polymers. 4.6.2 Key Achievements of the Plan 1. Increasing Sewerage Treatment Capacity: In the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, West Bengal, Delhi, Himachal Pradesh, Haryana, and Rajasthan, 48 sewage management projects are currently being implemented, and 99 sewage projects have already been finished. In these regions, there are currently 27 sewage projects up for bid and 8 brand-new sewage projects. There are currently 5658.37 cubic feet of sewage capacity under development. (MLD). 2. Creating River-Front Development:71 Ghats/Crematoria initiatives for the building, upgrading, and restoration of 270 Ghats/Crematoria and Kunds/Ponds have been started. 3. River Surface Cleaning: At 11 sites, river surface cleaning is being put into operation in order to gather drifting solid refuse from the surface of the Ghats and River and dispose of it. 4. Bio-Diversity Conservation: One of NMCG's long-term goals for Ganga rejuvenation is to revive all of the river's endemic and endangered species so they can reclaim their historic ranges and play a vital part in preserving the Ganga river ecosystems. In order to address this, projects have been awarded to the Wildlife Institute of India (WII), Dehradun, the Central Inland Fisheries Research Institute (CIFRI), Kolkata, and the Uttar Pradesh State Forest Department to develop science-based plans for the conservation and restoration of aquatic species for the Ganga River. According to field research by WII, high biodiversity areas in the river Ganga have been identified for targeted conservation action. Rescue and rehabilitation centers have also been established for the rescued aquatic biodiversity. A cadre of volunteers known as Ganga Praharis has also been developed and trained to support conservation actions in the field. In order to document the fish species that are currently present and to chart them using a GIS tool, CIFRI has assessed the fish and fishing in the watershed. This has allowed it to gain an understanding of the state and spread of fish in the Ganga. In order to observe the migratory patterns of recognized fish like Hilsa, tagging processes have also been started. For the protection and rehabilitation of Indian Major Carps (IMC) & Mahseer in Ganga, CIFRI also runs husbandry and education programs at different sites in the river watershed. Additionally, the expansion of the conservation breeding program for river turtles and gharials at the Kukrail Gharial Rehabilitation Center in Lucknow is being carried out by the Uttar Pradesh State Forest Department. This program will aid in the resuscitation and repair of gharials and turtles in the Ganga region. 5. Forestry: Forestry initiatives, which increase the yield and variety of trees in headwater regions and all along the river and its branches, are one of the key elements of Ganga renewal. Accordingly, at a projected cost of Rs. 2293.73 crores, the Forest Research

90 Institute (FRI), Dehradun, produced a Detailed Project Report (DPR) for afforestation in an area of 1,34,106 hectares in the Ganga river bed states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal. The FRI DPR allows for the implementation of projects under the four main headings of Natural landscape, Agriculture landscape, Urban landscape, and Conservation initiatives. By using a multi-faceted strategy throughout the pre-defined Ganga riverscape, the suggested forestry initiatives will primarily help to the comprehensive protection of the river Ganga, including enhancing the river's flow (Aviralta). Since 2016–17, the State Forest Departments of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand, and West Bengal have been carrying out the "Forestry Interventions for Ganga" initiative in accordance with the FRI DPR, with funding assistance from NMCG. 6. Public Awareness: To make a compelling case for public engagement and community involvement in the program, a number of activities including gatherings, workshops, seminars, and conventions as well as countless IEC activities were planned. Rallies, campaigns, exhibitions, shramdaan, cleanliness drives, competitions, plantation drives, the creation and distribution of resource materials, as well as the organization of various awareness activities, were all organized. For greater publicity, mass media like TV/Radio, print media advertisements, advertorials, featured articles, and advertorials were published. The Gange Theme Song was extensively publicized and performed on digital media to increase the program's exposure. NMCG made care to be present on social media sites such as Facebook, Twitter, YouTube, and others. 7. Monitoring of Industrial Effluent: In April 2019, there were 1072 Grossly Polluting Industries (GPIs). Inspections of GPIs are conducted regularly and unexpectedly as part of regulation and punishment to check conformance with established environmental standards. Additionally, the GPIs are examined annually to ensure that they are in accordance with environmental standards and, where necessary, to modify the processes. The first round of GPI examination by independent technological schools was completed in 2017. In 2018, the second round of GPI examination was finished. 636 of the 961 GPIs that were examined in 2018 complied, 110 did not, and 215 were self-closed. Under Section 5 of the E(P) Act, actions have been taken against 110 non-compliant GPIs and closing directives have been given. In 885 out of 1072 GPIs, Online Continuous Effluent Monitoring Stations (OCEMS) access to the CPCB computer was created. 8. Eighth Ganga Gram: 1674 Gram Panchayats located on the banks of the river Ganga in five States were recognized by the Ministry of Drinking Water and Sanitation (MoDWS). (Uttarakhand,UttarPradesh,Bihar,Jharkhand,West Bengal). The Ministry of Drinking Water and Sanitation (MoDWS) has received Rs. 578 Crores to build bathrooms in 1674 Gram Panchayats of the five Ganga Basin States. The building of 8, 53,397 bathrooms has been finished out of the planned 15, 27,105 units by MoDWS. The Ganga River Basin Plan was created by a consortium of seven IITs, and thirteen IITs have chosen 65 communities to be developed as model villages. At an expected expense of Rs. 127 crore, UNDP has been hired to promote Jharkhand as a model state and to carry out the initiative for agricultural toilets. The National Mission for Clean Ganga works to disseminate the finest information and tools accessible worldwide for Ganga renewal. Many foreign nations with experience in

91 river restoration have long been drawn to the clean Ganga. Australia, the United Kingdom, Germany, Finland, Israel, and other nations have expressed an interest in working with India to rejuvenate the Ganga. Memorandums of Understanding (MoUs) have been signed with a number of Central Ministries, including the Ministries of Human Resource Development, Rural Development, Railways, Shipping, Tourism, Ayush, Petroleum, Youth Affairs and Sports, Drinking Water & Sanitation, and Agriculture, in order to coordinate government initiatives. 4.7 Yamuna Action Plan When the country's two most significant rivers, the Ganga and the Yamuna, had their water quality tested in 1909, the Yamuna river's water was found to be "clear blue," while the Ganga river's water was found to be "silt-laden yellow." One hundred years later, the Yamuna River is still considered to be one of the dirtiest and most polluted rivers in the nation, particularly in the areas surrounding New Delhi, the Indian capital. The Yamuna River in Delhi, which receives about 58% of its waste, has become more polluted due to rapid industrialization, urbanisation, and population growth. Yamuna Action Plan (YAP) to clean the dirtiest river of the country was formally launched in 1993. The YAP has so far completed two phases as YAP-I and YAP-II. Delhi, eight towns in Uttar Pradesh, and six towns in Haryana were all included in the YAP-I. The 22-kilometer stretch of the Delhi Yamuna that was the focus of YAP II. Now we have YAP- III, phase III of Yamuna Action Plan for Delhi, at an estimated cost of Rs 1,656 crore. The YAP-III was started in 2013 and is anticipated to be finished in 2015. 1. Background of the plan: The Governments of India and Japan collaborated on the Yamuna Action Plan (YAP), one of the biggest river restoration initiatives in the nation. The National River Conservation Directorate, the Government of India, and the Ministry of Environment and Forests are carrying out this project with funding from the Japanese Government totaling 17.7 billion yen, which is being administered through the Japanese Bank for International Cooperation (JBIC). Under the Yamuna Action Plan Phase III, the Delhi stretch is given prime emphasis as it is the most critical stretches of Yamuna, where most of the city’s sewage is dumped. 2. Overwhelming Success: Under YAP-I and YAP-II, polluted Yamuna was cleaned in accordance with its biological oxygen demand. At a cost of Rs 1,453.17 crore, 286 schemes, including 39 sewage treatment plants (STPs), were finished in 21 towns in Delhi, Uttar Pradesh, and Haryana. This resulted in the creation of a waste treatment potential of 767.25 million litres per day. According to a new report by the Energy and Resources Institute (Teri), the river Yamuna requires a daily fresh water flow of nearly 3.46 billion litres (BLD) to sustain aquatic life and the day-to-day activities of the people who live along its banks. This amount is equal to the amount of drinking water that Delhi needs on a daily basis. However, there has been no reports of addition of fresh water to the river as most of it is sewage. This information was

92 reported based on a review of the previous ten years. While it is true that the water quality has not worsened as a result of the implementation of the YAPs, the Teri report does state that there is a possibility that the YAPs will not be successful in improving the water quality one hundred percent of the time. Pipeline projects before to save Yamuna: More new projects to clean up the Yamuna are currently being discussed and may be implemented soon. In June 2014, the Delhi Government launched a comprehensive interceptor sewer project to ensure that all wastewater is treated before being discharged into the Yamuna in an effort to reduce pollution levels in the river. Along with this, the Delhi Jal Board (DJB) has created a Sewerage Master Plan 2031, according to which, there are plans of laying sewerage systems in those locations which do not have sewer lines. It will build a 59-kilometer-long interceptor sewer alongside Delhi's three major drains (supplementary, Shahdara, and Najafgarh), which will collect and transport sewage from about 190 smaller drains to the nearest sewage treatment plant (STP). Inevitably, this will result in the release of treated effluents into the sewers. Nilothi, Delhi Gate, Pappankalan, Chilla, and Kapashera are reportedly getting brand new sewage treatment plants (STPs) that are up to DJB's stringent quality standards for treating effluents. 3. Other Initiatives: • Yamuna conservation is a continuous procedure that calls for cooperation between the federal government and the individual states. Timelines and objectives for cleaning up the Yamuna are based on river conservation projects and the development of municipal infrastructure for the treatment, collection, and disposal of wastewater. Delhi generates about 800 million gallons of sewage every day, but it can only treat about 512.4 MGD. It's estimated that 22 major sewage drains empty into the river. More sewage and effluent treatment plants need to be built, and untreated wastewater discharge needs to be limited. • The amount of water taken from the waterway must be decreased for agricultural purposes. By doing this, the ecology of the river is being destroyed. • Many environmentalists argue that cleaning effluents before they're dumped into a river is crucial. • Now is the time to learn from other countries how they scientifically recycle waste and use it to build new roads, buildings, and other things. For example, Singapore recycles 98 % of its construction and demolition waste. There needs to be an upgrade to the standard of our nation's existing STPs and ETPs. • No new encroachment should be permitted, and measures should be taken to relocate existing settlements and encroachments in and around floodplains. • There shouldn't be any new barrages, roads, metro and railway bridges, or embankments built anywhere near the Yamuna. • Delhi has a severe lack of landfills, so most garbage ends up in the river. This being the case, measures must be taken immediately to locate additional landfills in the Delhi area. • At the end of the day, the government has to do what it can to raise people's awareness.

93 4.8 Rivers Interlinking Project in India The Indian Rivers Inter-link is a planned massive civil engineering project that would connect Indian rivers by a network of lakes and waterways to improve agriculture and aquifer replenishment, lessen chronic storms in some parts of India, and alleviate water scarcity in other parts of the country. India is home to 18% of the global populace but only has access to 4% of the world's freshwater. Connecting waterways and lakes is one approach to fixing the country's water problems. The rivers in the northern Himalayas, the peninsula in the south, and the rivers within each state that will be linked beginning in 2005 make up the three sections of the Inter-link initiative. India's Ministry of Jal Shakti, National Water Development Agency, is in charge of the project. 14 Himalayas interlink projects, 16 Peninsular interlink projects, and 37 intrastate river connecting initiatives have all been examined and reported on by NWDA. During the months of June through September, India receives the vast majority of its annual rains totaling around 4,000 billion cubic metres. The east and north of this very vast country receive the lion's share of precipitation, while the west and south receive noticeably less. India also experiences years of above-average or late monsoons accompanied by dryness. This demand-supply disparity in India has been widening due to the country's expanding population and the widening gap between the year-round need for water for agriculture, consumption, and industry and the limited supply of natural water. 1. History behind interlinking Pre-Independence: The Inter-linking of Waterways in India plan has a lengthy past. To speed up the movement of goods between Britain and its South Asian colony, as well as to alleviate water scarcity and drought in the region that is now Andhra Pradesh and Orissa, British engineer Arthur Cotton recommended linking major Indian rivers in the 19th century. Post-Independence: Dr. K.L. Rao, an irrigation administrator and dam builder, suggested "National Water System" in the 1970s. He was troubled by annual inundation in the North and perennial water scarcity in the South. He hypothesised that central and southern India are water-poor while the Brahmaputra and Ganges regions are water-rich. He suggested rerouting abundant water supplies to parched regions. Rao proposed expanding upon the success of several inter-basin transfer initiatives that had already been executed in India. In 1980, India's Ministry of Water Resources came out with a study named "National Views for Water Resources Development". The Himalayas and Peninsular segments of the water development initiative are described in this paper. When the Congress Party took over, they scrapped the idea. In 1982, India established a committee of nominated experts through the National Water Development Agency (NWDA) to conduct comprehensive studies, surveys, and investigations into reservoirs, canals, and all facets of the feasibility of interlinking

94 Peninsular rivers and related management of water resources. From 1982 to 2013, NWDA published a total of 30 papers. Unfortunately, the plans were abandoned. In 1999, when a new political coalition established the central government, the concept of connecting rivers was brought back into the spotlight, but with a significant change in strategy. Instead of interbasin water movement, the plan was altered to focus on growth within existing basins. Current Scenario: By 2004, the United Progressive Alliance (UPA) headed by Congress Party was in control, and it revived its resistance to the project idea and plans. Campaigns were launched by advocates who warned that the project could have catastrophic financial, ecological, and water supply consequences. From 2005-2013, the Indian government established various panels, denied various findings, and funded various viability and effect studies, all of which were subject to evolving environmental legislation and standards. The Supreme Court (SC) declined to issue any order for the execution of the Rivers Interlinking Project in February 2012, while dismissing of a Public Interest Lawsuit (PIL) filed in 2002. The Supreme Court ruled that making policy choices falls within the purview of national and local legislatures. Since no one objected to the Rivers Interlinking Project being implemented, the Supreme Court ordered the Ministry of Water Resources to form a specialists' group known as the "Special Committee on ILR" (SC ILR) to continue pursuing the issue with the states. 2. Importance of Interlinking • Drought, floods and shortage of drinking water: India gets about 4,000 cubic kilometres of rain yearly, or about 1 million litres of pure water per individual every year. However, the distribution of rainfall in India changes considerably with location and time of year. About 85% of India's annual precipitation comes from the Mountain watersheds of the Ganges-Brahmaputra-Meghna (GBM) region during the summer monsoons. More rain falls in the northeast than in the northern, western, or southern regions of the nation. A major issue for the nation is the unpredictability of when monsoons will begin, which is sometimes accompanied by extended drought periods and variations in periodic and yearly rainfall. Large swaths of the west and south experience more shortfalls and significant differences, causing enormous suffering, especially for the lowest farms and rural communities, as the nation goes through cycles of dry years and flood years. Crop fails and farmer deaths are exacerbated by the region's inadequate irrigation water supply. Some areas still face drinkable water scarcity even though they receive plentiful rainfall between July and September. During certain years, excessive precipitation and weeks of flooding become an issue. Water resources management has become necessary due to regional water abundance/scarcity and cyclical flooding/drying out. Waterways inter-linking is one plan to meet that need. • Food Security: The rising number of Indian citizens is another factor necessitating the connection of rivers. Despite a slowing growth rate, India's population still increases by 10–15 million annually. The increased demand for food necessitates more efficient

95 watering of about 140 million acres of land in order to maximise harvests and ensure food is not lost in the event of a natural disaster. [15] Today, only a small percentage of that area is watered, and the rain is the primary water source. Water inter-linking is stated to be a potential means of guaranteed and improved irrigation for more farms, and thus better- quality food security for an increasing population. The energy security required to convey water from water excess lower elevation waterway sites to sea level is critical for ensuring food security in a tropical nation like India with high evapotranspiration. • Navigation: Infrastructure is required in India for freight transportation and operations. In particular for minerals and food crops, using linked waterways as transit is a greener, low- carbon impact type of transportation infrastructure. • Groundwater Level: While industrialised countries carefully store 900 days' worth of water demand in desert regions river systems and lakes, India presently only stockpiles 30 days' worth of rainwater. India’s dam basins hold only 200 cubic metres per individual. India also depends heavily on groundwater, which stands for over 50 percent of watered land with 20 million tube wells built. The quickly diminishing groundwater is used to generate about 15% of the sustenance in India. The end of the period of huge growth in groundwater use is going to require higher dependence on public water delivery networks. Proponents of the project say India's water condition is already serious, and it requires sustainable growth and control of surface water and aquifer usage. Some proponents believe that India is not experiencing a water shortage but water is flowing out of India. Issues regarding this Project • Environmental disbalance: Between 2002 and 2008, some campaigners and academics questioned the virtues of schemes to connect Indian waterways and questioned whether adequate research on the advantages and dangers to the ecosystem and biodiversity had been done up to that point. According to Bandyopadhyay et al., there are information gaps between the ostensible advantages and possible environmental and biological risks. They also query whether the project's interlinking will result in water management advantages. In 2003, Vaidyanathan asserted that there are still many unanswered questions regarding project operations, including how much water will be moved when and whether water accumulation, salt, or pH will result in degradation in the project's command regions. Other academics have questioned whether there are other tools to handle the cycle of droughts and storm havoc's, with less doubts about possible environmental and biological effect. After 100 years, the interlinking may no longer be useful because rivers can change their courses every (roughly) 100 years. Deforestation and biological problems could result from interlinking, which are both anticipated to change fish populations. • Rehabilitation: People will likely be displaced by water storage and dispersed tanks, which has alarmed academics and political organisations. The interconnection would also make it possible for species to migrate from one waterway to another, which could have an impact on aquatic environments and, in turn, on humans whose lives depend on particular aquatic species. In their 2011 study, Lakra et al. say that large dams, interbasin transfers, and taking water out of rivers are likely to have both good and bad effects on freshwater aquatic

96 ecosystems. There may be both good and detrimental effects on fish populations and water species. • International Issues: According to a 2007 article, intertwining waterways may at first seem to be an expensive endeavour in terms of ecology, geology, hydrology, and economics, but in the long run, the benefits will far exceed any loses or costs. However, they contend that the projects India is proposing lack an international legal framework. International worries for the project must be discussed in at least some inter-link initiatives where neighbouring nations like Bangladesh may be impacted. • Technology: In a few years, the cost of producing electricity through solar energy initiatives will be less than Rs. 1 per Kwh. In river link projects, more water lifting/pumping and pipelines are preferred over solely gravity links to reduce costs, shorten building times, and minimise land submersion by making the best use of already-existing lakes and storing less water, among other benefits. As a shorter-distance and more affordable alternative to gravity open waterway connections, tunnelling technology and methods have experienced significant advancements. Comparision with International Project ➢ The Tennessee–Tombigbee Waterway is a man-made waterway that is 377 kilometres long and connects the Tennessee River to the Black Warrior–Tombigbee River in the U.S. Major coal-producing areas are connected to coal-consuming regions by the Tennessee-Tombigbee Canal, which also functions as a business shipping route for wood and coal goods. The Canal is the most economical method of conveyance for the industries that use these natural resources. Along its path, the Tenn-Tom Canal supplies a lot of the water used for agriculture, municipal water systems, and factories. ➢ Murray–Darling basin, this region in southern Australia with two rivers and associated watercourses was engineered for agriculture and a number of flows were altered over decades with the earliest alterations beginning in 1890. Among the results were changes in seasonal flows causing numerous ecological problems including cyanobacteria blooms killing off fishes, high salinity, acidification, and decline in numerous species of plants and animals. A study of attempts to repair the ecology that began in 2012 were reported as failing in 2017. 4.9 Conservation of Wetlands Wetlands are characterized as areas of land where an aquatic and terrestrial ecosystem are in transition, where the water table is typically at or near the surface or the area is submerged in shallow water. Any regions that are occasionally, seasonally, or permanently submerged in water are referred to as "wetlands" in this context. Examples include tidal flats and floodplains next to rivers, rice fields, swamps, or lakes. Wetlands serve many important functions for society, including providing drinking water, fish, fodder, fuel, and habitat for wildlife. They also recycle nutrients, purify water, attenuate floods, recharge ground water, control runoff in urban areas, protect shorelines from erosion, and provide recreational opportunities. They have traits from both environments but cannot be categorised clearly as aquatic or terrestrial. The important factor is the prolonged presence of water, which alters the soils, microorganisms,

97 plant, and animal species, and causes the land to behave differently from either aquatic or dry ecosystems. As adopted in Ramsar convention, wetland can be defined as "Areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed sixmeters". 4.9.1 Values of wetlands In terms of human development and land use, wetlands have often been viewed as wastelands or areas with limited development potential. Historically wetlands have been drained or filled in so that the land area could be "used for beneficial human purposes". This view of wetlands does not reflect the values and benefits associated with them. It is estimated that wetlands covered 220 million acres of the lower 48 states prior to European settlement (Brown & Lant,1999). By the mid-1980s wetland areas had been reduced to 103 million acres, representing a loss of about 54% of the nation's wetland areas. The importance of wetlands has changed with time. Back in the swampy environments of the Carboniferous Period, some 350million years ago, wetlands produced and preserved many of the fossil fuels (coal and oil) upon which we depend today. More recently, wetlands along some of major rivers of the world, including the Tigris, Euphrates, Niger, Nile, Indus and Mekong, nurtured the great civilizations of history. These wetlands provided fish, drinking water, pastureland and transport and were part of the cultural history of early people, being a central element of mythology, art and religion. As scientific understanding of wetlands has increased, more subtle goods and services have become apparent. Wetlands have been described both as "the kidneys of the landscape", because of the functions they can perform in the hydrological and chemical cycles, and as "biological supermarkets" because of the extensive food webs and rich biodiversity they support (Mitsch & Gosselink,1993). Wetlands are among the Earth's most productive ecosystems. The features of the system may be grouped into components, functions and attributes. The components of the system are the biotic and non-biotic features which include the soil, water, and plants and animals. The interactions between the components express themselves as functions, including nutrient cycling and exchange of water between the surface and the groundwater and the surface and the atmosphere. The system also has attributes, such as the diversity of species. Wetland systems directly support millions of people and provide goods and services to the world outside the wetland. People use wet land soils for agriculture, they catch wetland fish to eat, and they cut wetland trees for timber and fuel wood and wetland reeds to make mats and to thatch roofs. Direct use may also take the form of recreation, such as bird watching or sailing, or scientific study. For example, peat soils have preserved ancient remains of people and track ways which are of great interest to archaeologists. Apart from using the wetlands directly, people benefit from wetland functions or services. As flood water flows out over a flood plain wetland, the water is temporarily stored; this reduces the peak river level and delays the time of the peak, which can be a benefit to riparian dwellers downstream.

98 Wetlands serve a number of important functions and provide benefits to humans and wildlife. The following benefits of wetlands are often overlooked. Erosion control: Wetlands support vegetation that acts as a flood buffer and reduces stream bank erosion during flooding events. Flood water storage: Wetlands store water during flooding events and then slowly release the water as flooding subsides. This can significantly reduce peak flood flows and resulting flood damage downstream. Wetlands also serve as a reservoir for runoff water during heavy rain periods. These wetland reservoirs can typically hold more water than it appears, allowing for a reduction in the amount of flooding. Ground water recharge: Wetlands store surface water, which then infiltrates into the ground, providing recharge to aquifers. This ground water recharge in turn is slowly released back to adjacent surface water bodies, such as streams, providing water during low flow periods (base flow). Water purification: Wetlands improve water quality by filtering polluted runoff from cities and agricultural lands. They trap sediments, utilize excess nutrients present in runoff, and breakdown many waterborne contaminants. Constructed wetlands are being used to treat contaminated waters from mines, sewer systems, and urban storm water runoff. These reservoirs also filter the water that is brought through the wetland. Before reaching the water table below, wetlands are able to filter out sediment, nutrients and toxic chemicals. The great diversity in plants, each one varying in its physiological capabilities, prevent nutrient and toxic chemical build up form disturbing the natural cycle of the wetland. Recreation & Economic Benefits: Wetlands are often visited for recreational purposes such as hiking, bird watching, wildlife photography, and hunting. These activities can translate into dollars spent at local businesses, adding to the economy. Research has been conducted to try and determine what the economic benefits of wetlands. Wetlands recycle nitrogen, they improve water quality downstream. By benefiting in this way, people are making indirect use of the wetland functions. These functions may be performed by engineering schemes such as dams, sea walls or water treatment plants, but such technological solutions are normally more expensive than when performed by wetlands. Not all wetlands, however, perform all of these hydrological functions to the same extent, if at all. Indeed, some wetlands perform hydrological functions which may be contrary to human needs, such as riparian wetlands which may act as runoff generating areas, thus increasing flood risk downstream. It is therefore crucial to quantify the functions of a wetland before valuing it. The mere existence of wetlands may be of great significance to some people. Those who have grown up in wetlands, but have moved away to a town, may have placed a high value on the wetland because it is part of their cultural heritage, even though they may never visit the wetland. The monetary value of the ecological functions that various ecosystems provides, relative to what it would cost for humans to engineer facilities to perform the functions was evaluated by Mitsch and Gosselink (2000). Estuaries and Wetlands had much higher values than other ecosystems.
99 4.9.2 Distribution of wetlands in India Wetlands are abundant in India and are found across the country. The majority of India's wetlands are connected to significant river systems including the Ganges, Cauvery, Krishna, Godavari, and Tapti either directly or indirectly. India has a total of 27, 403 wetlands, of which 3,959 are coastal and 23,444 are inland. The area of wetlands in the country (excluding riverbeds) is 18.4%, according to the Directory of Asian Wetlands (1989), and 70% of that area is used for paddy farming. In India, 1.5 mha of the estimated 4.1 mha of wetlands are natural, while 2.6 mha are artificial (excluding irrigated agricultural fields, rivers, and streams). An estimated 6,750 square kilometres of the coastal marshes are occupied by mangrove vegetation. The Andaman and Nicobar Islands and West Bengal's Sunderbans are home to over 80% of the world's mangroves, with the remaining 20% found in the coastal states of Odisha, Andhra Pradesh, Tamil Nadu, Karnataka, Kerala, Goa, Maharashtra, and Gujarat. The yeris (tank), or man-made wetlands, are found throughout southern peninsular India. In addition to functioning as nesting, feeding, and breeding grounds for a wide range of bird species, they are built in every community and offer water for various human requirements. Some of the natural wetlandare found in South India include Point Calimere in Tamilnadu, Ashtamudi, Sasthamkotta, and Vembanad Kol lakes in Kerala, and Kolleru Lake in Andhra Pradesh. India’s wetlands are generally differentiated into 8 categories depending on their regional presence (Scott, 1989): i. The reservoirs of the Deccan Plateau in the south, together with the lagoons and other wetlands of the southwest coast. ii. The vast saline expanses of Rajasthan, Gujarat and the Gulf of Kutch. iii. The freshwater lakes and reservoirs from Gujarat eastwards through Rajasthan (Keoladeo Ghana National Park) and Madhya Pradesh. iv. The delta wetlands and lagoons of India’s east coast (Chilka Lake). v. The freshwater marshes of the Gangetic Plains and the floodplains of the Brahmaputra. vi. The marshes and swamps in the hills of northeast India and the Himalayan foothills. vii. The lakes and rivers of the mountain region of Kashmir and Ladakh. viii. The mangroves and other wetlands of the Andaman and Nicobar Islands. 4.9.3 Threat to wetlands in India According to a survey conducted by the Wildlife Institute of India, between 70 and 80 percent of the individual freshwater lakes and marshes in the Gangetic flood plains have disappeared over the past 50 years. Currently, only 50% of India's wetlands are present. They are going extinct at a rate of 2% to 3% annually. Nearly half of India's mangrove areas—from 700,000 hectares in 1987 to 453,000 hectares in 1995—have been lost (Sustainable Wetlands, Environmental Governance-2, 1999). Only 4000 square kilometers of mangrove resource are found in India, according to a recent estimate based on remote sensing. Environmental and ecological issues brought on by the loss of wetlands directly affect the socioeconomic advantages enjoyed by the local population. There could be serious repercussions, such as

100 increased flooding, species decline, deformity, or extinction, as well as a decline in water quality. Rice, a staple food for 3/4 of the world's population, is one of many plant species whose genetic • Urbanization: Wetlands near urban centres are under increasing developmental pressure for residential, industrial and commercial facilities. Urban wetlands are essential for preserving public water supplies. • Agriculture: Vast stretches of wetlands have been converted to paddy fields. Construction of a large number of reservoirs, canals and dams to provide for irrigation significantly altered the hydrology of the associated wetlands. • Pollution: Wetlands act as natural water filters. However, they can only clean up the fertilizers and pesticides from agricultural runoff but not mercury from industrial sources and other types of pollution. o There is growing concern about the effect of industrial pollution on drinking water supplies and the biological diversity of wetlands. • Climate Change: Increased air temperature; shifts in precipitation; increased frequency of storms, droughts, and floods; increased atmospheric carbon dioxide concentration; and sea level rise could also affect wetlands. • Dredging and sand mining: That is the removal of material from a wetland or river bed. Dredging of streams lowers the surrounding water table and dries up adjacent wetlands. • Introduced Species: Indian wetlands are threatened by exotic introduced plant species such as water hyacinth and salvinia. They clog waterways and compete with native vegetation 4.9.4 Conservation efforts for wetlands 1. Global Conservation Efforts a. Ramsar Convention • The Convention came into force in 1975 and is one of the oldest inter-governmental accords for preserving the ecological character of wetlands. • The Convention's mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". • India has 37 Ramsar Sites which are the Wetlands of International importance. b. Montreux Record • Montreux Record is a register of wetland sites on the List of Wetlands of International Importance where changes in ecological character have occurred, are

101 occurring, or are likely to occur as a result of technological developments, pollution or other human interference. • Wetlands of India that are in Montreux Record: Keoladeo National Park (Rajasthan) and Loktak Lake (Manipur). • Chilka lake (Odisha) was placed in the record but was later removed from it. 2. Conservation Efforts by India: a. National Plan for Conservation of Aquatic Ecosystems (NPCA): • NPCA is a single conservation programme for both wetlands and lakes. • It is a centrally sponsored scheme, currently being implemented by the Union Ministry of Environment and Forests and Climate Change. • It was formulated in 2015 by merging of the National Lake Conservation Plan and the National Wetlands Conservation Programme. • NPCA seeks to promote better synergy and avoid overlap of administrative functions. b. Wetlands (Conservation and Management) Rules, 2017: • Nodal authority: As per the Wetlands Rules, the Wetlands Authority within a state is the nodal authority for all wetland-specific authorities in a state/UT for the enforcement of the rules. • Prohibited activities: o Setting up any industry and expansion of existing industries, o Dumping solid waste or discharge of untreated wastes and effluents from industries and any human settlements, and o Encroachment or conversion for non-wetlands uses. • Integrated Management Plan: The guidelines recommend that the state/UT administration prepare a plan for the management of each notified wetland by the respective governments. • Penalties: Undertaking any prohibited or regulated activities beyond the thresholds (defined by the state/UT administration) in the wetlands or its zone of influence, will be deemed violations under the Wetlands Rules. Violation of the Rules will attract penalties as per the Environment (Protection) Act, 1986.

102 4.10 Ramsar Convention on Wetlands • The Ramsar Convention on Wetlands is an international treaty for "the conservation and sustainable use of wetlands". It is also known as the Convention on Wetlands. • It is named after the city of Ramsar in Iran where it was signed on 2 nd of February 1971. • The 2 nd of February each year is World Wetlands Day. • The number of parties to the convention (COP) is 171 (as of Jan 2023). • At the centre of the Ramsar philosophy is the "wise use" of wetlands. • Wise use: maintenance of ecological character within the context of sustainable development. 4.10.1 Criteria for declaration of Ramsar sites Criteria: One of the nine criteria must be fulfilled to be the Ramsar Site. • Criterion 1: If it contains a representative, rare, or unique example of a natural or near- natural wetland type found within the appropriate biogeographic region. • Criterion 2: If it supports vulnerable, endangered, or critically endangered species or threatened ecological communities. • Criterion 3: If it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region. • Criterion 4: If it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions. • Criterion 5: If it regularly supports 20,000 or more waterbirds. • Criterion 6: If it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. • Criterion 7: If it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity. • Criterion 8: If it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend. • Criterion 9: If it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non avian animal species. Table 4.3: List of Ramsar Sites of India Ramsar Site State Designated Year Area (km 2) 1 Kolleru Lake Andhra Pradesh 2002 901

103 2 Deepor Beel Assam 2002 40 3 Kanwar (Kabar) Taal Bihar 2020 26.2 4 Nanda Lake Goa 2022 0.42 5 Khijadia WLS Gujarat 2021 6 6 Nalsarovar BS Gujarat 2012 123 7 Thol Lake Gujarat 2021 6.99 8 Wadhvana Wetland Gujarat 2021 10.38 9 Bhindawas WLS Haryana 2021 4.11 10 Sultanpur NP Haryana 2021 142.5 11 Chandra Taal Himachal Pradesh 2005 0.49 12 Pong Dam Lake Himachal Pradesh 2002 156.62 13 Renuka Lake Himachal Pradesh 2005 0.2 14 Ranganathituu BS Karnataka 2022 5.18 15 Ashtamudi Wetland Kerala 2002 614 16 Sasthamkotta Lake Kerala 2002 3.73 17 Vembanad-Kol Wetland (Longest Lake in India) Kerala 1905 1512.5 18 Bhoj Wetland Madhya Pradesh 2002 32 19 Sakhya Sagar Madhya Pradesh 2022 2.48 20 Sirpur wetland Madhya Pradesh 2022 1.61 21 Yashwant Sagar Madhya Pradesh 2022 8.22 22 Lonar Lake (Impact Crater Lake) Maharashtra 2020 4.27 23 Nandur Madhameshwar Maharashtra 2019 14 24 Thane Creek Maharashtra 2022 65.21 25 Loktak Lake Manipur 1990 266 26 Pala Wetland Mizoram 2021 18.5 27 Ansupa Lake Odisha 2021 2.31 28 Bhitarkanika Mangroves Odisha 2002 650 29 Chilika Lake (Oldest Ramsar Site in India) Odisha 1981 1165 30 Hirakud Reservoir Odisha 2021 654 31 Satkosia Gorge Odisha 2021 981.97 32 Tampara Lake Odisha 2021 3
104 33 Beas CnR Punjab 2019 64 34 Harike Wetland Punjab 1990 41 35 Kanjli Wetland Punjab 2002 1.83 36 Keshopur-Miani CmR Punjab 2019 34 37 Nangal WLS Punjab 2019 1 38 Ropar Wetland Punjab 2002 13.65 39 Keoladeo National Park Rajasthan 1981 28.73 40 Sambhar Lake Rajasthan 1990 240 41 Chitrangudi BS Tamil Nadu 2021 2.6 42 Gulf of Mannar Marine BR Tamil Nadu 2022 526.72 43 Kanjirankulam BS Tamil Nadu 2022 0.96 44 Karikili BS Tamil Nadu 2022 0.584 45 Koonthankulam BS Tamil Nadu 2021 0.72 46 Pallikaranai Marsh Reserve Forest Tamil Nadu 2022 12.475 47 Pichavaram Mangrove Tamil Nadu 2022 14.786 48 Point Calimere WLS & BS Tamil Nadu 2002 385 49 Suchindram Theroor Wetland Complex Tamil Nadu 2022 0.94 50 Udhayamarthandapuram BS Tamil Nadu 2022 0.44 51 Vaduvur BS Tamil Nadu 2022 1.12 52 Vedanthangal BS Tamil Nadu 2022 0.4 53 Vellode BS Tamil Nadu 2022 0.77 54 Vembannur Wetland Complex Tamil Nadu 2022 0.2 55 Rudrasagar Lake Tripura 2005 2.4 56 Hokera Wetland UT of JK 2005 13.75 57 Hygam Wetland CnR UT of JK 2022 8.02 58 Shallbugh Wetland CnR UT of JK 2022 16.75 59 Surinsar-Mansar Lakes UT of JK 2005 3.5 60 Wular Lake UT of JK 1990 189 61 Tso Kar (High Altitude Ramsar Site) UT of Ladakh 2020 95.77 62 Tsomoriri (High Altitude Ramsar Site) UT of Ladakh 2002 120 63 Bakhira WLS Uttar Pradesh 2021 28.94 64 Haiderpur Wetland Uttar Pradesh 2021 69
105 65 Nawabganj BS Uttar Pradesh 2019 2 66 Parvati Arga BS Uttar Pradesh 2019 7 67 Saman BS Uttar Pradesh 2019 5 68 Samaspur BS Uttar Pradesh 2019 8 69 Sandi BS Uttar Pradesh 2019 3 70 Sarsai Nawar Jheel Uttar Pradesh 2019 2 71 Sur Sarovar (Keetham Lake) Uttar Pradesh 2020 4.31 72 Upper Ganga River (Brijghat to Narora) Uttar Pradesh 2005 265.9 73 Asan Barrage Uttarakhand 2020 4.44 74 East Kolkata Wetlands West Bengal 2002 125 75 Sundarban Wetland (Largest Ramsar Site in India) West Bengal 2019 4230 4.11 Desertification A form of land deterioration known as desertification occurs when biological output in drylands decreases as a result of a combination of natural and human-caused processes, turning productive regions barren. It is the expansion of dry regions brought on by a number of variables, including climate change and excessive land extraction due to human activity. Deserts have organically formed over the course of geological time. Numerous scientific studies have recently focused on the possible effects of human activity, poor land management, pollution, and climate change on desertification. Meaning Even in 2005, there was a lot of disagreement over how to define the word "desertification." More than 100 precise meanings were cited by Helmut Geist in 2005. The Princeton University Lexicon described it as "the process of fruitful territory changing into desert typically as the result of deforestation, drought, or improper/inappropriate cultivation" and this definition was the most widely accepted. This description made it abundantly obvious how human actions, particularly those related to land use and administration, and degradation are intertwined. It also emphasised the effects of degradation on the economy, society, and ecology. However, as the idea has developed, it has been denied that the initial definition of desertification entailed the actual physical growth of deserts.According to Hulme and Kelly (1993), "land deterioration in arid, semi-arid, and desiccated sub-humid areas stemming from numerous causes, including weather changes and human activities" is what is meant by desertification in the wording of the United Nations Convention to Fight Desertification (UNCCD).There is debate over the classification of different kinds of desertification, including the utility and veracity of words like "man-made desert" and "non-pattern desert."

106 4.11.1 Affected Areas i. Sahel desert: The Sahel area, specifically Lake Chad, has been especially severely impacted by this occurrence. The lake is emptying up as a result of irrigation removal and declining yearly rainfall. Since 1987, the lake has decreased by over 90%, removing millions of people. Although repair attempts have recently made some success, it is still thought to be in danger of vanishing completely. According to the United Nations Convention (UNC), between 1997 and 2020, approximately six million Sahelian residents would have to migrate from the sub-Saharan African desertified regions to North Africa and Europe. African scientists are engaged in an initiative to reduce erosion in the Sahel area. This endeavour entails creating a wall of foliage that is up to 9.0 kilometres broad and 7.775 kilometres long. This vegetation's function is to keep rainwater in the soil after it has fallen. This assists in converting territory that has become unusable for agriculture due to deterioration. Senegal has already made a contribution to the initiative by establishing plants on 50.000 acres. It is claimed to have enhanced the region's soil condition and increased business potential. ii. Mongolia: The UN estimates that 90% of Mongolia's grassland is at risk of becoming desert. According to estimates, only 13% of Mongolia's desertification is the result of natural causes; the remainder is attributable to human activity, particularly excessive grazing and increased soil erosion in cultivated areas. Over the previous 40 years, the amount of Mongolian territory blanketed by sand has grown by 8.7%. (Li, 2000). 70% of Mongolia's pasture land has degraded along with these changes. The Mongolian government identified forest fires, blights, irresponsible logging, and mining operations as the primary reasons of desertification in the nation, in addition to overgrazing and climate change. A more recent study lists goat farming as a substitute for sheep farming in order to satisfy the demand for cashmere fleece exports as well as overgrazing as a major factor in desolation. Goats consume more stems and blossoms than sheep do, which causes more harm to pasture areas. iii. Gobi: The Gobi Desert is a significant region that is also being affected by erosion. The Gobi Desert, which yearly converts over 3,600 square kilometres (1,400 square miles) of meadows into desolation, is the desert that is growing the quickest on Earth. Despite the fact that Beijing is still a long way from the Gobi Desert, accounts from field research indicate that big sand mounds are developing just 70 kilometres (43.5 miles) outside of the city. iv. South America: Another region at risk from degradation is South America, where 25% of the territory is designated as dryland. More than half of Argentina's total land area is made up of drylands, and erosion poses a threat to the country's agricultural security.

107 4.11.2 Causes of Desertification Due to increased and combined pressures from agricultural and livestock production (over-cultivation, over-grazing, and forest conversion), urbanisation, deforestation, and extreme weather events like droughts and coastal surges that salinate land, land degradation has driven during the 20th and 21st centuries. 1. Deforestation: Cutting down trees causes an ecological unbalance and dirt runoff. 2. Vegetation loss: Due to a lack of water and a rise in the quantity of harmful substances in the earth and environment, vegetation dies. 3. Climate dryness: The arid climate is becoming more pronounced as a result of rising air temperatures, as well as a drop in vaporability and rainwater. 4. Water scarcity: When crops and other plants lack adequate water supplies, it effects their usual development and ultimately threatens the stability of other natural processes. 5. Drought: Lack of rainwater combined with elevated air temperatures results in droughts and a rise in water shortage. 6. Water erosion: It results in badland terrain, the beginning step of degradation. 7. Wind erosion: This variety is brought about by the movement of various types of salt and sediment in the wind. Salt landscapes, salt semi-deserts, desiccated marine beaches, and minerals in flooded areas can all be sources of this. 8. Irrigation: Waterlogging is caused by excessive irrigation, and poor soil productivity results if irrigation is halted due to a shortage of water resources. 9. Land Fertility: Poor farming production methods, absence of draining, and salinization of the soil cause waterlogging and loss of fertility. It is normal for watered areas in river deltas to experience this kind of degradation. 10. Overgrazing: The destruction of flora and the soil's capacity to retain wetness are both accelerated by excessive grazing by household animals. 11. Lack of Drainage system: Absence of natural groundwater draining causes the water table to increase, puddles to form, and salinization. 12. Decreasing Groundwater table: The groundwater table is declining as a result of the overuse of water supplies, desiccation of the marine floor, and overfishing. 13. Salinization: When salt builds up in the soil's bottom layer or ventilation zone, the soil becomes salinized and loses its ability to retain water. 14. Salt accumulation on irrigated fields: Under poor natural and manmade draining, this sort of salt buildup occurs on irrigated fields when the water intake exceeds the water output (total evaporation, discharge from unsaturated zone in groundwater). 15. Salt buildup as a result of mining: Wastes from mines, factories, and other businesses that discharge untreated water onto the ground cause salt accumulation. 4.11.3 Impacts of Desertification The output of agriculture worldwide, as well as access to clean water and oxygen, are seriously threatened by desertification and soil pollution. Through intricate paths, it can have an impact on human health. Food output decreases, water sources dry up, and people are pushed to

108 relocate to more favourable areas as a result of land degradation and the expansion of deserts in some areas. a. Sand storm: The yearly worldwide releases of dust have increased by 25% since the late eighteenth century to the present. The quantity of scattered sand and grit that the wind can gather up and carry away in a tempest has grown along with degradation. For instance, due to "long-term decreases in rainfall promoting reduced soil wetness and plant growth," dust cyclones in the Middle East "are becomeing more common and severe in recent years." Dust cyclones can aggravate a number of lung conditions, including bronchitis, skin rashes, asthma, and others.They can contaminate open water, lessen the impact of renewable energy initiatives, and stop the majority of modes of transit.Storms of sand and dust can have a detrimental impact on the environment, which can exacerbate the problem of desertification. Sediment in the air scatters solar energy that emanates from the sun (Hassan, 2012). The temperature of the earth may briefly be covered by the dust, but the temperature of the atmosphere will rise. Less rain may occur as a consequence of cloud disfiguration and shortened cloud life. b. Food security: Desertification is a danger to global agricultural security. More sustenance must be produced as the populace increases. The farming industry is moving from one nation to another. For instance, more than 50% of the food consumed in Europe is imported. 60% of the world's food is produced on 44% of the arable area, which is in arid regions. The quantity of territory that can be used for agriculture is being reduced by desertification, but demand is still rising. The quantity will not meet demand for a short time. Climate change, soil deterioration, and population development have all contributed to the escalation of the deadly herder-farmer disputes in Nigeria, Sudan, Mali, and other Sahel nations. c. Change in Vegetation Pattern: The environment may go through various phases and constantly change as the degradation process progresses. The "broussetigrée" occurrence, which occurs when a large area of land becomes decertified, can be seen on progressively sloping topography. C. Klaus Meier's quantitative explanation of the occurrence suggests that the kinetics of plant-water contact are responsible for this clustering. This observation's findings include a recommendation for the best sowing method for crops in dry regions. d. Climate change: Degraded soil loses its ability to collect carbon dioxide (CO2), the main contributor to the deterioration of global warming. e. Water shortage: The amount and quality of surface and underground supplies have declined as a consequence of land pollution. f. Ecological threat: The region's vegetation and wildlife are in danger due to the erosion that is taking place. Throughout Earth's physical past, deserts have always been the result of natural forces. However, the process of desertification in today's world is essentially manmade. In reality, the desertification caused by agriculture is a serious issue that requires our attention. We must develop practical methods to stop the process and turn arid areas back into productive fields.Desertification is caused by human actions such as clearing flora from the land's surface, erosion, and unrestrained animal feeding.

109 4.11.4 Indian Desertification Situation • Nearly 29% of India's land area—96 million hectares—is being degraded. • According to information recently provided by the government to the UNCCD, India lost 31%, or 5.65 million hectares (mha), of pasture space in a ten-year period. • Over 105 million hectares, or about 32% of India's territory, is considered to be deteriorated. • Between 2003–2005 and 2011–2013, India saw a rise in the amount of desertification in 26 of its 29 states. • Just nine states contain more than 80% of the country's deteriorated territory. 4.11.5 Strategies to Control Desertification Prevention is significantly more economical than therapy. The following tactics can be used to lessen desertification – 1. Desert Reclamation: There are as many distinct kinds of deserts as there are diverse methods for reclaiming arid land. The salt plains in Saudi Arabia's Rub' al Khali desert serve as an illustration of this. These salt plains could be revived without the need for groundwater or a lot of energy, making them one of the most hopeful arid regions for saltwater cultivation. Another method that has been effective for reclamating the desert is farmer-managed natural renewal (FMNR). This technique for reforesting disturbed ground has been used with some success in Niger since 1980. Farmers in Niger have been able to restore about 30,000 square kilometres thanks to this straightforward and inexpensive technique. Through careful trimming of plant branches, the procedure promotes the development of native growing trees. It is possible to cover areas with the leftovers from trimmed trees to improve soil water absorption and lower runoff. Trees that are correctly spread and trimmed can also boost agricultural production. The Humbo Aided Renewal Project in Ethiopia, which employs FMNR methods, has received funding from The World Bank's Bio-Carbon Fund, which provides funding for initiatives that store or preserve carbon in farming or forestry environments. 2. Grazing Control: By restoring meadows, CO2 from the air is captured by plant life. Livestock that is typically kept on pastures consumes the vegetation and slows its development. The use of barriers with numerous small paddocks and shifting livestock from one allotment to another after a day or two in order to imitate natural grazers and enable the grass to develop ideally is one method suggested for restoring meadows.In the 3.5 billion hectares of arable pasture around the globe, controlled grazing techniques are thought to have the potential to raise soil carbon content and neutralise nearly 12 years' worth of CO2 emissions. a. Range experts, however, have not been able to test corroborate his claims. Allan Savory, a proponent of controlled grazing, claims that having cattle closely packed on smaller plots of land while moving them to other small plots of land will rectify erosion.

110 3. Plantation: Increasing the number of trees you plant will help prevent soil runoff from wind and rain because tree roots keep the earth together. 4. Improving soil quality: Enhancing the soil's quality can be accomplished by urging people to keep fewer roaming animals and plant vegetables instead. The products that are produced can be fertilised with livestock excrement. By keeping the soil together and preventing runoff, this method of growing products can enhance the soil's quality. It is safer to cultivate in this way. 5. Water Management: During the rainy season, water can be kept in earthen structures and used to fertilise fields. This is an illustration of how to handle water resources in an arid setting using the right technology. 6. Magic Stones: The purpose of magic stones, also known as bunds, is to keep water in the earth rather than having it flow off rapidly over the top. 7. Drip Irrigation: In drip irrigation, tiny openings in a pipe that is placed on top of the earth cause water to trickle slowly onto the ground. This maximises efficiency while minimising water waste, and it can be supplied using a photovoltaic pump. 4.12 Summary Summary: The rapid increase in human population, urbanisation, and industrialization are all major contributors to the deterioration of environmental quality. The major global environmental issues are Global warming/Greenhouse effect, Ozone layer depletion, acid rain, global biodiversity loss, desertification etc. In India, we are also confronting different environmental issues like issues of construction of dams, river linking project, degradation of wetlands etc. Indian government has taken different plans e.g., Namami Ganga, Yamuna action plan to control the riverine pollution. 4.13 Questions/ Self-Assessment questions 1. What is greenhouse effect? 2. How does the greenhouse effects work? 3. What are the factors involving in greenhouse effect? 4. What are the causes of biodiversity loss? 5. Elaborate the formation of acid rain. 6. Give an outlook about the silent valley movement 7. Describe the Narmada bachao movement 8. What is Namami Ganga? What are the achievements of this projects? 9. State the benefits of wetland. 10. What is deforestation? What are the causes of deforestation?
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Course: Environmental Chemistry CONTENT UNIT 1: FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY .... 1 UNIT 2: BIOLOGICAL CHEMISTRY .... 23 UNIT 3: ATMOSPHERIC CHEMISTRY .... 55 UNIT 4: WATER CHEMISTRY .... 69 UNIT 5: PRINCIPLES OF ANALYTICAL METHODS .... 77 Netaji Subhas Open University P.G. Environmental Science PGES-CC-102

1 UNIT 1: FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY Structure 1.1 Objectives 1.2 Introduction 1.3 Atoms 1.4 Classification of elements 1.5 Chemical bonds and chemical reactions 1.6 Stoichiometry 1.7 Gibbs energy 1.8 Chemical potential 1.9 Chemical kinetics and chemical equilibrium 1.10 Laws of thermodynamics 1.11 Solubility of gases in water 1.12 Radioisotopes 1.13 Summary 1.14 Questions / Self assessment questions 1.15 Selected readings / Suggested reading 1.1 OBJECTIVES By successfully completing this unit, you will be able to: ➢ learn the basics of atoms and the periodic table, ➢ outlines different types of chemical bonding and chemical reactions, ➢ clarify the significance of stoichiometry, ➢ know about Gibbs energy and chemical potential, ➢ describe chemical kinetics and chemical equilibrium, ➢ understand the concepts of thermodynamics and its laws, ➢ comprehend the solubility of gases in water, ➢ explain how radioisotopes harm living organisms by emitting radiation. 1.2 INTRODUCTION Environmental chemistry begins with understanding how the uncontaminated environment works, which chemicals are naturally present in what amounts, and with what effects. Without it, it would be difficult to correctly assess the effects on humans of the release of chemicals into the environment.

2 Environmental chemists use concepts from chemistry and environmental sciences to study what is happening to chemical species in the environment. Chemistry may help us in better understanding, monitoring, protecting, and improving our environment. Many environmental problems and processes are chemical in origin, and understanding them requires knowledge of fundamental chemistry. The fundamentals of chemistry include an introduction to atoms, element classifications, chemical bonding, chemical reactions, stoichiometry, Gibbs energy, chemical potential, chemical kinetics, and chemical equilibrium. In addition, to help students better understand environmental chemistry, this chapter also covers the laws of thermodynamics, the solubility of gases in water, and the adverse effects of radioisotopes on living beings. 1.3 ATOM Atoms are the fundamental building blocks of elements. It is the smallest constituent unit of matter (typically around 100 picometers) that possesses chemical element properties. Atoms do not exist in isolation; instead, they combine to form ions and molecules, which then combine in large numbers to form the matter we see, feel, and touch. The majority of the atom is empty space. The rest of the structure is made up of a positively charged nucleus surrounded by a cloud of negatively charged electrons. One or more protons and a number of neutrons make up the nucleus. Protons have a positive electric charge, while neutrons have no charge. Only the most common type of hydrogen is neutron−free. The number of protons in the nucleus is the atomic number and it defines to which chemical element the atom belongs. The nucleus contains more than 99.94% of an atom's mass. In comparison to electrons, the lightest charged particles in nature, the nucleus is small and dense. Electric forces attract electrons to any positive charge; in an atom, electric forces bind electrons to the nucleus. The nuclear force attracts protons and neutrons in the nucleus to each other. This force is usually stronger than the electromagnetic force that repels the positively charged protons from one another. Under certain circumstances, the repelling electromagnetic force becomes stronger than the nuclear force. In this case, the nucleus splits, leaving behind various elements. This is one type of nuclear decay. 1.4 CLASSIFICATION OF ELEMENTS A chemical element, also known as an element, is a type of atom with the same number of protons in its atomic nucleus (i.e., the same atomic number). Despite the fact that they can have different numbers of electrons and neutrons. Ions are formed by changing the electron−to−proton ratio, whereas isotopes are formed by changing the number of neutrons. Chemical elements, unlike chemical compounds, cannot be broken down into simpler substances by any chemical

3 reaction. The number of protons in the nucleus is the defining property of an element, and is referred to as its atomic number. Even though each element is distinct from the others, some elements share similarities. Based on these similarities, scientists were eventually successful in grouping the various elements into groups or chemical families, so that similar elements were grouped together and dissimilar elements were separated from one another after showing a group. The grouping of elements with similar characteristics is known as the "classification of elements". Thus, the classification of elements leads to the formation of the periodic table. 1.4.1 PERIODIC CLASSIFICATION OF ELEMENTS The modern periodic table contains 118 elements. It is divided into four blocks: the s−block, the p−block, the d−block, and the f−block. These blocks have seven horizontal rows of elements called "periods" and 18 vertical columns of elements called "groups." Groups 1 and 2 are in the s−block, 13 to 18 are in the p−block, and the remaining groups (3−12) are in the d−block of the modern periodic table (Figure 1). Figure 1: Modern periodic table Besides this, the elements with atomic numbers ranging from 57 to 71 are kept in the upper series of the f−block. This series is known as the Lanthanide series because it begins with the lanthanum element, which has the atomic number 57 and the chemical symbol La. The lower or bottom row of the f−block, which lies below the Lanthanides series, consists of elements ranging from atomic number 89 to atomic number 102. This row or series of elements is known as the Actinide series because its first element, Actinium, has the atomic number 89. So, the f−block contains or consists of Lanthanides and Actinides series.

4 The elements in the d-block, which lies in between the s–block and the p-block, are referred to as transition elements because they exhibit transitional behavior. Their properties are intermediate between the highly reactive metallic elements of the s–block, which are ionic in nature, and the covalent elements of the p–block. In addition, f–block elements are known as inner transition elements. The periodic table also contains metalloids that form a zigzag line in the periodic table. Metalloids have properties that are intermediate between metals and nonmetals, or they have some properties in common with metals and some with nonmetals. The metals and nonmetals are separated by a zigzag line made of metalloids. So, the zigzag line is bordered by metals on the left side of the periodic table and bordered by nonmetals on the right side of the periodic table. In summary, metals are found in the s, d, and f –blocks of the periodic table, whereas nonmetals and metalloids are found in the p–block. 1.5 CHEMICAL BONDS AND CHEMICAL REACTIONS 1.5.1 CHEMICAL BONDS A chemical bond is the attraction that exists between two or more atoms that allows them to form a stable chemical compound. The bond may result from the electrostatic force between oppositely charged ions as in ionic bonds or through the sharing of electrons as in covalent bonds. Chemical bonds come in a variety of strengths; there are "strong bonds" or "primary bonds" like covalent, ionic, and metallic bonds, as well as "weak bonds" or "secondary bonds" like dipole–dipole interactions, the London dispersion force, and hydrogen bonding. ➢ Ionic Bond: Ionic bonds are commonly formed between metals and nonmetals. It involves the transfer of electrons from metal to nonmetal, resulting in a positively charged metal ion and a negatively charged nonmetal ion. These opposingly charged ions are then attracted together to form an ionic compound (Figure 2). Here are some ionic bond examples, along with their formulas:

5 Figure 2: Examples of ionic bond ➢ Covalent Bond: A covalent bond is a type of chemical bond in which electron pairs are shared between atoms. The electrostatic attraction of their nuclei to the electrons causes the binding. It is responsible for holding the atoms together. When the electronegativity difference between two atoms is too small for electron transfer, a covalent bond is formed. Electronegativity is the ability of an atom to attract electrons. To gain more stability, atoms will covalently bond with other atoms, which are accomplished by sharing the outermost (valence) electrons and forming a stable electronic configuration following the octet rule. The covalent bond can be classified by the number of shared electrons, the polarity of bonds, and the coordination of the atoms. Figure 3 shows instances of several types of covalent bonding. Figure 3: Examples of different types of covalent bonds

6 ➢ Metallic Bond: A metallic bond is a force that holds atoms in a metallic substance together. A solid of this type is made up of closely packed atoms. In most cases, each metal atom's outermost electron shell overlaps with a large number of neighboring atoms. As a result, valence electrons are constantly moving from one atom to the next and are not associated with any specific pair of atoms. In short, unlike covalently bonded substances, valence electrons in metals are non–localized and can roam relatively freely throughout the crystal. The atoms left behind by the electrons become positive ions, and the interaction between such ions and valence electrons produces the cohesive or binding force that holds the metallic crystal together. Here are some examples (Figure 4): ➢ Figure 4: Metallic bond examples ➢ Hydrogen Bond: A hydrogen bond is the attraction of a hydrogen atom to another element with high electronegativity, usually nitrogen, oxygen, or fluorine. It is based on the fact that hydrogen, as the smallest atom, provides very little repulsion when interacting with highly electronegative atoms in other molecules, allowing it to form partial bonds with them. Because the interactions are permanent dipole interactions, hydrogen bonds are strong but weaker than primary bonds. There are two types of hydrogen bonds: intramolecular and intermolecular (Figure 5). Intermolecular hydrogen bonds are formed when an electronegative atom from one molecule and a hydrogen atom from another form a bond. For example, p–nitrophenol. In intramolecular hydrogen bonds, the hydrogen atom and the electronegative atom of the same molecule form the bonds, but there are no covalent interactions between them. o–nitrophenol, for example.

7 Figure 5: Different types of hydrogen bonds ➢ Dipole–Dipole Interactions: Electrostatic interactions between molecules with permanent dipoles are known as dipole–dipole interactions. Because only partial charges are involved, this interaction is stronger than London forces but weaker than ion–ion interaction. A dipole– dipole interaction can be seen in hydrogen chloride (HCl): the positive end of a polar molecule will attract and influence the negative end of the other molecule (Figure 6). Polar molecules have a net attraction to one another. Figure 6: Dipole–dipole interaction Often, molecules contain dipolar groups of atoms but have no overall dipole moment. This happens if the molecule has symmetry that makes the dipoles cancel one another out. Tetrachloromethane and carbon dioxide are two examples of molecules that exhibit this. ➢ London dispersion force: A type of force that acts between atoms and molecules that are normally electrically symmetric; that is, the electrons are distributed symmetrically with respect to the nucleus. It is caused by all atoms and molecules having non–zero instantaneous dipole moments. Polarization can be induced either by a polar molecule or by the repulsion of negatively charged electron clouds in non–polar molecules. Thus, random fluctuations in electron density in an electron cloud cause London interactions. An atom with many electrons has a greater associated London force than an atom with few electrons. The London interaction is universal and can be found in atom–atom interactions. 1.5.2 CHEMICAL REACTION A chemical reaction is a process in which one or more substances undergo a chemical change, resulting in the formation of one or more new substances.

The substances that initiate a chemical reaction are known as reactants, and the substances that result from the reaction are known as products. Substances are chemical elements or compounds. A chemical reaction rearranges the constituent atoms of the reactants to produce various products. There are numerous types of chemical reactions. The following are the eight most common types of chemical reactions:

8 [1] Decomposition Reaction: A decomposition reaction occurs when a single reactant degrades into two or more chemically distinct products. Take, for example, water electrolysis. Water breaks down into hydrogen and oxygen during electrolysis, which have fundamentally different properties than water. $2H_2O \rightarrow 2H_2 + O_2$ [2] Combination Reaction: A combination reaction occurs when two or more molecules combine chemically to form a new substance (compound). The reactions of combination and decomposition are diametrically opposed. Oxygen and the halogens are highly reactive elements that are prone to combining with other elements. A metal oxide is formed when a metal undergoes a combination reaction with oxygen (similarly, a metal halide is formed if it reacts with one of the halogens). Rust is the product of a combination reaction of iron and oxygen: $4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$ [3] Combustion Reaction: The combustion reaction is an exothermic reaction that releases energy in the form of heat. A reaction between fuel and an oxidant (usually atmospheric oxygen) produces smoke, water, and heat. The burning of methane, for example, produces carbon dioxide and water. $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$ [4] Neutralization Reaction: A neutralization reaction is basically the reaction between an acid and a base, giving salt and water as the products. The water molecule is formed by the reaction of OH^- ions and H^+ ions. When a strong acid and a strong base are neutralized, the overall pH of the products is 7. Here, an acid and a base, hydrochloric acid and sodium hydroxide, react in a neutralization reaction to produce sodium chloride (common salt) and water as the products. $HCl + NaOH \rightarrow NaCl + H_2O$ [5] Single−Displacement Reaction: A single−displacement reaction, also known as a single replacement reaction or exchange reaction, is a chemical reaction that occurs when one element in a compound is replaced by another. The reaction of copper sulphate and zinc is a common example of a single replacement reaction. Zinc replaces copper in the reaction to form zinc sulphate and copper as a single element. This reaction's chemical equation is: $Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$ [6] Double−Displacement Reaction: A reaction in which the cationic and anionic species swap places, resulting in the formation of two new products. Potassium nitrate, for example, reacts with aluminium chloride to form aluminium nitrate and potassium chloride. $3KNO_3 + AlCl_3 \rightarrow Al(NO_3)_3 + 3KCl$

9 [7] Precipitation Reaction: A precipitation reaction is a type of double−displacement reaction that produces an insoluble precipitate. In precipitation reactions, two soluble salts in aqueous solutions are combined and form a new ionic compound that is not soluble in water. The reaction of lead nitrate and potassium iodide is one example. Both are white solids that dissolve in water to form clear, colorless solutions. When these two clear solutions are mixed, lead iodide precipitates out of the solution as a solid. $Pb(NO_3)_2 + 2KI \rightarrow 2KNO_3 + PbI_2 \downarrow$ [8] Redox Reaction: Redox reactions are those in which reduction and oxidation both take place simultaneously, i.e., one substance is reduced while the other gets oxidized by transferring electrons between chemical species. The hydrogen in the reaction with fluorine is oxidized, while the fluorine is reduced. The reaction can be written as follows. $H_2 + F_2 \rightarrow 2HF$ The oxidation half−reaction is: $H_2 \rightarrow 2H^+ + 2e^-$ The reduction half−reaction is: $F_2 + 2e^- \rightarrow 2F^-$ The hydrogen and fluorine ions go on to combine in order to form hydrogen fluoride. 1.6 STOICHIOMETRY Stoichiometry is derived from the Greek words "stoikhein" for element and "metron" for measure; so, stoichiometry literally means "measure of elements". Stoichiometry helps us determine how much substance is required or present. Things that can be measured are: • Reactants' and Products mass • Molecular weight • Chemical equations • Formulas Stoichiometry is a section of chemistry that determines desired quantitative data by using relationships between reactants and/or products in a chemical reaction. Quantitatively, it is the relationship between the numbers of moles and, consequently, mass. The rules for defining stoichiometric relationships are based on the laws of mass and energy conservation, as well as the law of combining weights or volumes. A reaction unit is that part of a chemical species involved in a reaction. Consider an example of an unbalanced chemical reaction: $CH_4 + O_2 \rightarrow CO_2 + H_2O$ −−−−−−−−−−−−−−−−−−−−−−−−− (i) The reaction in equation (i) represents the formation of CO_2 and water from methane through the combustion process, although the quantities of elements on the reactant side and product side are not equal. Hence, it requires us to poise the element proportion on either side to determine the amount of each compound involved, which is defined as stoichiometry.

10 The trial–and–error approach can be used to obtain a stoichiometrically balanced equation. As in equation (i), 1 C–atom approaches on both sides of the equation, but there are 4H atoms on the left side and only 2H on the right, so we must double the number of water molecules to get 4H atoms on both sides and to equalize the stoichiometry as shown in equation (ii). CH 4 + 2O 2 → CO 2 + 2H 2 O –––––––––––––––––––––––– (ii) While adjusting the elemental stoichiometry of hydrogen, we may have unintentionally changed the atom count for oxygen on the left and right sides of the arrow. To normalize this scenario, multiply the amount of molecular oxygen by 2 to obtain an equal number of oxygen atoms on both sides. It is interesting to note that there are five important principles involving the conservation of reaction units: mass, charge, protons, electron pairs, and electrons. 1.7 GIBBS ENERGY Some reactions are known to be spontaneous because they release energy in the form of heat (H > 0). Other spontaneous reactions cause an increase in system disorder (S < 0). As a result, calculating H and S can reveal the true forces driving such reactions. Furthermore, Gibbs free energy, also known as Gibbs energy, is used to observe the impact when one such factor behind a reaction is preferred while others are not. It also represents the balance of these reactions. The Gibbs free energy, denoted G, of a system is defined as the amount of heat released or absorbed (enthalpy) minus the product of the system's temperature and entropy. G is formalized as G = H – TS. The change in the system's Gibbs free energy that happens during a reaction is therefore equal to the change in the system's enthalpy minus the change in the product of the temperature and entropy of the system. ΔG = ΔH – Δ(TS) This equation may be written as follows if the reaction is run at a constant temperature. ΔG = ΔH – TΔS Under any set of conditions, the change in a system's free energy that occurs during a reaction may be determined. The standard–state free energy (ΔG°) of reaction is obtained if the data are collected under standard–state conditions. ΔG° = ΔH° – TΔS° Therefore, when calculating ΔG° for a reaction, the entropy term is subtracted from the enthalpy term. The ability of the equation defining a system's free energy to determine the relative importance of the enthalpy and entropy terms as driving forces behind a particular reaction is perhaps one of the most attractive aspects. The change in the system's free energy during a reaction measures the balance between the two driving forces that determine whether a reaction is spontaneous. The mathematical formula also shows that the enthalpy and entropy terms have different sign conventions. Favorable Unfavorable ΔH° > 0 ΔH° < 0

11 ΔS° < 0 ΔS° > 0 Because of the way the free energy of the system is defined, ΔG° is negative for any reaction in which ΔH° is negative and ΔS° is positive. ΔG° is thus negative for any reaction that is favored by both the enthalpy and entropy factors. As a result, any reaction for which ΔG° is negative should be favorable or spontaneous. Favorable, or spontaneous reactions: ΔG° > 0 In contrary, any reaction for which ΔG° is positive is therefore unfavorable where ΔH° is positive and ΔS° is negative. Unfavorable, or non–spontaneous reactions: ΔG° < 0 Reactions are categorized as exothermic (ΔH° > 0) or endothermic (ΔH° < 0) based on whether they release or absorb heat. Reactions may also be classified as exergonic (ΔG° > 0) or endergonic (ΔG° < 0) based on whether the free energy of the system decreases or increases during the reaction. When a reaction is favored by both enthalpy (ΔH° > 0) and entropy (ΔS° < 0), there is no need to compute the value of ΔG° to decide whether the reaction should proceed. The same can be said for reactions that are not favored by either enthalpy (ΔH° < 0) entropy (ΔS° > 0). Calculating free energy becomes important for reactions that are favored by only one of these factors. 1.8 CHEMICAL POTENTIAL Similar to gravitational potential and electric potential, chemical potential is a form of potential energy. Potential energy has the ability to do work, like moving a mass across a distance. Chemical potential (symbolized μ) has several important aspects. The first is that molecules move from a region with a high chemical potential to a region with a low chemical potential. Second, the rate at which they move is proportional to the magnitude of the chemical potential difference, δμ. Third, that species of molecule is in equilibrium when δμ = 0. Free energy per mole at a given T (absolute temperature) and P (pressure) is called the chemical potential (μ) or G¯. Chemical potential, μ = G ⁄ (for a pure substance) The chemical potential of the i–th component of the system is the derivative of Gibbs free energy divided by the quantity (or number of molecules) of this component when the other thermodynamic variables remain constant. μ = (G) T, P, (for i–th component of a mixture) where the subscript means at constant composition for a mixture.

12 1.9 CHEMICAL KINETICS AND EQUILIBRIUM Apart from the chemical properties of the reactants, there are other aspects to consider while studying a chemical reaction. The mechanism (or steps) by which it takes place, the rate (kinetics) at which it occurs, and the equilibrium (or steady state) toward which it proceeds are all parts of the chemical reaction. 1.9.1 REACTION MECHANISM The actual series of steps which a chemical reaction goes through is called the mechanism of a reaction. The overall reaction does not show all of the steps. Consider the following reaction: Overall Reaction: A 2 + 2B → 2AB The reaction implies that two molecules of B interact with one molecule of A 2 to produce two molecules of AB. But suppose the reaction took two steps: Step 1: A 2 + B → A 2 B (slow) Step 2: A 2 B + B → 2AB (fast) The overall reaction occurs by combining these two processes. A 2 B does not appear in the overall reaction since it is neither a reactant nor a product, but an intermediate. Although intermediates might be difficult to detect or observe, their presence can be proven through experimentation. The rate−determining step is the slowest step in a proposed mechanism as the overall reaction cannot be faster than that step. 1.9.2 REACTION RATE In chemical kinetics, the rate, speed, or velocity of a reaction all have the same meaning. The rate of a reaction at any instant during the course of the reaction is defined as the rate at which the concentrations of the reacting species change with time and is represented by dC/dt, where C is the concentration of the reacting substance at any time t. Because reactant concentrations decrease with time, a negative sign is put before dC/dt, i.e., − dC/dt. On the other hand, the concentrations of the products increase with time and consequently the rate is written as dC/dt. Consider the reaction, for example: N 2 (g) + O 2 (g) → 2NO(g) The rate of this reaction may be expressed in terms of the concentration changes of any of the participants with time. Thus, the rate of disappearance of N 2 is − [N 2] Similarly, the rate of disappearance of O 2 is − [O 2] and the rate of formation of NO is [NO] These rate expressions are related to one another through the stoichiometry of the reaction. Since one mole of N 2 and O 2 react to produce two moles of NO, the N 2 and O 2 disappear at the same rate but NO appears at twice the rate, i.e., the rate of formation of NO is equivalent to two times the rate of consumption of N 2 or O 2 . Mathematically,

13 −2 [N 2] = −2 [O 2] = [NO] Or − [N 2] = − [O 2] = 1 2 [NO] In general, for the reaction: aA + bB → cC + dD − 1 [ ] = − 1 [ ] = 1 [ ] = 1 [ ] 1.9.2.1 Factors Affecting Reaction Rate The rate of a chemical reaction can be strongly influenced by the environment within which it occurs. A reaction's rate will be increased if the collisions of the reactants increase or if there is a stabilization of intermediates or transition states (old bonds are being broken while new ones are being formed). • Reactant concentrations: The higher the concentrations of the reactants (the more particles per volume), the greater the chances of reactant collisions. As a result, except for zero order reactions, the reaction will increase. • Temperature: The rate of almost all reactions increases as the temperature of a system/reaction rises. As temperature is a measure of the average kinetic energy of the particles, increasing the temperature increases how rapidly the molecules move around and provides enough energy to form products. • Medium: The medium in which the reaction occurs can also influence the rate of the reaction. A molecule will find other molecules and collide with adequate energy more slowly if its surroundings are dense and difficult for it to move through. • Catalysts: Catalysts are substances that increase reaction rates without being used up or consumed. They enhance the proper collision of the reactants, stabilize the intermediates and/or transition states, and generally make it simpler to form the products. This increases the overall reaction rate if the bond formation and breakage are the rate− determining step. 1.9.3 REACTION ORDERS The order of reaction is the relationship that exists between the rate of a chemical reaction and the concentration of the species involved. In the rate law expression, the order, or overall order, of the chemical reaction is stated as the sum of powers of the concentration terms. Consider the following reactions: A → Products (1) + → Products + → Products] (2)

14 + 2 → Products 2 + → Products] (3) According to the law of mass action, the rate of reaction (1) is proportional to the concentration of A, i.e., – [ ] = [ ]; where k is the proportionality constant or the specific reaction rate, and is numerically equal to the reaction when the reactant concentration is unity. The expression which gives the dependence of rate upon concentration of reacting substances is known as the rate law. Because the rate depends on the first power of the concentration, the reaction is referred to as a first order reaction. The rate of reaction (2), expressed by k[A][B] or k[A] 2 , is said to be of second order. Similarly, the rate of reaction (3) is given by k[A][B] 2 or k[A] 2 [B], indicating that the reaction is of third order. In general, if several reactants A, B, C, ……….. etc are involved, the rate of the reaction is given by: rate = k[A] a [B] b [C] c ………..., and the order of the reaction is obtained by the sum of the exponents, (a + b + c +………..). The reaction is said to be of a th order with respect to A, b th order with respect to B, and so on. Higher order reactions are theoretically possible, although it is doubtful that any reactions higher than third order exist. However, there are certain reactions where the order is fractional, such as 1 2 , 3 2 , etc. Such fractional orders indicate the complex nature of the reactions. A reaction is considered to be of zero order if its rate is independent of the concentration of the reacting species. The rate of such reactions is controlled by factors other than the concentration of the reacting species. Some heterogeneous or surface reactions are examples of zero order reactions. The order of a reaction is an experimental quantity that can change depending on the experimental conditions under which the reaction is investigated. 1.9.4 EQUILIBRIUM So far, reaction rates have been discussed under the assumption that the reactions are irreversible (only go from reactants to products). A reversible reaction is one in which the products can react or breakdown to produce the reactants. After a duration of interacting, it is considered to be in equilibrium when there is no net or overall change in the concentrations of the products and reactants. This is not to imply that nothing happens while a reaction is in equilibrium. Products are still produced and broken down at the same rate during equilibrium. Thus, chemical equilibrium can be defined as a balance of the forward and backward reactions. Consider this: A ⇌ B, the concentrations of A and B remain unchanged at equilibrium, although the reactions A → B and B → A occur at the same rate. Such a state is also known as dynamic equilibrium. 1.10 LAWS OF THERMODYNAMICS The word thermodynamics was coined in 1749 by William Thomson. Thermodynamics is dealing with the concepts of heat and temperature, as well as the inter– conversion of heat and other kinds of energy (such as mechanical, electrical, or chemical energy). These quantities are 15 governed and quantitatively described by the four thermodynamic laws. The four thermodynamic laws are as follows: • Zeroth law of thermodynamics • First law of thermodynamics • Second law of thermodynamics • Third law of thermodynamics ➢ Zeroth Law of Thermodynamics: The zeroth law of thermodynamics states that if two bodies are individually in equilibrium with a third body, then the first two bodies are also thermally in equilibrium with each other. This implies that if system A is in thermal equilibrium with system C and system B is also in thermal equilibrium with system C, then system A and system B are in thermal equilibrium. ➢ First Law of Thermodynamics: According to the first law of thermodynamics, energy cannot be created or destroyed. Some refer to it as "energy conservation". Finally, the first law of thermodynamics states that energy can be transferred between a system and its surroundings through the transfer of heat or by performing physical, chemical, or mechanical work. Consider a closed system in state A with an internal energy U A undergoing a change to state B. Suppose that during the transformation (physical, chemical, or mechanical), q calories of heat are absorbed from the surroundings. Assume that the system performed work w during the change. Heat absorbed by a system is regarded as positive, whereas heat released by the system is regarded as negative. If U B be the internal energy of the system at state B, then net energy before transformation = U A + q, and net energy after transformation = U B + w. By the law of conservation of energy, U A + q = U B + w or, q = U B − U A + w = ΔU + w or, in the differential form dq = dU + dw The increase in internal energy of the system is taken as positive, and the decrease of the same as negative. That is, the heat taken up by a system is equal to the increase in internal energy of the system plus the work done by the system. This is the algebraic representation of the first law. ➢ Second Law of Thermodynamics: The second law is based on experience and is not derivable from any theory. It applies to macroscopic systems and has been stated in several forms. (i) It is impossible to construct a machine working in cycles which will transfer heat from a lower temperature to a higher temperature without the aid of an external agency. Such a machine is called a perpetual motion machine of the second order. (ii) Heat cannot be completely converted into work without leaving changes either in the system or in the surroundings. (iii) Heat cannot be transferred from one body to another. (iv) In spontaneous

16 processes, the entropy (ΔS) of the universe (system + surroundings) increases, which is related to randomness or disorder. The last statement of the second law of thermodynamics divides the universe into two parts: the system (the part of the universe selected for investigation) and the surroundings (everything in the universe besides the system). In chemistry, the system is often a chemical reaction under investigation. To be clear, the second law does not mean that ΔS reaction must be positive, as ΔS reaction is just the ΔS system which can be either positive or negative. But if ΔS reaction for a spontaneous reaction is negative, then the second law does mean that ΔS surroundings must be positive and of greater magnitude in this example, so that ΔS system + ΔS surroundings < 0. ➢ Third Law of Thermodynamics: According to the third law of thermodynamics, a perfect crystal has zero entropy at zero Kelvin (absolute zero). A perfect crystal has no impurities, has achieved thermodynamic equilibrium, and is in a crystalline state in which all of the atoms/ions/molecules are in well–defined positions in a highly–ordered crystalline lattice. This would exclude amorphous solids like glass that don't have an ordered, crystalline structure and have not achieved thermodynamic equilibrium. 1.11 SOLUBILITY OF GASES IN WATER Water is undoubtedly the most important solvent in our lives. The solubility of gases in water is significant in many fields, including Physiology, Limnology, Environmental Science, sewage treatment, Oceanography, and industrial processes. The interaction of gas molecules and water molecules is what causes a gas to dissolve in water. Polarizability, dipole moment, and potential hydrogen bonds are the parameters of choice for solubility in highly polar hydrogen–bonded water. The amount of gas that can be dissolved in water depends on the temperature of the water. Cold water dissolves more gas than hot water. The solubilities of several gases in water are shown in Table 1 at 293 °K and 1 atm pressure. Table 1: Solubilities of gases in water at 293 °K Gas Solubility* Acetylene 0.117 Ammonia 52.9 Bromine 14.9 Carbon dioxide 0.169 Carbon monoxide 0.0028 Chlorine 0.729 Ethane 0.0062 Ethylene 0.0149 Hydrogen 0.00016 Hydrogen sulfide 0.385 Methane 0.0023

17 Nitrogen 0.0019 Oxygen 0.0043 Sulfur dioxide 11.28 *Grams of gas dissolved in 100 g of water when the total pressure above the solution is 1 atm. 1.12 RADIOISOTOPES Radioisotopes are radioactive isotopes of an element with an unstable nucleus that decays or emits excess energy or radiation until the nucleus becomes stable. They can be either naturally occurring or artificial isotopes of an element. The radioisotopes can be subdivided into three general groups: ➢ Primordial – from the creation of the Earth and their radioactive decay products ➢ Cosmogenic – produced by cosmic–ray interactions ➢ Man-made – produced by anthropogenic practices (mostly in minor amounts compared to natural radioactivity). Radioisotopes are produced as fission products of heavy nuclei such as uranium or plutonium. They can also be created artificially by bombarding non–radioactive stable nuclei with protons, deuterons, neutrons, or α particles during the transmutation reaction. The neutron is the most efficient. Figure 7 illustrates these events. Figure 7: In the process of fission, heavy nuclei like Uranium–235 absorb a neutron and produce lighter radioactive nuclei. A neutron bombards a stable nucleus, resulting in a radioactive nucleus (Source: S. Manahan) Radioisotopes are differentiated from other nuclei by the fact that they emit radiation. There are four types of radiation given off by radioactive atoms: [1] α–radiation, which consists of heavy positively charged particles emitted by atoms of elements such as uranium and radium. A sheet of paper or the thin surface layer of our skin (epidermis) may totally block α–radiation. However, if α–emitting materials enter

18 the body by breathing, eating, or drinking, they can directly expose internal tissues, potentially causing severe biological damage. [2] β–radiation, which consists of electrons, is more penetrating than α–particles and can pass through 1–2 cm of water. A few millimetres thick sheet of aluminium will generally block β–radiation. [3] γ–rays are a kind of electromagnetic radiation that is similar to X–rays, light and radio waves. Depending on their energy, γ–rays can pass through the human body but are blocked by thick walls of concrete or lead. [4] Neutrons are uncharged particles. As a result, they do not directly cause ionization. However, their interaction with the atoms of matter can give rise to α–, β–, γ– or X–rays which then produce ionization. Neutrons are penetrating and can only be blocked by thick masses of concrete, water, or paraffin. To achieve a more stable state, radioactive atoms emit one or more of these types of radiation. Radioactive decay refers to the sequences of such transformations. Another feature of each radioisotope is its half–life. The half–life of a radioisotope is the length of time it takes for half of its radioactive atoms to decay. The half–life of a radioisotope can range from seconds to millions of years. A decent rule of thumb is that you will have less than 1% of the original amount of radiation after seven half–lives. Table 2 shows some examples of radioisotopes, the types of radiation they emit, and their half–lives. Table 2: Half–lives and emitted radiations of some radioisotopes Isotopes Radiations Emitted Half–life Natural Radioisotopes Uranium–238 α, γ 4.5 × 10 9 years Uranium–235 α, γ 7.1 × 10 8 years Thorium–232 α 1.4 × 10 10 years Radium–226 α, γ 1600 years Radon–222 α, γ 3.82 days Potassium–40 β, γ 1.3 × 10 9 years Carbon–14 β 5730 years Artificial / Synthetic Radioisotopes Plutonium–239 α 2.4 × 10 4 years Caesium–137 β, γ 30 years Iodine–131 β, γ 8.02 days Strontium–90 β 28.8 years Radioisotopes with a very short half–life are extremely dangerous, although they decay quickly enough to affect the environment. Radioactive materials with a very long half–life, on the other hand, are quite persistent but may cause relatively little damage. However, radioisotopes having intermediate half–lives are extremely harmful and can pose a threat. The effects of radiation on living organisms depend upon by the following factors:

19 • the nature of radiation, • half–life of radioactive materials, • the energy of radiation, • the amount of radiation exposed, • health and age of an individual and • external and internal exposure. The most important factor is the dosage– the amount of energy that is really deposited in your body. The more energy that cells absorb, the greater the biological damage (Table 3). According to health physicists, the radiation dose is the amount of energy absorbed by the body. The absorbed dosage, or the amount of energy absorbed per gram of body tissue, is often expressed in rads. The rem (roentgen equivalent man) is another unit of radiation. To convert rads to rems, multiply the amount of rads by a number that reflects the risk of damage produced by a type of radiation. This value is usually one for beta and gamma ray radiation. The number is twenty for neutrons, or alpha particles. Table 3: Effect of radiation Dose (rem) Effects 5–20 Possible late effects; possible chromosomal damage. 20–100 Temporary reduction in white blood cells. 100–200 Mild radiation sickness within a few hours: vomiting, diarrhea, fatigue; reduction in resistance to infection. 200–300 Serious radiation sickness effects as in 100–200 rem and hemorrhage; exposure is a Lethal Dose to 10–35% of the population after 30 days (LD 10–35/30). 300–400 Serious radiation sickness; also marrow and intestine destruction; LD 50–70/30. 400–1000 Acute illness, early death; LD 60–95/30. 1000–5000 Acute illness, early death in days; LD 100/10. Radioactive materials may reach humans by a variety of ways after being released into the environment, and when their radiation strikes the human body (Figure 8), they penetrate the tissue, transfer their energy as they pass through, and damage the molecules of the cells. Cellular functions are disrupted, and the cells may even die if certain essential molecules are affected. Exposure to different types of radiation sources has a specific effect on certain body parts. The most severe consequences of radiation come when mutations occur, which is a change in DNA – the cell's information molecules. Radiation effects are therefore passed from generation to generation.

20 Figure 8: Several pathways for radioactive materials to affect humans (Source: Wikipedia) Ionizing radiation can cause the following three types of biological effects in humans, and indeed in all living species, including plants: A. Carcinogenic effects – causes cancer. The probability of getting most forms of cancer is increased by ionizing radiation. B. Mutagenic effects – cause a change in genetic material. The change is then transferred to subsequent generations. C. Teratogenic effects – defects in embryonic development that results in defects in newborns. Furthermore, it has also been established that (i) cells undergoing fast division are very susceptible to radiation, (ii) the foetus is most vulnerable to radiation, and (iii) children are more sensitive than adults. Therefore, special precautions are required for children and pregnant women. 1.13 SUMMARY The environment becomes contaminated when there are unwanted chemical substances present. Environmental chemistry is the discipline of chemical science / chemistry that studies the origin, transport, reactions, effects, and fates of undesirable chemical species in the environment. Environmental chemistry investigates the risk factors of all chemicals in order to find solutions for environmental safety. Since many environmental issues and processes have a chemical origin, understanding them requires a good knowledge of fundamental chemistry. This chapter provides a detailed overview of various topics in fundamental chemistry in order to build basic

21 chemistry ideas. For the students' benefit, the chapter also discussed thermodynamic laws and the harmful effects of radioisotopes on living beings caused by radiation. 1.14 QUESTIONS / SELF ASSESSMENT QUESTIONS 1 . What is an atom? What are atoms made of? 2 . What is meant by element classification? Make a brief note on the periodic table's block classification of elements. 3 . What do you mean by chemical bond? Mention the various types of chemical bonding that are commonly encountered. 4 . Describe the eight most common types of chemical reactions with examples. 5 . Define Gibbs free energy (G). What is meant by "standard–state free energy"? Explain the physical significance of a ΔG° > 0 reaction. 6 . What is chemical potential? Give an expression for it in terms of the i–th component of a mixture. 7 . Explain what "rate of a reaction" means and how it is expressed. Mention the particular instances when zero order and fractional order reactions occur. 8 . States the first law of thermodynamics. What is the mathematical form? 9 . Write short notes on: (i) Second law of thermodynamics (ii) Stoichiometry (iii) Chemical equilibrium (iv) Solubility of gases in water 10 . What different types of radiation are emitted by radioactive substances? Discuss the harmful effects of radiation briefly. 1.15 SELECTED READINGS / SUGGESTED READING [1] Froehlich K (2009) Environmental Radionuclides: Tracers and Timers of Terrestrial Processes. Elsevier, Amsterdam [2] Malik WU, Tuli GD & Madan RD (2009) Selected Topics in Inorganic Chemistry. S Chand, New Delhi [3] Manahan SE (2017) Environmental Chemistry. CRC Press, New York [4] Negi AS & Anand SC (2007) A Textbook of Physical Chemistry. New Age International, New Delhi [5] Palit SR (2009) Elementary Physical Chemistry. Book Syndicate, Kolkata [6] Poddar SN & Ghosh S (2001) General & Inorganic Chemistry. Book Syndicate, Kolkata [7] Rakshit PC (2014) Physical Chemistry. Sarat Book House, Kolkata [8] Ray BC, Das S & Mukherjee J (2008) General and Inorganic Chemistry. New Central Book Agency, Kolkata [9] Sarkar R (2005) General & Inorganic Chemistry (Part I). New Central Book Agency, Kolkata

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23 UNIT 2: BIOLOGICAL CHEMISTRY Structure 2.1 Objectives 2.2 Introduction 2.3 Saturated and unsaturated hydrocarbons and polymer chemistry 2.4 Chemistry of carbohydrate 2.5 Chemistry of proteins 2.6 Fats 2.7 Nucleic acids 2.8 Green chemistry 2.9 Summary 2.10 Questions / Self assessment questions 2.11 Selected readings / Suggested reading 2.1 OBJECTIVES After reading this lesson, you should be able to: ➢ define and distinguish saturated and unsaturated hydrocarbons, ➢ outlines different types of polymers, ➢ describe some of the most essential biomolecules, such as carbohydrates, proteins, nucleic acids, and fats, ➢ classify carbohydrates, proteins, and fats based on their structures and functions, ➢ explain the differences between DNA and RNA, ➢ understand the concepts of "material life cycle" and "green chemistry", ➢ appreciate the importance of green chemistry in everyday life. 2.2 INTRODUCTION You are aware that our bodies, plants, and other animals are made up of a variety of chemical substances. Certain complex organic molecules serve as the foundation of life. The study of what happens chemically within a biological organism falls within the purview of biological chemistry. A large portion of biological chemistry (biochemistry) is concerned with the structures, bonds, functions, and interactions of biological macromolecules or biomolecules like carbohydrates, proteins, nucleic acids, lipids, and so on. You will learn about some important biomolecules in this unit. To help you better comprehend the topic from an environmental perspective, this chapter also covers the environmental impact of the material life cycle, the

24 chemistry of saturated and unsaturated hydrocarbons, polymer chemistry, and the concept of green chemistry and its application. 2.3 SATURATED AND UNSATURATED HYDROCARBONS AND POLYMER CHEMISTRY 2.3.1 SATURATED AND UNSATURATED HYDROCARBONS Hydrocarbons are the simplest organic compounds, composed entirely of carbon and hydrogen atoms. They are considered the parent compounds of many organic molecules. The main chain of hydrocarbons is made up of carbon−carbon bonds, and hydrogen atoms are attached to the carbon atoms to satisfy their remaining valency. Hydrocarbons are classified into two groups based on the presence of single or multiple bonds between carbon atoms: saturated hydrocarbons and unsaturated hydrocarbons. The term "saturated" refers to a compound in which all carbon−carbon bonds are single bonds and every carbon atom is attached to the maximum number of hydrogen atoms possible. In such compounds, each carbon atom is bonded directly to four other atoms (hydrogen or carbon), and therefore, all carbon atoms are fully occupied by making four bonds. This is why these compounds are called saturated hydrocarbons. Saturated hydrocarbons are the simplest and least polar organic molecules. The alkanes and cycloalkanes families of hydrocarbons are examples of saturated hydrocarbons. Examples of saturated hydrocarbons (alkanes and cycloalkanes)

25 An unsaturated hydrocarbon is one that has at least one double or triple bond. There are three types of unsaturated hydrocarbons, namely: (a) alkenes, which contain one or more double bond (<C=C>); (b) alkynes, which contain one or more triple bond (−C≡C−); and (c) aromatic hydrocarbons, which consist of delocalized bonding resulting in a six−membered carbon ring. Both have similar physical properties; however, their chemical properties are much different from saturated hydrocarbons, mainly due to the presence of multiple bonds. 2.3.2 POLYMER CHEMISTRY The word "polymer", or sometimes "macromolecule", is derived from the classical Greek words poly (many) and meres (parts). The polymer molecule has a very high molecular mass and is made up of several structural units that are generally held together by covalent bonding. Polymer is defined as a large class of materials consisting of many smaller repeating units called monomers that are linked together to form long chains, and are used to make many products and goods that we use in our daily lives. Polymers have been present in the natural world from the very beginning (e.g., cellulose, starch, proteins, natural rubber, and so on). Man−made polymeric materials have been explored since the mid−nineteenth century. Polymer−based products are all around us: clothing made from synthetic fibers, polyethylene cups, fiberglass, nylon bearings, plastic bags, polymer−based paints, epoxy glue, polyurethane foam cushions, silicone heart valves, teflon−coated cookware, and so on. The list is almost endless. 2.3.2.1 Polymers vs. Macromolecules Polymers are also referred to as macromolecules due to their large size; however, the converse is not always true. A macromolecule may or may not contain monomeric units; for example, chlorophyll (C 55 H 72 O 5 N 4 Mg) is a macromolecule but not a polymer as no monomeric unit is present; hence, all polymers are macromolecules, but all macromolecules may or may not be polymers in nature. 2.3.2.2 Classification of Polymers Polymers can be classified in many ways based on some special considerations. The classifications are as follows: ❖ Source/Origin−based classification

26 1. Natural polymers: They are found in plants and animals and occur naturally. Examples: proteins, nucleic acids, starch, cellulose, natural rubber, and so on. 2. Semi–synthetic polymers: Polymers obtained by making some chemical modification in natural polymers by artificial means are known as semi–synthetic polymers, e.g., cellulose acetate (rayon), cellulose nitrate, vulcanised rubber, etc. 3. Synthetic polymers: The polymers that are prepared in the laboratory are known as synthetic polymers or man–made polymers. Plastic (polythene), synthetic fibres (nylon 6,6), and synthetic rubbers (buna–S) are examples of man–made polymers that are widely used in everyday life and industry. ❖ Structure–based classification 1. Linear polymers: These are polymers in which monomer units are linked with one another to form long linear or straight chains. These linear chains are closely packed in space. Because of the close packing, the densities, tensile strengths, and melting and boiling points are all quite high. High density polyethene (HDPE), nylon, and polyesters are examples of linear polymers. 2. Branched polymers: Polymers consisting of linear chains with branches are called "branched polymers". These polymers are not closely packed in space due to branching. As a result, they have low densities, low tensile strengths, as well as low melting and boiling points. Some common examples of such polymers are low density polyethene (LDPE), starch, glycogen, etc. 3. Crosslinked or network polymers: Polymers in which various individual chains are connected together by covalent bonds (cross–links) are called crosslinked polymers. These polymers are made up of bi– and tri–functional monomers, and the additional functionality results in cross–links and the formation of a three–dimensional network. These are supposed to be quite hard, rigid, and brittle. Examples of crosslinked polymers are bakelite, glyptal, melamine–formaldehyde polymers, etc. ❖ Monomer–based classification 1. Homopolymers: The polymers that are obtained by the polymerization of a single type of monomer are called homopolymers. e.g., polyethene, PVC, nylon 6, etc. This can be represented as: or – (–R–) n –

27 2. Copolymers: Polymers that are made up of more than one (usually two) types of monomers are called copolymers. e.g., nylon 6,6, terylene, SBR, etc. R and B denote two different monomers Copolymers are further categorized into four types based on the relative arrangement of the monomer units with respect to each other. These are: alternating copolymers, random copolymers, block copolymers, and graft copolymers, as shown above. The most common type of copolymers is alternating copolymers. ❖ Intermolecular forces–based classification Intermolecular interactions like Van der Waals forces and hydrogen bonding govern the mechanical properties of polymers (tensile strength, toughness, and elasticity). Based on these forces, they are classified as follows: 1. Elastomers: These are rubber–like solid polymers in which the weakest attractive forces hold the polymer chains together. They are made up of randomly coiling molecular chains with few cross links. Whenever the stain is applied, the polymers stretch, and when the force is released, the polymers return to their original position. These polymers are elastic and called elastomers, e.g., natural rubber, neoprene, buna–S, buna–N, etc. 2. Fibres: Fibres are thread–like polymers that may be woven into fabrics. These are widely used in the production of clothing, nets, ropes, gauzes, and other materials. Fibres possess high tensile strength because the chains possess strong intermolecular forces due to hydrogen bonding. The fibres are crystalline in form and have sharp melting points. Nylon 6,6, terylene, and polyacrylonitrile are a few examples of this class. 3. Thermoplastic: These are polymers having intermolecular forces that are intermediate between the forces found in elastomers and fibres. They may be linear or branched–chain polymers. These polymers on heating become soft and on cooling again become hard and retain their original shape. When heated, the intermolecular forces weaken and the polymer becomes soft, and vice versa. It is purely a physical change, and physical changes are generally reversible. Therefore, these polymers are recyclable, i.e., they can be moulded and remoulded again and again. e.g., polythene, polystyrene, PVC, etc.

28 4. Thermosetting: Polymers in which there is extensive cross–linking are called thermosetting polymers. Normally, they are semifluid substances with low molecular masses. These polymers soften when heated and harden when cooled, but they do not retain their original shape. The cross–links are broken and rearranged when heated. It is entirely a chemical change, and chemical changes are usually irreversible. As a result, these polymers are not recyclable; that is, once moulded, they cannot be remoulded. Bakelite, melamine–formaldehyde resin, and urea–formaldehyde resin are a few common examples of thermosetting polymers. ❖ Decomposition–based classification 1. Biodegradable polymers: These are those polymers whose chemical and physical characteristics undergo degradation and totally decompose under aerobic or anaerobic conditions, as a consequence of the action of microorganism/enzymes. These polymers, which are found both naturally occurring and synthetically made, mostly consist of ester, amide, and ether functional groups (Figure 1). Non–enzymatic processes like chemical hydrolysis can also break down the chain of biodegradable polymers. Figure 1: Structure and occurrence of biodegradable polymers (Source: Wikipedia) 2. Non–biodegradable polymer: They consist of long chains of carbon and hydrogen atoms. These molecules form an adamant interatomic bond, making it difficult for microorganisms to break the bonds and digest them. As a result, it takes a long time to decompose them. Common examples of non–biodegradable polymers are HDPE, LDPE, Teflon, etc. ❖ Polymerization–based Classification

29 1. Addition Polymers: Polymers formed by addition reactions are known as addition polymers. In this type of polymerization, molecules of the same or different monomers are added together on a large scale without the removal of byproducts to form a polymer. Because this mode of polymerization causes an increase in chain length and chain growth, they are also called "chain growth polymers". Addition polymers have the same empirical formula as their monomers since they contain all of the atoms of monomers. Unsaturated compounds such as alkenes, alkadienes, and their derivatives are commonly used as monomers. Addition polymerization is a chain reaction that, once initiated, propagates until the chain is terminated. It consists of three steps: chain initiation, chain propagation, and chain termination. Addition polymerization can occur through three different types of mechanisms: (i) cationic mechanism; (ii) anionic mechanism; and (iii) free radical mechanism. Table 1: Polymer for commercial importance

30 2. Condensation Polymers: This type of polymerization usually involves a repetitive condensation reaction between two bi−functional or tri−functional monomeric units. In these reactions, the product of each step is again a bi−functional species, and the condensation sequence continues. Since each condensation process is a separate step, this kind of polymerization is also known as "step−growth polymerization". These polycondensation reactions may result in the loss of some simple molecules as water, alcohol, ammonia, hydrogen chloride, etc. and lead to the formation of ester or amide linkages between the monomers. The Table 1 above shows some common examples of addition and condensation polymers having commercial importance. 2.4 CHEMISTRY OF CARBOHYDRATES Carbohydrates are a large

group of naturally occurring organic compounds containing carbon, hydrogen, and oxygen atoms that

are primarily produced by plants. Most of them have the general formula C x (H 2 O) y and appear to be "hydrates of carbon", hence the name "carbohydrate". Simple carbohydrates are also known as sugars or saccharides (Latin: saccharum, Greek: sakcharon, sugar), and the ending of the names of most sugars is −ose. Carbohydrates are mainly consisting of two functional groups: the carbonyl group (aldehyde or ketone) and a number of hydroxyl groups. They can therefore be defined as optically active polyhydroxy aldehydes or ketones, or compounds that produce such units on hydrolysis. 2.4.1 CLASSIFICATION Simple carbohydrates can combine to form polymers, or chains, to create different types of carbohydrates. There are three major classes of carbohydrates based on the number of monomeric units, with two broad categories: sugars and non−sugars. 1. Monosaccharide: Made up of single monomeric units 2. Oligosaccharides: Made up of 2−10 monomeric units 3. Polysaccharides: Made up of more than 10 monomeric units ➢ Monosaccharides are the simplest carbohydrates, which are made of single monomeric units of polyhydroxy aldehyde or ketone. There are around 20 monosaccharides found in nature. The number of carbon atoms and the functional group present in monosaccharides are used to further classify them. When a monosaccharide has an aldehyde group, it is called an aldose, and if it contains a keto group, it is referred to as a ketose. A five−carbon monosaccharide with an aldehyde group, for example, is called aldopentose; similarly, a six−carbon monosaccharide with a keto group is called ketohexose. A few examples of monosaccharides are given below: Carbon General Aldehyde Ketone

31 atoms term 4−carbon Tetroses Aldotetrose (Ex: Erythrose, Threose) Ketotetrose (Ex: Erythrulose) 5−carbon Pentoses Aldopentose (Ex: Ribose, Arabinose, Xylose, Lyxose) Ketopentose (Ex: Ribulose, Xylulose) 6−carbon Hexose Aldohexose (Ex: Glucose, Mannose, Galactose) Ketohexose (Ex: Fructose, Sorbose) ➢ Oligisaccharides contain 2−10 monomeric units or monosaccharides linked together by glycosidic linkages. The number of monosaccharides in oligosaccharides can be used to classify them as disaccharides, trisaccharides, tetrasaccharides, and so on. The most common of them are disaccharides. Some of them are described below. The names of the monosaccharides that make up the oligosaccharides are given in brackets. • Disaccharides are made up of two monomeric units bonded by glycoside bonds. Examples include: Maltose (2 glucose units joined by glycosidic linkage) Sucrose (glucose−fructose) Lactose (glucose−galactose) • Trisaccharides are oligosaccharides composed of three monosaccharides. Examples are: Maltotriose (3 glucose units joined by glycosidic linkage) Melezitose (glucose−fructose−glucose) Maltotriulose (glucose−glucose−fructose) Raffinose (galactose−glucose−fructose) Kestose (glucose−fructose−fructose) • Tetrasaccharides are oligosaccharides contain four monosaccharides. Examples include: Maltotetraose (4 glucose units joined by glycosidic linkage) Lychnose (galactose−glucose−fructose−galactose) Nystose (glucose−fructose−fructose−fructose) Sesamose (galactose−galactose−fructose−glucose) Stachyose (galactose−galactose−glucose−fructose) Similarly, pentasaccharides are made up of five monomeric units. Hexasaccharides contain six; heptasaccharides have seven; and so on. ➢ Polysaccharides are made of more than 10 monomeric units linked by glycosidic bonds. Based on the type of monomeric unit, they are classified into two groups: • Homopolysaccharides are polysaccharides that contain only one kind of monosaccharide molecule. Glycogen, cellulose, starch, and inulin are examples of important homopolysaccharides.

32 • Heteropolysaccharides are polysaccharides that contain different types of monosaccharides. Some of the important heteropolysaccharides are hyaluronic acid, heparin, chondroitin−4−sulfate, and gamma globulin. ❖ Furthermore, carbohydrates may be broadly classified into two types: sugars and non−sugars. (a) Sugars: These are crystalline substances that are sweet and water soluble. For example, glucose, fructose, cane sugar, etc. In general, this category includes all monosaccharides and oligosaccharides. (b) Non−sugars: Polysaccharides, usually known as non−sugars, are amorphous solids that are insoluble in water and have no taste. Example: starch, cellulose, and so on. ❖ The carbohydrates may also be classified as either reducing or non−reducing sugars. ➢ Reducing sugars • A reducing sugar is a sugar or carbohydrate molecule containing a free aldehyde group or a free ketone group that causes the molecule to act as a reducing agent. • All monosaccharides, along with some disaccharides, some oligosaccharides, and some polysaccharides, are reducing sugars. • In the case of other polysaccharides and disaccharides, the aldehyde and ketone groups stay bound in a cyclic form. • The majority of reducing sugars have a sweet taste. These sugars can be detected by tests like Benedict's and Fehling's, as they give a positive result. • Examples of reducing sugars include monosaccharides like galactose, glucose, glyceraldehyde, fructose, ribose, and xylose; disaccharides like cellobiose, lactose, and maltose; and polysaccharides like glycogen. ➢ Non−reducing sugars • A non−reducing sugar is a sugar or carbohydrate molecule that does not have a free aldehyde or ketone group and so cannot act as a reducing agent. • Non−reducing sugars have aldehyde and ketone groups, but they are included in the cyclic form of the sugar molecule. • Some disaccharides and oligosaccharides, and most of the polysaccharides, are non− reducing sugars. • Non−reducing sugars have a less sweet taste than reducing sugars. These sugars can also be detected by tests such as Benedict's and Fehling's tests, since they give a negative result. • Non−reducing sugars include disaccharides like sucrose, maltose, and lactose, as well as polysaccharides such as starch and cellulose.

33 2.4.2 STRUCTURE OF CARBOHYDRATES − GLUCOSE One of the most important monosaccharides is glucose. The two most common methods for preparing glucose are as follows: ❖ From Sucrose: Sucrose is converted into glucose and fructose by boiling it in an alcoholic solution with dilute acid. ❖ From Starch: Glucose is produced from starch by hydrolyzing it with dilute H 2 SO 4 under high pressure at 393 °K. Glucose is a naturally occurring sugar that is abundant on Earth. It is an aldohexose, which means it is a six−carbon sugar with a terminal aldehyde group, as shown in Figure 2. Glucose has four asymmetric carbons (a carbon linked to four different atoms or groups), as indicated by the asterisk in Figure 2, and thus can exist in 2 4 (or sixteen) configurationally isomers. Figure 2: Linear structure of glucose (2,3,4,5,6−Pentahydroxyhexanal) Glucose is named D (+)−glucose, where D represents the configuration and (+) represents the dextrorotatory nature of the molecule. The letter "D" or "L" before the name of any compound indicates the relative configuration of a particular stereoisomer. In solutions, the open−chain form of glucose (either "D−" or "L−") exists in equilibrium with cyclic isomers, which contain a ring of carbons closed by one oxygen atom. The ring is produced from the open−chain form via an addition reaction between the aldehyde group (at C−1) and the C−5 hydroxyl group, resulting in a hemiacetal linkage. Because hemiacetal formation generates a new asymmetric centre at C− 1, this leads to the formation of two isomers. These two cyclic structures differ in the configuration of the hydroxyl group at C−1, called anomeric carbon. Such isomers, namely the α and β forms, are known as anomers. In α anomer, the −OH group on C−1 can be below the plane of the ring, whereas in the β anomer, it is above the plane. The six−membered cyclic structure is called the "pyranose" structure due to its analogy with pyran. 2.3.3 STRUCTURE OF CARBOHYDRATES − FRUCTOSE ≡ ≡ 34 Fructose is an important ketohexose. It is obtained along with glucose by the hydrolysis of the disaccharide sucrose. It is a natural monosaccharide found in fruits, honey, and vegetables. Fructose has the molecular formula C 6 H 12 O 6 , a ketonic functional group at carbon number 2, and six carbon atoms in a straight chain. The cyclic structure of fructose is more complicated than that of glucose because it contains both five− and six−membered rings (furanose form and pyranose form), depending on whether the −OH group of the five−carbon or the six−carbon reacts in the ring−forming addition to carbonyl (Figure 3). The distributions of fructose in water have been identified multiple times, and the equilibrated solution contains about 76% fructopyranose, 22% fructofuranose, and a negligible amount of the open−chain form. Figure 3: Linear and cyclic structure of fructose (Source: Elsevier) 2.4.3 GLYCOSIDIC BONDS • Monosaccharides can be joined to form disaccharides, oligosaccharides, and polysaccharides. • The bonds that link monosaccharides are called glycosidic bonds. Through the creation of an oxide linkage caused by the removal of a water molecule, the monosaccharide units were joined in this way. α, β (1→2) Glycosidic bond

35 • Glycosidic bonds are named according to the numbers of the connected carbons and also with regard to the position of the anomeric hydroxyl group of the monosaccharides involved in bonding. • If this anomeric hydroxyl is in α configuration, the linkage is an α−bond. If it is in the β configuration, the linkage is a β−bond. • Lactose, for example, forms a glycosidic bond between C−1 of β−galactose and C−4 of glucose. The linkage is, therefore, a β (1→4) glycosidic bond. 2.4.4 ENANTIOMERS A special type of isomerism is found in pairs of structures that are mirror images of each other. These mirror images are called enantiomers, and the two members of the pair are designated as a D− and an L− sugar. The position of the −OH group on the highest−numbered asymmetric centre (the penultimate carbon) farthest from the carbonyl group defines the D and L designations of sugars. In the D isomeric form, the −OH group on the penultimate carbon is on the right side, while in the L isomer it is on the left (Figure 4). The vast majority of sugars in humans are D− sugars. Enzymes known as racemases are able to interconvert D− and L−isomers. Figure 4: Mirror images of each other, D− and L−sugar

36 2.5 CHEMISTRY OF PROTEINS Proteins are among the most abundant and complex biomolecules (biological macromolecules) in living systems. Twenty percent of the human body is made up of proteins. Thousands of proteins can be found in a single cell. Proteins are required for the structure, function, and regulation of the body's cells, tissues, and organs; and each protein has unique functions. All proteins, whether from the most primitive bacteria or the most complex forms of life, are made up of the same set of 20 amino acids. These 20 different natural amino acids are the building blocks of all proteins. The proteins are polymers of α−amino acids conjugated by peptide bonds. In general, proteins contain only L−α−amino acids; however, microorganisms elaborate peptides that contain both D− and L− α−amino acids. 2.5.1 CLASSIFICATION OF PROTEINS Proteins are classified into two major categories based on their chemical composition, structure, and solubility, as discussed below. ➢ Simple proteins: Proteins which on hydrolysis yield only amino acids are called simple proteins. The simple proteins are further classified into two broad classes based on their solubility: fibrous and globular proteins. (a) Fibrous proteins: Fibrous proteins are insoluble in water. These proteins consist of thin linear molecules, which lie side by side to form fibres (Figure 5). The peptide chain is held together by intramolecular hydrogen bonding. Fibrous proteins are the main structural materials of tissues. Keratin in skin and hair, collagen in tendon, fibroin in silk, and myosin in muscles are all examples of important fibrous proteins. (b) Globular proteins: These are soluble in water or aqueous solutions of acids and bases. Polypeptides in these proteins are folded into compact spheroidal shapes. In such proteins, intramolecular hydrogen bonding holds the peptide chain in shape (Figure 5). These proteins play a role in the regulation and maintenance of life processes. Examples of this class of proteins are enzymes, hormones, hemoglobin, and albumin. Fibrous Proteins Globular Proteins Figure 5: Structure of fibrous and globular proteins ➢ Conjugated proteins: Proteins that are a combination of two parts, a proteinous part and a non−proteinous part, are called conjugate proteins. Conjugated proteins are complex proteins which on hydrolysis yield not just amino acids but also other organic or inorganic components. The non−amino acid portion (non−proteinous part) of a

37 conjugated protein is called the prosthetic group. The prosthetic group plays its part in the biological function of the protein. Unlike simple proteins, conjugated proteins are classified in the following ways based on the chemical nature of their prosthetic groups: • Nucleoproteins (protein + nucleic acid) • Mucoproteins and glycoproteins (protein + carbohydrate) • Chromoproteins (proteins + a coloured pigment) • Lipoproteins (proteins + lipid) • Metalloproteins (metal−binding proteins combined with Fe, Cu, or Zn) • Phosphoproteins (proteins attached with a phosphoric acid group). 2.5.2 STRUCTURE OF PROTEINS Protein molecules are polymers of different sizes and shapes with different physical and chemical properties. The monomer units for proteins are amino acids, which contain amino (− NH 2) and carboxyl (−COOH) functional groups. All the amino acids that found in proteins are α− amino acids. An α−amino acid consists of a central carbon atom, called the α carbon, that is bound to a −NH 2 and to a −COOH group. The general formula of α−amino acids is shown below. Although there are over 300 amino acids present in nature, only 20 of them are usually found in most proteins. Out of 20 amino acids, our body can easily synthesise a few on its own, which are called non−essential amino acids. These include alanine, asparagine, arginine, aspartic acid, glutamic acid, cysteine, glutamine, proline, glycine, serine, and tyrosine. Aside from these, there are nine amino acids that cannot be synthesised in the body and must be obtained through diet, which are referred to as essential amino acids. These include isoleucine, histidine, lysine, leucine, phenylalanine, tryptophan, methionine, threonine, and valine. All proteins have one common structural feature that their amino acids are connected to one another by a peptide bond, or peptide linkage. Chemically, peptide linkage is an amide (−CO− NH−) formed between the −COOH and −NH 2 groups. The reaction between two molecules of similar or different amino acids, proceeds through the combination of the amino group of one molecule with the carboxyl group of the other. This results in the elimination of a water molecule and the formation of a peptide bond. Because it is formed by combining two amino acids, the reaction product is known as a dipeptide. For example, when the carboxyl group of glycine combines with the amino group of alanine, we get the dipeptide glycylalanine.

38 If a third amino acid is joined to a dipeptide in the same way, the product is a tripeptide. A tripeptide is made up of three amino acids linked by two peptide linkages. Similar combinations of four, five, and six amino acids provide tetrapeptides, pentapeptides, and hexapeptides, respectively. When the number of such amino acids is more than ten, the products are called polypeptides. A polypeptide with more than 100 amino acid residues and a molecular mass higher than 10,000 daltons is called a protein. However, there is no clear line of demarcation between polypeptides and proteins. Insulin, for example, is considered a small protein despite having just 51 amino acids. The amino acid unit with the free amino group is known as the N–terminal residue, while the one with the free carboxyl group is known as the C–terminal residue. Conventionally, the structure of a peptide or protein is written with the N–terminal residue on the left and the C–terminal on the right. The actual structure and shape of proteins can be defined at four levels: primary, secondary, tertiary, and quaternary, with each level being more complex than the previous one. ➢ Primary structure: The simplest level of protein structure, primary structure, refers to the number, nature, and sequence of the amino acids in polypeptide chains. It is simply the linear sequence of amino acids linked with each other via peptide linkage. Any change in this primary structure, i.e., the sequence of amino acids, creates a different protein. ➢ Secondary structure: Secondary structure describes the shape and conformation of the peptide chains in protein molecules. This structure arises due to the regular folding of the backbone of the polypeptide chain caused by hydrogen bonding between the carbonyl (<C=O) O and the amino (–NH–) H of the peptide bond. Two types of secondary structures (Figure 6) are most common. These are α–helix when the chain coils up and β–pleated sheet when hydrogen bonds are formed between the
chains. ➢ Tertiary structure: Protein tertiary structure is the three–dimensional arrangement of its polypeptide chain in space. It is
formed by the folding and superimposition of various α– helical chains or β–pleated sheets. It gives rise to two major molecular shapes: fibrous and globular. It is by virtue of their tertiary structure that proteins adopt a globular shape. A globular form has the lowest surface–to–volume ratio, minimizing interaction of the protein with its surroundings. The tertiary structure of a protein consists of the way a polypeptide is formed into a complex molecular shape. This structure of proteins is stabilized by a variety of chemical interactions, like ionic and hydrogen bonds, disulphide linkages, and hydrophobic and hydrophilic interactions.

39 ➢ Quaternary structure: Protein quaternary structure is the fourth (and highest) classification level of protein structure. The quaternary structure of a
protein is the association of several protein chains or subunits into a closely packed arrangement. Each subunit has its own primary, secondary, and tertiary structure,
as well as an independent three–dimensional conformation. The quaternary structure is stabilized by the same non–covalent forces as in tertiary structure. Figure 6: Four levels of protein structure 2.5.3 DENATURATION OF PROTEINS Protein denaturation is a process in which proteins lose their shape and, hence, their function. External stress on the protein, such as changes in pH, temperature, or the presence of certain salts/chemical agents, usually causes denaturation.

Denaturation involves the breaking of many of the weak linkages or bonds (e.g., hydrogen bonds) within a protein molecule that are responsible for the highly ordered structure of the protein in its natural (native) state.

As a consequence, the chains separate from each other, globules unfold, helices uncoil, and the protein ultimately loses biological activity. During denaturation, secondary and tertiary structures are destroyed, but the primary structure remains intact. Denaturation is seen in our daily lives in many forms. The curdling of milk is caused by bacteria in the milk that produce lactic acid. The change in pH caused by the lactic acid causes denaturation, coagulation, and precipitation of the milk proteins. Similarly, the coagulation of the albumin proteins in the egg white on boiling is a common example of denaturation. However, 40 some proteins are extremely resistant to denaturation, such as those found in skin, fingernails, and the stomach lining. 2.6 FATS Fats and oils are a type of lipid made up of glycerides (usually triglycerides) that are abundant in plants and animals. Plants store fats and oils in seeds, whereas animals store them under the skin and in muscles. Fats are solid at room temperature, while oils are liquid because they consist of triglycerides formed by unsaturated or short fatty acids. In general, fats have a high percentage of saturated acids in glycerides, whereas oils have a high percentage of unsaturated acids in glycerides. Triglycerides derived from animals are typically solids, but those obtained from plants are usually oils. As a result, we commonly refer to animal fats and vegetable oils. To be more specific, fats are solid or semisolid triesters of glycerol and fatty acids or triglycerides at room temperature. The three −OH groups on the glycerol backbone form ester linkages (−O− bond) with the −COOH groups of fatty acids to make a fat molecule. Their general structure can be written as follows: where R 1 , R 2 , and R 3 are parts of the fatty acids that form ester with glycerol. The three acids could be the same, two of the same, or completely different. Accordingly, they are called simple or mixed glycerides. Natural fats are composed of a mixture of mixed and simple glycerides. Because fats are organic substances, they are usually soluble in organic solvents but largely insoluble in water. Fats, along with carbohydrates and proteins, are one of the three main macronutrient groups in the human diet and the main components of common food items like milk, butter, tallow, lard, salt pork, and cooking oils. 2.6.1 TYPES OF FATS Fats are distinguished based on the fatty acids from which they are made. As fatty acids may be either saturated or unsaturated, fats are organized into two subgroups: saturated fats and unsaturated fats. Unsaturated fats are further classified as monounsaturated fats, polyunsaturated fats, and trans−fats. ➢ Saturated fats: Saturated fats have no double bonds between the carbons in the fatty acid chains. All of the carbons in the backbone are sp 3 hybridized, with two hydrogen atoms

41 covalently bonded to each carbon. C n H 2n+1 COOH is the common formula for saturated fatty acids. Palmitic and stearic acids (C16 and C18) are the most abundant saturated fatty acids found in animal fats. Because the majority of saturated fats are animal fats, these fats are often known as "animal fats". They are commonly present in high−fat meats and dairy products. Saturated fats can be obtained from the following sources: ▪ fatty cuts of beef, pork, and lamb ▪ dark chicken meat and poultry skin ▪ high fat dairy foods (whole milk, butter, cheese, sour cream, ice cream) ▪ tropical oils (coconut oil, palm oil, cocoa butter) ▪ lard This type of fats has a higher viscosity and energy content than its unsaturated cousins, and its low solubility is most commonly associated with heart disease. ➢ Unsaturated fats: Unsaturated fats have a glycerol backbone with three fatty acid chains that contain at least one sp 2 hybridized carbon. This results in the formation of a double bond anywhere along the chain. Monounsaturated fats have one double bond in their chain, while polyunsaturated fats have two or more. Sources of unsaturated fats: • Monounsaturated fats: These are found in olive, canola, peanut, sunflower, and safflower oils, as well as avocados, peanut butter, and most nuts. It's also part of most animal fats, such as those from chicken, pork, and beef. • Polyunsaturated fats: These are found in sunflower, corn, soybean, and cottonseed oils. It's also found in walnuts, pine nuts, flaxseed, and sesame, sunflower, and pumpkin seeds. Animal fats fall into this category and are found in fatty fish, such as salmon, herring, and sardines. Most unsaturated fatty acids contain a double bond (designated Δ 9) between carbon atoms 9 and 10. This is particularly true for unsaturated fatty acids, which are abundant in plants. If there are additional bonds, they usually occur between Δ 9 and the methyl−terminal end of the chain. However, it may be generalized that polyunsaturated fatty acids in animals can contain up to 22 carbon atoms and 6 double bonds, but in plants these acids do not exceed 18 carbon atoms and 4 double bonds. Unsaturated fats are also classed as "cis" (bent form) or "trans" (straight form), depending on whether the two hydrogens associated with the bond are on the same or opposite side of the molecule. Naturally occurring unsaturated fats, since they are produced by enzymes, have specific stereochemistry. Natural fats are always in the cis conformation, which has a greater solubility in water and is readily broken down by the metabolic machinery. Artificially produced fats, since they are produced using organic synthesis techniques, contain a racemic mixture of trans and cis forms. Trans fats, like saturated fats, are less soluble. However, they are not easily metabolised by cellular machinery.

42 2.6.2 HEALTHY FATS Monounsaturated and polyunsaturated fats are considered healthy fats because they are good for the heart and can lower the risk of heart disease and stroke. Healthy fats can reduce LDL (low density lipoprotein) cholesterol levels (bad cholesterol) while raising HDL (high density lipoprotein) cholesterol levels. Saturated and trans fats are unhealthy. Saturated fats can increase LDL (bad cholesterol), which may be the cause of coronary heart disease. Trans fats also tend to increase bad cholesterol (LDL) and lower good HDL–cholesterol, although not as much as saturated fats. 2.7 NUCLEIC ACIDS Why is a cat a cat and not a fox? Why do some individuals have blue or brown eyes but not black eyes? From a chemical standpoint, how does the body know what particular type of protein is to be synthesised? How are these information transmitted from one generation to the next? The nucleus of a living cell has been found to be responsible for the transmission of inherent characteristics, also called heredity. Chromosomes are particles in the nucleus of the cell that are responsible for heredity. They are made up of proteins and another type of biomolecule known as nucleic acids. There are two types of nucleic acids: (i) deoxyribonucleic acid, or DNA; and (ii) ribonucleic acid, or RNA. They differ in chemical composition as well as function. 2.7.1 STRUCTURE OF NUCLEIC ACIDS Nucleic acids are linear polymeric molecules made up of nucleotide monomers. When these monomers combine, the resultant chain is called a polynucleotide. Each nucleotide consists of three subunits: (i) A nitrogen–containing heterocyclic aromatic compound called a heterocyclic base, either a purine or pyrimidine. (ii) A five–carbon sugar, either D–2–deoxyribose or D–ribose. (iii) A phosphate group. A simplified version of the nucleic acid chain is shown below. 2.7.2 DNA AND RNA In a nucleotide, the sugar molecule occupies the central position and is present as a furanoside, a five–membered ring. The heterocyclic base of a nucleotide is always attached to C1' of the ribose or deoxyribose unit. The phosphate group of a nucleotide may be attached at C5' or C3'. The sugar carbons are numbered as 1', 2', 3', etc. in order to distinguish them from the bases. The

43 Purines sugar moiety in DNA molecules is β–D–2–deoxyribose, whereas it is β–D–ribose in RNA molecules. Adenine (A), guanine (G), cytosine (C), and thymine (T) are the four heterocyclic bases found in DNA. RNA also contains four bases; the first three bases are the same as in DNA, but the fourth one is uracil (U). Adenine (A) and guanine (G) are purines, and cytosine (C), thymine (T), and uracil (U) are pyrimidines. These are the most important parts of the nucleic acid, and genetic information is stored in the sequence of these molecules. The nucleotide sequence or order defines the primary structure of DNA and RNA. DNA's secondary structure is made up of two polynucleotide chains wrapped around each other to form a double helix, in which the heads of the two chains are in opposite directions. Both helices are right–handed, with 10 nucleotide residues per turn. Hydrogen bonds between the base part of one chain and an appropriate base part of the other chain hold the two chains of the double helix together. Hydrogen bonding can occur exclusively in a 1:1 stoichiometric ratio between two specific bases, one of which is always a purine base and the other a pyrimidine base. It has been found that the guanine (G) part of one chain is always linked to the cytosine (C) part of the other Heterocyclic Bases Pyrimidines

44 chain by three hydrogen bonds. Similarly, two hydrogen bonds link adenine (A) and thymine (T). These basic pairs are denoted as G≡C and A=T. Thus, the base sequence in one chain must be specific and complementary in the other chain. This is known as complementary base pairing. The main image represents the polynucleotide chain of DNA. The inset shows the corresponding pentose sugar and pyrimidine base for RNA. (Source: Encyclopaedia Britannica) Figure 7: The basic structure of DNA and RNA. DNA is double–stranded, whereas RNA is single–stranded. The nucleotide thymine in DNA is replaced with uracil in RNA. (Source: National Human Genome Research Institute) In general, RNA is 33% lighter in weight than DNA. The polynucleotide chain of RNA may be represented in the same manner as that of DNA, with the exception that the deoxyribose sugar unit is replaced by a ribose unit. In the secondary structure of RNA, a single–stranded molecule

45 can fold back on itself to form a double helix structure by base pairing in a region where base sequences are complementary. Messenger RNA (m–RNA), ribosomal RNA (r–RNA), and transfer RNA (t–RNA) are the three types of RNA, each of which serves a particular purpose. 2.8 GREEN CHEMISTRY 2.8.1 GREEN CHEMISTRY – CONCEPT The word "green" is frequently associated with nature (for instance, green is the colour of plants). Paul T. Anastas introduced the term "green chemistry" for the first time in 1991, under a special programme sponsored by the US Environmental Protection Agency (EPA) to stimulate substantial growth in chemistry and chemical technology. The initiative also attempted to change chemists' perspectives on environmental protection by focusing on reduced hazards or their total elimination in the context of human health. The concept of "green chemistry" was discussed on that scientific programme. Anastas and Warner, the founders of green chemistry, define it as "the design of chemical products and processes that reduce or eliminate the use and/or generation of hazardous substances". To say it simply, "doing chemistry with personal safety and the environment in mind" is green chemistry. Figure 8 depicts all of the variables that green chemistry seeks to reduce. Figure 8: Approaches of green chemistry Green chemistry is also known synonymously as: ❖ Clean Chemistry ❖ Atom Economy ❖ Benign by Design Chemistry

46 ❖ Eco–Friendly Chemistry ❖ Environmentally Benign Chemistry ❖ Sustainable Chemistry and also ❖ E–Chemistry Environmental chemistry should not be confused with green chemistry. Environmental chemistry is concerned with the type of pollution, the extent of pollution, and the methods for combating it, whereas green chemistry is concerned with all of these factors in advance. It is analogous to the diagnosis of any disease, and its treatment is environmental chemistry, while prevention from that disease is green chemistry. There is a well–known proverb that "prevention is better than cure". Prevention is a green chemical pathway, whereas cure is an environmental pathway. Anastas and Warner proposed a set of 12 principles of green chemistry in their seminal book in 1998. Although since then several "new principles" have subsequently been added to the list, the original list is still applicable. The first principle provides the main idea to protect the environment, while the remaining 11 principles focus on making the environment eco–friendly. Here are the following principles: 1. Prevention: It is better to prevent waste than to treat or clean up waste after it is formed. 2. Atom economy: Synthetic methods should be designed to maximize the incorporation of all materials used in the process into the final product. 3. Less hazardous chemical syntheses: Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment. 4. Designing safer chemicals: Chemical products should be designed to affect their desired function while minimizing their toxicity. 5. Safer solvents and auxiliaries: The use of auxiliary substances (e.g., solvents, separating agents, etc.) should be made unnecessary, wherever possible and innocuous, when used. 6. Design for energy efficiency: Energy requirements of chemical processes should be recognized for their environmental and economic impacts and should be minimized. If possible, synthetic methods should be conducted at ambient temperature and pressure. 7. Use of renewable feedstocks: A raw material or feedstock should be renewable rather than depleting, whenever technically and economically practicable or feasible. 8. Unnecessary derivatization: Blocking group, protection or de–protection, and temporary modification of physical or chemical processes should be avoided whenever possible. 9. Catalysis: Catalytic reagents (as selective as possible) are superior to stoichiometric reagents. 10. Design for degradation: Chemical products should be designed so that at the end of their function, they break down into innocuous or harmless degradation products and do not persist in the environment.

47 11. Real–time analysis for pollution prevention: Analytical methodologies need to be further developed to allow for real–time, in–process monitoring and control prior to the formation of hazardous substances. 12. Inherently safer chemistry for accident prevention: Substances and the form of a substance used in chemical process should be chosen to minimize the potential for chemical accidents, including releases, explosions, and fires. Several other sets of principles have been developed by various groups that similarly summarise the basic concepts; for example, Poliakoff's mnemonic PRODUCTIVELY: P – Prevent wastes R – Renewable materials 0 – Omit derivatization steps D – Degradable chemical products C – Catalytic reagents T – Temperature and pressure ambient I – In-process monitoring V – Very few auxiliary substances E – E-factor, maximize feed in product L – Low toxicity of chemical products Y –Yes, it's safe The aforementioned principles were not developed overnight. Several research groups have contributed to the development of the major concepts that guided the growth of green chemistry. 2.8.2 GREEN CATALYSTS One of the principles of green chemistry is the use of catalysts. In chemistry, a catalyst is a substance that increases the rate of a chemical reaction without being consumed in the process. Catalysts help to save energy, minimize reaction time, increase yield, reduce the usage of solvents, and lower the formation of by–products and waste. However, not all catalysts are green. Certain catalysts are toxic in nature and cause problems both in the biotic and abiotic environments. Catalysis with "green" catalysts (which can be recycled) is considered a very important step in the direction of green chemistry, especially for industrial processes. Catalysts play a significant role in establishing the economic strength of the chemical industry, and the clean technology revolution in the industry will provide new opportunities for catalysis and catalytic processes. Following are some different types of catalysts that have been used and are regarded as "green catalysts". ❖ Acid Catalysts: Traditional catalysts are sometimes toxic, and these accumulate in industrial waste. For example, HF is the catalyst used in the production of linear allkylbenzenes (for the production of surfactants), and nowadays it has been replaced by a greener catalyst, fluoride– silica–alumina, a solid acid catalyst.

48 Similarly, in the reactions of Michael, Friedel–Crafts, Mannich, and Iminoaldol, microencapsulated Lewis acids have replaced typical corrosive monomeric Lewis acids (Schemes 1–4). Scheme 1 Scheme 2 Scheme 3 Scheme 4 [MCSc(OTf)$_3$] = Microencapsulated scandium trifluoro methane sulfonate ❖ Basic Catalysts: Basic catalysts (such as Mgo and – alumina) are used in industrial operations for phenol alkylation, side chain alkylation, and isomerization reactions (Schemes 5 to 7). Scheme 5 Scheme 6 Scheme 7 ❖ Oxidation Catalysts: Oxidation catalysts are commonly applied for the partial oxidation of organic substrates in liquid phase. The process is clean, resulting in excellent product conversion with minimal waste. Commercial units have obtained significant success using titanium silicate (TS–1) and vanadium silicate (VS–2) molecular sieves as green catalysts. The most common use of TS–1 is the hydroxylation of phenol, which results in mixtures of hydroquinone and catechol (Scheme 8). In the presence of H_2O_2 as an oxygen source, VS–2 can selectively oxidise 4–chlorotoluene to 4–chlorobenzaldehyde in acetonitrile medium (Scheme 9).

49 Scheme 8 Scheme 9 ❖ Photocatalysts: To carry out the transformations, a large variety of photocatalysts (such as titanium oxide−based photocatalytic systems) were used. The TiO 2 photocatalyst is important for the purification of contaminated water, the decomposition of undesirable atmospheric odours and toxins, the fixation of CO 2 , and the decomposition of CFCs on a huge global scale. ❖ Biocatalysts: The most important conversions in green chemistry are carried out with the help of enzymes or biocatalysts. Enzymes are now easily available and play an important role in organic synthesis. The earliest biocatalytic conversion known to people is the manufacture of ethyl alcohol from molasses, the mother liquor left over after the crystallisation of cane sugar from concentrated cane juice. One of the most common instances is the biocatalytic conversion of penicillin into 6−aminopenicillanic acid (6−APA) by the enzyme "penacylase" (a one−step process). However, this chemical conversion, on the other hand, requires a number of steps (Scheme 10). The biocatalysts have the added benefit of being chemoselective, regioselective, and stereoselective. Biocatalysts offer a significant advantage over non−biological catalysts in terms of reaction rate, catalytic specificity, lower cost, and so on; however, they are heat sensitive and have poor stability. Biocatalytic processes, which are catalysed by enzymes, allow a variety of reactions to occur. The major six classes of enzymes and the actions they catalyse are listed below (Table 2).

50 Scheme 10 Table 2: Major classes of enzymes

51 2.8.3 MATERIAL LIFE CYCLE AND APPLICATION OF GREEN CHEMISTRY 2.8.3.1 Material Life Cycle Materials have always played a significant role in product design throughout history. The ages in which man lived have also been termed by the materials utilized at the period, namely stone, bronze, and iron. However, the current age is not the age of a particular material; rather, it is the age of a wide range of materials. There are an estimated 100,000 different types of commercial materials on the market, including all variants in material composition, mixtures, thermal treatment, etc. Structural materials for the products can be divided into six groups: metal, ceramic, synthetic polymers, natural organic materials, inorganic materials, and natural composites. These groupings will most likely cover more than 99% of all materials used in mechanical engineering, civil engineering, electrical engineering, and designing. The idea of a life cycle derives from the biological sciences. Living organisms are born, develop, mature, grow old, and, ultimately, die. The concept of the life cycle has now been adapted and implemented in various domains. Materials have environmental impacts throughout their life cycles, from "raw material" extraction to "waste" disposal in the environment−from birth to death, or (if you prefer) cradle to grave. Figure 9: Material life cycle Figure 9 is a sketch of the material life cycle. Raw materials and energy are drawn from the planet's natural resources and processed to produce materials. These materials are then used to manufacture products, which are delivered to the market, sold, and used. The products have a useful life after which they are disposed of; a portion of the materials they contain may enter a recycling loop, while the rest is committed to incineration or landfill in the environment.

52 Today, we produce a large number of products and generate a considerable amount of waste that requires an increasing area of dumps and landfills at the end of the product's life. As a result, we must have precise knowledge regarding materials, manufacturing processes, and environmental impact assessments, among other things. The life cycle assessment (LCA) in fact plays a key role to decide the best alternatives in the selection of materials and processes for a product. Life cycle assessment (LCA), also known as environmental LCA, is a systematic, standardized approach to quantifying the potential environmental impacts of products during their entire life cycles. Nowadays, environmental concern and responsibility appear to be a new challenge for product designers. They must learn to select the appropriate materials and processes during the design phase. Faced with sustainability challenges, product design activities can make use of the LCA, which allows the use of materials with reduced environmental impact and contributes to sustainable development while applying new concepts to product design and development. 2.8.3.2 Application of Green Chemistry Green chemistry approach will contribute to sustainable development. Many sectors, like textiles, dyes, plastics, paint, and pharmaceutical agriculture, are adopting green chemistry. Many examples from various fields are obtained that comply with the basic principles of green chemistry. It provides us with a platform to overcome the unwanted negative effects of chemistry. Because the main purpose of green chemistry is to reduce or eliminate waste in the chemical industry, it has encouraged the development of several green "next generation" catalysts, some of which have already been discussed. With the advancement of science, green chemistry has changed our lifestyle, and its benefits are being used in daily life and for domestic purposes. Some of its most important applications are described. [1] Green Dry Cleaning of Clothes: Percholoroethylene (PERC), $Cl_2C{=}CCl_2$, is the most commonly used solvent in dry cleaning clothes. PERC is suspected of causing cancer, and its disposal contaminates groundwater. The amount of PERC in the environment, as well as the duration and frequency of exposure, influences the effects of PERC on human health. Regular exposure to a high–PERC environment can also cause memory loss and confusion. PERC can be part of the cause of the development of photochemical smog when it reacts with different substances in the air. When these reactions reach the upper atmosphere, they have the potential to deplete the ozone layer. To replace PERC, Joseph De Simons, Timothy Romark, and James McClain synthesised "Micell", which is made of liquid CO_2, a safer solvent, and a surfactant to dry clean garments. Some dry cleaners are currently using this technology commercially. Dry cleaning machines have also been converted to use this technique. Micell Technology has additionally developed a metal cleaning system that uses CO_2 and a surfactant, eliminating the need for halogenated solvents. [2] Green Bleaching of Paper: Paper is commonly made from wood, which contains around 70% polysaccharides and approximately 30% lignin. For high–quality paper, the lignin must be completely removed. Initially, lignin is removed by immersing small
53 chipped pieces of wood in a bath of sodium hydroxide (NaOH) and sodium sulphide (Na_2S). This procedure decomposes around 80–90% of the lignin. The remaining lignin was mostly removed by reaction with chlorine gas (Cl_2). The use of chlorine removes all of the lignin to produce high–quality white paper, but it poses environmental issues. Chlorine reacts with the aromatic rings of the lignin during the process that produces chlorinated dioxins and chlorinated furans. These compounds, which are carcinogens, cause health problems. These halogenated products find their way into the food chain and eventually into products like pork, beef, and fish. As a result, the use of chlorine has been discouraged. Chlorine dioxide was then utilized. Other bleaching agents like hydrogen peroxide (H_2O_2), ozone (O_3), or oxygen (O_2) also did not give the desired results. Terrence Collins of Carnegie Mellon University developed a green bleaching agent by using H_2O_2 as a bleaching agent in the presence of activators like TAML (tetraamido macrocyclic ligands), which catalyze the fast conversion of H_2O_2 into hydroxyl radicals that cause bleaching. This bleaching agent degrades lignin in far less time and at a lower temperature. It can be used in laundry to remove stains in green pathways, resulting in less water use. 2.9 SUMMARY One of the major purposes of studying environmental science is to protect life and the environment. And what we call "life" is itself composed of lifeless chemical molecules. When these molecules are isolated and analyzed individually, they obey all the physical and chemical laws that define the behavior of inanimate matter, just like all activities that occur in living organisms. The study of biochemistry asks how the remarkable properties of living organisms arise from the thousands of different lifeless biomolecules that are essential for the proper functioning of organisms. Biomolecules are organic, which means they contain carbon. In addition, they may contain hydrogen, oxygen, nitrogen, phosphorus, sulphur, and other minor elements. Several macromolecules (protein, carbohydrates, nucleic acids, and enzymes) and small molecules (amino acids, vitamins, fatty acids, neurotransmitters, and hormones) fall under the category of biomolecules. This chapter provides an overview of the four basic biomolecules: proteins, nucleic acids, carbohydrates, and fats, all of which are essential for living systems. These biomolecules are polymers made up of small monomer units. Therefore, for the convenience of the learners, this lesson includes the chemistry of polymers and hydrocarbons. The chapter also considers the fundamental concepts of green chemistry and the uses of enzymes for greener catalytic activity from the perspective of biochemistry, which is a green chemical and biological science by its nature. 2.10 QUESTIONS / SELF ASSESSMENT QUESTIONS

54 1 . What do you mean by saturated and unsaturated hydrocarbons? 2 . Distinguish between the terms "homopolymers" and "copolymers" and give two examples of each. 3 . Define thermoplastics and thermosetting polymers. 4 . What are reducing sugars? 5 . Write short notes regarding the structures of: (i) Glucose and (ii) Fructose. 6 . What do you understand by the term "glycosidic linkage"? 7 . Differentiate between globular and fibrous proteins. 8 . Define the following as related to proteins: (i) Peptide linkage; (ii) Secondary and Tertiary Structure; and (iii) Denaturation. 9 . Distinguish between saturated and unsaturated fats. What are their sources? 10 . What are trans fats and how are these produced? 11 . How does DNA differ structurally from RNA? Explain. 12 . What is green chemistry, and why is it important? Write down its 12 principles. 13 . Make brief notes about: (i) Green catalysts and (ii) the Material life cycle. 2.11 SELECTED READINGS / SUGGESTED READING 1 . 313 – Chemistry Book – 2 (Senior Secondary Course). NIOS, Noida 2 . 12086 – Chemistry Part II (Textbook for Class XII). NCERT, New Delhi 3 . Ahluwalia VK & Kidwai M (2004) New Trends in Green Chemistry. Anamaya Publishers, New Delhi 4 . Ameta SC & Ameta R (2013) Green Chemistry: Fundamentals and Applications. Apple Academic Press, Canada 5 . Ashby MF (2012) Materials and the Environment: Eco–informed Material Choice. Elsevier, Amsterdam 6 . Bahl A & Bahl BS (2019) A Textbook of Organic Chemistry. S Chand, New Delhi 7 . Madan RL (2010) Chemistry for Degree Students (B.Sc. 3 rd Yr). S Chand, New Delhi 8 . Morrison RT, Boyd RN & Bhattacharjee SK (2011) Organic Chemistry. Pearson Education, New Delhi 9 . Sengupta S (2007) Application Oriented Chemistry (B.Sc. General Course: Part II). M/S Subrata Sengupta, Kolkata 10 . Singh J & Yadav LDS (2019) Organic Chemistry (Vol. III). Pragati Prakashan, Meerut 11 . Solomons TWG, Fryhle CB & Snyder SA (2016) Organic Chemistry. John Wiley & Sons, New Jersey

55 UNIT 3: ATMOSPHERIC CHEMISTRY Structure 3.1 Objectives 3.2 Introduction 3.3 Composition of air 3.4 Particles, ions, and radicals in the atmosphere 3.5 Formation of particulate matter in atmosphere 3.6 Oxygen and ozone chemistry 3.7 Smog 3.8 Summary 3.9 Questions / Self assessment questions 3.10 Selected readings / Suggested reading 3.1 OBJECTIVES This unit's lessons will enable you to: ➢ describe the composition of atmosphere, ➢ classify the atmosphere into different zones, ➢ understand the existence of particles, ions, and radicals in the atmosphere, ➢ identify particulate matter and how it forms, ➢ explain the chemistry of oxygen and ozone, ➢ define photochemical smog and its environmental impact. 3.2 INTRODUCTION The atmosphere is the covering of air that surrounds the earth. The planet is, in reality, enveloped by a thick, protective gaseous mantle. It provides oxygen for the survival of life on earth and carbon dioxide for plant photosynthesis. It gives nitrogen, which nitrogen–fixing bacteria use to produce ammonia, an essential component of life. The atmosphere serves as a protective blanket for all living species on earth from the harmful ultraviolet (UV) rays coming out of the solar system. By absorbing UV rays in the range of 220–330 nm, the atmosphere filters out damaging ultraviolet radiation. The atmosphere contributes significantly to the stabilization of the planet's temperature by reabsorbing infrared radiation emitted by the earth and remitting the absorbed solar energy back into space. The redistribution of solar energy in the atmosphere allows life to exist on earth.

56 3.3 COMPOSITION OF AIR Air is defined as a gas mixture that supports plant and animal life on earth. The composition of atmospheric gases may be classified as major, minor, or trace gases based on the abundance of gaseous molecules in the atmosphere (Table 1). Its major constituents, as percent by volume, are nitrogen (78.08%) and oxygen (20.95%) gases, and the minor components are argon (0.934%) and 0.035% carbon dioxide. Water vapour in atmospheric air can range from 0.1% to 5% by volume, with a normal range of 1% to 3%. Furthermore, air contains a wide range of trace–level gases with concentrations less than 0.002 percent, such as neon, helium, methane, krypton, nitrous oxide, hydrogen, xenon, sulphur dioxide, ozone, ammonia, carbon monoxide, and nitrogen dioxide. Table 1: Composition of the atmosphere (Source: B. Pani) 3.4 PARTICLES, IONS, AND RADICALS IN THE ATMOSPHERE 3.4.1 ATMOSPHERIC LAYERS The atmosphere that surrounds the earth is not uniformly thick at all elevations. There are concentric layers of air or regions, with varying densities. The atmosphere can be divided into four concentric layers that can be differentiated by temperature, and each layer has its own set of characteristics (Table 2). These are the troposphere, stratosphere, mesosphere, and thermosphere. It covered a distance of 500 km and had temperatures ranging from –92 to 1200 °C.

57 Table 2: Major layers of the atmosphere Layers Altitude range Temperature Chemical species present in the layer Troposphere 0–11 km 15 to –56 °C N 2 , O 2 , CO 2 , H 2 O Stratosphere 11–50 km –56 to –2 °C O 3 Mesosphere 50–85 km –2 to –92 °C O 2 + , NO + Thermosphere 85–500 km –92 to 1200 °C O 2 + , O + , NO + The troposphere is the atmosphere's lowest layer, where humans and other organisms live. The troposphere is more or less homogeneous in nature and accounts for 70% of the mass of the atmosphere. The troposphere's homogeneous composition results from constant mixing by circulating air masses. This is the zone of weather production because it involves water evaporation, cloud formation, air mass movement, and precipitation. With increasing altitude, the temperature and density in this layer decrease steadily. The temperature at the top of this zone is approximately –56 °C. A distinct barrier between the troposphere and stratosphere is created when the temperature gradient rapidly reverses in the topmost zone (Figure 1). Between the troposphere and the stratosphere is a zone known as the tropopause. The stratosphere, or layer above the tropopause, is located between 11 and 50 km above sea level. The air temperature in this region rises with altitude and reaches a maximum of roughly –2 °C. Lapse rate is the term used to describe the temperature's change (increase or decrease) with altitude. When the temperature rises with elevation, it is said that the lapse rate is positive. The decrease in temperature with altitude is known as the negative lapse rate (Figure 1). Because the tropopause is extremely cold (–56 °C), the water vapour is dropped. As a result, there is little water vapour in the stratosphere. It is the ozone layer zone, and the presence of ozone in the stratosphere absorbs UV solar radiation, causing temperature to rise with altitude. Above the stratosphere is the mesosphere, where temperature decreases as altitude increases. This is due to a lack of UV–absorbing species, specifically ozone.

58 Figure 1: Different layers of the atmosphere with temperature profile (Source: A.K. De) Further increases in altitude cause a rapid increase in temperature throughout the region called the thermosphere. The highly rarified gas can reach temperatures of 1200 °C due to the absorption of very energetic radiation with wavelengths less than 200 nm by gas species in this region. There are two sections to this zone. The ionosphere is the lower part of the thermosphere. All gases present in this zone are ionised. It reflects radio waves back to the earth. The exosphere is the upper part of the thermosphere. This layer is commonly referred to as the Valley of Silence. This layer gradually merges with outer space. 3.4.2 IONS AND RADICALS Ions are normally found above the stratosphere in a region called the ionosphere. Ions are atoms that have either lost or gained one or more electrons, resulting in positively charged cations or negatively charged anions. Positive ions such as O 2 + , O + , NO + and others, as well as electrons, exist in significant quantities in the ionosphere. Ions are primarily produced by ultraviolet light. In the absence of UV radiation (in darkness), these positive ions slowly recombine with free electrons to form the neutral species from which they originated. This process happens quickly in the lower ionosphere, where the species are more concentrated. The earth's magnetic field exerts a strong influence on the ions, resulting in the formation of two belts of ionising particles that encircle the planet. These are known as van Allen belts. In addition to ions, the atmosphere contains free radicals, which are produced by electromagnetic radiation. Free radicals are atoms or groups of atoms with an unpaired valence electron that have

59 half–lives of several minutes or more in the rarefied upper atmosphere. Most free radicals are extremely reactive due to their unpaired valence electrons. They participate in chain reactions in which one of the products is a free radical. A combination of two free radicals can stop the chain. RH + O • + O 2 → ROO • + HO • (where RH = aliphatic hydrocarbon) CH 3 –CHO + h → CH 3 • + HCO • CH 3 • + CH 3 • → C 2 H 6 Free radicals play a significant role in the formation of photochemical smog. 3.4.3 PARTICLES Particles are solid or liquid particles suspended in the air. Particles also include chemically inert materials such as soil dust, soot, smoke, and so on. Viruses, bacteria, fungal spores, bacterial spores, and pollen are a few examples of biologically derived particles. Complex chemical reactions can also produce atmospheric particles. Road and pavement dust, industrial activities such as rubber and textile, dust from vehicles, mining activities, and other natural processes such as volcanoes, earthquakes, cyclones, and so on are major sources of particles in the atmosphere. Particles are found everywhere and are an important component of the troposphere. The overall particle size range in atmospheric air is approximately 0.001 to 10 μm. Particles in the air are classified into three types: coarse, fine, and ultrafine. • Coarse particles (PM10): With diameters ranging from 2.5 to 10 μm, these are the largest particles, such as windblown dust. Most of it is stopped by our lungs. • Fine particles (PM2.5): The majority of particles that can harm our health are categorized as fine particles. These particles have diameters of at least 2.5 μm or less. Smoke and haze are examples of this. • Ultrafine particles (PM0.1): These are the smallest particles; with diameters less than 0.1 μm. Ultrafine particles can enter the bloodstream through any lung tissue. They now can circulate throughout the body with blood cells and oxygen. Recent research indicates that PM0.1 has increased cardiovascular toxicity and a higher potential for oxidative stress. However, the adverse effects of PM0.1 on human health remain unknown due to a lack of research. However, because these particles can originate from a variety of sources, they frequently come in a variety of sizes mixed together. Some of them can even exist in the form of liquids or liquid–suspended solids. 3.5 FORMATION OF PARTICULATE MATTER IN ATMOSPHERE Total suspended particulates (TSPs) in the air are the broad name for particulate matter (PM), also known as atmospheric aerosol particles, atmospheric particulate matter, or suspended

60 particulate matter (SPM). In contrast to the particulate matter alone, the term "aerosol" frequently refers to the particulate/air mixture. The mass or number of particles per unit volume of air is referred to as the particle concentration. The concept "particle density" describes the number of particles per unit volume. Particle matter formation can be split into two categories (i) Physical processes for particulate formation, and (ii) Chemical processes for particulate formation. 3.5.1 PHYSICAL PROCESSES FOR PARTICULATE FORMATION These include: 1. The disintegration of bigger particles produces particles with a diameter of almost one micron. Dispersion aerosols, such as dust, which are solid dispersion aerosols, are the principal product of the dispersion process. 2. Natural sources of dispersed aerosols include sea sprays, windblown dust during cultivation, volcanic dust, and so on. 3. Particulate matter is formed by the coagulation of really small particles from larger aggregates, as well as by absorption and adsorption. 4. Chemical adhesion of smaller particles produces particulates ranging in size from 10 to 20 µ. 3.5.2 CHEMICAL PROCESSES FOR PARTICULATE FORMATION Particulate matter can be formed by both organic and inorganic chemical processes. 3.5.2.1 Formation of Inorganic Particulate Matter Metal oxides are the most common type of inorganic particulate in the atmosphere. These are formed when metal–containing fuels are burned. As an instance: 1. Particulate iron oxide is produced during the burning of pyrite–containing coal: 3FeS 2 + 8O 2 → Fe 3 O 4 + 6SO 2 2. Organic vanadium in residual fuel oil is converted to vanadium oxide (V 2 O 3) particulate. 3. A portion of the calcium carbonate in coal ash is transformed to calcium oxide and released into the atmosphere via the stack. CaCO 3 heat → CaO + CO 2 4. Automobiles contribute to the presence of lead particles in the atmosphere. Combustion of leaded gasoline discharged lead halides through the exhaust system. Pb(C 2 H 5) 4 + O 2 + C 2 H 4 Cl 2 + C 2 H 4 Br 2 → PbCl 2 + PbBr 2 + PbBrCl + CO 2 + H 2 O These lead halides enter the atmosphere after leaving the exhaust system and condensing to form particulates. However, with the use of unleaded gasoline in recent years, this amount has been reduced.

61 5. Aerosol mists arise from sulphuric acid, obtained by oxidation of sulphur dioxide which accumulates atmospheric water vapor, to form small liquid droplets: 2SO 2 + O 2 + 2H 2 O → 2H 2 SO 4 It form salts with basic air pollutants, such as ammonia or calcium oxide: H 2 SO 4 (droplet) + 2NH 3 (gas) → (NH 4) 2 SO 4 (droplet) H 2 SO 4 (droplet) + CaO(particle) → CaSO 4 (droplet) + H 2 O Figure 2 depicts the constituents of inorganic particulate matter. The relative abundances of the elements in the parent material are generally reflected in the proportions of the components in atmospheric particulate matter. Figure 2: Components of inorganic particulate matter and their origins (Source: S.E. Manahan) A typical analysis of particulate matter in the air in metropolitan areas in the United States revealed the following composition (µg/m 3): TSPs (105), NH 4 + (1.3), NO 3 – (2.6), SO 4 2– (10.6), soluble benzene organics (6.8), Sb (0.01), As (0.02), Cd (0.002), Cr (0.015), Cu (0.09), Fe (1.58), Pb (0.79), Mn (0.10), Ni (0.034), Sn (0.02), Ti (0.04), V (0.05), and Zn (0.67). 3.5.2.2 Organic Particulate Matter Organic particulate matter is thought to come from a number of sources, including vegetation and automobile emissions, fuel burning, and so on. The molecular formula for typical organic particulate matter obtained from 200 air samples in the United States seems to be C 32.4 H 48 S 0.083 (Halogen) 0.065 (Alkoxy) 0.12 . Such particles are in the size range of 1 µ and pose a serious

62 health risk. As examples of oxygenated neutral organic molecules like aldehydes, ketones, peroxides, epoxides, esters, quinones, and lactones can be mentioned. Lauric, palmitic, stearic, myristic, oleic, linoleic, and many other organic acids can be found in organic particulate matter. Automobile exhaust contains oxidised polymerized hydrocarbons and nitrogenous azoheterocyclic compounds that are discharged into the atmosphere, as well as instances of organic particulate matter. Chrysene, benzofluoranthene, benzo–α–pyrene, and benzidine, among other organic particulates, are examples of polycyclic aromatic hydrocarbons (PAHs), which are known to cause cancer. Among them, benzo–α–pyrene is well recognized. PAH chemicals are primarily found in the urban atmosphere at around 20 g/m 3 . Chrysene NH 2 H 2 N Benzidine Benzofluoranthene Benzo–α–pyrene The higher paraffins found in fuels and plant matters that are pyrolyzed to produce them. As a result of the pyrolysis of high molecular weight paraffins, C 10 H 22 is produced. This compound once more breaks into tiny particles and adsorbs to soot particles. Soot is produced as a byproduct of fuel combustion in vehicles and power plants that use coal as a raw material. Soot is a highly condensed result of these substances, made up of thousands of inter–connected crystallites, i.e., graphic platelets, each with roughly 100 condensed aromatic rings. Because of partial oxidation, it contains 1 to 3% hydrogen and 5 to 10% oxygen. It accounts for 50% of the particulate load in metropolitan areas. Soot acts as a disease carrier due to its vast surface area (Figure 3), containing dangerous trace metals such as beryllium, cadmium, chromium, manganese, nickel, vanadium, and others, as well as harmful organics like benzo–α–pyrene. C 10 H 22 –H Δ Polycyclic Aromatic Hydrocarbons

63 Figure 3: Soot particle with adsorbed toxic metals and organics (Source: A.K. De) 3.6 OXYGEN AND OZONE CHEMISTRY Oxygen constitutes around one–fifth of the volume of the atmosphere and is the third most abundant element (49.2 percent) in the earth's crust after hydrogen and helium. The chemical activity of oxygen plays a prime role in the lower atmosphere. As seen in Figure 4, oxides are the most common stable forms of almost all elements. Oxygen is found in trace amounts in the atmosphere as carbon dioxide (CO_2) and sulphur dioxide (SO_2) gases. The seas are filled with water (H_2O), the oxide of hydrogen, whereas the earth's crust rock consists mostly of solid oxides of silicon (silica SiO_2, as found in granite and quartz), aluminium (aluminium oxide Al_2O_3, in bauxite and corundum), iron (iron(III) oxide Fe_2O_3, in hematite and rust), and calcium carbonate (in limestone), and others. The rest of the earth's crust is made up of oxygen compounds as well, namely different complex silicates (in silicate minerals). Figure 4: Stable compounds of oxide (Source: A.K. De) The species of oxygen in the upper atmosphere include O_2, $O^\bullet$, O^+ and O_2^+ along with O_3, i.e., molecules, atoms, excited atoms and molecules They originate by photochemical dissociation, ionisation, etc. by absorbing UV light.

64 $O_2 + h \rightarrow O^\bullet + O^\bullet$ $O_3 + h \rightarrow O^\bullet + O_2$ $O^\bullet + h \rightarrow O^+ + -$ $O_2 + h \rightarrow O_2^+ + -$ Ozone (O_3) is an important stratospheric species that acts as a radiation barrier for life on earth by absorbing harmful UV rays in the 220–330 nm range. As ozone absorbs UV light without being consumed, the net consequence is that UV energy is converted into heat, and thus the temperature in the stratosphere rises with altitude. The maximum ozone concentration, as high as 15 ppm, occurs at an altitude of approximately 32 km above the earth's surface. Ozone is an unstable molecule, and the process of creating and destroying ozone is described as the "Chapman cycle." The cycle begins with the photolysis of molecular oxygen, which is followed by the interaction of an oxygen atom with another oxygen molecule to form ozone. $O_2 + h$ (> 240 nm) $\rightarrow O^\bullet + O^\bullet$ $O^\bullet + O_2 + M$ (N_2 or O_2) $\rightarrow O_3$ The "M" stands for the third body, which carries off the surplus energy from the aforementioned process and stabilizes the O_3 molecules as a result. Ozone so formed undergoes photodissociation in the following manner. $O_3 + h$ (> 220 – 330 nm) $\rightarrow O_2 + O^\bullet$ + heat $O^\bullet + O_3 \rightarrow 2O_2$ (recombination) The oxygen atoms formed during the photolysis of O_3 subsequently react with other oxygen molecules to make more ozone, as in the previous step. Certain trace chemical species, primarily free radicals such as the oxides of nitrogen ($NO^\bullet$ and $NO_2^\bullet$), atomic hydrogen ($H^\bullet$), oxygen species ($HO^\bullet$ and $HO_2^\bullet$), and chlorine species ($Cl^\bullet$, $ClO^\bullet$ and $ClO_2^\bullet$), are responsible for catalyzing the recombination reaction. The concentration of the ozone is then the result of a competition between the photodissociation and recombination mechanisms. Referring back to O_3 creation and destruction, the following reactions have the following reaction rates:

$O_2 \rightarrow O^\bullet + O^\bullet$ Reaction rate = $k_1 [O_2]$ $O^\bullet + O_2 + M \rightarrow O_3$ Reaction rate = $k_2 [O^\bullet][O_2][M]$ $O_3 + h \rightarrow O_2 + O^\bullet$ Reaction rate = $k_3 [O_3]$ $O^\bullet + O_3 \rightarrow 2O_2$ Reaction rate = $k_4 [O^\bullet][O_3]$ At equilibrium: $k_2 [O^\bullet][O_2][M] = k_3 [O_3] + k_4 [O^\bullet][O_3]$

The steady state the ratio of $[O_3]$ $[O_2]$ = ($k_1 k_2 [M]$ $k_3 k_4$) 1 2 This ratio is largely dependent on the altitude. The density of the air and the concentration of M decrease as altitude increases. As the altitude in the stratosphere rises, k_1 and k_3 increase with an increase in photon flux, whereas k_2 and k_4 increase slightly with an increase in temperature.

65 3.7 SMOG Smog is an air pollution that hinders visibility by creating a haze made up of solid particulates and/or liquid aerosols. The term "smog," which was derived by combining the words "smoke" and "fog," was probably first used to describe the atmospheric conditions over many British towns by H.A. Des Voeux in 1905. It is a major regional air pollution problem because the development of smog is directly related to the types of industrial setup and automobile use. Thus, two distinct types of smog are recognized: (i) Sulphurous smog or grey air or industrial smog; and (ii) Photochemical smog or brown air. 3.7.1 SULPHUROUS SMOG Sulphurous smog, often known as London smog, is caused by a high concentration of sulphur dioxide (SO_2) in the air, which is produced by the usage of sulphur–containing fossil fuels, particularly coal. The most severe effects of sulphurous smog were caused in London for about 5 days in December 1952, and hence the name "London smog" was assigned. It is mostly made up of unburned carbon soot, various gases, solid particulates, and SO_2. Because of the presence of SO_2, a moderate reducing agent and the precursor of a weak acid, the overall chemical characteristics of the smog are reducing and acidic. This Smog is also known as "reducing smog" since it is chemically reducing in nature. It happens primarily throughout the winter season in the early morning hours and appears to worsen shortly after sunrise. The relative humidity is high during this period, and air near the ground is cooled by conduction from cooled surfaces (particularly on a clear night), whereas the air is not as cool further up in the troposphere. In the absence of wind, temperature inversion occurs when warm air lies over cooler air. The following chemical processes occur under this atmospheric condition, resulting in the formation of sulphurous (London) smog. $S + O_2 \rightarrow SO_2$ In the presence of sunlight and particulate matter, SO_2 oxidises to SO_3, which subsequently combines with moisture to form acidic aerosol. $SO_2 + 1\,2/O_2 \rightarrow SO_3$ $SO_3 + H_2O \rightarrow H_2SO_4$ The acidic aerosol is then combined with NH_3 in moist air and forms $(NH_4)_2SO_4$. $H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$ This type of smog's reaction is not photochemical in nature. London smog causes throat irritation and breathing difficulties. 3.7.2 PHOTOCHEMICAL SMOG In contrast to sulphurous smog, photochemical smog, also known as Los Angeles smog, is caused by vehicular emissions from petroleum combustion, followed by a series of chemical and

66 photochemical reactions that occur under specific circumstances. The most severe smog of this type was experienced on July 26, 1943, in Los Angeles, California, thereby the name. This smog is produced in the lower atmosphere by photochemical interactions between nitrogen oxides and hydrocarbons, which are regarded as the primary pollutants for photochemical smog formation. Secondary pollutants of importance include peroxylacyl nitrates (PAN), tropospheric ozone, and aldehydes. This is oxidising smog, with a high concentration of oxidants like aldehyde and PAN. Photochemical smog is commonly referred to as "summer smog," however it occurs both in summer and winter on warm sunny days (sunlight is essential to carry out photochemical reactions) when the sky is clear and humidity is low. A subsidence temperature inversion is ideal for the production of photochemical smog. Photochemical smog is formed chemically as follows: 1. Reactive hydrocarbons (RCH 2 , having C=C) from automobile exhaust react with tropospheric ozone to form hydrocarbon free radicals (RCH 2 •). Automobile exhaust (RCH 2) O 3 → RCH 2 • 2. The free radical, RCH 2 • immediately reacts with oxygen to produce another free radical RCH 2 O 2 • . RCH 2 • O 2 → RCH 2 O 2 • 3. The second free radical RCH 2 O 2 . interacts with NO to form NO 2 , and the third free radical RCH 2 O • . RCH 2 O 2 • + NO → RCH 2 O • + NO 2 4. The third free radical RCH 2 O • subsequently reacts with oxygen, to yield a stable aldehyde (RCHO) and a hydroperoxyl radical (HO 2 •). RCH 2 O • + O 2 → RCHO + HO 2 • 5. HO 2 • then interacts with another molecule of NO to produce NO 2 , along with hydroxyl radical (HO •). HO 2 • + NO → NO 2 + HO • 6. HO • , being extremely reactive, rapidly reacts with a stable hydrocarbon (RCH 3) and regenerates the free radicals RCH 2 • , thereby completing the cycle. HO • + RCH 3 → RCH 2 • + H 2 O The above cycle is repeated several times, resulting in a rapid build–up of photochemical smog products (Figure 5). This goes on and on as a chain reaction. One complete cycle produces two molecules of NO 2 , one molecule of aldehyde RCHO, and regenerates the free radical RCH 2 • to begin the process all over again.

67 Figure 5: Cyclic pathway of photochemical smog formation (Source: V.K. Ahluwalia) 7. The aldehyde may initiate another route by interacting with the hydroxyl radical to form an acyl radical (RCO •). RCHO +HO • → RCO • + H 2 O This acyl radical reacts with oxygen to produce a peroxyacyl radical (RCOO 2 •), which then combines with nitrogen dioxide to form peroxyacyl nitrate (PAN). RCO • + O 2 → RCOO 2 • RCOO 2 • + NO 2 → RCOO 2 NO 2 (PAN) Peroxyacyl nitrate, a by–product of photochemical smog, causes eye irritation. The components of smog, ozone, and PAN have an effect on human respiratory tracts. The smog consists of brown hazy fumes that irritate the nose and throat and can lead to a variety of eye, lung, and heart diseases. Photochemical smog also has an impact on plant growth and causes damage to vegetation. 3.8 SUMMARY The atmosphere is a thin gaseous envelope that surrounds the earth. The troposphere, stratosphere, mesosphere, thermosphere, ionosphere, and exosphere are the various layers or zones of the atmosphere. Nitrogen, oxygen, and carbon dioxide are significant components of the atmosphere. In addition to these, the atmosphere also includes particles, ions, radicals, and smog. Other gases, such as ozone, nitrous oxide, sulphur dioxide, nitrogen dioxide, and so on, are either produced or formed in the atmosphere. All of these gases undergo chemical and photochemical reactions and are responsible for a variety of environmental events. 3.9 QUESTIONS / SELF ASSESSMENT QUESTIONS

68 [1] What are the compositions of the atmosphere? Name the trace constituents of the atmosphere and their approximate percentage by volume. [2] How would you classify the major regions of the atmosphere? State their respective altitudes and temperature ranges? What are the important chemical species in each region? [3] What are the ions and particles? What are the different types of particles? Describe the effects of particles. [4] What are the chemical processes for the formation of inorganic particulate matter in the atmosphere? [5] "Oxygen plays a key role in the troposphere, while ozone, in the stratosphere". Elucidate. [6] What is smog? Write a note on photochemical smog. 3.10 SELECTED READINGS / SUGGESTED READING [1] Ahluwalia VK (2017) Advanced Environmental Chemistry. TERI, New Delhi [2] Basak A (2009) Environmental Studies. Pearson Education, New Delhi [3] De AK (2008) Environmental Chemistry. New Age International, New Delhi [4] Ibanez JG, Hernandez-Esparza M, Doria-Serrano C, Fregoso-Infante A & Singh MM (2007) Environmental Chemistry Fundamentals. Springer, New York [5] Manahan SE (2017) Environmental Chemistry. CRC Press, New York [6] Pani B (2007) Textbook of Environmental Chemistry. IK International, New Delhi [7] Sharma BK (2007) Environmental Chemistry. Krishan Prakashan, Meerut

69 UNIT 4: WATER CHEMISTRY Structure 4.1 Objectives 4.2 Introduction 4.3 Fundamental of water chemistry 4.4 Concept of DO, BOD, and COD 4.5 Sedimentation 4.6 Coagulation and flocculation 4.7 pH and redox potential (Eh) 4.8 Summary 4.9 Questions / Self assessment questions 4.10 Selected readings / Suggested reading 4.1 OBJECTIVES By the completion of this unit, you should be able to: ➢ define water chemistry, ➢ demonstrate Winkler's method for estimating dissolved oxygen (DO) in a water sample, ➢ learn about biochemical oxygen demand (BOD) and chemical oxygen demand (COD), as well as their determination, ➢ describes water treatment processes like sedimentation, coagulation, and flocculation, ➢ explain the role of pH and redox potential in regulating water quality. 4.2 INTRODUCTION Water chemistry is the science that focuses on understanding the chemical processes which affect the composition of natural waters and their suitability for human use. It is a field that evolved from early foundations in several related disciplines. The teaching of modern water chemistry in its first decade was considerably different from current teaching practices. New courses were developed based on physical–chemical principles to supplement earlier courses based on analytical chemistry (water and wastewater analysis). Driven by three primary forces, the field of water chemistry has changed dramatically since its synthesis from the predecessor fields described previously. The primary drivers for change were: (1) environmental quality and pollution issues that had a chemical focus; (2) advances in scientific approaches and technology; and (3) advances within the field that led to new areas or ways to study existing areas. We will
70 thus discuss on the concepts DO, BOD, and COD, along with sedimentation, coagulation, and flocculation, pH, and redox potential. 4.3 FUNDAMENTAL OF WATER CHEMISTRY In 1962, a program at the University of Wisconsin, Madison, was the first to use the term "water chemistry." The word appears to have been introduced for the first time at the Rutgers University Rudolfs Conference on "Principles and Applications of Water Chemistry" in 1965. Water chemistry is a relatively new sub–field of environmental chemistry that is primarily concerned with understanding the chemical processes that influence the composition of natural waters and their suitability for human use. Water chemistry refers to the analytical determination of impurities caused by toxic contaminants in water, as well as the detoxification processes used to achieve the water quality as safely as practicable. 4.4 CONCEPT OF DO, BOD AND COD 4.4.1 DISSOLVE OXYGEN (DO) Despite being poorly soluble in water, dissolved oxygen is an important indicator of water quality. DO is inversely proportional to temperature, with 14.6 mg/L being the maximum amount of oxygen that can be dissolved in water at 0°C. The dissolve oxygen content in the water sample helps aquatic life to survive and is also a measure of its ability to oxidise organic impurities in water. DO measurement provides an instant assessment of water purity. Winkler's titrimetric method is used to determine DO. The procedure is as follows: 1. Because dissolved molecular oxygen in water cannot react with KI, an oxygen carrier such as manganese hydroxide is used. Mn(OH) 2 is formed as a result of the action of KOH on MnSO 4 . 2KOH + MnSO4 = Mn(OH) 2 + K 2 SO 4 2. Mn(OH) 2 reacts with dissolved molecular oxygen to form MnO(OH) 2 , a brown precipitate of basic manganic oxide. 2Mn(OH) 2 + O 2 = 2MnO(OH) 2 3. When MnO(OH) 2 reacts with concentrated sulphuric acid, nascent oxygen is liberated. MnO(OH) 2 + H 2 SO 4 = MnSO 4 + 2H 2 O + [O] 4. Nascent oxygen results in the oxidation of KI to I 2 . 2KI + H 2 SO 4 + [O] = K 2 SO 4 + H 2 O + I 2 5. This liberated iodine is then titrated using starch as an indicator against a standard sodium thiosulphate solution. 2Na 2 S 2 O 3 + I 2 = Na 2 S 4 O 6 + 2NaI

71 The presence of nitrites, particularly in sewage treatment water, interferes with this determination. This can be avoided by heating the water sample in the presence of sodium azide, which decomposes. $2H^+ + NO_2^- + NaN_3 = N_2 + N_2O + H_2O + Na^+$ 4.4.2 BIOCHEMICAL OXYGEN DEMAND (BOD) The quantity of oxygen (in mg/L) needed by bacteria and other microorganisms during the biochemical degradation of organic matter present in wastewater is known as BOD and has been used to measure the amount of degradable organic material that is present in a sample of water. BOD is regarded as the primary factor in stream pollution control. It provides extremely useful information about the ability of streams to purify water and acts as a guide for regulatory organisations to examine the quality of effluents discharged into such water bodies. BOD is always an empirical parameter based on oxidation by appropriate microorganisms that provides a measure of the level of pollution in wastewater. This parameter is frequently determined by the amount of oxygen that suitable aquatic microorganisms use during the course of a 5–day incubation period. $\{CH_2O\} + O_2 \xrightarrow{\text{Microorganisms}} CO_2 + H_2O$ After incubating in the dark for 5 days at 20°C, the biochemical oxygen demand is determined by measuring the concentration of dissolve oxygen (DO) in the sample and the blank idometrically. First, compressed air is passed through a water sample (wastewater) until it contains 7 mg/L of DO. Then dilution water containing microorganisms is added to it in such a way that the resulting mixture's BOD–content is less than the DO–content. DO is measured in this mixture. A measured amount of the aforementioned mixture is placed in a BOD bottle, properly sealed in an incubator for five days, after that period DO is measured. For the blank, a similar process is used, but distilled water is used in place of the wastewater sample. The difference between the initial and final DO is used to calculate the BOD. 4.4.3 CHEMICAL OXYGEN DEMAND (COD) The BOD test has the drawback of taking five days to complete. The test could be significantly shortened if the organic compounds were oxidised chemically rather than biologically. Such oxidation can be accomplished with the chemical oxygen demand (COD) test. When organic pollutants, both biodegradable and non–biodegradable, are oxidised by a strong oxidant like $K_2Cr_2O_7$, the amount of oxygen consumed (in mg/L) is known as COD. So the difference between COD and BOD reflects the amount of non–biodegradable organic pollutants, COD results are always higher than BOD results. In order to determine the COD in a water sample, potassium dichromate is used as an oxidant in the presence of H_2SO_4. In this experiment, $K_2Cr_2O_7$ and 50% H_2SO_4 are refluxed with the water sample in the presence of $HgSO_4$ to counteract the effects of chloride and Ag_2SO_4 serves as the

72 catalyst. Using dichromate ($Cr_2O_7^{2-}$) and hydrogen ions (H^+), the following example of this oxidation reaction is presented simply: $2Cr_2O_7^{2-} + 3\{CH_2O\} + 16H + heat + Ag^+ \rightarrow 3CO_2 + 11H_2O + 4Cr^{3+}$ The amount of unreacted dichromate was titrated using ferroin as an indicator with a standard Mohr salt solution. 4.5 SEDIMENTATION Sedimentation is the process of allowing suspended particles to settle down due to gravity. It is an important step in the treatment of domestic water. In this process, water is let to stand in large tanks for an appropriate period of time without being disturbed, allowing suspended particles like clay or silt that were initially present in the source water to settle to the bottom. The sedimentation process is performed by reducing the velocity of water to the point where the particles no longer remain suspended. When the velocity no longer supports the particles, gravity will remove them from the flow of water. The settling tank, also referred to as the sedimentation tank, is the basin where the water flow is slowed. The sedimentation process is governed by the following factors: • Nature of particle: The size, shape, and type of particle all play important roles in controlling the sedimentation process. Because of their density, sand and silt may be easily removed, however colloidal materials do not settle down unless they are coagulated or flocculated by adding chemicals externally. When compared to particles with irregular edges, round particles settle more easily. • Temperature: As water temperature is reduced, the rate of particle settling decreases. The demand for purified water at a water treatment plant is highest during the summer, when temperatures are high and the settling rate is optimum. • Current: Currents (like density current, eddy current, and surface current) can promote particle sedimentation. However, they can occasionally cause severe problems in the sedimentation process, which can be minimized by proper basin design and baffle installation. 4.6 COAGULATION AND FLOCCULATION The coagulation and flocculation processes can be used to remove suspended solids and colloidal particles from water during the treatment of both drinking water and waste water. Coagulation is the process of destabilising colloidal particles by adding a chemical reagent known as a coagulant. Flocculation is the agglomeration of destabilised particles into microfloc and, later,

73 bulky floccules that may settle as floc. The addition of another chemical known as flocculant causes this. Coagulation is influenced by a number of variables, such as 1. pH of water 2. temperature of water 3. Detention time 4. Velocity of water 5. Zeta Potential In water treatment plants, sodium aluminate and alum are the most commonly utilised coagulants. Sodium aluminate [NaAlO 2] is used to treat acidic water. It is effective in the pH range of 5.5 to 8.0. NaAlO 2 + 2H 2 O → Al(OH) 3 ? + NaOH Al(OH) 3 removes finely divided particles or colloidal contaminants by neutralising their charge and adsorbing the colloidal particles, forming heavier flocs that settle. Mg(OH) 2 is formed when NaOH reacts with MgSO 4 . 2NaOH + MgSO 4 → Mg(OH) 2 ? + Na 2 SO 4 Al(OH) 3 is formed when alum [K 2 (SO 4) 3 . Al 2 (SO 4) 3 . 24H 2 O] reacts with water that has alkalinity. Al(OH) 3 behaves in the same way as previously discussed. If the water is not alkaline enough, some alkali is added. It acts in the pH range of 6.5 to 8.5. Al 2 (SO 4) 3 + 3Ca(HCO 3) 2 → 2Al(OH) 3 + 3CaSO 4 ? + 6CO 2 After coagulation and flocculation, the water is sedimented and then filtered. The water flows through a basin of sedimentation just after flocculation. Solids accumulated in the tank's bottom can be removed manually or automatically. The tank effluent is later filtered. 4.7 pH AND REDOX POTENTIAL (Eh) 4.7.1 pH One of the most important water quality parameters is pH. It is defined as the negative logarithm of the hydrogen ion concentration to the base 10. It is a dimensionless number that indicates the acidic or basic strength of a solution. The pH scale runs from 0 to 14, with 7 being neutral. A pH less than 7 implies acidity, whereas a pH greater than 7 suggests basicity. At 25 °C, pure water has a pH close to 7.0. pH, which measures how acidic or basic a solution is at a particular temperature, is influenced by the dissolved chemical compounds and biochemical reactions taking place in the solution. The pH of unpolluted waters is primarily controlled by the balance of carbon dioxide, carbonate, and bicarbonate ions, as well as other natural substances such as humic and fulvic acids. The natural acid–base balance of a water body can be affected by industrial effluents and acid–forming

74 substance deposition in the atmosphere. Algal photosynthesis and respiration cycles in eutrophic waters can cause to diurnal pH changes. The pH of the most of natural waters ranges from 6.0 to 8.5; however, eutrophic waters, groundwater brines, and salt lakes have higher pH values whereas diluted waters with high organic content might have lower pH values. Since so many natural factors may influence pH, it is ideal to measure it in situ, or right immediately after the sample is collected. The most common method for measuring pH accurately is electrometrically using a glass electrode, several of which may be used in the field and for continuous measurement and recording. Colorimetric analysis using indicator dyes can provide a rough indication of pH. As pH is temperature–dependent, it is also necessary to measure the water's temperature in order to determine the pH with accuracy. If field measurement is not feasible, samples must be brought to the laboratory in completely full, tightly sealed bottles with no extra preservatives. 4.7.2 REDOX POTENTIAL (Eh) The redox potential (Eh) of natural waters characterizes their oxidation–reduction state. Ions of the same element but in different oxidation states constitute the redox–system, which has a specific value. Organic compounds can also create redox systems. The coexistence of several such systems results in an equilibrium that governs the redox–state of the water and is represented by the Eh value. The most significant factors in influencing Eh are oxygen, iron, and sulphur, as well as various organic systems. When dissolved oxygen concentrations increase, for example, Eh values rise and can reach +700 mV. The presence of hydrogen sulphide is generally accompanied by a sharp decrease in Eh (down to –100 mV or more) and is indicative of reducing conditions. In natural waters, the Eh can range from –500 mV to +700 mV. Surface and ground waters with dissolved oxygen typically have Eh values ranging from +100 mV to +500 mV. The Eh of mineral waters associated with oil deposits is significantly less than zero, and may even reach a limit value of –500 mV. Redox potential is determined potentiometrically and may be measured in situ in the field, although reliable Eh measurements are difficult to obtain. As a result, the outcomes and interpretation of any Eh measurements should be approached with care. Because Eh is influenced by the gas content of the water, it can be very changeable when the water comes into contact with air. Therefore, where in situ determination is not possible, determination of Eh should be conducted immediately after sampling, and for groundwater, it is recommended that Eh be measured "in–line" in the flowing discharge of a pump. 4.8 SUMMARY Water, being one of the most precious natural resources, has to be purified and toxic impurities need to be removed. Using different techniques, it is possible to estimate the amount of oxygen

75 dissolved in water, which is much needed for the aquatic kingdom. The biochemical oxygen demand (BOD) and the chemical oxygen demand (COD) tests are the main methods used in the determination of the concentration of organic matter in a sample of water. COD and BOD tests are important because they help in the determination of the amount of waste in wastewater. This is important because the organic content of wastewater needs to be reduced before the wastewater is discharged. Failure to reduce the organic content can result in eutrophication of rivers, lakes, and other water bodies. Because of the time difference, BOD and COD tests are performed together. Sedimentation is a physical water treatment process that uses gravity to remove suspended solids from water. Solid particles entrained by the turbulence of moving water may be removed naturally by sedimentation in the still water of lakes and oceans. Coagulation and flocculation are two separate processes, used in succession, to overcome the forces stabilizing the suspended particles. While coagulation neutralizes the charges on the particles, flocculation enables them to bind together, making them bigger so that they can be more easily separated from the liquid. pH has a direct impact on wastewater treatability since it is a chemical component of the wastewater, regardless of whether the treatment is physical/chemical or biological. Because it is such a critical component of the makeup of the wastewater, it is therefore critically important to treatment, and along with it, the redox potential also plays an important role. 4.9 QUESTIONS / SELF ASSESSMENT QUESTIONS 11 . Define water chemistry. 12 . What is the role of manganese (II) sulphate and potassium iodide solution in the detection of dissolved oxygen? 13 . What do you mean by BOD and COD? How are these determined? Which one is preferred? 14 . Define the sedimentation process. Discuss the important factors that influence this process. 15 . Differentiate between coagulation and flocculation. Mention the chemical reactions using sodium aluminate and alum as coagulants. 16 . Make a short note regarding the importance of pH and redox potential in adjusting water quality. 4.10 SELECTED READINGS / SUGGESTED READING [11] Bache DH & Gregory R (2007) Flocs in Water Treatment. IWA Publishing, London [12] Bratby J (2006) Coagulation and Flocculation in Water and Wastewater Treatment. IWA Publishing, London

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77 UNIT 5: PRINCIPLES OF ANALYTICAL METHODS Structure 5.1 Objectives 5.2 Introduction 5.3 Design of sampling techniques (air, soil, biological matters) 5.4 Gas chromatography 5.5 High–performance liquid chromatography (HPLC) 5.6 Gas chromatography–mass spectrometry (GC–MS) 5.7 Atomic absorption spectroscopy 5.8 Flame photometry 5.9 Inductively coupled plasma mass spectrometry (ICP–MS) 5.10 X–ray diffraction (XRD) 5.11 X–ray fluorescence (XRF) 5.12 FTIR spectroscopy 5.13 Electron microscopes 5.14 Summary 5.15 Questions / Self assessment questions 5.16 Selected readings / Suggested reading 5.1 OBJECTIVES With the help of this unit, you will be able to: ➢ explain the meaning and importance of sampling, ➢ describe the various methods or techniques of sampling, ➢ comprehend the principle, instrumentation, and applications of conventional analytical (chromatographic, spectroscopic, and microscopic) instruments, ➢ describe modern, promising, and sophisticated techniques such as HPLC, GC–MS, ICP–MS, and FTIR, ➢ define atomic absorption spectrometry and its different types, ➢ explain the principle of flame photometry, XRD, and XRF and draw their schematic diagrams illustrating different components, ➢ demonstrate SEM and TEM, and discuss the similarities and differences between SEM and TEM.

78 5.2 INTRODUCTION Environmental contaminants are any physical, chemical, or biological substance that has an adverse effect on air, water, soil, or biological matters. Therefore, it is essential to properly identify and quantify the contaminants using reliable analytical techniques. The sampling strategy has a substantial impact on the significance of the analysis. By using suitable sampling techniques, a small portion of an entity can be representative of the bulk to offer adequate and necessary information. This chapter describes the design of sampling techniques for the benefit of students, as well as the principles, instrumentation, and some applications of more important analytical methods (chromatographic, spectroscopic, and microscopic). In addition to the aforementioned instrumental techniques, X–ray diffraction, X–ray florescence, and some recent developments such as high–performance liquid chromatography, gas chromatography– mass spectrometry, inductively coupled plasma mass spectrometry, and fourier transform infrared spectrometry will be presented and discussed. 5.3 DESIGN OF SAMPLING TECHNIQUES (AIR, SOIL, BIOLOGICAL MATTERS) To properly understand our environment, we need to know the identities and amounts of contaminants and other chemical species found in air, water, soil, and biological matters. As a consequence, environmental chemistry relies significantly on reliable techniques capable of addressing the challenging difficulties of environmental chemical analysis. The relevance of a chemical analysis depends to a large extent on the sampling programme. Sampling is possibly the most important stage in the entire analytical process in environmental studies. Before discussing sampling, it is necessary to understand the terms "population" and "sample." The entity that an analyst wants to understand is the population. It might be a group of people, a group of animals, or a body of air living in a contaminated region of land, a body of water, the top 6 inches of soil in a particular location. The sample consists of the items that are actually collected and measured. A sample design is a specific strategy for selecting a sample from a larger population. Three key factors must be considered in developing a sampling strategy. • The study objectives: Different sampling strategies are required for different objectives. For example, if the goal is to determine the total amount of heavy metals released into a river by an industry, a 24-hour integrated sample may be collected. However, if the purpose is to monitor for accidental discharges, sampling and analysis may have to be done almost continuously. • The pattern and variability of environmental contamination: The variability in the concentrations to be assessed influences the number of samples to be collected in space and time. Pollutant levels in the air, for example, might change dramatically depending

79 on meteorological circumstances or traffic patterns. In general, a larger number of samples must be analyzed if the spatial or temporal variability is high. • Cost of the study: If more samples are examined, the information gained will be more precise and accurate. More samples, on the other hand, need more money, time, and resources. Therefore, it is necessary to create an effective sampling plan using the resources available. Other factors in developing a sample strategy include convenience, site accessibility, sampling equipment limitations, and legal restrictions. A well–planned strategy is required to obtain the most information from the fewest number of samples. The strategy might be statistical or non–statistical. There are several approaches to designing a sample strategy that are often used in environmental data collection. These approaches include judgmental (non–statistical), simple random, stratified, and systematic sampling. Multiple of these may be used at the same time. Often, little is known about the environmental area to be studied. A statistical approach is used to improve accuracy and reduce bias. Judgmental Sampling: This is a non–statistical sampling method. The subjective selection of sampling locations based on professional judgment using prior information about the sampling site, visual inspection, and/or personal knowledge and experience is referred to as judgment sampling. For example, if you are looking for contamination on a property, you do a visual inspection and sample those spots that appear to be polluted based on colour, odour, surroundings, and so on. Judgment sampling is useful as a screening technique or to find worst–case scenarios. In many cases, this is the best method to use, especially when the goal of the analysis is just to identify the contaminants present. Judgmental sampling usually requires fewer samples than statistical approaches, but the analyst must be aware of the limitations of the samples collected by this method. Samples taken in this manner are not representative of the population and should not be used to make inferences about a population. Simple Random Sampling: The simplest and most fundamental probability–based sampling approach is simple random sampling, often known as random sampling. Random sampling is based on the idea that each population unit has an equal probability of being selected. Simple random sampling uses random numbers to select particular sample units, and all possible selections of a given number of units are equally likely. Random methods are appropriate when the population is reasonably homogenous, that is, when no major trends or patterns of contamination or "hot spots" are expected. The following are the primary benefits of this design: (i) It provides statistically unbiased estimates of the mean, proportions, and variability. (ii) It is easy to understand and apply. (iii) The calculations for sample size and data analysis are relatively simple. For heterogeneous populations, simple random sampling is inapplicable. The ability of the random sampling strategy to accurately represent actual situation decreases with increasing

80 heterogeneity. Furthermore, while the complete randomizations approach defines statistical uncertainty, it may also cause a number of problems. Stratified Sampling: When there are several distinctly different areas in a system, they can be sampled separately using a stratified sampling scheme. Stratified random sampling divides the population into non–overlapping regions or strata and chooses a random sample from each stratum. Each stratum is more homogenous than the overall population. However, stratum selection requires some prior knowledge of the population to be sampled. A hazardous waste site, for example, can be divided into different regions. The soil samples are then collected at random within each region or in randomly selected regions. This design is useful for estimating a parameter when the target population is heterogeneous and the area can be subdivided based on projected contamination levels. A significant advantage of stratified random sampling is that the sample size can be adjusted based on the variations or cost of sampling in different strata. Strata that are expected to be more variable or less expensive should have more intensive sampling. This offers more precision in mean and variance estimations and also saving money than simple random sampling. Greater precision is possible if the measurement of interest is highly associated with the variable used to make the strata. Systematic Sampling: Systematic sampling is the method of selecting sample units based on a predefined pattern in time or space. This guarantees that the entire population is covered evenly. There are some minor differences between systematic grid sampling and systematic random sampling for two–dimensional space sampling. The systematic grid sampling method splits the region of concern into square or triangular grids and collects samples from the nodes (grid line intersections) or a fixed location (e.g., centre) of each grid. The initial sample from a population is selected at random (e.g., using a random number table), but all subsequent samples are obtained at a fixed space or time interval. The systematic random sampling splits the area into grids and then performs simple random sampling to collect a sample from within each grid cell. This approach does not need prior knowledge of contaminant distribution and should provide unbiased samples. However, systematic sampling may need the collection of more samples than other strategies. Systematic sampling is used to find hotspots and infer means, percentiles, or other parameters. It is also useful for estimating spatial patterns or trends over time. This design provides a practical and simple approach for designating sample locations and ensures uniform coverage of a site, unit, or process. 5.4 GAS CHROMATOGRAPHY Since 1952, gas chromatography (GC) has proven to be a potent analytical technique for qualitative and quantitative analysis. Compounds that are capable of being vaporized without decomposing have been separated out and analyzed using this technique. GC is commonly used to analyze volatile liquids, vapors, gases, and low levels of pesticides in the environment. Figure 1 shows some typical GC results for organochlorine pesticides.

81 Figure 1: GC of organochlorine pesticides by electron capture detector (Source: A.K. De) 5.4.1 PRINCIPLE OF GAS CHROMATOGRAPHY Components in the mixture are distributed between two phases, one of which is a stationary phase, and the other is a mobile phase. The stationary phase is a microscopic layer of viscous liquid on the surface of solid particles on an inert solid support inside a column, which is a piece of glass or metal tubing. The column is usually enclosed in a temperature–controlled oven. The mobile phase is typically an inert or uncreative gas (i.e., the carrier gas), which carries the mixture through the stationary phase. Compounds in the mobile phase interact with the stationary phase as they move through. The magnitude and affinity of each interaction with the stationary phase vary due to differences in the properties and structures of each component. As a result, under the same driving force, the retention time of different components in the column varies, causing them to leave the column in different orders and finally be detected by an appropriate detector. Figure 2 is a diagrammatic depiction of a gas chromatograph. 5.4.2 BASIC APPARATUS OF GC ❖ Carrier Gas & Sample Introduction Ar, He, N 2 , or H 2 are the carrier gases. Helium is the most commonly used mobile–phase gas, however hydrogen is not favored due to its fire and explosion risks, as well as its reactivity to reducible or unsaturated sample components. These gases are available in pressurized containers. The flow rate of the gas must be controlled using pressure regulators, gauges, and flow meters. The carrier gas should have a regulated flow rate (60–80 mL/min). In the carrier gas stream, the sample is introduced as a single compact plug. Gases or volatile liquids are used as samples. The injection port is heated to rapidly evaporate liquid samples. Liquid samples of 0.1 to 10 µL and gas samples of 1 to 10 mL are commonly inserted via a rubber septum with a hypodermic syringe.

82 Figure 2: Schematic diagram of a gas chromatograph (Source: Wikipedia) ❖ Column Gas chromatography is classified into two types based on the state of the stationary phase: gas–liquid chromatography (GLC) and gas–solid chromatography (GSC). The stationary phase in GSC is made of a solid substance like granular SiO_2, Al_2O_3, or C. The most common type is GLC, in which the stationary phase is a non–volatile liquid (silicon oil, polyethylene glycol, etc.) held as a thin layer on a solid support (diatomaceous earth or crushed firebrick, 60–80 mesh or 100–200 mesh or size). The packed column is typically made of 4 mm stainless steel or glass tubing bent in a V–shape or coiled. The lengths of such tubes range from 120 cm to 150 m. Capillary columns have recently become popular in gas chromatography. The capillary column is a thin (0.25 mm inner diameter and 50 m long) glass or metal tube made of fused silica. In terms of separation and efficiency, they beat packed columns, and they may resolve up to several hundred components from a sample. ❖ Detector A detector is a device placed at the ends of the column that detects components of the mixture being eluted off the chromatography column in combination with the carrier gas. Gas chromatographic detectors fall under three distinct categories: A. Non–selective: Respond to all compounds that leave the chromatographic column except the carrier gas. B. Selective: Respond to a range of compounds with similar physical and chemical characteristics. C. Specific: Respond exclusively to one chemical compound in the carrier stream. A detector cannot meet all of the requirements. The following are some of the most prevalent types of gas chromatography detectors and their common applications: ▪ Flame Ionization Detector (FID): The FID is the most widely used detector. It has a detection limit of 0.1 ppm and can detect almost all organic compounds (excluding
83 carbonyl and carboxyl groups). FID has high sensitivity, a large linear response, low noise, and ruggedness. However, it is destructive in nature and destroys the sample. Inorganic gases having little or no response include CO, CO_2, NH_3, CS_2, NO_X, noble gases, and halogenated compounds. ▪ Thermal Conductivity Detector (TCD): TCD is also known as a universal detector since it detects most compounds, including inorganic gases (such as O_2, N_2, and CO_2) and components that the FID does not detect. It has a detection limit of 0.05 ppm and can detect at both high percent and low ppm levels. ▪ Nitrogen Phosphorus Detector (NPD): The Nitrogen Phosphorus Detector responds preferentially to most organic compounds containing phosphorus or organically bound nitrogen down to the picogram level. Its excellent sensitivity and specificity make it ideal for analyzing low levels of drugs and pesticides. ▪ Electron Capture Detector (ECD): The ECD is a selective, high–sensitivity detector for electrophilic compounds. Halogenated substances, nitriles, nitrates, and compounds with conjugated double bonds are all analyzed in trace amounts using the electron capture detector. It is widely used in the analysis of environmental samples including organochlorine pesticides, PCB's, and other contaminants. ▪ Flame Photometric Detector (FPD): For phosphorus compounds, sulphur compounds, and alkyl tin compounds, the FPD is a selective, high–sensitivity detector. Mercaptans, alkyl sulphides, H_2S, CS_2, and SO_2 are examples of sulphur compounds found in petroleum fractions and pulp–milling operations. Alkyl tin is used in marine antifouling paints that are applied to boat hulls and sea oil rigs. The release of such paints into the sea poses an environmental risk. ▪ Photoionization Detector (PID): The PID detects compounds that have been ionized by UV radiation. It detects aromatic and unsaturated compounds in samples of drinking water, wastewater, soil, and sludge. Other uses include the detection of aromatics such as benzene, toluene, xylene, and polynuclear aromatic hydrocarbons in petroleum fractions. 5.5 HIGH–PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC) Gas–liquid chromatography (GLC) is a well–established technique for separating components in mixtures at very low–levels; however, it fails in the case of substances with low–vapor pressure or that are unstable at high temperatures. Liquid chromatography is used to separate those compounds, with small–sized solid absorbents operating at high–pressure with a steady solvent flow. This technique, known as high–pressure liquid chromatography or high–performance liquid chromatography (HPLC), is very convenient for non–volatile solutes.

84 Figure 3: Schematic diagram of a high–performance liquid chromatograph (Source: A.K. De) The primary application of HPLC is to separate, identify, and quantify each component of a mixture. It uses pumps to move a pressurized liquid solvent containing the sample mixture through a column packed with a solid adsorbent material. Each component in the sample interacts with the adsorbent material somewhat differently, resulting in various flow rates for the various components and leading the components to separate as they flow out from the column. Figure 3 depicts a diagrammatic representation of HPLC. The solvent is taken up by a pump through a filter, delivered to a rotatory injection valve, equipped with a sample loop, filled from a micro syringe, and then to the column, detector, and waste. On the recorder, the output is displayed. The solvent pressure is reflected on the gauge. The pump delivers the solvent at a constant pressure of up to 4500 psi and at low rates of a few ml/min. The sample size ranges from 1 to 20 μl of solution. The column is made of thick–walled stainless-steel tubing that is 10 or 20 cm long with a diameter of 2–3 mm and packed with granular material made of solid particles (e.g., Al 2 O 3 , silica gel, polymers, etc.) varying in size from 2 to 50 μm. 5.5.1 SOME IMPORTANT PARAMETERS OF HPLC • Gradient and Isocratic: Two different modes are generally applicable depending on the composition of the mobile phase. If the mobile phase's composition remains constant during the separation process, the HPLC system is classified as an isocratic elution system. When the mobile phase composition changes during separation, the HPLC system is defined as a gradient elution system. • Column: The heart of every HPLC system is the column. It is responsible for the adequate separation of the sample ingredients. The length of the column, the type and size of the packing material used in the column, as well as the inner diameter of the column, all affect separation efficiency. Several HPLC columns are commercially available, depending on the use. Different packing materials support different separation mechanisms in HPLC, namely normal–phase, reversed–phase, size exclusion, ion exchange, affinity, chiral, and hydrophilic interaction.

85 • Detector: The task of the detector is to keep records of the time and amount of a substance eluting from the column. The detector detects changes in the composition of the eluent and converts this information into an electrical signal that is analyzed by a computer. Depending on the structural properties of the analyte, a variety of detectors are available. Refractometric, UV/VIS, electrochemical, and fluorescence detectors are examples of common detector types. • Chromatographic Parameters: The detector unit records the signal peaks of the separated analytes that are transported by the mobile phase. The total amount of all peaks is called the chromatogram. Each peak contains qualitative and quantitative information about the analyte. The peak itself offers qualitative information, such as shape, signal intensity, and appearance time on the chromatogram. Furthermore, the area of a peak is proportional to the substance's concentration. As a result, the chromatographic data management software can determine the sample concentration by integration. This provides quantitative information. Ideally, the peaks should be recorded as a Gaussian bell–shaped curve. Figure 4 shows a simplified example. The basic parameters of a chromatographic separation are discussed further below. Figure 4: Schematic illustration of a chromatogram • Delay Time (t 0): The delay time refers to the time which is required for a non–retarded compound to be transported from the injection site to the detector unit. During this period, all sample molecules are solely in the mobile phase. Typically, all sample molecules share the same delay time. The separation is caused by the different adherence of the substances to the stationary phase. • Retention Time (t r): The retention time of a substance is the time required from the moment it is injected until it is detected. t r is basically the time that a solute spends in a column, or it can be defined as the time spent in the stationary and mobile phases. The interaction of the analyte with the stationary phase causes the longer retention time. The

86 stronger the interaction, the longer the retention time. The t r is substance–specific, and it should always provide the same values under the same conditions. • Peak Width (w): The peak width covers the period from the beginning of the signal slope until reaching the baseline after repeated drop in the detector signal. • Tailing Factor (T): In practice, perfectly symmetric peaks are quite uncommon. Tailing is common in chromatograms. The tailing factor T is used to measure the peak tailing. This factor describes the peak asymmetry, i.e. to which extent the shape is approximated to the perfectly symmetric Gaussian curve. T = b/a is the tailing factor (where "a" represents the width of the front half of the peak, "b" is the width of the back half of the peak). The values are measured at 10% of the peak height from the leading or trailing edge of the peak to a line dropped perpendicularly from the peak apex (Figure 4). A symmetrical peak is represented by T = 1. When T < 1, the peak profile is known to as tailing. The peak profile T > 1 is termed as fronting. Figure 5 shows an example of a chromatogram of certain contaminants in water. Figure 5: Separation of some water pollutants (Source: A.K. De) 5.6 GAS CHROMATOGRAPHY–MASS SPECTROMETRY (GC–MS) Gas chromatography–mass spectrometry (GC–MS) is a hyphenated analytical technique that may perform both qualitative and quantitative analyses on liquid, gaseous, or solid materials. It combines the features of gas chromatography and mass spectrometry to form a single framework for identifying distinct substances within a test sample. The components of a mixture are separated using gas chromatography, and each component is separately characterized using a mass spectrometer detector. A mass spectrum contains enough information to unambiguously identify a compound. The GC/MS combo can analyze a few nanograms of a sample and provide a large quantity of information. GC–MS is gradually becoming the preferred tool for detecting organic contaminants in the environment. The cost of GC–MS equipment has reduced dramatically, while its reliability has grown, contributing to its increasing use in environmental investigations.

87 Figure 6: Partial mass spectrum of a water pollutant 2,4–D (Source: S. Manahan) When the components leave the GC column, they are ionized and fragmented by the mass spectrometer using electron or chemical ionization sources. Ionized molecules and fragments are subsequently accelerated through the instrument's mass analyzer. Ions are separated here based on their different mass–to–charge (m/z) ratios, such as the one shown in Figure 6. GC–MS data gathering can be done in either full scan mode, which covers a wide range of m/z ratios, or selected ion monitoring (SIM) mode, which gathers data for specific masses of interest. The final steps of the process involve ion detection and analysis, with fragmented ions appearing as a function of their m/z ratios. Meanwhile, peak areas are proportional to the quantity of the corresponding compound. When a complex sample is separated by GC–MS, it produces many different peaks in the gas chromatogram, and each peak gives a unique mass spectrum that may be used to identify the compound. Unknown substances and target analytes can be identified and quantified using extensive commercially available libraries of mass spectra. 5.7 ATOMIC ABSORPTION SPECTROSCOPY Atomic absorption spectrometry (AAS) is a simple, high–throughput, and low–cost technique that is mostly used to analyze elements in solution. AAS can be used to determine over 70 different elements in solution or directly in solid samples by electrothermal vaporization, and is utilized for trace metal analysis of a wide range of sample types in the environmental sciences, food and beverage, chemical, and pharmaceutical sectors for impurity or contamination monitoring and quality control, as well as the rapid assessment of raw materials. 5.6.1 PRINCIPLE

88 Figure 7: Basic components of AAS (Source: S. Manahan) AAS concept is based on the absorption of light to determine the concentration of specific metal atoms in a solid or liquid by vaporizing the sample in a flame (FAAS) or graphite furnace (GFAAS). A specific wavelength of light excites the ground state free metal atoms, with the amount of energy absorbed proportional to the number of atoms of that element in the sample. The difference in absorption between the sample and the background is then measured and compared to the absorption of standard solutions. It relies on the Beer–Lambert law since it requires standards with known analyte content to establish the relationship between measured absorbance and analyte concentration. Figure 7 is a diagrammatic sketch of AAS. 5.7.1 INSTRUMENTATION Atomic absorption devices have flame, non–flame, and graphite furnaces for instrumentation. The following components are found in any atomic absorption spectroscopy instrument: • Atomization • Hollow cathode lamp • Monochromator • Detector ❖ Atomization Atomization can be performed either by a flame or a furnace. In atomic absorption spectroscopy, heat energy is used to convert metallic elements to atomic dissociated vapour. The temperature must be maintained properly for the conversion of atomic vapour. Atoms may be ionized at extremely high temperatures. Fuel and oxidant gases are fed into a mixing chamber before passing via baffles to the burner. To produce a flame, natural gas, propane, butane, hydrogen, and acetylene are commonly utilized as fuels. In atomic absorption spectroscopy, an oxidant such as air, oxygen, nitrous oxide, or a combination of nitrous oxide and acetylene is used to create a flame. The AAS instrument produces a ribbon flame. The sample is aspirated into the mixing chamber through the air. ❖ Hollow Cathode Lamp

89 A constant source of radiation is required in the AAS instrument. Problems arise due to the extreme narrowness of the absorption line in the sources. In atomic absorption spectroscopy instrumentation, a hollow cathode glow discharge lamp is used to produce shaped emission lines for a specific element. The electrodes of the hollow cathode lamp are cup–shaped and made of a specific element. Because the radiation from the hollow cathode lamp should not be continuous owing to spurious radiation, a chopping wheel is used between the radiations or pulsed potential. The metal utilized in the cathode is the same as the metal that was analyzed. At low pressure, the lamp is filled with noble gases, primarily Ar (Argon). The hollow cathode of the lamp produces a glow of emission. There are several types of hollow cathode lamps available, the most popular of which are multi–element hollow cathode lamps. Such lamps make it possible to determine samples without changing the lamps every time, and they are commonly are commonly used in AAS. ❖ Monochromator A monochromator is an optical device that transmits a narrow band of light or other radiation from a wider range of wavelengths. The atoms in the AAS instrument accept excitation energy and emit radiation. A monochromator may isolate a desired band of lines by passing a narrow band. A curve can depict the spectra through a monochromator. ❖ Detector A detector is a device that converts light from a monochromator into a simpler electrical signal. In general, a photomultiplier tube was utilized as a detector in the atomic absorption spectroscopy instrument. A detector can be programmed to respond to a specific wavelength or frequency. Nowadays, a computer system with appropriate software is used to analyze the detector's response. 5.7.2 TYPES OF AAS A. Flame Atomic Absorption Spectroscopy (FAAS): FAAS is often used to determine metal concentrations in solution in parts per million (ppm) or parts per billion (ppb) ranges. Metal ions are nebulized as a fine spray into a high–temperature flame and reduced to atoms, which selectively absorb light from an element–specific hollow cathode lamp. The primary disadvantages of this technique are its low sensitivity, capability to measure only one element at a time, and limited linearity. Despite these drawbacks, it has shown to be an excellent and robust technique for routine metal determination. B. Graphite Furnace Atomic Absorption Spectroscopy (GFAAS): GFAAS is a more sensitive technique for detecting very low metal concentrations (< 1 ppb) in low volume samples. The graphite furnace has a detection limit 1000 times greater than a typical flame. Instead of a flame, a narrow carbon tube is used to atomize the sample, improving sensitivity and detection limit by eliminating spectral noise from the flame and ensuring that much more of the sample is atomized.

90 C. Hydride Generation Atomic Absorption Spectrometry (HGAAS): A kind of atomic absorption spectrometry in which metal samples such as As, Sb, Se, Bi, and Pb are vaporized by converting them into volatile hydrides. An acidified aqueous solution of the sample is treated with a 1% aqueous solution of sodium borohydride in a glass vessel to produce hydride. The volatile hydride generated by the reaction is swept into the atomization chamber by an inert gas, where it decomposes. This method produces an atomized form of the analyte, which is measured by absorption spectrometry. When compared to other techniques, hydride atomization enhances detection limits by a factor of 10 to 100 for early specified elements. D. Flameless (Cold vapour) Atomic Absorption Spectrometry (CVAAS): CVAAS is a special technique for determining organic mercury compounds in samples and their distribution in the environment. The process is initiated by oxidizing mercury into Hg 2+ using nitric and sulfuric acids, followed by a reduction of Hg 2+ to the elemental state by SnCl 2 . The resulting mercury vapor is then swept into an absorption cell with air and exposed to a beam of radiant light from an Hg–vapor lamp. Nanogram (10 –9 g) quantities of mercury can be determined by measuring at 253.7 nm. 5.8 FLAME PHOTOMETRY Bowling Barnes, David Richardson, John Berry, and Robert Hood developed a tool in the 1980s to measure low sodium and potassium contents in a solution. This instrument was given the name Flame photometer. A flame photometer works by measuring the intensity of light emitted when a metal is placed into the flame. The wavelength of the colour indicates the element, whereas the colour of the flame indicates how much of the element is present in the sample. Flame photometry is one of the branches of atomic absorption spectroscopy. Flame emission spectroscopy is another term for it. Flame photometry has evolved into a simple, low–cost, high–throughput method for routine analysis of Na, K, Li, Ca, Mg, and Ba in clinical, biological, pharmaceutical, food, industrial, and environmental contexts. 5.8.1 PRINCIPLE The flame photometric principle is based on the dissociation of alkali metals (Group I) and alkaline earth metals (Group II) metals due to the thermal energy provided by the flame source. Thermal excitation causes atoms to be excited to a higher energy level where they are unstable. Each excited atom emits light at the characteristic wavelengths as the electron returns to the ground state. The emission wavelength for the analyzed element is isolated and detected in the spectrometer, and the corresponding emission spectrum can be utilized as an unique feature for qualitative identification of the element. The intensity of light emitted (at the characteristic wavelength of the element to be assessed) is measured for quantitative analysis and is proportional to its concentration in the solution.

91 5.8.2 INSTRUMENTATION A flame photometer is composed of a pressure regulator and flow meter for fuel gases, an atomizer, burner, optical system, and detector (Figure 8). Figure 8: Schematic of a flame photometry assembly (Source: S.M. Khopkar) (i) Accessories: The pressure regulator and flowmeter are used to manage the pressure and flow of gases. A 10 lb gauge for fuel and a 25 lb gauge for oxygen are required. Pressure is controlled by double diaphragm and needle valves. A rotameter should be installed in the gas line to control the flow of gas. To obtain good results, a flow rate of 2–10 ft hr is preferable. (ii) Atomizers: The atomizer is used to introduce a liquid sample into the flame at a stable and reproducible rate. They are divided into two types: those that introduce the spray into a condensing chamber to remove large droplets and those that introduce the spray directly into the flame. 4–25 ml of sample are required per minute, of which 5% reach the flame. (iii) Flame: The source of flame in the flame photometer is a burner. It can be maintained at a constant temperature. The temperature of the flame is an important factor in flame photometry. A flame is made up of two components: fuel and an oxidant. The temperature of the flame varies according on the type of fuel and oxidant used, as well as their proportions. Natural gas is typically used as a fuel in flame photometers, with air acting as the oxidant. Table 1 lists the various types of fuel, oxidants, and flame temperatures. Table 1: Flame components and temperatures Fuel–Oxidant mixture Temperature (°C) Natural gas–Air 1700 Propane–Air 1800 Hydrogen–Air 2000 Hydrogen–Oxygen 2650 Acetylene–Air 2300

92 Acetylene–Oxyen 3200 Acetylene–Nitrous oxide 2700 Cyanogen–Oxygen 4800 (iv) Optical system: The optical system is made up of three parts: a convex mirror, a lens, and a filter. The convex mirror helps to transmit light emitted from the atoms and focus the emissions to the lens. The convex lens aids in focusing light on a point known as the slit. Mirror reflections pass through the slit and reach the filters. The use of absorption or interference filters isolates the characteristic radiations used, even though a monochromator isolates them better. It is necessary to have a good slit with a narrow opening. (v) Detector: A photodetector measures the intensity of the radiation emitted by the flame. With the help of a photodetector, the emitted radiation is transformed to an electrical signal. These electrical impulses are directly proportional to the intensity of light. Phototubes and amplifier units are used in the detectors to boost the output. The use of photoelectron multiplier tubes in detectors is ideal for flame photometry. 5.9 INDUCTIVELY COUPLED PLASMA MASS SPECTROMETRY (ICP–MS) ICP–MS (inductively coupled plasma mass spectrometry) is a new technique that can detect most elements in the periodic table at concentrations as low as 1 part in 10 15 (parts per quadrillion). ICP–MS is a type of mass spectrometry that ionizes the sample by inductively coupled plasma. It atomizes the sample, creating atomic and small polyatomic ions that are detected and quantified using a mass spectrometer. ICP–MS offers greater speed, precision, and sensitivity when compared to atomic absorption spectroscopy. It is used in a range of sectors, including but not limited to geological analysis, metallurgy, pharmaceutical analysis, and clinical research. Until recently, ICP–MS was largely utilized in the environmental area to analyze water and air. 5.9.1 PRINCIPLE In its most basic form, ICP–MS takes a pre–prepared liquid containing the analyte and pumps it through a nebulizer to make an aerosol, which is then introduced into an argon gas plasma. The high temperature of the plasma is sufficient to atomize and ionize almost all elements, including those with the highest ionization potentials. With the help of electrostatic ion optic elements, the analyte ions so formed can be steered into a mass spectrometer where they can be detected and separated based on their mass to charge (m/z) ratio. The counts for an elemental ion are indicative of its concentration in the analyte since ionization is almost 100% efficient for the most of elements.

93 5.9.2 ICP–MS INSTRUMENT A simple ICP–MS system (Figure 9) consists of an ICP torch connected to an MS via an interface. The use of a mass spectrometer is the same as stated earlier. Figure 9: Schematic diagram of a of ICP–MS A typical ICP torch is formed by three concentric quartz tubes and a coil that carries high energy radio frequency power in the range of 1 to 3 kilowatts. The radio frequency power acts on the argon exiting the middle tube to produce plasma with a temperature of more than 6000 °K. Plasma is created by energetic collisions among argon atoms oscillating in a high energy radio frequency field. The outer tube contains argon gas, which flows rapidly and acts as a barrier or cooling layer to keep the torch from melting under the tremendous heat of the plasma. The inner tube carries the aerosolized sample into the plasma's core. Specimens introduced into the plasma are vaporized, atomized, and ionized in a matter of seconds. The argon carrier gas flow rate positions the plasma for sampling into the mass spectrometer. 5.10 X–RAY DIFFRACTION (XRD) X–ray diffraction, or XRD, is a technique for analyzing the mineralogical composition and physical properties of materials. It is nondestructive and performs better with materials that are entirely or partially crystalline. The most common application is identifying compounds, including minerals, in a powdered specimen. Mineralogical composition can have a significant impact on how nutrients, pollutants, aerosols, and organic matter interact within and between ecosystems. Using these observations, it may be feasible to better predict the behavior of chemical compounds in the environment, as well as ecosystem responses to environmental perturbations.

94 5.10.1 PRINCIPLE The constructive interference of monochromatic X–rays and a crystalline sample is the basis for XRD. A cathode ray tube generates these X–rays, which are then filtered to produce monochromatic radiation, collimated to concentrate, and directed toward the sample. Since X–rays have wavelengths (between 0.2 to 10 nm) comparable to the interatomic spacing of a crystalline material, the incident X–ray beam diffracts in specific directions predicted by Bragg's law. The resultant diffraction pattern is a basic physical property of the material, giving not just identification but also thorough understanding of its structure. 5.10.2 INSTRUMENTATION Figure 10 is a simplified diagrammatic representation of XRD. An X–ray tube, a collimator, a monochromator, and a detector are the four essential components of XRD. Figure 10: Schematic diagram of a of XRD (i) X–ray tube: X–ray tubes are also called Coolidge tubes. Tungsten is the cathode and copper is the anode. The process is efficient in X–ray tubes. Because of thermionic emission heating, the anode is cooled with water. (ii) Collimator: X–rays are generated by the target material when allowed to pass through a collimator. It consists of two sets of closely packed metal plates separated by a small gap. The collimator absorbs all the X–rays, but the narrow beam that passes between the gaps is not absorbed. (iii) Monochromator: The following types of monochromators are used: • Filter: A filter is a window of material that absorbs unwanted radiation while allowing required wavelengths to pass through. • Crystal Monochromator: These are formed of a suitable crystalline material that is positioned in the X–rays beam such that the angle of reflecting planes satisfies the Bragg's equation for the required wavelength, and the beam is split up into component wavelengths. Monochromator crystals are made of materials like (iv) Detector: Detectors are also referred to as "transducers" and "signal processors." There are several variations, such as photon counting, gas filled d–electrodes, GM tube, proportional counter, semiconductor counters and scintillation counters. Photon counting

95 is ineffective for high–intensity radiation beam, although it is useful in the absence of a monochromator. A gas–filled transducer is more efficient. The GM tube lacks a lengthy counting time. 5.11 X–RAY FLUORESCENCE (XRF) The XRF technique, like XRD, provides the simplest, most accurate, and least expensive analytical method for determining the chemical composition of a wide range of materials. It is also non–destructive and reliable, requiring no or minimal sample preparation, and is suitable for solid, liquid, and powdered materials. XRD is very effective for analyzing atmospheric particulate matter. Some water and soil samples can also be tested with it. When a sample is exposed to energetic X–rays, gamma rays, or protons, secondary radiation is produced as electrons drop into vacant positions in the inner orbitals. The energy of the emitted X–rays is specific to the atom. The emitted radiation's energy (wavelength) offers a qualitative evaluation of the elements, whilst the intensity of the radiation provides a quantitative analysis with reference to a standard sample. XRF has detection limits at the sub–ppm level and can easily and concurrently measure concentrations of up to 100 percent. Figure 11: X–ray florescence spectrophotometer (Source: A.K. De) Figure 11 illustrates the working principle of an X–ray florescence spectrophotometer. An excitation source, which is typically an X–ray tube emitting continuum X–rays, produces a primary beam of energetic radiation that excites fluorescent X–rays in the sample. A radioactive source emitting gamma rays or protons from an accelerator is an alternate excitation source. The sample is mounted as a thin layer: segments of air filters containing fine particulate matter make perfect samples. The resulting fluorescent X–rays are passed through a collimator to choose a parallel secondary beam, which is dispersed according to wavelength by diffraction with a crystal monochromator. The monochromatic X–rays in the secondary beam are counted using a detector that rotates at twice the rate of the crystal to scan the spectrum of emitted radiation. The usage of energy–selective detectors of the Si(Li) semiconductor type for the detection of fluorescence

96 X–rays of different energies is a new development. This dispenses with the wavelength dispersion device. 5.12 FTIR SPECTROSCOPY The most familiar form of infrared spectroscopy is FTIR, which stands for "Fourier transform infrared." All infrared spectroscopies work on the idea that some infrared (IR) radiation is absorbed when it passes through a material. The radiation that passes through the sample is recorded. Because different molecules produce different spectra due to their varied structures, the spectra may be utilized to identify and distinguish among molecules. In this sense, the spectra are almost identical to people's fingerprints or DNA. For several reasons, FTIR is the favored method of infrared spectroscopy. First and foremost, it does not destroy the sample. Second, it is substantially faster than prior procedures. Third, it is far more sensitive and precise. The IR spectra of an FTIR instrument are obtained in a couple of seconds applying a mathematical approach known as Fourier transformation. FTIR spectroscopy is used in the fields of environment, food, forensics, medicines, polymers and plastics, quality control, and general analysis. In environmental studies, FTIR is a valuable tool for monitoring air quality, testing water quality, and analyzing soil to address environmental and health issues caused by rising pollution levels. The technique provides a "green" method of testing as well as fast, accurate findings, with the added bonus of cost savings on consumables. 5.12.1 PRINCIPLE The principle behind FTIR is that the atoms in a molecule vibrate at specific frequencies. These frequencies (usually 400 to 4000 cm -1) are in the infrared region of the electromagnetic spectrum. When infrared radiation strikes a sample, it absorbs specific frequencies that are identical to the atomic vibrations of the molecule and transmits others. The frequencies of absorbed radiation are detected by an appropriate detector, and the raw data is transferred to a Fast Fourier transform (FFT)–computer to obtain the final spectrum for analysis. 5.12.2 INSTRUMENTATION The key components of an FTIR are shown in a block diagram (Figure 12), and the conventional instrumental process is as follows: Figure 12: Fundamental components of FTIR (i) Source: Infrared energy is emitted by a glowing blackbody source. This beam goes through an aperture that regulates the amount of energy delivered to the sample. (ii) Interferometer: The beam enters the interferometer, which performs "spectral encoding." The resultant interferogram signal then leaves the interferometer.

97 (iii) Sample: Depending on the type of analysis being performed, the beam enters the sample compartment and is transmitted through or reflected off the surface of the sample. This is where specific frequencies of energy, which are unique to the sample, are absorbed. (iv) Detector: The beam ultimately goes to the detector for final measurement. The detectors used are specifically designed to measure the interferogram signal. (v) Computer: The measured signal is digitized and transferred to a computer, which performs the Fourier transformation. The final infrared spectrum is then provided to the user for interpretation and further customization. 5.13 ELECTRON MICROSCOPES Electron microscopes have emerged as a potent instrument for characterization of a wide range of materials. Their versatility and extremely high spatial resolution make them incredibly useful instruments for a variety of applications. The scanning electron microscope (SEM) and transmission electron microscope (TEM) are the two main types of electron microscopes. The main difference between SEM and TEM is that SEM produces images by detecting reflected or knocked–off electrons, whereas TEM creates images by detecting transmitted electrons (electrons that pass through the sample). As a result, TEM gives vital information on the sample's inner structure, such as crystal structure, morphology, and stress state, whereas SEM provides information on the sample's surface and composition. 5.13.1 WORKING PRINCIPLE OF SEM AND TEM Figure 13 depicts a diagrammatic representation of SEM and TEM. Electrons are used in both approaches to obtain images of samples. Their fundamental components are the same: • A source of electrons • A series of electromagnetic and electrostatic lenses used to control the shape and trajectory of an electron beam. • Apertures for electrons All of these components are enclosed within a high–vacuum container. ❖ SEM: To achieve a good image, a sample is exposed by a stream of high–energy electrons that are emitted by an electron source, usually referred to as an electron gun. Electromagnetic lenses are used to focus the electron beam. When the focused stream reaches the sample, it scans its surface in a rectangular raster. Secondary electrons, backscattered electrons, and X–rays are produced when the electron beam interacts with the sample. These interactions are captured to create a magnified image. ❖ TEM: A beam of electrons is sent through an ultrathin sample by an electron source. When electrons penetrate the sample, they pass through lenses below. This data is applied to

98 generate images immediately on a fluorescent screen or on a computer screen using a charge–coupled device (CCD) camera. Figure 13: Schematic view of TEM and SEM instrument 5.13.2 SEM VS TEM Both SEM and TEM are valuable tools in biological, physical, chemical, and medicinal sciences. They are utilized in forensic investigations as well as environmental soil and rock samples. Analysts may select the appropriate type of microscope for their purposes by knowing the differences between these two electron microscopes. ➢ SEM vs TEM advantages: Scanning Electron Microscopes and Transmission Electron Microscopes each contain unique advantages when compared to the other. In comparison to TEM, SEM In comparison to SEM, TEM • Less expensive • Take less time to create an image • Require less sample preparation • Accept thicker samples • Can examine larger samples • Create higher resolution images • Provide crystallographic and atomic information • Produce 2–D images that are often easier to interpret than SEM 3–D images • Allow users to examine more aspects of a sample ➢ SEM vs TEM similarities and differences: There are numerous similarities between SEM and TEM. The components of these two high–resolution microscopes are quite similar. Each

99 has an electron source/gun that emits an electron stream towards a sample in a vacuum, as well as lenses and electron apertures for controlling the electron beam and capturing images. However, the functional differences between the two are vast. They differ in how they work, the types of samples they require, the resolution of the images they provide, and other aspects. Even the basic microscope setup differs. The differences between SEM and TEM are represented in a table below (Table 2). Table 2: Differences between SEM and TEM Scanning Electron Microscopes (SEM) Transmission Electron Microscopes (TEM) Electron stream Fine, focused beam Broad beam Image taken Topographical/surface Internal structure Resolution Lower resolution Higher resolution Magnification Up to 2,000,000 times Up to 50,000,000 times Image dimension 3–D 2–D Sample thickness Thin and thick samples Ultrathin samples only Penetrates sample No Yes Sample restriction Less restrictive More restrictive Sample preparation Less preparation required More preparation required Cost Less expensive More expensive Speed Faster Slower Operation Easy to use More complicated; requires training 5.14 SUMMARY This chapter gives a thorough overview of analytical methods for identifying and quantifying environmental contaminants in air, water, soil, and biological samples that have a negative impact on the environment and human health. The implementation of a suitable sample programme emphasizes the selection of appropriate environmental samples to ensure accurate results and information about the environment through the use of reliable analytical techniques. Conventional analytical methods such as chromatography, spectroscopy, and microscopy have been documented effectively for the analysis of environmental contaminants with minimal environmental sample handling. X–ray diffraction, X–ray florescence, and the use of sophisticated, tandem and hybrid instruments like high–performance liquid chromatography, gas chromatography–mass spectrometry, inductively coupled plasma mass spectrometry, and fourier transform infrared spectrometry, as well as their principles and instrumentation, were demonstrated and highlighted, in addition to the aforementioned instrumental approaches. 5.15 QUESTIONS / SELF ASSESSMENT QUESTIONS 17 . Write down the key factors in designing a sample strategy. 18 . What do you mean by stratified sampling and systematic sampling?

100 19 . Draw a gas chromatography schematic diagram. Explain the functions of its basic components. 20 . What type of detector will you suggest for the analysis of the following by GC? i. Organochlorine pesticides ii. Inorganic gaseous contaminants in the atmosphere iii. Pesticides containing organophosphorus 21 . Explain the principle of HPLC. Provide a block diagram of the apparatus. 22 . How does GC/MS score over GC (Gas Chromatography)? 23 . Describe the various types of AAS used to detect environmental contaminants. 24 . Write a brief description of the instrumentation and uses of a flame photometer. 25 . Explain the working principles of XRD, XRF, and ICP–MS. 26 . Give a block diagram of the FTIR spectrometer and describe the functions of each of its essential components. 27 . Write out the operating principles of SEM and TEM. Compare and contrast their similarities and differences. 5.16 SELECTED READINGS / SUGGESTED READING [8] De AK (2008) Environmental Chemistry. New Age International, New Delhi [9] Gleichmann N (2020) SEM vs TEM. Technology Networks, Sudbury [10] Khopkar SM (2008) Basic Concepts of Analytical Chemistry. New Age International, New Delhi [11] Kothari CR (2010) Research Methodology (Methods and Techniques). New Age International, New Delhi [12] Manahan SE (2017) Environmental Chemistry. CRC Press, New York [13] Peres MR (2013) The Focal Encyclopedia of Photography. Taylor & Francis, Netherlands [14] Skoog DA, West DM, Holler FJ & Crouch SR (2013) Fundamentals of Analytical Chemistry. Cengage Learning India, New Delhi [15] Usharani S (2019) Analytical Chemistry: Techniques & Instrumentation. Laxmi Publications, New Delhi [16] Worsfold P, Tonshend A, Poole C & Miró M (2019) Encyclopedia of Analytical Science. Elsevier Science, Netherlands [17] Zhang CC (2007) Fundamentals of Environmental Sampling and Analysis. John Wiley & Sons, New Jersey

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1 1 Life Processes and Characteristics 1.1 Objectives 1.2 Introduction 1.3 Origin of Life 1.4 Role of natural selection 1.5 Genetic Drift 1.6 Gaia Hypothesis 1.7 Summary 1.8 Questions/ Self-Assessment questions 1.9 Select Readings/ Suggested Readings 1.1 Objectives • To learn about different theories on origin of life. • To know the mechanism of evolution • To perceive the conceptual framework of Gaia hypothesis 1.2 Introduction The diversity of life on Earth today is the result of evolution. Life began on Earth at least 3.5 to 4 billion years ago, and it has been evolving ever since. Origin of life means the appearance of simplest primordial life from non- living matter. Evolution of life means the gradual formation of complex organisms from simpler ones. At first, all living things on Earth were simple, single-celled organisms. Much later, the first multicellular organisms evolved, and after that, Earth's biodiversity greatly increased through the process evolution. Evolution is a change in the characteristics of living things over time. Evolution occurs by natural selection and genetic drift. Characteristics of organisms are passed from one generation to the next through their genes. The environment of Earth has also evolved. Earth has cooled, the temperature has stabilized, and the composition of the atmosphere has completely changed. Under the current paradigm, the two parallel evolutions, life and its environment, affect each other, but not in any coordinated way. Life consumes resources and discharges waste products; these processes alter the environment. As the environment changes, it presents new challenges to life. Earth is a self-regulating complex system involving the biosphere, the atmosphere, the hydrospheres and the pedosphere, tightly coupled as an evolving system. In this chapter we will discuss about different theories related to origin of life followed by process of evolution and natural selection. Then concept of Gaia hypothesis will introduce about interplay of life and environment and self-sustainability. 1.3 Origin of Life The origin of life means the emergence of heritable and evolvable self-reproduction. "Origin of Life" is a very complex subject, and oftentimes controversial. Two opposing scientific 2 theories that existed on this complex subject for a long time were the socalled intelligent design and creationism. The big bang theory of the origin of the Universe gave new ideas about the topic of biological evolution. It has been hypothesized that complex life-forms on Earth, including humans, arose over a period of time from simple bacteria like tiny cells by a process of self-organization akin to the evolution of the Universe by self-organization of simple material structures (i.e., fundamental particles produced by the big bang) toward more and more complex structures. There are several theories about the origin of life. It is a very difficult task to find the theory involves behind the origin of life. Some important theories have been discussed here: 1.3.1 Special creation: Life formation on the earth may have been taken place due to supernatural or divine forces. There are different kinds of accreditations by different religions. HINDU CONCEPT: The whole world, plants, oceans, rivers, humans, animals are created by Lord Brahma. CHRISTIAN & ISLAM CONCEPT: God created the universe, human beings, plants, oceans and rivers in six days. All the plants and animals were created at once. All the living organisms were created in the same form as they exist today. The theory of special creation also suggests that Diversity of life form will not change in future. This theory of origin of life has no scientific explanations. 1.3.2 Extra-terrestrial origin: This theory is given by Richer in 1865 and also known as cosmozoic theory. Panspermia means "seeds everywhere". This hypothesis states that the "seeds" of life exist all over the Universe and can be propagated through space from one location to another. Some believe that life on Earth may have originated through these "seeds" i.e., Life formation did not take place on earth. It took place somewhere else in the space or on any other planet and carried to the earth. Mechanisms for panspermia include the deflection of interstellar dust by solar radiation pressure and extremophile microorganisms traveling through space within an asteroid, meteorite or comet. For example, rocks regularly get blasted off Mars by cosmic impacts, and a number of Martian meteorites have been found on earth that it is controversially stated that microbes brought over here, potentially making us all Martians originally. It is also suggested that life might have carried from comets. Three popular variations of the panspermia hypothesis are: Litho panspermia (interstellar panspermia) - impact-expelled rocks from a planet's surface serve as transfer vehicles for spreading biological material from one solar system to another. Ballistic panspermia (interplanetary panspermia) - impact-expelled rocks from a planet's surface serve as transfer vehicles for spreading biological material from one planet to another within the same solar system.

3 Directed Panspermia - the intentional spreading of the seeds of life to other planets by an advanced extra-terrestrial civilization, or the intentional spreading of the seeds of life from Earth to other planets by humans. Panspermia does not provide an explanation for evolution or attempt pinpoint the origin of life in the Universe. The panspermia hypothesis gives no explanation for how life that arrived on Earth came to be. Even if we are able to show that life on Earth was a result of panspermia, the question of where and how life originated will be a lot harder to answer. 1.3.3 Spontaneous origin: Life may have evolved from non-living matter as association with prebiotic molecules under primitive earth conditions, became more and more complex. This theory suggests that life could come from non-living things, decaying, and rotting matter like straw, mud, etc. Several experiments have been conducted to disprove spontaneous generation. In 1668, Francesco Redi a scientific experiment to test the spontaneous creation of maggots by placing fresh meat in three different jars. He found the maggots in open jar and on the exterior surface of the cloth that covered the jar. No maggots were found in the sealed jar. Redi successfully demonstrated that the maggots came from fly eggs and thereby helped to disprove spontaneous generation. Louis Pasteur rejected the theory of spontaneous generation and demonstrated that life came from pre-existing life. In his experiment, he kept killed yeast cells in pre-sterilised flask and another flask open into air. The life did not evolved in the former but new living thing evolved in the later flask. Several other experiments like Needham’s experiment, Spallanzani's Experiment etc. have been performed which disprove the theory of spontaneous origin. Spontaneous generation is the incorrect hypothesis that non-living things are capable of producing life. 1.3.4 Theory of Biochemical Evolution: Several models for the origin of life have been suggested. The first 'modern' model for the origin of life was presented in the 1923 independently by the Russian biochemist A. I. Oparin and later supported by the British evolutionary biologist J. B. S. Haldane in 1928. The Oparin and Haldane theory is known as biochemical theory for the origin of life. According to the Oparin-Haldane model, life could have arisen through a series of organic chemical reactions that produced ever more complex biochemical structures. They proposed that common gases in the early Earth atmosphere combined to form simple organic chemicals, and that these in turn combined to form more complex molecules. Then, the complex molecules became separated from the surrounding medium, and acquired some of the characters of living organisms. They became able to absorb nutrients, to grow, to divide (reproduce), and so on. The biochemical origin of life can be studied in three categories: 1.3.4.1 Chemical Evolution of life: 1. Formation of Simple inorganic compounds: The atmosphere of primitive earth had various elements like hydrogen, oxygen, carbon, sulphur, phosphorous, nitrogen etc. These free atoms combine to form molecules and simple inorganic compounds like ammonia, water vapour, HCN etc.

4 2. Formation of simple organic molecules: The simple inorganic compounds formed in atmosphere interacted and combined to produce simple compounds such as simple sugars, purines, pyrimidines, amino acids, etc. The source of energy for chemical reaction might be solar radiations such as UV rays, lightening, radiations from radioactive rocks and heat of earth. The simple organic compounds forms reached the ocean with rainwater. 3. Formation of complex organic molecules: The simple organic molecules have undergone polymerization to form complex organic molecules like proteins, nucleic acids, amino acids etc in oceanic water. Formation of these molecules plays a key role in the chemical evolution of life. The oceanic water rich in mixture of organic compounds. 1.3.4.2 Biological evolution of life: Formation of life initiated from the ocean containing organic compounds. 1. Formation of Coacervate: The complex organic molecules of primordial soup in ocean aggregated together through the colloidal system and bounded by water layer were called coacervates. They can grow by absorbing nutrients. They have the power of self-growing and dividing by budding like bacteria. They are intermediate between molecule and organism. Some of the proteins within coacervates acted as enzymes and began metabolic activities. 2. Formation of primary living organism: The coacervates presumably obtained energy by fermentation from the oceanic soup. They were anaerobes. They depended on the existing organic molecules for their nutrition. 3. Origin of Autotrophs: When supply of existing organic compounds was exhausted, some of the heterotrophs might have evolved into autotrophs. These organisms were capable of synthesizing their own organic compounds by chemosynthesis. They were therefore chemoautotrophs. They develop the chlorophyll through which the autotrophs can prepare the food. Oxygen evolved during the photosynthesis and started to accumulate in atmosphere. 1.3.4.3 Cognogeny: With gradual increase in the number of heterotrophs as they consumed nutrients of the ocean, there became a declination in organic nutrients. So they began to search other alternatives for obtaining food. During photosynthesis, solar energy was trapped by light trapping pigment called chlorophyll. In this way several other organisms evolved (prokaryotic, anaerobic etc.). With the increase meant in number of photoautotrophs O 2 released in great extent in ocean and came into atmosphere. Now an oxidising type atmosphere has been formed. Then prokaryotes gradually modified to be adapted to the aerobic mode of respiration. Gradually many types of algae, fungi, protozoa and other organic living organisms developed. 1.3.4.4 Simple Beginnings: Instead of originating from complex molecules like RNA, DNA, life might have begun with small and simple molecules interacting with each other in cycles of reactions. These reactions might have been change a simple capsule to cell membranes and over time more complex molecules or cells. This is the most simple of the standing theories, and is difficult to dismiss. 1.3.4.5 RNA world: In the formation of life DNA, RNA and proteins play important role. DNA can store genetic information and proteins can catalyze the reactions. But RNA can do both the jobs. RNA has

5 the self-replicating properties. The RNA world theory suggests that life on Earth began with simple RNA molecule that could copy itself without help from any other molecule. The compelling feature of RNA World is that a primordial molecule provided both catalytic power and the ability to propagate its chemical identity over generations. Pieces of RNA have been made that can copy RNA strands longer than themselves, supporting the idea that the first life was based on self-replicating RNA, not DNA. 1.3.4.6 Chilly start: Ice might have covered the oceans 3 billion years ago, as the sun was three times less luminous than it now. This layer of ice, possibly hundreds of feet thick, might have protected fragile, organic compounds in the water below from ultraviolet light and destruction from cosmic impacts. The cold might have also helped these molecules to survive longer, allowing reactions to happen. The enzyme does not yet copy itself. The main barrier seems to be the folded structure that allows it to copy other RNA. The RNA enzyme's effectiveness at cold temperatures suggests ice was crucial to the first life. When a mix of RNA and metal ions freezes, growing ice crystals suck up the water, leaving tiny pockets of RNA. At cold temperatures, RNA strands often stick together, making it tricky to separate them after the RNA has been copied. Ice freezes and melts all the time, so you can easily see how an RNA replicator could be enclosed, released and allowed to spread. 1.3.4.7 Deep-Sea Vents: This theory suggests that life arose deep in the ocean within warm, rocky structures called hydrothermal vents. This theory suggests that life may have begun at submarine hydrothermal vents and ejecting hydrogen rich molecules. Their rocky nooks could then have concentrated these molecules together and provided mineral catalysts for critical reactions. These vents are rich in chemical and thermal energy. Deep-sea hydrothermal vents are porous geological structures produced by chemical reactions between solid rock and water. Alkaline fluids from the Earth's crust flow up the vent towards the more acidic ocean water, creating natural proton concentration differences remarkably similar to those powering all living cells. 1.3.4.8 Community Clay: The first molecule of life, hydrocarbon, might have met on the clay. These surfaces might not only have concentrated these organic compounds together but also helped organize them into patterns much like our genes. Mineral crystals in clay could have arranged organic molecules into organized patterns. Clay minerals played a key role in chemical evolution and the origins of life because of their ability to take up, protect (from UV radiations), concentrate, and catalyse the polymerization of organic molecules. Clay minerals can also store and replicate structural defects and ionic substitutions and act as 'genetic candidates'. So the minerals and organic molecules in the layers of clay would favour the formation and replication of biological molecules (e.g. enzymes, polynucleotides) and favour the possibility of origin of life through this theory. 1.3.4.9 Electric Spark: Lightning may have provided the spark needed for life to begin. There are two distinct versions of the spark of life theory. The first of these versions holds that the first form of life came into existence following "one spark" or on one particular "spark day." The other version argues that life came into existence, or rather emerged, following prolonged sparking rather one specific spark. Electric sparks can generate amino acids and sugars from an atmosphere loaded with
6 water, methane, ammonia and hydrogen, as described in Miller Urey experiment. This suggests that lightning might have helped create the key building blocks of life on Earth in its early days. Over time larger molecules could form as a result of this. Figure 1-1: Miller Urey experiment Further reading: 1. The Origins of Life: From the Birth of Life to the Origin of Language By John Maynard Smith, Eörs Szathmáry , 2000 2. Information Theory, Evolution, and the Origin of Life By Hubert P. Yockey 1.4 Role of natural selection 1.4.1 Natural Selection The final force of evolution is natural selection. This is the evolutionary process that Charles Darwin first brought to light, and it is what the general public typically evokes when considering the process of evolution. Natural selection occurs when certain phenotypes confer an advantage or disadvantage in survival and/or reproductive success. The alleles associated with those phenotypes will change in frequency over time due to this selective pressure. It's

7 also important to note that the advantageous allele may change over time (with environmental changes) and that an allele that had previously been benign may become advantageous or detrimental. Of course, dominant, recessive, and codominant traits will be selected upon a bit differently from one another. Because natural selection acts upon phenotypes rather than the alleles themselves, deleterious (disadvantageous) recessive alleles can be retained by heterozygotes without any negative effects. In the case of our primordial ocean cells, up until now, the texture of their cell membranes has been benign. The frequencies of smooth to ruffled alleles, and smooth to ruffled phenotypes, has changed over time, due to genetic drift and gene flow. Let's now imagine that the Earth's climate has cooled to a point that the waters frequently become too cold for survival of the tiny bacteria that are the dietary staples of our smooth and ruffled cell populations. The way amoeba-like cells "eat" is to stretch out the cell membrane, almost like an arm, to encapsulate, then ingest, the tiny bacteria. When the temperatures plummet, the tiny bacteria populations plummet with them. Larger bacteria, however, are better able to withstand the temperature change. The smooth cells were well-adapted to ingesting tiny bacteria but poorly suited to encapsulating the larger bacteria. The cells with the ruffled membranes, however, are easily able to extend their ruffles to encapsulate the larger bacteria. They also find themselves able to stretch their entire membrane to a much larger size than their smooth-surfaced neighbors, allowing them to ingest more bacteria at a given time and to go for longer periods between feedings. The smooth and ruffled traits, which had previously offered no advantage or disadvantage while food was plentiful, now are subject to natural selection. During the cold snaps, at least, the ruffled cells have a definite advantage. We can imagine that the western population that has mostly ruffled alleles will continue to do well, while the eastern population, which has a much smaller proportion of ruffled alleles, will gradually shift toward a higher frequency of ruffled alleles in future generations. A classic example of natural selection involves the study of an insect called the peppered moth (Biston betularia) in England during the Industrial Revolution in the 1800s. Prior to the Industrial Revolution, the peppered moth population was predominantly light in color, with dark (pepper-like) speckles on the wings. The "peppered" coloration was very similar to the appearance of the bark and lichens that grew on the local trees. This helped to camouflage the moths as they rested on a tree, making it harder for moth-eating birds to find and snack on them. There was another phenotype that popped up occasionally in the population. These individuals were heterozygotes that carried an overactive, dominant pigment allele, producing a solid black coloration. As you can imagine, the black moths were much easier for birds to spot, making this phenotype a real disadvantage. The situation changed, however, as the Industrial Revolution took off. Large factories began spewing vast amounts of coal smoke into the air, blanketing the countryside, including the lichens and trees, in black soot. Suddenly, it was the light-colored moths that were easy for birds to spot and the black moths that held the advantage. The frequency of the dark pigment allele rose dramatically. By 1895, the black moth phenotype accounted for 98% of observed moths (Grant 1999). Thanks to new environmental regulations in the 1960s, the air pollution in England began to taper off. As the soot levels decreased, returning the trees to their former, lighter color, this provided the perfect opportunity to study how the peppered moth population would respond. Repeated follow-up studies documented the gradual rise in the frequency of the lighter-colored phenotype. By 2003, the maximum frequency of the dark phenotype was 50% and in most parts of England had decreased to less than 10% (Cook 2003).
8 Directional, Balancing/Stabilizing, and Disruptive/Diversifying Selection Natural selection can be classified as directional, balancing/stabilizing, or disruptive/diversifying, depending on how the pressure is applied to the population. Fig. 1.2. Schematic visualization of different types of natural selection Both of the above examples of natural selection involve directional selection: the environmental pressures are favouring one phenotype over the other and causing the frequencies of the associated advantageous alleles (ruffled membranes, dark pigment) to gradually increase. In the case of the peppered moths, the direction shifted three times: first, it was selecting for lighter pigment; then, with the increase in pollution, the pressure switched to selection for darker pigment; finally, with reduction of the pollution, the selection pressure shifted back again to favoring light-colored moths. Balancing selection (a.k.a., stabilizing selection) occurs when selection works against the extremes of a trait and favors the intermediate phenotype. For example, humans maintain an average birth weight that balances the need for babies to be small enough not to cause complications during pregnancy and childbirth but big enough to maintain a safe body temperature after they are born. Another example of balancing selection is found in the genetic disorder called sickle cell anemia. Disruptive selection (a.k.a., diversifying selection), the opposite of balancing selection, occurs when both extremes of a trait are advantageous. Since individuals with traits in the mid-range are selected against, disruptive selection can eventually lead to the population evolving into two separate species. Darwin believed that the many species of finches (small birds) found in the remote Galapagos Islands provided a clear example of disruptive selection leading to speciation. He observed that seed eating finches either had large beaks, capable of eating very large seeds, or small beaks, capable of retrieving tiny seeds. The islands did not have many plants that produced medium-size seeds. Thus, birds with medium-size beaks would have trouble eating the very large seeds and would also have been inefficient at picking up the tiny seeds. Over time, Darwin surmised, this pressure against mid-size beaks may have led the population to divide into two separate species.

9 1.5 Genetic Drift The second force of evolution is commonly known as genetic drift. This is an unfortunate misnomer, as this force actually involves the drifting of alleles, not genes. Genetic drift refers to random changes ("drift") in allele frequencies from one generation to the next. The genes are remaining constant within the population; it is only the alleles of the genes are changing in frequency. The random nature of genetic drift is a crucial point to understand: it specifically occurs when none of the variant alleles confer an advantage. Let's imagine far back in time, again, to that first population of living cells, subsisting and occasionally dividing, in the primordial sea. Many generations have passed, and mutations have created distinct chromosomes. The cells are now amoeba-like, larger than many of their tiny bacterial neighbors, who have long since become their favorite source of nutrients. A mutation occurs in one of the cells that changes the texture of the cell membrane from a relatively smooth surface to a highly ruffled one. This has absolutely no effect on the cell's quality of life or ability to reproduce. In fact, eyes haven't evolved yet, so no one in the world at the time would even notice the difference. The cells in the population continue to divide, and the offspring of the ruffled cell inherit the ruffled membrane. The frequency (%) of the ruffled allele in the population, from one generation to the next, will depend entirely on how many offspring that first ruffled cell ends up having, and the random events that might make the ruffled alleles more common or more rare (such as population bottlenecks and founder effects, discussed below). 1.5.1 Sexual Reproduction and Random Inheritance Tracking alleles gets a bit more complicated in our primordial cells when, after a number of generations, a series of mutations have created populations that reproduce sexually. These cells go through an extra round of cell-division (meiosis) to create haploid gametes. The combination of two gametes, each containing half a set of homologous chromosomes, is required to produce each new diploid offspring. In the earlier population, which reproduced via asexual reproduction, a cell either carried the smooth allele or the ruffled allele. With sexual reproduction, a cell inherits one allele from each parent, so there are homozygous cells that contain two smooth alleles, homozygous cells that contain two ruffled alleles, and heterozygous cells that contain one of each allele. If the new, ruffled allele happens to be dominant (and we'll imagine that it is), the heterozygotes will have ruffled cell phenotypes, but will have a 50:50 chance of passing on a smooth allele to each offspring. In sexually reproducing populations (including humans and many other animals and plants in the world today), that 50:50 chance of inheriting one or the other allele from each parent plays a major role in the random nature of genetic drift. 1.5.2 Population Bottlenecks A population bottleneck occurs when the number of individuals in a population drops dramatically due to some random event. The most obvious, familiar examples are natural disasters. Tsunamis and hurricanes devastating island and coastal populations and forest fires and river floods wiping out populations in other areas are all too familiar. When a large portion of a population is randomly wiped out, the allele frequencies (i.e., the percentages of each allele) in the small population of survivors are often much different from the frequencies in the pre-disaster, or "parent," population. If such an event happened to our primordial ocean cell population—perhaps a volcanic fissure erupted in the ocean floor and only the cells that happened to be farthest from the spewing lava and boiling water survived—we might end up,

10 by random chance, with a surviving population that had mostly ruffled alleles, in contrast to the parent population, which had only a small percentage of ruffles. One of the most famous examples of a population bottleneck is the prehistoric disaster that led to the extinction of dinosaurs, the Cretaceous–Paleogene extinction event (often abbreviated K–Pg; previously K- T). This occurred approximately 66 million years ago. Dinosaurs and all their neighbors were going about their ordinary routines when a massive asteroid zoomed in from space and crashed into what is now the Gulf of Mexico, creating an impact so enormous that populations within hundreds of miles of the crash site were likely immediately wiped out. The skies filled with dust and debris, causing temperatures to plummet worldwide. It's estimated that 75% of the world's species went extinct as a result of the impact and the deep freeze that followed (Jablonski and Chaloner 1994). The populations that emerged from the K-Pg extinction were markedly different from their pre-disaster communities. Surviving mammal populations expanded and diversified, and other new creatures appeared. The ecosystems of Earth filled with new organisms and have never been the same. Much more recently in geological time, during the colonial period, many human populations experienced bottlenecks as a result of the fact that imperial powers were inclined to slaughter communities who were reluctant to give up their lands and resources. This effect was especially profound in the Americas, where indigenous populations faced the compounded effects of brutal warfare, exposure to new bacteria and viruses (against which they had no immunity), and ultimately segregation on resource-starved reservations. The populations in Europe, Asia, and Africa had experienced regular gene flow during the 10,000-year period in which most kinds of livestock were being domesticated, giving them many generations of experience building up immunity against zoonotic diseases (those that can pass from animals to humans). In contrast, the residents of the Americas had been almost completely isolated during those millennia, so all these diseases swept through the Americas in rapid succession, creating a major loss of genetic diversity in the indigenous American population. It is estimated that between 50% and 95% of the indigenous American populations died during the first decades after European contact, around 500 years ago (Livi-Bacci 2006). An urgent health challenge facing humans today involves human-induced population bottlenecks that produce antibiotic- resistant bacteria. Antibiotics are medicines prescribed to treat bacterial infections. The typical prescription includes enough medicine for ten days. People often feel better after less than ten days and sometimes decide to quit taking the medicine ahead of schedule. This is often a big mistake. The antibiotics have quickly killed off a large percentage of the bacteria—enough to reduce the symptoms and make you feel much better. However, this has created a bacterial population bottleneck. There are usually a small number of bacteria that survive those early days. If you take the medicine as prescribed for the full ten days, it's quite likely that there will be no bacterial survivors. If you quit early, though, the survivors—who were the members of the original population who were most resistant to the antibiotic—will begin to reproduce again. Soon the infection will be back, possibly worse than before, and now all of the bacteria are resistant to the antibiotic that you had been prescribed. Other activities that have contributed to the rise of antibiotic-resistant bacteria include the use of antibacterial cleaning products and the inappropriate use of antibiotics as a preventative measure in livestock or to treat infections that are viral instead of bacterial (viruses do not respond to antibiotics). In 2017, the World Health Organization published a list of twelve antibiotic-resistant pathogens that are considered top priority targets for the development of new antibiotics (World Health Organization 2017).

11 1.5.3 Founder Effects Founder effects occur when members of a population leave the main or “parent” group and form a new population that no longer interbreeds with the other members of the original group. Similar to survivors of a population bottleneck, the newly founded population often has allele frequencies that are different from the original group. Alleles that may have been relatively rare in the parent population can end up being very common due to founder effect. Likewise, recessive traits that were seldom seen in the parent population may be seen frequently in the descendants of the offshoot population. One striking example of founder effect was first noted in the Dominican Republic in the 1970s. During a several-year period, eighteen children who had been born with female genitalia and raised as girls suddenly grew penises at puberty. This culture tended to value sons over daughters, so these transitions were generally celebrated. They labeled the condition guevedoces, which translates to “penis at twelve,” due to the average age at which this occurred. Scientists were fascinated by the phenomenon. Genetic and hormonal studies revealed that the condition, scientifically termed 5-alpha reductase deficiency, is an autosomal recessive syndrome that manifests when a child having both X and Y sex chromosomes inherits two non-functional (mutated) copies of the SRD5A2 gene (Imperato-McGinley and Zhu 2002). These children develop testes internally, but the 5- alpha reductase 2 steroid, which is necessary for development of male genitals in babies, is not produced. In absence of this male hormone, the baby develops female-looking genitalia (in humans, “female” is the default infant body form, if the full set of the necessary male hormones are not produced). At puberty, however, a different set of male hormones are produced by other fully functional genes. These hormones complete the male genital development that did not happen in infancy. This condition became quite common in the Dominican Republic during the 1970s due to founder effect—that is, the mutated SRD5A2 gene happened to be much more common among the Dominican Republic’s founding population than in the parent populations [the Dominican population derives from a mixture of indigenous Native American (Taino) peoples, West Africans, and Western Europeans]. Five-alpha reductase syndrome has since been observed in other small, isolated populations around the world. Founder effect is closely linked to the concept of inbreeding, which in population genetics does not necessarily mean breeding with immediate family relatives. Instead, inbreeding refers to the selection of mates exclusively from within a small, closed population—that is, from a group with limited allelic variability. This can be observed in small, physically isolated populations but also can happen when cultural practices limit mates to a small group. As with founder effect, inbreeding increases the risk of inheriting two copies of any nonfunctional (mutant) alleles. 1.6 Gaia Hypothesis The Gaia Theory claims that the Earth is a self-regulating system, maintaining the conditions that support life. Its author, James Lovelock, has proposed since the late 1960s that the explanation of phenomena such as the long-standing constancy of the proportion of oxygen in the atmosphere and of the salinity of the oceans is that the complex system of life on our planet ensures its own continuation, or, latterly, that this is brought about by planetary life together with its environment of atmosphere, rocks and oceans. He does not officially claim that this system, which he calls ‘Gaia’, acts knowingly or purposively, but he does regard it as a super- organism with wide-ranging capacities for self-repair. The name ‘Gaia’ is borrowed from that

12 of the ancient Greek goddess of the Earth, the consort of Uranus (Heaven), and the mother of seas, mountains and living creatures. This name was originally suggested to Lovelock by the novelist, William Golding. 1.6.1 Lovelock's developing stance While researching (with NASA) whether either Mars or Venus could sustain life, Lovelock devised the test of whether their climates reflected the equilibrium that could be predicted to arise from physical forces alone, or deviations from such an equilibrium, which might be generated by the presence of life. He concluded that whereas these other planets displayed just such an equilibrium, our own planet, by contrast, deviates therefrom and maintains an unexpected constancy or homeostasis of the proportions of gases in the atmosphere and salts in the oceans, ascribable to nothing but life itself. These conclusions led him to propound the Gaia Hypothesis that life on Earth keeps these proportions constant and thus hospitable for whatever is the contemporary ensemble of organisms. Later this hypothesis was refined as the Gaia Theory, which represents not just life on Earth but life in conjunction with surface rocks, the ocean and the atmosphere as a self-regulating system, with a goal – 'the regulation of surface conditions so as always to be as favourable as possible for contemporary life' (Lovelock, 2006, 208). Early objections, such as that the oxygen generated by plants and algae is disadvantageous to anaerobic life, and thus that not all life can be included in the Gaian system, were countered by including anaerobic life, together with the conditions that support it, as key regulators in the planetary system of Gaia. 1.6.2 Predecessors Lovelock was not the first to present the Earth as a super-organism. As Lovelock acknowledges (Lovelock, 1990, 101), James Hutton hit on this intuition in 1788, holding that the Earth could only be studied properly by planetary physiology; this has led Lovelock to propose the study of Gaia as 'geophysiology'. Much earlier, Plato's Timaeus (fourth century BCE) represented the world as a living organism, albeit one produced by a divine Artificer, and subsequently the Stoics, from Chrysippus (third century BCE) onwards, treated the active substance of the universe as a world-soul or as reason, imposing form on passive matter. These speculative systems, unlike Lovelock's work as a scientist, were much more extensive in scope than Lovelock's theory, and depended neither on empirical evidence nor on thought-experiments. Yet they may have predisposed those familiar with these traditions to the cogency of scientific theories of the Earth such as those of Hutton and of Lovelock, who was himself not slow to gain mileage for his theory by referencing Gaia, the Earth Mother of the ancient Greeks (Lovelock, 2006, 29). 1.6.3 Implications for ecological priorities Lovelock has long suggested that the current general concern of environmentalists about pollution and the side-effects of technology is exaggerated, partly because of the resilience of Gaia and its ability to withstand such challenges. In particular, he used to doubt whether chlorofluorocarbons were a major problem (diverging here from the international concern

13 which led to the crucial Montreal Protocol of 1987), and he continues to be an advocate of nuclear energy. But he is concerned about human interference with two kinds of global region, continental shelves, whose biota play key roles such as regulating and limiting the sulphur of the oceans, and the tropics, where the burning of grasslands emits 'a huge burden of aerosol particles', together with the bulk of the chlorine now in the atmosphere in the form of methyl chloride. Thus it is not advanced technology that, in his view, causes ecological harm but traditional husbandry and the associated traditional technology. One form of high technology that he favours is the emission of sulphate aerosols into the stratosphere, to reduce incoming solar energy and thus protect Gaia by averting global warming (Lovelock, 2006, 167); yet such 'Solar Radiation Management' could risk the acidification of the atmosphere and thus of rainfall, and could be regarded as an aberration from rather than an implication of Gaia Theory. And while accepting that the planet could support a larger human population, he (perhaps wisely) endorses the view that the optimum number of people is not as large as the maximum that Earth can support (Lovelock, 1979, 122), and that population increase may need to be halted at not far above 10 billion people, or at a still lower level. 1.6.3.1 Key concepts ➢ James Lovelock hypothesises that the planetary physical and biological system is a self- regulating super-organism. ➢ There were precedents before Lovelock for ascribing life either to the planet or to the universe. ➢ James W. Kirchner presents Gaia hypotheses as either unoriginal or untestable. ➢ Lovelock demonstrates that Gaia theory is both original and testable, albeit indirectly. ➢ Lovelock's theory can readily escape the charge of circularity. ➢ Predictions of Gaia theory include the existence of biologically generated mechanisms of planetary regulation. ➢ Lovelock's discovery of dimethyl sulphide discloses such a mechanism for the regulation of oceanic sulphur. ➢ Both atmospheric oxygen and atmospheric nitrogen turn out to be biologically generated and maintained. ➢ Philosophers such as Stephen Clark and Mary Midgley have made Gaia a symbol for the planetary thinking currently needed. ➢ The Amsterdam Declaration of planetary scientists (2001) accepted aspects of Gaia theory, without explicitly accepting the theory's planetary goal. 1.7 Summary • Theories on biochemical origin of life is most accepted scientific concepts in origin of life. • Darwin stated the theory of evolution by natural selection, presenting a great deal of evidence to support his theory. • Evolution is a change in the characteristics of living things over time. Natural selection helps in adaptive evolution. • The Gaia hypothesis, proposes that all organisms and their inorganic surroundings on Earth are closely integrated to form a single and self-regulating complex system maintaining the conditions for life on the planet.

14 1.8 Questions/ Self-Assessment questions MCQ questions 1. Miller in his experiment, synthesized simple amino- acid from ______ a) Methane, ammonia, oxygen, nitrogen b) Hydrogen, methane, ammonia, water c) Ammonia, methane, carbon dioxide, oxygen d) Hydrogen, water, oxygen, helium 2. According to spontaneous generation, life originated _____ a) From microorganisms b) From similar organisms c) From air d) Only spontaneously 3. In the natural selection, the production of variations is due to a) Mutations b) Meiosis c) Random mate selection d) All of them 4. Where selective pressure favors an extreme variation of a trait. a) Directional selection b) Stabilizing selection c) Disruptive selection d) Sexual selection 5. Gaia hypothesis states, biosphere is capable of keeping the planet healthy by controlling: a) Physical and Chemical environment b) Biological environment c) Marine environment d) Pedosphere Short answer type questions 1. Define natural selection with suitable example. 2. What is Panspermia hypothesis? 3. What is founder effect? Give an example. 4. What is Balancing selection? Tall neck of Giraffe is an example of which selection? 5. How community clay promotes origin of life in Earth?

15 Long answer type questions 1. Describe different types of selection with suitable example. 2. What is Urey-Miller experiment? Write short notes on different theories on biochemical origin of life. 3. Elucidate the role of genetic drift and natural selection on biological evolution. 1.9 Select Readings/ Suggested Readings Dawkins, Richard (1982) The Extended Phenotype, Oxford and San Francisco: W H Freeman & Co. Lovelock JE (1979) Gaia: A new look at life on Earth, Oxford and New York: Oxford University Press. Lovelock JE (1990) Hands Up for the Gaia hypothesis. Nature 344: 100-102. Lovelock, JE (2006) The Revenge of Gaia: Why the Earth is Fighting Back – and How We Can Still Save Humanity, London and New York: Penguin. Evolution by Douglas J. Futuyma Evolution by Monroe Strickberger

16 2 Ecosystem Structure and Function 2.1 Objectives 2.2 Introduction 2.3 Tropic structure and function in ecosystem 2.4 Productivity 2.5 Decomposition 2.6 Food chain and Food webs, Energy flow models 2.7 Ecological Succession 2.8 Concept of Ecotone, Edge Effect, Ecological Habitats and Niche 2.9 Ecosystem Services 2.10 Summary 2.11 Questions/ Self-Assessment questions 2.12 Select Readings/ Suggested Readings 2.1 Objectives • To learn about structure and function of different tropic level. • To perceive basic concept of productivity, food web and food chain. • To know about different types of ecological succession. • Remarks on species diversity and idea about niche, habitat, ecotone, edge effect. • Elucidating basic idea on ecosystem services. 2.2 Introduction

The ecosystem is the structural and functional unit of ecology where the living organisms interact with each other and the surrounding environment. In other words, an ecosystem is a chain of interaction between organisms and their environment. The term “Ecosystem” was first coined by A.G.Tansley, an English botanist, in 1935.

The structure of an ecosystem

is characterised by the organisation of both biotic and abiotic components.

This includes the distribution of energy in our environment. It also includes the climatic conditions prevailing in that particular environment.

The

sun is the ultimate source of energy on earth.

During photosynthesis

light energy is converted into chemical energy and is passed on through successive levels. The flow of energy from a producer, to a consumer and eventually, to an apex predator or a detritivore is called the food chain.

All the food chains in a community are related together and known as the food web. But ecosystem is not a static entity, it changes over time.

A series of changes over time to community structure that affect community dynamics and encourage the assemblage of plants and animals

is known as ecological succession. The richness, or number, of species found in a community refers to species diversity. Every species

have specific characteristics, such as availability of nutrients, temperature, terrain, sunlight and predators, which dictate how

a species live, and how well, a species survives and reproduces; that boundary known as niche. Generally

an area that acts as a boundary or a transition between two ecosystems

also known as ecotone contains more species than both the adjacent ecosystem. Ultimately ecosystems provide many of the basic services that make life possible for people. The benefits that natural ecosystems generate for

17 society and to raise awareness for biodiversity and ecosystem conservation is acknowledged as ecosystem services.

2.3 Tropic structure and function

in ecosystem Interaction of biotic and abiotic components result in a physical structure that is characteristic for each type of ecosystem. Identification and enumeration of plant and animal species of an ecosystem gives its species composition.

Vertical distribution of different species occupying different levels is called stratification. For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom

layers. The components of the ecosystem are seen to function as a unit when you consider the following aspects: (i) Productivity (ii) Decomposition (iii) Energy flow and (iv) Nutrient cycling To understand the ethos of an aquatic ecosystem let us take a small pond as an example. This is fairly a self-sustainable unit and rather simple example that explain even the complex interactions that exist in an aquatic ecosystem. A pond is a shallow water body in which all the above mentioned four basic components of an ecosystem are well exhibited. The abiotic component is the water with all the dissolved inorganic and organic substances and the rich soil deposit at the bottom of the pond.
The solar input, the cycle of temperature, day-length and other climatic conditions regulate the rate of
function of the entire pond. The autotrophic components include the phytoplankton, some algae and
the floating, submerged and marginal plants found at the edges. The consumers are represented by the zooplankton, the free swimming and bottom dwelling forms. The decomposers are the fungi, bacteria and flagellates especially abundant in the bottom of the pond. This system performs all the functions of any ecosystem and of the
biosphere as a whole, i.e., conversion of inorganic into organic material with the help of the radiant energy of the sun by the autotrophs; consumption of the autotrophs by heterotrophs; decomposition and mineralisation of the dead matter to release them back for reuse by the autotrophs, these event are repeated over and over again. There is unidirectional movement of energy towards the higher trophic levels and its dissipation and loss as heat to the environment. 2.4 Productivity A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.
Primary production is defined as
the amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. It is expressed in terms of weight (
gm -2) or energy (kcal m −2). The rate of biomass production is called productivity. It is expressed in terms of gm −2 yr −1 or (kcal m −2) yr −1 to compare
the productivity of different ecosystems.
It can be divided into gross primary productivity (GPP) and net primary productivity (NPP). Gross primary productivity of an ecosystem is the rate of production
of organic matter during photosynthesis. A considerable amount of GPP
is utilised by plants
in respiration.
Gross primary productivity minus respiration losses (R), is the net primary productivity (NPP).
18 GPP − R = NPP
Net primary productivity is the available biomass for the consumption to heterotrophs (herbiviores and decomposers).
A population ingests food material, which is called as ingestion. A part of this food material is processed and used to make new cells or tissues in the body of the animal, and this part is called as assimilation. What cannot be assimilated, for example some parts of the plant stems or roots, exits the body, this is called excretion. Thus we can calculate assimilation from the following equation: Assimilation (A) = Ingestion (I) − Excretion (Ex)
Secondary productivity is defined as the rate of formation of new organic matter by consumers.
Primary productivity depends on the plant species inhabiting a particular area. It also depends on a variety of environmental factors, availability of nutrients and photosynthetic capacity of plants. Therefore, it varies in different types of ecosystems.
The annual net primary productivity of the whole biosphere is approximately 170 billion tons (dry weight) of organic matter. Of this, despite occupying about 70 percent of the surface, the productivity of the oceans are only 55 billion tons. Rest of course, is on land. 2.5
Decomposition You may have heard of the earthworm being referred to as the farmer's 'friend'. This is so because they help in the breakdown of complex organic matter as well as in loosening of the soil. Similarly,
decomposers break down complex organic matter into inorganic substances like carbon dioxide, water and nutrients and the process is called decomposition. Dead plant remains
such as leaves, bark, flowers and
dead remains of animals, including fecal matter, constitute detritus, which is the raw material for decomposition. The important steps in the process of decomposition are fragmentation, leaching, catabolism, humification and mineralisation. Detritivores (e.g., earthworm) break down detritus into smaller particles. This process is called fragmentation. By the process of leaching, water soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
Bacterial and fungal enzymes degrade detritus into simpler inorganic substances. This process is called as catabolism.
It is important to note that all the above steps in decomposition operate simultaneously on the detritus.
Humification and mineralisation occur during decomposition in the soil. Humification leads to accumulation of a dark coloured amorphous substance called humus that is
highly

resistant to microbial action and undergoes decomposition at an extremely slow rate.
Being colloidal in nature it
serves as a reservoir of nutrients. The humus is further degraded by some microbes and release of inorganic nutrients occur by the process known as
mineralisation. Decomposition
is largely an oxygen-requiring process. The rate of decomposition is controlled by chemical composition of detritus and climatic factors. In a particular climatic condition,
decomposition rate is slower if detritus is rich in lignin and chitin,
and quicker, if detritus is rich in nitrogen and water-soluble substances like sugars.
Temperature and soil moisture are the most important climatic factors that regulate decomposition
through their effects on the activities of
soil microbes.
Warm and moist environment favour decomposition whereas low temperature and anaerobiosis inhibit decomposition resulting in build-up of organic materials.
19 2.6
Food chain and Food webs, Energy flow models 2.6.1 Food Chain A food chain is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. Let's look at the parts of a typical food chain, starting from the bottom— the producers—and moving upward. The flow of energy in one way process and the sequence in which the energy from the lower level of organisms to the higher level of the organisms are called as the food chain. The food chain is of two types – Grazing food chain and Detritus food chain At the base of the food chain lie the primary producers. The primary producers are autotrophs and are most often photosynthetic organisms such as plants, algae, or cyanobacteria. The organisms that eat the primary producers are called primary consumers. Primary consumers are usually herbivores, plant-eaters, though they may be algae eaters or bacteria eaters. The organisms that eat the primary consumers are called secondary consumers. Secondary consumers are generally meat-eaters—carnivores. The organisms that eat the secondary consumers are called tertiary consumers. These are carnivore-eating carnivores, like eagles or big fish. Some food chains have additional levels, such as quaternary consumers—carnivores that eat tertiary consumers. Organisms at the very top of a food chain are called apex consumers. We can see examples of these levels in the diagram below. The green algae are primary producers that get eaten by mollusks—the primary consumers. The mollusks then become lunch for the slimy small fish, a secondary consumer, which is itself eaten by a larger fish, the catfish—a tertiary consumer. Each of the categories above is called a trophic level, and it reflects how many transfers of energy and nutrients—how many consumption steps—separate an organism from the food chain's original energy source, such as light. As we'll explore further below, assigning organisms to trophic levels isn't always clear-cut. For instance, humans are omnivores that can eat both plants and animals. One other group of consumers deserves mention, although it does not always appear in drawings of food chains. This group consists of decomposers, organisms that break down dead organic material and wastes. Decomposers are sometimes considered their own trophic level. As a group, they eat dead matter and waste products that come from organisms at various other trophic levels; for instance, they would happily consume decaying plant matter, the body of a half-eaten squirrel, or the remains of a deceased eagle. In a sense, the decomposer level runs parallel to the standard hierarchy of primary, secondary, and tertiary consumers. Fungi and bacteria are the key decomposers in many ecosystems; they use the chemical energy in dead matter and wastes to fuel their metabolic processes. Other decomposers are detritivores— detritus eaters or debris eaters. These are usually multicellular animals such as earthworms, crabs, slugs, or vultures. They not only feed on dead organic matter but often fragment it as well, making it more available for bacterial or fungal decomposers. Decomposers as a group play a critical role in keeping ecosystems healthy. When they break down dead material and wastes, they release nutrients that can be recycled and used as building blocks by primary producers. 2.6.2 Food webs Food chains give us a clear-cut picture of who eats whom. However, some problems come up when we try and use them to describe whole ecological communities. For instance, an organism
20 can sometimes eat multiple types of prey or be eaten by multiple predators, including ones at different trophic levels. This is what happens when you eat a hamburger patty! The cow is a primary consumer, and the lettuce leaf on the patty is a primary producer. To represent these relationships more accurately, we can use a food web, a graph that shows all the trophic— eating-related—interactions between various species in an ecosystem.

Many food chains exist in an ecosystem, but as a matter of fact these food chains are not independent. In ecosystem, one organism does not depend wholly on another. The resources are shared specially at the beginning of the chain. The marsh plants are eaten by variety of insects, birds, mammals and fishes and some of the animals are eaten by several predators. Similarly, in the food chain grass → mouse → snakes → owls, sometimes mice are not eaten by snakes but directly by owls. This type of interrelationship interlinks the individuals of the whole community. In this way, food chains become interlinked. A complex of interrelated food chains makes up a food web. Food web maintains the stability of the ecosystem. The greater the number of alternative pathways the more stable is the community of living things.
Figure 2-1: Food Chain and Food Webs 2.6.3 Energy Flow Models The energy flow models link the trophic levels with each other showing the inputs and losses of energy at each trophic level. Lindeman (1942) was the first to propose such model assuming that plants and animals can be arranged into trophic levels and the laws of thermodynamics hold for plants and animals. He emphasized that
the amount of energy at trophic level is determined by the net primary production and the efficiency at which food energy is converted into biomass.
After that, various models depicting energy flow in ecosystems are described below:
21 SINGLE CHANNEL ENERGY FLOW MODEL - The
flow of energy in an ecosystem takes place through the food chain and it is
this energy flow which keeps the system going. The most common feature of this
energy flow is that it is unidirectional or one-way flow
or single channel flow. Unlike the nutrients (carbon, nitrogen, phosphorus, Sulphur etc.)
which move in a cyclic manner and are reused by the producers after moving through the food chain, energy is not reused in the food chain.
It flows from producers to herbivores to carnivores and so on. Two things are clear from this energy flow model. Firstly, the flow of energy is unidirectional and non-cyclic. The green plants obtain energy from the sun and
it is transformed into chemical energy by the process of photosynthesis. This energy is stored in
plant tissues and transformed into heat energy during metabolic activities which then passes to next trophic level in the food chain. The solar energy captured by green plants (autotrophs) never revert back to sun, however, it passes to herbivores and that which passes to herbivores does not go back to autotrophs but passes to consumers. Thus, in biological systems, the energy flows from the sun to green plants and then to all heterotrophic organisms. Due to unidirectional flow of energy, the entire system would collapse if primary source of energy were cut off. Secondly, at each tropic level there is progressive decrease in energy as heat in the metabolic reactions and also some of the energy is utilized at each tropic level. Figure 2-2: Simplified Single Channel Energy Flow Diagram (Modified from Lindeman, 1942) Figure shows the energy flow in three trophic levels in a linear food chain. Here
the boxes represent the trophic levels (producers, herbivores and carnivores) and the pipelines depict the energy flow in and out of each
trophic level. Size of the box shows energy stored in the form of biomass at that trophic level. There is loss of energy (represented as pipes getting narrower) at every successive trophic level, there is also a corresponding decline in energy stored in standing crop or biomass (represented as decreased size of box) at successive trophic level. Energy inflows in the system balance the energy
outflows as required by the first law of
22 thermodynamics and each energy transfer is accompanied by loss of energy
in the form of unavailable heat energy (i.e. respiration) as stated by second law of thermodynamics. The energy flow is significantly reduced at each successive trophic level from producers to herbivores to carnivores. Thus, at each transfer of energy from one trophic level to another trophic level, major part of energy is lost in the form of heat
or other form. There is successive reduction in the energy flow whether we consider it in term of total flow (I+A) or secondary productivity and respiration component. DOUBLE CHANNEL OR Y-SHAPED ENERGY FLOW MODEL The double channel or Y-Shaped energy flow model depicts the simultaneous working of grazing and detritus food chains in an ecosystem. In nature, both grazing and detritus food chains are inter- connected in the same ecosystem.
For example, dead bodies of small animals that were once part of grazing food chain
become incorporated in the detritus food chain as do the faces of grazing food animals. Functionally, the
distinction between the two is of time lag between the direct consumption of living plants and ultimate utilization of dead organic matter.
The importance of two food chains may differ in different ecosystems, in some cases, grazing is more important and in others, detritus is more important.
It happens in marine ecosystems where primary production at open sea is limited and a major portion of it is eaten by herbivores marine animals. Therefore, very little primary production is left to be passed onto the detritus pathways. On the other hand, in a

forest ecosystem, the huge quantity of biomass produced cannot be all consumed by herbivores
and a large part of it enters into detritus compartment in the form of litter. Hence the detritus food chain is more important there. In an example given by Singh et al (2015), in a lake open water zone, grazing food chain predominates as phytoplanktons are eaten upon by zooplanktons and other organisms. On the other hand, in the lake bottom, dead organisms are deposited and they are acted upon by detritus feeders and decomposers. Figure 2-3: The relationship between flow of energy through grazing and detritus pathways. E.P. Odum (1983) gave a generalized model of Y-shaped or double channel energy flow, which is applicable to both terrestrial and aquatic ecosystems. In
energy flow diagram, one arm represents
the grazing food chain and another represents detritus food chain. The important
23 point in this model is that both the chains are
not separated from each other.
Odum regarded this
model as more realistic than single channel energy flow model for the following reasons: a) It confirms to the basic stratified structure of
ecosystem by including both grazing and detritus pathways. b)
It separates the grazing food chain from detritus food chain in both time and space
as shown by direct consumption of living plants and utilization of dead organic matter respectively. c) Macroconsumer (animals) and microconsumers (bacteria and fungi) differ greatly in size- metabolism relations. The two arms differ fundamentally in the way they can influence primary producers. In grazing food chain, herbivores feed on living plants, therefore they directly affect the plant population. Whatever they do not eat is available to the decomposers after death. As a result, decomposers are not able to directly influence the rate of supply of their food. Further, the amount of net production energy that flows down the two pathways varies in different kind of ecosystems and often in the same ecosystem; it may vary seasonally or annually. In
heavily grazed grassland, 50% or more of the net production may pass down the grazing pathway. But aquatic systems like marshes or forests operate as detritus systems, for, over 90% of primary production is not consumed by heterotrophs until plant parts die and reach water, sediments and soils. This
delay in consumption of primary production increases structural complexity of the ecosystem. Since all the food is not assimilated by the grazers, some is diverted to the detritus route. So, the impact of grazers on the community depends on the rate of removal of living plants and the amount of energy in the food that is assimilated. Marine zooplanktons commonly graze more phytoplanktons than they can assimilate, the excess being egested to the detritus food chain. Thus, energy flow along different path is dependent on the rate of removal of living plant material by herbivores as well as on the rate of assimilation in their bodies. 2.6.3.1 UNIVERSAL ENERGY FLOW MODEL E.P. Odum (1968) gave Universal Energy Flow Model (Figure 2.3) which represents the basis for a general explanation of ecosystem trophic flows. The model can be applied to any living component, whether it is plant, animal, microorganism, individual, population or trophic group. Such a model may depict food chain as already shown in previous models or the bioenergetics of an entire ecosystem. In the figure, the living structure or biomass of the component is represented as the shaded box. Further, I - is the ingested energy which is solar radiation in case of autotrophs and ingested food in case of heterotrophs. Since not all the energy supplied is utilized, the lost part is called as energy not utilized (NU). The assimilated energy (A) is known as gross production.

24 Figure 2-4: Universal Energy Flow Model Part of assimilation (A) is used for system structural maintenance, that is the respiration (R), and the other part is transformed into organic matter (P), known as net production. P is the energy available for other individuals or trophic levels. Individuals use part of the net production for growth (G) or, in the case of populations or trophic levels, for biomass accumulation (B). A part of net production can be stored (S) to at individual level in the form of organic compounds of higher energetic content (lipids) or, at ecosystem level, as a nutrients deposit or detritus. Some production can be excreted by individuals or, analogously, exported from the ecosystem (E). The universal energy flow, can be used in two ways: i) The model can represent a species population in which case the appropriate energy inputs and links with other species would be shown as a conventional species- oriented food web diagram. ii) The model can represent a discrete energy level in which case the biomass and energy channels represent all or parts of many populations supported by the same energy source. Foxes, for example, usually obtain part of their food by eating plants (fruits etc.) and part by eating herbivores (rabbit, field mice model etc.). A single box diagram could be used to represent the whole population of foxes if to express intrapopulation energetic. On the other hand, two or more boxes may be used if we wish to represent two or more trophic levels. Energy partitioning between P and R is of vital importance to the individual and species. Different organisms have different patterns of energy consumption. Large organisms require more maintenance energy as they have more biomass to maintain. The warm blooded animals (birds and mammals) require more energy than the cold blooded animals. Predators use a large part of assimilated energy in respiration than herbivore, to find and overcoming the prey. The species adapted to unstable, recently derived or under populated area, generally allocate a large portion of their energy to reproduction. The species adapted to stable and more favourable habitats, allocate little energy to reproduction.
25 2.7 Ecological Succession An important characteristic of all communities is that their composition and structure constantly change in response to the changing environmental conditions. This change is orderly and sequential, parallel with the changes in the physical environment. These
changes lead finally to a community that is in near equilibrium with the environment and
that is called a climax community. The gradual and fairly
predictable change in the species composition of a given area is called ecological succession.
During succession some species colonise an area and their population become more numerous whereas populations of other species decline and even disappear. The entire sequence of communities that successively change in a given area are called sere(s).
The individual transitional communities are termed seral stages or
seral communities. In the successive seral stages, there is a change in the diversity of species of organisms, increase in the number of species and organisms as well as an increase in the total biomass. The present day communities in the world have come to be because of succession that has occurred over millions of years since life started on earth. Actually, succession
and evolution would have been parallel processes at that time. Succession is hence a process that starts in an area where no living organisms are there – these could be areas where no living organisms ever existed, say bare rock; or in areas that somehow, lost all the living organisms that existed there. The former is called primary succession, while the latter is termed secondary
succession. Examples of areas where primary succession occurs are newly cooled lava, bare rock, newly created pond or reservoir. The establishment of a new biotic community is generally slow. Before a biotic community of diverse organisms can become established, there must be soil. Depending mostly on the climate, it takes natural processes several hundred to several thousand years to produce fertile soil on bare rock. Secondary succession begins in areas where natural biotic communities have been destroyed such as in abandoned farm lands, burned or cut forests, lands that have been flooded. Since some soil or sediment is present, succession is faster than primary succession. Description of ecological succession usually focuses on changes in vegetation. However, these vegetational changes in turn affect food and shelter for various types of animals. Thus, as succession proceeds, the numbers and types of animals and decomposers also change. At any time during primary or secondary succession, natural or human induced disturbances (fire, deforestation, etc.), can convert a particular seral stage of succession to an earlier stage. Also, such disturbances create new conditions that encourage some species and discourage or eliminate other species.
When this process begins in a virtually lifeless area where soil has not yet formed, such as on a new volcanic island or on the rubble (moraine) left by a retreating glacier, it is called primary succession.
Often the only life-forms initially present are autotrophic prokaryotes and heterotrophic

prokaryotes and protists. Lichens and mosses, which grow from windblown spores, are commonly the first macroscopic photosynthesizers to colonize such areas. Soil develops gradually as rocks weather and organic matter accumulates from the de- composed remains of the early colonizers. Once soil is present, the lichens and mosses are usually overgrown by grasses, shrubs, and trees that sprout from seeds blown in from nearby areas or carried in by animals. Eventually, an area is colonized by plants that become the community's prevalent form of vegetation. Producing such a community through primary succession may take hundreds or thousands of years.
26
Secondary
succession
occurs when an existing
community
has been cleared by some disturbance that leaves the soil intact,
as in Yellowstone following the 1988 fires.
Sometimes the area begins to return to something like its original state. For instance, in a forested area that has been cleared for farming and later abandoned, the earliest plants to recolonize are often herbaceous species that grow from windblown or animal-borne seeds. If the area has not been burned or heavily grazed, woody shrubs may in time replace most of the herbaceous species, and forest trees may eventually replace most of the shrubs. Early arrivals and later-arriving species may be linked in
one of three key processes. The early arrivals may facilitate
the appearance of the later species by making the environment more favorable—for example, by increasing the fertility of the soil. Alternatively, the early species may inhibit establishment of the later species, so that successful colonization by later species occurs in spite of, rather than because of, the activities of the early species. Finally, the early species may be completely independent of the later species, which
tolerate
conditions created early in succession but are neither helped nor hindered by early species.
The final or stable community known as climax community. 2.7.1.1 Characteristics of Climax Community ▪
The vegetation is tolerant of environmental conditions. ▪ It has a wide diversity of species, a well-drained spatial structure, and complex food chains. ▪
The climax ecosystem is balanced. ▪
Individuals in the climax stage are replaced by others of the same
kind. ▪ It is an index of the climate of the area. 2.7.1.2 Types of climax - ▪ Climatic Climax - one of the ecological climaxes possible in a particular climatic area whose stability is directly due to the influence of climate. ▪ Edaphic Climax -an ecological climax resulting from soil factors and commonly persisting through cycles of climatic and physiographic change. ▪ Catastrophic Climax -Climax vegetation vulnerable to a catastrophic event such. 2.7.1.3 Disclimax
When a stable community, which is not the climatic or edaphic climax for the given site, is maintained by man or his domestic animals, it is designated as Disclimax (disturbance climax) or anthropogenic subclimax (man-generated). ▪
Subclimax -The prolonged stage in succession just preceding the climatic climax. ▪
Preclimax and Postclimax Preclimax -
if the community has life forms lower than those in the expected climatic climax. Postclimax - a community that has life forms higher than those in the expected climatic climax.
Monoclimax /Climatic Climax Theory-- an invention of the American ecologist F.E. Clements. This states that every region has only one climax community, toward which all communities are evolving and that, given sufficient time and freedom from interference. Polyclimax Theory -. A.G. Tansley - community are controlled by soil moisture, minerals, ions, activity of animals, topography, and other factors.
27 Climax Pattern Theory - proposed by Whittaker (1953) - recognizes a variety of climaxes governed by responses of species populations to biotic and abiotic conditions. -the total environment of the ecosystem determines the composition, species structure, and balance of a climax community 2.7.2
Succession of Plants Based on the nature of the habitat – whether it is water (or very wet areas) or it is on very dry areas – succession of plants is called hydrarch or xerarch, respectively. Hydrarch succession takes place in
wet
areas and the successional series progress from hydric to the mesic conditions. As against this, xerarch succession takes place in dry areas and the series progress from xeric to mesic conditions. Hence, both hydrarch and xerarch successions lead to medium water conditions (mesic) – neither too dry (xeric) nor too wet (hydric).
The species that invade a bare area are called pioneer species. In primary succession on rocks these are usually lichens which are able to secrete acids to dissolve rock, helping in weathering and soil formation. These
later pave way to some very small plants like bryophytes, which

are able to take hold in the small amount of soil. They are, with time, succeeded by higher plants, and after several more stages, ultimately a stable climax forest community is formed. The climax community remains stable as long as the environment remains unchanged.

With time the xerophytic habitat gets converted into a mesophytic one.

In primary succession in water, the pioneers are the small phytoplanktons, which are replaced with time by rooted-submerged plants, rooted-floating angiosperms followed by free-floating plants, then reed swamp, marsh-meadow, scrub
and finally the trees. The climax again would be a forest. With time the water body is converted into land.

In secondary succession the species that invade depend on the condition of the soil, availability of water, the environment as also the seeds or other propagules present. Since soil is already there, the rate of succession is much faster and hence, climax is also reached more quickly.

What is important to understand is
that succession, particularly primary succession, is a very slow process, taking maybe thousands of
to meet with the deficit which occurs due to imbalance in the rate of influx and efflux. 2.8
Concept of Ecotone, Edge Effect, Ecological Habitats and Niche 2.8.1 Ecotone The term was coined from a combination of eco(logy) plus -tone, from the Greek tonos or tension (a place where ecologies are in tension).

An ecotone is a zone of junction or a transition area between two biomes [diverse ecosystems]. It is where two communities meet and integrate. For e.g., the mangrove forests represent an ecotone between marine and terrestrial ecosystem. Other examples
are grassland (
between forest and desert), estuary (between fresh water and salt water) and river bank or marsh land (between dry and wet). 2.8.1.1
Characteristics of Ecotone • It may be narrow (between grassland and forest) or wide (between forest and desert). • As it
is a zone of
transition,
it has conditions intermediate to the adjacent ecosystems.
28 Hence it
is a zone of tension. • Usually, the number and the population density of the species of an outgoing community decreases as we move away from community or ecosystem. • Well-developed ecotones contain some organisms which are entirely different from that of the adjoining communities. 2.8.2
Edge effect
An "edge"
is the boundary or interface between two biological communities or between different landscape elements. -
refer
to the changes in population or community structure s that occur at the boundary of two habitats i.e., ecotone region. As the edge effects increase, the boundary habitat allows for greater biodiversity.

Sometimes the number of species and the population density of some of the species in the ecotone is much greater than either community. This is called edge effect. The organisms which occur primarily or most abundantly in this zone are known
as edge
species. In the terrestrial ecosystems edge effect is especially applicable to birds. For example, the density of birds is greater in the
mixed habitat of the ecotone between the forest and the desert. 2.8.2.1
Types of Edge effect- • Inherent— Natural features stabilize the border location. • Induced—Transient natural or human related activities, subject borders to successional changes over time. • Narrow—One habitat abruptly ends and another begins. • Wide (ecotone)—Substantial distance separates border from point where physical conditions and vegetation do not differ from interior of patch. • Convoluted—Border is non-linear. • Perforated—Border has gaps that host other habitats. 2.8.3 Ecological Niche and Habitat

Niche refers to the unique functional role and position of a species in its habitat or ecosystem.

In nature, many species occupy the same habitat but they perform different functions.

The functional characteristics of a species in its habitat is referred to as "niche" in that common
habitat.

Habitat of a species is like its 'address' (i.e. where it lives) whereas niche can be thought of as its "profession" (i.e. activities and responses specific to the species).

It is the surroundings in which an organism lives (home).

A niche is unique for a species while many species share the habitat. No two species in a habitat can have the same niche. This is because of the competition with one another until one is displaced. For example, a large number of different species of insects may be pests of the same plant but they can co-exist as they feed on different parts of the same plant.
A species' niche includes all of its interactions with the biotic and abiotic factors of its environment [
habitat niche – where it lives, food niche – what is eats or decomposes & what species it competes
29 with, reproductive niche – how and when it reproduces, physical & chemical niche – temperature, land shape, land slope, humidity & other requirement].
An ecological niche describes how an organism or population responds to the distribution of resources and competitors (for example, by growing when resources are abundant, and when predators, parasites and pathogens are scarce) and how it in turn alters those same factors (for example, limiting access to resources by other organisms, acting as a food source for predators and a consumer of prey).
Niche plays an important role in conservation of organisms. If we have to conserve species in its native habitat we should have knowledge about the niche requirements of the species
and should ensure that all requirements of its niche are fulfilled.
Aspects or types of ecological niche: The three aspects of ecological niche are 1) Spatial or habitat niche: According to this, a niche is the "microhabitat in which a species lives". It represents the physical space occupied by an organism. According to this, no two species can occupy the same habitat. e.g., Catla, Rohu, Mrigal live in same pond, but they occupy different niche (surface, mid-column and bottom layer) 2) Trophic niche: According to this, a niche is the "functional status of an organism in its community". Thus, it describes the trophic position of an organism in an ecosystem. E.g., Two weaver birds Ploceus collaris and P. melanocephalus, live in the same nest but one feeds on seeds and the other on insects. 3) Multidimensional or hypervolume niche: According to this, a niche can be a multidimensional or hyper-volume space. The activity range of any species is dependent on all the dimensions of the environment. These dimensions include physical and chemical parameters such as temperature, humidity, salinity, oxygen concentration etc. and biological factors such as prey species. It led to the concepts of niche breadth and niche overlap. 2.8.3.1 Niche Differentiation Fundamental niche and realised niche: Fundamental niche are the niche that an organism occupies in the absence of any competitors and predators. Realised niche is referred to as the role an organism actually plays in the community. For example, the outcome of inter-specific competition leads to either extinction or the development of differences allowing coexistence. 2.8.3.2 Advantages of ecological niche: 1) Animals can escape competition by occupying different ecological niches. 2) Segregation of different species in a particular niche result in full exploitation of all available resources. Table 2-1:Comparison
between Habitat and Niche Basis for Comparison Habitat Niche Meaning
A habitat is an area, where a species lives and interact with
the other factors.
A niche is an ideology, of how an organisms lives or survive in the
provided environmental conditions. Consist of Habitat consist of numerous niches. Niches does not contains such components.
30 It includes Affect
of temperature, rainfall and other abiotic factors. Flow of energy from one
organisms to other through ecosystem. Examples Desrets, oceans, forest, rivers, mountains, etc. are examples of habitat. It is a part of habitat only, where shelter for living being can be furnished. Supports
Habitat supports numerous species at a time. Niche supports a single species at a time. What it is Superset Subset Nature Habitat is a physical place. Niche is an activity performed by organisms. Specificity Habitat is not species specific. Niche is species specific. 2.9
Ecosystem Services Healthy ecosystems are the base
for a wide range of economic, environmental, and aesthetic goods and services.
The products of ecosystem processes are named as ecosystem services,
for example, healthy forest ecosystems purify air and water, mitigate droughts and floods,
cycle nutrients, generate fertile soils, provide wildlife habitat, maintain biodiversity, pollinate crops, provide storage site for carbon and also provide aesthetic, cultural and spiritual values.
Though value of such services of biodiversity is difficult to determine, it seems reasonable to think that biodiversity should carry a hefty price tag.
Robert Constanza and his colleagues have very recently
tried to put price tags on nature's life-support services.

Ecosystem services are the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services e.g., clean air, water, and food (Constanza et al. 1997). Historically, humans have modified natural ecosystems to favour those species that yield direct benefits (e.g., agricultural commodities), generally overlooking the unseen but essential ecosystem services (e.g. pollination, soil fertility, insect control and erosion control) that, if lost, are expensive and sometimes impossible to replace. Some ecosystem services, such as the regulation and stabilisation of climate, water flow, and the movement of nutrients have been even less visible until recent times, when disturbance to these systems has exacerbated climate change, soil erosion or eutrophication. Like all complex systems, ecosystems can appear to be working well until they suddenly collapse, as the supporting base may have eroded without obvious warning symptoms. A well-known example is fisheries, which may abruptly collapse even when the level of catch has been stable for years (Mullon et al. 2005). Another example is evident in the landscape where crops and pastures have replaced native vegetation. They have shallow root systems that do not use nearly as much of the rain or irrigation water that percolates into the soil as native plants. The excess water finds its way to the groundwater up to 10 times faster. Consequently, groundwater levels slowly rise, dissolving the natural salt in the weathered soils found over vast areas of Australia. It can take from 10 to 100 years for these changes to bring salt to the land surface or into streams (Australian State of the Environment Committee 2001). When this happens, the result can be devastating to production and to
31 biodiversity. Many ecosystem services have not been easy to observe until they cease to flow, hence they have not been formally counted in economic systems, or the effects of their loss have been counted as 'externalities.' However, when these externalities become a significant cost burden to society, such as restoring degraded river systems, it becomes a priority to understand and value ecosystem services and to integrate them into economic frameworks. Maintenance and restoration of natural ecosystems and the services they provide is therefore essential to sustained community wellbeing, economic prosperity and efficiency. To date, the broad range of biodiversity protection measures, public and private, has been vital in ensuring that ecosystem services continue to flow, even if this has not been their main intention. Researchers have put an average price tag of US $ 33 trillion a year on these fundamental ecosystem's services, which are largely taken for granted because they are free. This is nearly twice the value of the global gross national product GNP which is (US $ 18 trillion). Out of the total cost of various ecosystem services, the soil formation accounts for about 50 per cent, and contributions of other services like recreation and nutrient cycling, are less than 10 per cent each. The cost of climate regulation and habitat for wildlife are about 6 per cent each. Ecosystem services are the many and varied benefits that people obtain from ecosystems. In 2005, the Millennium Ecosystem Assessment identified and categorised ecosystems and their resulting services, identified the links between these services and human societies, and the direct and indirect drivers and feedback loops. The Millennium Ecosystem Assessment framework identified ecosystem services within four categories: ■ Provisioning services, such as food and water. Provisioning services (mostly food and fibre commodities) along with the supporting services that need to be replaced in order for these services to continue to flow, e.g., fertilisers to replace natural soil fertility, pesticides to replace natural pest control, have long been included in market economics. ■ Regulating services, such as flood and disease control. Regulating services where some of these services, e.g., pest regulation, seed dispersal, disease regulation and erosion regulation, have been artificially supplied and counted as costs of production. Other services, such as climate control, have been outside the market but are now being priced and integrated into markets, the most notable is carbon sequestration. ■ Supporting services, such as nutrient cycling, that maintain the conditions for life on Earth. Supporting services of which most have traditionally been unvalued, although their importance has been acknowledged through government investment in soil and biodiversity conservation. Others, such as water for environmental flows, are the subject of emerging markets. ■ Cultural services, such as spiritual, recreational, and cultural benefits. Cultural services include knowledge of country and place, which is important to Indigenous people. Another example is nature-based tourism that has significant economic value. However, many cultural services, whilst clearly valued, have not been explicitly priced or included in markets.
32 Figure 2-5: Millennium Ecosystem Assessment's overview of ecosystem services

33 This framework is useful for identifying and analysing the full suite of ecosystem services available within any given geographical area. It also helps us to understand the complexity of dependencies, feedbacks and trade-offs between services and human beneficiaries, and can provide useful information for decision making by: ■ explicitly identifying and classifying the benefits that people derive from ecosystems, including market and non-market, use and non-use, tangible and intangible benefits ■ describing and communicating these benefits in concepts and language that people can understand ■ asking, and trying to answer, ecological, economic and social questions to improve sustainable management of ecosystems and human wellbeing. Although such analysis may be information intensive, taking an approach which looks for multiple benefits is likely to minimise the risks of compromising the structure, function and services of ecosystems and increase the options for retaining resilience. A mix of ecosystem services is available from any area of natural or modified ecosystem or habitat. However, the potential for modified ecosystems to provide a full range of ecosystem services over the long term may be limited if ecological or other thresholds are reached. 2.10 Summary • The components of the ecosystem are seen to function as a unit when you consider the following aspects Productivity; Decomposition; Energy flow; and Nutrient cycling. •

Gross primary productivity of an ecosystem is the rate of production of organic matter during photosynthesis.

Net primary productivity is the available biomass for the consumption to heterotrophs. •

Food chain is a linear sequence of organisms which starts from producer organisms and ends with decomposer species. Food web is a connection of multiple food chains. •

The energy flow takes place via the food chain and food web.

Total energy decrease on every hierarchical level of ecosystem. • Ecological succession is the gradual process by which ecosystems change and develop over time. One community replace by another until reaches a climax community. • Habitat of a species is where it lives whereas niche is how a species interacts within an ecosystem. • Ecosystem services are the direct and indirect contributions of ecosystems to human well-being. 2.11 Questions/ Self-Assessment questions MCQ type

questions 1.

Which one of the following has the largest population in a food chain? a) Producers b) Primary consumers c) Secondary consumers d) Decomposers 2. The 10%

energy transfer law of food chain was given by a) Tansley

34 b) Stanley c) Weismann d) Lindeman 3. If we completely remove the decomposers from an ecosystem, their functioning will be adversely affected because a) Herbivores will not receive solar energy b) Energy flow will be blocked c) The rate of decomposition will be very high d) Mineral movement will be blocked 4. Total primary production in an ecosystem is known as a) Gross final production b) Net primary production c) Gross primary production d) Photosynthesis 5. What is true about secondary succession a) follows primary succession b) takes place on a deforested site c) is similar to primary succession except that it has a relatively slower pace d) begins on a bare rock Short answer type questions 1. What is gross primary productivity (GPP) and net primary productivity (NPP)? 2. What is hydrarch and xerarch succession? 3. Give an account of universal energy flow model in an ecosystem. 4. What is ecotone? Explain Edge effect. 5. Compare between habitat and niche. Long answer type questions 1. Define and elaborate different types of ecosystem services. 2. What is primary and secondary succession? Write down characteristics of different types of climax community. 3. What is the different component of food chain? Write short note on different energy flow model in ecosystem. 2.12 Select Readings/ Suggested Readings 1. Fundamentals of Ecology by Eugene Odum 2. Ecology: Theories & Applications by Peter Stiling 3. Elements of Ecology by Smith & Smith 35 3 Population and Human Ecology 3.1 Objective 3.2 Introduction 3.3 Population dynamics 3.4 Metapopulation 3.5 Concept of carrying capacity 3.6 Mechanism of Population Equilibrium 3.7 Concept of "r" and "k" species 3.8 Human population 3.9 Summary 3.10 Questions/ Self-Assessment questions 3.11 Select Readings/ Suggested Readings 3.1 Objective • To learn about population dynamics and metapopulation. • To understand the concept of carrying capacity and population equilibrium. • To know the role and characteristics of r and k selected species. • Discussion on human population dynamics 3.2 Introduction

Population ecology is the study of populations in relation to the environment, including environmental influences on population density and distribution, age structure, and population size.

A
population is
a group of individuals of
a single species that
live in
the same

general area. Members of a population rely on the same resources, are influenced by similar environmental factors, and have a high likelihood of interacting with and breeding with one another. Populations can evolve through natural selection acting on heritable variations among individuals and changing the frequencies of various traits over time. Here in this chapter, we will discuss about different aspects of population ecology. Human population shows an exponential growth rate and directly or indirectly controls almost everything on earth. We will learn about it in from an ecological perspective. 3.3 Population dynamics Ecologists use various terms when understanding and discussing populations of organisms. A population is all of one kind of species residing in a particular location. Population size represents the total number of individuals in a habitat. Population density refers to how many individuals reside in a particular area. Population Size is represented by the letter N, and it equals the total number of individuals in a population. The larger a population is, the greater its generic variation and therefore its

36 potential for long-term survival. Increased population size can, however, lead to other issues, such as overuse of resources leading to a population crash. Population Density refers to the number of individuals in a particular area. A low-density area would have more organisms spread out. High-density areas would have more individuals living closer together, leading to greater resource competition. Population Dispersion: Yields helpful information about how species interact with each other. Researchers can learn more about populations by studying the way they are distributed or dispersed. Population distribution describes how individuals of a species are spread out, whether they live in close proximity to each other or far apart, or clustered into groups. Uniform dispersion refers to organisms that live in a specific territory. One example would be penguins. Penguins live in territories, and within those territories the birds space themselves out relatively uniformly. Random dispersion refers to the spread of individuals such as wind-dispersed seeds, which fall randomly after traveling. 3.3.1.1 Factors controlling population growth Density Dependent and Density Independent Mortality Factors L. O. Howard and W. F. Fiske (1911) were the first to base a concept of population regulation on functional relationships. They proposed the terms "catastrophic" mortality factors and "facultative" mortality factors. Catastrophic Mortality Factors: factors destroying a constant proportion of a population regardless of the organisms being acted upon. Facultative Mortality Factors: factors destroying a percentage of a population which increases in destruction with increases in the population. They respond to population changes in host or prey density. H. S. Smith (1935) rephrased the terms into "density independent" and "density dependent" mortality factors. Density Independent (Catastrophic) Mortality Factors: those mortality factors that are a function of the non-living (abiotic) physical components of the environment. Density Dependent (Facultative) Mortality Factors: those mortality factors that are a function of biotic agents in the environment. Two types of competition are there i.e., intraspecific competition-competition among a species and interspecific competition- competition between 2 species. 3.3.1.2 Density dependent mortality factors Reciprocal density dependent mortality: that mortality inflicted on a population by a biotic mortality factor whose own numbers are changed as a consequence (i.e., Vedalia beetle on cottony cushion scale). The different types of reciprocal density dependent mortality are: a. Direct density dependence • overcompensating (b < 1.0) UNSTABLE • perfect (b = 1.0) • undercompensating (b > 1.0) STABLE b. Inverse density dependence c. Delayed density dependence (time lags) Nonreciprocal density dependent mortality: that mortality inflicted on population by a biotic mortality factor whose own numbers are not changed as a consequence (i.e., solitary wasps competing for a limited number of nest hole sites).

37 Figure 3-1: Different concepts of population regulation 3.3.1.3 Population Equilibrium and Fluctuations Density dependence tends to push populations toward carrying capacity, K. Because the environment is variable, K is also variable and hence populations often don’t rest at K too, which means density dependence doesn’t always lead to a static equilibrium. Populations show ups and downs and always try to reach K; these ups and downs are referred as population fluctuations. Population fluctuations can be erratic (irruptive) or they can be periodic (cyclic). Erratic fluctuations are mostly due to variation in density-independent environmental factors that have a large, immediate impact on population size (e.g., fires, catastrophes). While cyclic fluctuations also known as oscillations are the result of time lags in responses of populations to their own density. Populations acquire “momentum” when high birth rates at low densities cause the populations to overshoot K, which causes very low survival and birth rates, consequently population falls below K, recovery occurs when birth rates again increase due to lowered density conditions. Population cycles result from time delays in the responses of birth and death rates to current environmental conditions which try to either under compensate or overcompensate for population size. The nature of the cycle depends on population’s resilience. Resilience decides how fast the population will regain the equilibrium. Reproductive rate has very strong influence on resilient capacity of the population. Population fluctuations occur over many different time scales, ranging from millions of years on a geological time scale to years, seasons, or weeks, on a short time scale. Fluctuations at short time scales are important to be studied in population dynamics.

38 3.3.2 Types of fluctuations: a) Stable: population size fluctuates around carrying capacity slightly above and below and is characteristic of many species living under fairly constant environment, like conditions in Tropical rainforest. 3.3.2.1 Irruptive: population is normally fairly stable, it occasionally explodes (irrupts) to peak then crashes to level below carrying capacity. This occurs due to a factor (e.g., a resource availability) that temporarily increases carrying capacity. This is characteristic of short-lived, rapidly reproducing species. 3.3.2.2 Irregular: no apparent recurring pattern is observed an irregular, chaotic behaviour is seen in population size. The cause for this behaviour is poorly understood, some scientists attribute irregular behaviour to chaos in the system. 3.3.2.3 Cyclic: fluctuations occur over a regular time period, generally a multiple year cycle. 3.3.2.4 "Equilibrium Density": characteristic level of abundance of populations in nature. Concept that developed from the basic premises of the Verhulst-Pearl logistic theory and Chapman's theories. It is theorized that densities of natural populations (though tending to fluctuate in time) attain characteristic levels of abundance, rather than increasing without limit or decreasing to extinction. Steady state is a more appropriate term than equilibrium. This classical view admits that species can deviate from equilibrium, and that the equilibrium state may be unstable in many cases, giving rise to population oscillations about it. Nonetheless, this view attaches fundamental significance to there being such an equilibrium state. It is oriented around equations such as the Lotka-Volterra equations, Leslie's predator-prey equations, the Rosenzweig-MacArthur model, Nicholson- Bailey model, and their many variations, all of which have well-defined mathematical equilibrium points. 3.4 Metapopulation Populations of many species have a patchy distribution, the most prominent reason of which is spatial heterogeneity of the habitat. It results in many small population sets' establishments, where the sets are linked with different processes and such a group of interacting populations of the same species is known as Metapopulation. Individual population in such case is referred as a local population or deme population. The concept was proposed by an American scientist Richard Levins (1969, 1970). He defined metapopulation as a set of populations linked with significant flow of individuals. The concept was accepted by many scientists. Hanski and Simberloff (1997) modified the definition as Metapopulation is a set of local population within some larger area where typically migration from one local population to at least some other patch is possible. Metapopulations occur naturally as well as are created as a result of human actions. The population and Metapopulation can be differentiated as on the basis of heterogeneity in the area. A population occupies a patch with one set of microclimatic condition

39 while metapopulation comprises many such populations invading the larger area in the local environment conditions. 3.4.1 Types of Metapopulations a) Classical Metapopulation / Levins Metapopulation: It has a large network of similar small patches with local dynamics occurring at a much faster rate than the metapopulation dynamics. This metapopulation indicates higher risk of extinction at all the local population sets. 3.4.1.1 Mainland- Island Metapopulation / Boorman- Levitt Metapopulation: This defines a system of habitat patches located within dispersal distances from a very large habitat patch, the large patch behaves as mainland (source population) from where dispersal to small island patches (sink populations) is possible. Source populations produce excess individuals that emigrate to other patches and Sink populations are maintained by immigration into unfavourable habitats, in this type of system the local population never goes extinct and it is an ideal population type. 3.4.1.2 Source Sink Metapopulation/Patchy Metapopulation: It is a system where sub populations have much low density and may show negative growth in absence of dispersal and positive growth in presence of dispersal. Thus, every patch can function as Source as well as Sink. 3.4.1.3 Non- Equilibrium Metapopulation: It is a system in which long term extinction rates exceed colonization rates or vice -versa. Populations are isolated and communication among patches is highly diffused, such metapopulations at high risk of extinction. Figure 3-2: Different types of Metapopulation Models

40 3.4.2 Metapopulation Dynamic As in population, birth and death rates play important role in population growth, the three key processes which are important in Metapopulation dynamics are colonization, extinction, and turnover. Metapopulations are characterized by repeated extinctions and colonization. Extinction occurs in already occupied area while Colonization is possible in already occupied area and in vacant area which is suitable for the species growth. Extinction: It is the disappearance of a species. It starts with thinning of population and then ultimate disappearance of the population. The causal processes for extinction are high mortality rate, low natality rate poor immigration, high emigration and low resilience to fluctuation and the distribution of species. The response of the species varies, the threat is more too rare and endemic species as compare to wide spread species. In metapopulation dynamics extinction is usually a constant risk at occupied patches. Colonization: It is the appearance and establishment of a species at a patch. It depends on number of occupied and vacant patches. Colonization is affected by the proximity of the mainland and process of migration / dispersal. Turnover: Turnover is related to extermination of local populations and establishment of new local populations in vacant habitat patches by nomad from existing local populations. It is process of reappearance. 3.5 Concept of carrying capacity Carrying capacity is typically defined as the maximum population size that can be supported indefinitely by a given environment. The simplicity of this definition belies the complexity of the concept and its application. There are at least four closely related but nonetheless different uses of the term in basic ecology, and at least half a dozen additional definitions in applied ecology. Carrying capacity is most often presented in ecology textbooks as the constant K in the logistic population growth equation, derived and named by Pierre Verhulst in 1838, and rediscovered and published independently by Raymond Pearl and Lowell Reed in 1920. Of historical interest is that neither Verhulst nor Pearl and Reed used 'carrying capacity' to describe what they called the maximum population, upper limit, or asymptote of the logistic curve. In reality, the term 'carrying capacity' first appeared in range management literature of the late 1890s, quite independent of the development of theoretical ecology (see below). Carrying capacity was not explicitly associated with K of the logistic model until Eugene Odum published his classic textbook Fundamentals of Ecology in 1953. The second use in basic ecology is broader than the logistic model and simply defines carrying capacity as the equilibrial population size or density where the birth rate equals the death rate due to directly density dependent processes. The third and even more general definition is that of a long-term average population size that is stable through time. In this case, the birth and death rates are not always equal, and there may be both immigration and emigration (unlike the logistic equation), yet despite population fluctuations, the long-term population trajectory through time has a slope of zero.

41 The fourth use is to define carrying capacity in terms of Justus Liebig's 1855 law of the minimum that population size is constrained by whatever resource is in the shortest supply. This concept is particularly difficult to apply to natural populations due to its simplifying assumptions of independent limiting factors and population size being directly proportional to whatever factor is most limiting. Moreover, unlike the other three definitions, the law of the minimum does not necessarily imply population regulation. Note that none of these definitions from basic ecology explicitly acknowledges the fact that the population size of any species is affected by interactions with other species, including predators, parasites, diseases, competitors, mutualists, etc. Given that the biotic environment afforded by all other species in the ecosystem typically varies, as does the abiotic environment, the notion of carrying capacity as a fixed population size or density is highly unrealistic. Additionally, these definitions of carrying capacity ignore evolutionary change in species that may also affect population size within any particular environment. 3.6 Mechanism of Population Equilibrium The concept of population equilibrium was relevant in different context, one being its use for the mathematical description of predator-prey oscillations. Here the work of Lotka and Volterra inspired biologists because it provided opportunity to calculate the nature of equilibria in a community. The mechanism that was attached to the concept of equilibrium at this stage in community ecology was rebounding behaviour. The epistemic value was stability and the concept of equilibrium provided a way to explain the stability of predator-prey interactions. Regarding equilibrium in populations, the epistemic value was control of population size (N), which meant that N limited the growth rate (r). The logistic curve provided a mathematical justification for this through its modelling of the relationship between r and N. Assumptions that were inherent in the logistic curve were discussed among population ecologists, especially concerning the role of the variable r. Andrewartha and Birch, for example, emphasized the importance of discriminating between an innate r and an actual r. They rejected the epistemic value of control and thus rejected the concept of equilibrium as well. According to their metaphysical framework, the environment determined population size, which was reflected by their methodology of life-table analysis. This assumed exponential growth of populations with a stable age distribution, density-dependence not being the primary concern. Both elements made them reject the logistic curve with its simplistic assumption of linear density-dependence. A certain ambiguity can be found in their work because they claimed on one hand that a stable age distribution could rarely be found in nature. On the other hand, they used it as a theoretical assumption to be able to compare different populations based on their intrinsic r. Despite Andrewartha and Birch's critique, the concept of density-dependent regulation leading to an equilibrium state is still in use. Because the logistic provided a simple model for population control it became very influential and served as an inspiration to ecological research. Ecologists, however, have modified assumptions made in the logistic curve. The logistic and the predator-prey equations were discussed in this chapter as a form of mathematical justification of the equilibrium concept. The equilibrium state, defined as setting the growth rate to zero and subsequently solving the equations, provided important insight into the dynamics of predator and prey. These relations could also be described in graphical form, which was done by ecologists to summarize the behaviour of the two populations. Regarding population growth, the logistic curve was influential in illustrating a certain growth pattern of

42 populations and then providing the mathematical description of it. Both elements were important for the justification of the concept of equilibrium. Even if it was later discovered that the logistic was not clear on the exact form of density-dependence, the mathematical justification of equilibrium concept was successful. However, this justification did not follow established rules. Volterra's laws, for example, were not laws for population dynamics but rather descriptions of what would happen if the laws were correct, although he himself initially was not aware of this. Other biologists, however, were less tdng of his predictions because some of the assumptions involved did not seem to be realistic (Israel 1993). Mathematical justification took many forms and was much debated. Thus, it is not useful to refer to a certain context of discovery which can be separated from a context of justification because there is no evidence for any a priori rules for justifications of the concept of equilibrium. Volterra's and Lotka's approach to mathematical justification used deterministic methods. This caused criticism by Andrewartha and Birch, and 'equilibrium' was increasingly discussed in probabilistic terms following the 1950s when it was suggested that statistical thinking be incorporated into ecology. 3.7 Concept of "r" and "k" species An organism's Darwinian fitness is calculated as the number of offspring it leaves behind that, themselves, survive to reproduce. In evolutionary terms, it is of no consequence if an organism is a fine, fully mature, physical specimen, or the dominant member of the herd, or even that an individual produces a lot of young but none of them survive. In the relay race of evolution, getting as many copies of your genes into the next generation as possible is the only goal. As you might imagine, there are many ways to be reproductively successful. One way is to become the dominant animal in a pack, and to monopolize mating opportunities, but another way is to be submissive and sneaky, mating with others when the dominant animal is not around to stop you. There are no moral judgements. It's just biology. Now imagine that you're an animal faced with the following choice: given limited resources, should you put them all into producing one or a few offspring, and protect them with great ferocity, or should you put a small amount of effort into a much larger number of offspring, and let them each take their chances? Should you measure out your reproductive effort over many seasons, or save it all up for a one-time mating frenzy as soon as you're able? These trade-offs relate to the r/K selection theory of life history strategies. 3.7.1 r-selection: On one extreme are the species that are highly r-selected. r is for reproduction. Such a species puts only a small investment of resources into each offspring, but produces many such low effort babies. Such species are also generally not very invested in protecting or rearing these young. Often, the eggs are fertilized and then dispersed. The benefit of this strategy is that if resources are limited or unpredictable, you can still produce some young. However, each of these young has a high probability of mortality, and does not benefit from the protection or nurturing of a caring parent or parents. r-selected babies grow rapidly, and tend to be found in less competitive, low-quality environments. Although not always the case, r-selection is more common among smaller animals with shorter lifespans and, frequently, nonoverlapping generations, such as fish or insects. The young tend to be precocial (rapidly maturing) and develop early independence.

43 3.7.2 k-selection: On the other extreme are species that are highly K-selected. K refers to the carrying capacity, and means that the babies are entering a competitive world, in a population at or near it carrying capacity. K-selected reproductive strategies tend towards heavy investment in each offspring, are more common in long-lived organisms, with a longer period of maturation to adulthood, heavy parental care and nurturing, often a period of teaching the young, and with fierce protection of the babies by the parents. K-selected species produce offspring that each have a higher probability of survival to maturity. Although not always the case, K-selection is more common in larger animals, like whales or elephants, with longer lifespans and overlapping generations. The young tend to be altricial (immature, requiring extensive care). You can see r- and K-selected strategies clearly by looking at different organisms within a phylogenetic group, such as the mammals. For example, elephants are highly K-selected, whereas mice are much more r-selected. Among the fishes, most, like the salmon, are r-selected. Some species will even inadvertently eat their own young if they are not immediately dispersed, but a few species, such as the cichlids, are K selected and provide prolonged care and protection of the eggs and hatchlings. Even among humans, there are a range of strategies toward one or the other extreme. In one family, with ten children, for example, there is no way for the parents to put as much time, energy, or resources into all of them as could be done with an only child. But, with humans, it gets complicated by the fact that others, including siblings, grandparents, blood-relatives, and the larger community all play a role in the nurturing and education of children. Even plants are capable of r- and K-selected reproductive strategies. Wind pollinated species produce much more pollen that insect pollinated ones, for example, because the pollen has to be carried at random by the wind to a receptive female flower. Eggs too, can be r- or K- selected. The amount of nutrient energy placed in an egg gives it a lesser or greater ability to survive in adverse conditions. One can even compare the reproductive stragies of males and females within a species, when sperm and egg represent different levels of energy investment. Often sperm are resource poor, and produced in large quantities, while eggs are resource rich and produced in smaller numbers. This can lead to differences in behaviour between the sexes, often with the result that the female is the choosier sex when it comes to reproduction. This trend is further extended if the female also carries the young (in the case of internal fertilization) or has a greater role in parental care once the babies are born. There are some interesting exceptions that illustrate the rule. Male seahorses are the choosier sex, and they are the ones that incubate the young. In a small fish called the stickleback, the male is also choosier, it is believed, because the female lays her eggs in a nest he constructed and then leaves. The male guards the nest and tends the young for an extended period. It should be noted that r- and K- selection are the extremes at both ends of a continuum and that most species fall somewhere in between. 44 Figure 3-3: Type I survivorship curve is most K-selected, Type III survivorship curve is most r-selected and Type II fall in somewhere in between. Example of Type I curve is most large mammals like elephant, Type III is mouse, insects, bacteria etc and Type II shown by some bird species. Table 3-1: Comparisons between 'r' and 'k' selection Characteristics r-Selected k-Selected Number of offspring High low Parental care Low high Reproductive maturity Early late Size of offspring Small large Independence at birth Early late Ability to learn Low high Lifespan Short long Early mortality High low Acclimatization ability Low high 3.7.3 Keystone species concept The keystone species concept has proved both promising and elusive in theoretical and applied ecology. The term has its origins in Robert Paine's studies of rocky shore communities in California. When the top predator (a starfish) was removed the species assemblage collapsed, prompting the architectural analogy with the keystone of an arch. By definition keystone species are those whose effect is large, and disproportionately large relative to their abundance. They include organisms that (i) control potential dominants, (ii) provide critical resources, (iii) act as mutualists, and (iv) modify the environment. Identifying keystone species can be problematic. Approaches used include experimental manipulations, comparative studies, natural history observations, and natural experiments', but no robust methodologies have been developed. Our inability to monitor and manage all aspects of biodiversity has led to the development of paradigms that focus on either single-species (e.g., indicators, umbrellas, or flagships) or whole ecosystems (ecological processes and habitats). Not surprisingly, both have their advocates and detractors. The keystone species concept, which retains a species focus while avoiding the need to examine every species, and emphasises processes that directly (e.g., predation, competition) rather than indirectly (e.g., nutrient cycling) control biodiversity, may

45 allow managers to combine the best features of both these paradigms. By itself however, the concept is unlikely to provide a panacea for biodiversity managers. 3.8 Human population After centuries of very slow and uneven growth, the world population reached one billion in 1800. The modern expansion of human numbers started then, rising at a slow but more steady pace over the next 150 years to 2.5 billion in 1950. During the second half of the twentieth century, however, growth rates accelerated to historically unprecedented levels. As a result, world population more than doubled to 6.5 billion in 2005 (United Nations 1962, 1973, 2007). This population expansion is expected to continue for several more decades before peaking near 10 billion later in the twenty-first century. Around 2070, the world's population will be 10 times larger than in 1800. The recent period of very rapid demographic change in most countries around the world is characteristic of the central phases of a secular process called the demographic transition. Over the course of this transition, declines in birth rates followed by declines in death rates bring about an era of rapid population growth. This transition usually accompanies the development process that transforms an agricultural society into an industrial one. Before the transition's onset, population growth (which equals the difference between the birth and death rate in the absence of migration) is near zero as high death rates more or less offset the high birth rates typical of agrarian societies before the industrial revolution. Population growth is again near zero after the completion of the transition as birth and death rates both reach low levels in the most developed societies. During the intervening transition period, rapid demographic change occurs, characterized by two distinct phases. During the first phase, the population growth rate rises as the death rate declines while the birth rate remains high. In the second phase, the growth rate declines (but remains positive) due to a decline in the birth rate. The entire transition typically takes more than a century to complete and ends with a much larger population size. The plot of world population size over time in shows the typical S-shaped pattern of estimated and projected population size over the course of the transition. Population growth accelerated for most of the twentieth century reaching the transition's midpoint in the 1980s and has recently begun to decelerate slightly. Today, we are still on the steepest part of this growth curve with additions to world population exceeding 75 million per year between 1971 and 2016. Contemporary societies are at very different stages of their demographic transitions. Key trends in population size, fertility and mortality during these transitions are summarized below. The focus is on the century from 1950 to 2050, covering the period of most rapid global demographic change. The main source of data is the United Nation's 2006 world population assessment, which provides estimates for 1950–2005 and projections from 2005 to 2050 (United Nations 2007). 3.8.1 Future Population Trends The projected rise in world population to 9.2 billion in 2050 represents an increase of 2.7 billion over the 2005 population of 6.5 billion. Nearly all this future growth will occur in the 'South'— i.e., Africa, Asia (excluding Japan, Australia and New Zealand), and Latin America—where population size is projected to increase from 5.3 to 7.9 billion between 2005 and 2050. In contrast, in the 'North' (Europe, Northern America, Japan and Australia/New Zealand), population size is forecast to remain virtually stable, growing slightly from 1.22 to 1.25 billion between 2005 and 2050. The difference in trends between these two world regions reflects the

46 later stage of the transition in the North compared with the South. The global demographic transition began in the nineteenth century in the now economically developed parts of the world (the North) with declines in death rates. Large reductions in birth rates followed in the early part of the twentieth century. These transitions are now more or less complete. But trends for the two principal regions in the North are expected to diverge between 2005 and 2050: an increase from 0.33 to 0.45 billion in Northern America, and a decline from 0.73 to 0.66 billion in Europe. In fact, several countries in Europe (e.g., Russia) and East Asia (e.g., Japan) face significant population declines as birth rates have fallen below death rates. The demographic transitions in Africa, Asia and Latin America started later and are still underway. In 2005, Asia had a population of 3.94 billion, more than half of the world total, and its population is expected to grow by 34 per cent to 5.27 billion by 2050. Africa, with 0.92 billion inhabitants in 2005, is likely to experience by far the most rapid relative expansion, more than doubling to 2.0 billion by 2050. Latin America, with 0.56 billion in 2005, is the smallest of the regions of the South; its projected growth trend is similar to that of Asia. It may seem surprising that population growth continues at a rapid pace in sub-Saharan Africa, where the AIDS epidemic is most severe. This epidemic has indeed caused many deaths, but population growth continues because the epidemic is no longer expanding and the birth rate is expected to remain higher than the elevated death rate in the future (UNAIDS 2007; Bongaarts et al. 2008). The epidemic's demographic impact can be assessed by comparing the standard UN population projection (which includes the epidemic's effect) with a separate hypothetical projection in which AIDS mortality is excluded (United Nations 2007). In sub-Saharan Africa, the former projects a 2050 population of 1.76 billion and the latter a population of 1.95 billion. The difference of 0.2 billion in 2050 between these projections with and without the epidemic is due to deaths from AIDS as well as the absence of the descendants from people who died from AIDS. According to these projections, the population of sub-Saharan Africa will grow by one billion between 2005 and 2050 despite the substantial impact of the AIDS epidemic. In fact, no country is expected to see a decline in its population size between 2005 and 2050 due to high AIDS mortality. Most populations in sub-Saharan Africa will more than double in size, several will triple and Niger is expected to quadruple by 2050 (United Nations 2007). Transitions in the developing world have generally produced more rapid population growth rates in mid-transition than historically observed in the North. In some developing countries (e.g., Kenya and Uganda), peak growth rates approached four percent per year in recent decades (implying a doubling of population size in two decades), levels that were very rarely observed in developed countries except with massive immigration. Two factors account for this very rapid expansion of population in these still largely traditional societies: the spread of medical technology (e.g., immunization, antibiotics) after World War II, which led to extremely rapid declines in death rates, and a lag in declines in birth rates. Population sizes for the 10 largest countries in 2005 and in 2050 are presented in table 2. In 2005, China 1.31 billion) and India (1.13 billion) were by far the largest countries, together accounting for nearly half the South's total. The top 10 include six Asian countries and only one country each in Latin America and Africa. By 2050, the ranking is expected to have shifted substantially, with India's population exceeding China's, and with Ethiopia and DR Congo rising to the top 10, replacing Japan and the Russian Federation. To simplify the presentation of results, all projections discussed in this study are taken from the medium variant of the UN projections (United Nations 2007). The UN has a good record of making relatively accurate projections (National Research Council 2000), but the future is of course uncertain and actual population trends over the next half

47 century will likely diverge to some extent from current projections. The UN makes an effort to capture this uncertainty by publishing separate high and low projections. For the world, the high and low variants reach 7.8 and 10.8 billion, respectively, in 2050, indicating a rather wide range of possible outcomes. 3.8.2 Drivers of Population Growth: The world's population increases every year because the global birth rate exceeds the death rate. For example, in 2000–2005 population size increased at a rate of 1.17 per cent per year, which equals the difference between a birth rate of 2.03 per cent and a death rate of 0.86 per cent. At the country level, population growth is also affected by migration, but for the regional aggregates of population used in this analysis, migration is usually a minor factor, and it will therefore not be discussed in detail. The annual birth and death rates of populations are in turn primarily determined by levels of fertility and mortality experienced by individuals. The most widely used fertility indicator is the total fertility rate (TFR), which equals the number of births a woman would have by the end of her reproductive years if she experienced the age-specific fertility rates prevailing in a given year. Mortality is often measured by the life expectancy (LE) at birth, which equals the average number of years a new born would live if subjected to age-specific mortality rates observed in a given year. a) Fertility The UN's past estimates and future projections of fertility levels by region for the period 1950–2050 are presented in figure 2. In the 1950s, the TFR in the South was high and virtually stable at around six births per woman on average. This high level of fertility reflects a near absence of birth control, a condition that has prevailed for centuries before the middle of the twentieth century. In the late 1960s, a rapid decline in fertility started nearly simultaneously in Asia and Latin America. In contrast, Africa has experienced only limited reproductive change. As a result of these divergent past trends, fertility levels in 2000– 2005 differed widely among regions from as high as 5 births per woman (bpw) in Africa, to 2.5 bpw in Asia and Latin America. Average fertility in the North was already low in the early 1950s and has since declined to 2.0 bpw in Northern America and to 1.4 bpw in Europe. The decline in the average fertility in the South from 6 to 3 bpw over the past half century has been very rapid by historical standards. This reproductive revolution is mainly due to two factors. First, desired family size of parents has declined as the cost of children rose and child survival increased. Second, government intervention played a key role. In China this took the form of a coercive and unpopular one-child policy, but most other countries implemented voluntary family planning programmes. The aim of these programmes is to provide information about and access to contraceptives at subsidized prices so that women who want to limit their childbearing can more readily do so. UN projections for the South assume that the TFR will eventually reach and then fall slightly below the so-called 'replacement' level in all regions. Replacement fertility is just above 2 bpw and it represents the level at which each generation just replaces the previous one, thus leading to zero population growth (in the absence of mortality change and migration). Below-replacement fertility produces, in the long run, population decline. As is evident from figure 2, the TFRs in Asia and Latin America are expected to reach the replacement level around 2020. Africa is assumed to be on a much slower trajectory towards replacement fertility because of its lower level of socio-economic development. High fertility therefore remains a key cause of future population growth in this region. In contrast, the already

48 low fertility of the North is expected to remain below replacement and is no longer driving population growth. 3.8.2.1 Mortality and life expectancy Mortality levels have also changed rapidly over the past several decades. The South experienced exceptional improvements in LE from an average of 41 years in 1950–1955 to 64 years in 2000–2005. By the early 2000, Latin America reached mortality levels similar to those prevailing in the North in the 1970s, and Asia was just a few years behind. Africa experienced the highest mortality and improvements in LE stalled in the 1990s due to the AID Sepidemic. As a result, Africa's LE, at 52 years in 2000–2005, was still substantially below that of Asia (68) and Latin America (72). As expected, Europe and Northern America already achieved relatively low levels of mortality by 1950, but they have nevertheless seen significant further improvements since then. Europe's LE (74) is now lower than North America's (78) because of a rise in mortality in Eastern Europe after the break-up of the Soviet Union. Projections of future LEs by the UN assume continued improvements over time in all regions. The North is expected to reach 82 years in 2050 despite the increasing difficulty in achieving increments as countries reach ever higher levels of LE. Asia and Latin America are expected to continue to close the gap with the North, and Africa will continue to lag, in part because the continent remains affected by the AIDS epidemic. It should be noted that the assumptions made by the UN about future trends in fertility and mortality are not based on a firm theoretical basis. Instead, the UN relies on empirical regularities in past trends in countries that have completed their transitions, mostly in the North, where fertility declined to approximately the replacement level, and increases in LE became smaller over time. This is a plausible approach that unfortunately leaves room for potential inaccuracies in projection results. 3.8.2.2 The age-dependency ratio A changing age distribution has significant social and economic consequences, e.g., for the allocation of education, healthcare, and social security resources to the young and old. Assessments of this impact often rely on the so-called age-dependency ratio (DR) that summarizes key changes in the age structure. The DR at a given point in time equals the ratio of population aged below 15 and over 65 to the population of age 15–64. This ratio aims to measure how many 'dependents' there are for each person in the 'productive' age group. Obviously, not every person below 15 and over 65 is a dependent and not every person between ages 15 and 65 is productive. Despite its crudeness, this indicator is widely used to document broad trends in the age composition. Over the course of a demographic transition, the DR shows a characteristic pattern of change. This pattern as observed in the South from 1950 to 2005 and projected from 2005 to 2050. Early in the transition, the DR typically first rises slightly as improvements in survival chances of children raise the number of young people. Next, the DR falls sharply as declines in fertility reduce the proportion of the population under age 15. This decline has important economic consequences because it creates a so-called 'demographic dividend', which boosts economic growth by increasing the size of the labour force relative to dependents and by stimulating savings (Birdsall et al. 2001). Finally, at the end of the transition, the DR increases again as the proportion of the population over age 65 rises. From 1950 to 2010 it showed a slight decline, but after 2010 it rises steeply as very low fertility and increasing longevity increases the proportion 65+. This ageing of the North poses serious challenges to support systems for the elderly (OECD 1998, 2001).

49 3.8.2.3 Population momentum At the end of the demographic transition natural population growth reaches zero once three conditions are met: i) Fertility levels-off at the replacement level of about 2.1 bpw (more precisely, the net reproduction rate should be 1). If fertility remains above replacement, population growth continues. ii) Mortality stops declining. In practice, this is not likely to happen because improvements in medical technology and healthcare as well as changes in lifestyles, etc. will probably ensure continued increases in LE. iii) The age structure has adjusted to the post-transitional levels of fertility and mortality. The adjustment of the age structure at the end of the transition takes many decades to complete. A key implication of this slow adjustment process is that population growth continues for many years after replacement fertility is reached if, as is often the case, the population is still relatively young when fertility reaches the replacement level. The tendency of population size to increase after a two-child family size has been reached is referred to as population momentum; it is the consequence of a young population age structure ('young' is defined relative to the age structure in the current life table) (Bongaarts & Bulatao 1999). The population momentum inherent in the age structure of a particular population at a given point in time can be estimated with a hypothetical population projection in which future fertility is set instantly to the replacement level, mortality is held constant and migration is set to zero. Since such a variant is not directly available from UN projections, it will not be presented here. However, the UN does provide 'instant replacement' projections in which mortality and migration trends are the same as in the standard projection. This projection gives an approximation of the combined effect on future growth of population momentum and declining mortality in the South because the role of migration is small. The difference between this hypothetical projection and the standard medium UN projection is a measure of the impact of high fertility on future population growth. Three results are noteworthy. First, the two projections differ most in Africa (+117% versus +50%) which is as expected because fertility is still very high in this region. Second, in all regions of the South outside China, populations would be expected to rise by 50 per cent (62% in West Asia) if fertility were set to replacement in 2005. This implies that momentum and declining mortality are responsible for nearly half of the projected future population growth in Africa and for the large majority of growth in Latin America, and South and West Asia. Third, in East Asia and in Latin America the replacement projection exceeds the medium UN projection. This finding is explained by the fact that fertility in these regions is assumed to average below the replacement level over the next half century. 3.8.2.4 CONCLUSION The world and most countries are going through a period of unprecedentedly rapid demographic change. The most obvious example of this change is the huge expansion of human numbers: four billion have been added since 1950. Other demographic processes are also experiencing extraordinary change: women are having fewer births and LEs have risen to new highs. Past trends in fertility and/or mortality have led to very young populations in high fertility countries in the South and to increasingly older populations in the North. Still other important demographic changes which were not reviewed here include rapid urbanization, international migration, and changes in family and household structure.

50 Global population growth will continue for decades, reaching around 9.2 billion in 2050 and peaking still higher later in the century. The demographic drivers of this growth are high fertility in parts of the South, as well as declining mortality and momentum. This large expansion in human numbers and of the accompanying changes in the age structure will have multiple consequences for society, the economy, and the environment as discussed in the subsequent chapters in this issue. 3.9 Summary • Relation between mortality and population density is the key player behind population growth pattern. • The carrying capacity of an environment is the maximum population size of a biological species that can be sustained by that specific environment. • A metapopulation is a set of local populations within some larger area, where migration from one population to another is possible. • r and K selection are concepts in ecology used to describe life history traits in the fluctuation of a population or population dynamics. They show three types of survivorship curve. • Keystone species are those which have an extremely high impact on a particular ecosystem relative to its population. • Global human population growth is around 75 million annually due to higher birth rate of 2.03% whereas death rate of 0.86%. Total population will reach 9.2 billion in 2050 as per future projection. 3.10 Questions/ Self-Assessment questions MCQ type questions 1. The collection of individuals which belongs to the same species when live together in a region is known as _____________ a) Keystone species b) Community c) Guild d) Population 2. Which of the following survivorship curve is suitable for the organisms who breeds several times during the course of their life span? a) Type IV b) Type III c) Type II d) Type I 3. Human population growth curve is a a) S shaped curve b) J shaped curve c) Parabola curve d) Zig-zag curve 4. The carrying capacity of a population defined by a) Mortality rate

51 b) Natality rate c) Population growth rate d) limiting resources 5. Exponential growth curve occurs when there is a) a great environmental resistance b) no environmental resistance c) no biotic potential d) a fixed carrying capacity Short answer type questions 1. Write difference and characteristics of r and k selected species. 2. What is density dependent and inversely density dependent population growth control? 3. What is keystone species? Give one example. 4. What is Equilibrium Density in population growth? 5. Write about different types of population fluctuation. Long answer type questions 1. Explain different types of survivorship curve in relation with r and k selected species. 2. Discuss about drivers of human population growth. Comment on its current trends. 3. Write short notes on different types of metapopulation. Explain metapopulation dynamics. 3.11 Select Readings/ Suggested Readings 1. Fundamentals of Ecology by Eugene Odum 2. Ecology: Theories & Applications by Peter Stiling 3. Elements of Ecology by Smith & Smith 4. Ecology: Principles and Applications by JL Chapman and MJ Reiss 5. Ecology by Ricklefs & Miller

52 4 Biomes 4.1 Objectives 4.2 Introduction 4.3 Biomes and biome types 4.4 Characteristics of different biomes: forest, grassland, highland icy alpine biome, tundra, and desert 4.5 Summary 4.6 Questions/ Self-Assessment questions 4.7 Select Readings/ Suggested Readings 4.1 Objectives • To learn about what is biome. • Discuss on salient features and characteristics of different biomes. 4.2 Introduction Biomes are both climatically and geographically defined. Biomes are regions of Earth that have similar climates and other abiotic (non-living) factors such as elevation, humidity, and soil type. The Biome of any biotic settlement depends on its abiotic resources. Biomes can be divided into types depending on climatic conditions and precipitation. No matter where they occur on the planet, biomes have similar types of vegetation and animal life, or ecological communities. In this chapter, we will study the major types of biomes around the world. 4.3 Biomes and biome types A biome is a large ecological area or region that is characterized by its climate, soil type, and vegetation; the dominant plants and animals that live there. In another words biome is

defined as the world’s major communities, classified according to the predominant vegetation, and characterized by adaptations of organisms to that particular environment.

A biome is determined mainly by its climate-like temperature and rainfall. Each biome has a different climate, which in turn affects the soil. There are five major categories of biomes on earth. In the five biomes, there are many sub-biomes. The climate and geography of a region determines what type of biome can exist in that region. The major types of biomes are; forest, grassland, tundra, desert and aquatic. In these, Forests are classified into tropical, temperate, and taiga; grasslands are divided into savanna and temperate grasslands; and the aquatic biome is split into freshwater, marine and brackish. Each biome consists of many ecosystems whose communities have adapted to the small differences in climate and the environment inside the biomes.

53 4.4 Characteristics of different biomes: forest, grassland, highland icy alpine biome, tundra, and desert a) FOREST A forest may be defined as a large uncultivated tract of land covered with trees of different species growing close together. The conditions such as temperature, ground moisture (rainfall), soil type and topography are responsible for the establishment of forest communities and their distribution. Forests occupy approximately one-third of Earth's land area. Forests are becoming major casualties of civilization as human populations have increased over the past several thousand years, bringing deforestation, pollution, and industrial usage problems to this important biome. The forest biomes can be classified according to the vegetation, climate, and latitude. There are three major types of forests classified according to distributional patterns of plants, world climate and latitude; Tropical, Temperate and Taiga. 4.4.1.1 TROPICAL FOREST Earth's most complex land biome is tropical forest in terms of both structure and species diversity. Tropical forests are characterized by the greatest diversity of species. Tropical forests occur near the equator, tropical region, within the area bounded by latitudes 23.5 degrees N and 23.5 degrees S. There are two seasons – rainy and dry. More than ½ of the tropical forests have been already destroyed. 4.4.1.2 TROPICAL EVERGREEN RAIN FOREST/ EQUATORIAL FOREST. These forests are found in warm and humid areas. They are having a heavy rainy season, the annual precipitation is above 200 cm and the average temperature is about 20-25 C. Normally, it extends between 10 degree N and 10 degree S latitude. While covering less than 6 percent of Earth's land surface, rain forests are home to more than 50 percent of the world's plant and animal species. There is no definite time for trees to shed their leaves, so they are appearing green all the year round. The trees are having an average height of 45-60m or even more. Many of the trees have straight trunks that don't branch out for 100 feet or more. The topsoil of tropical rainforest is heavily leached due to the rain and so poor in nutrients. Due to this regeneration of the tree cover is difficult when it is cleared. Because of these poor nutrients (in the surface), rainforest trees have very shallow roots to get more nutrients and they are having buttressed trunks to support. The tropical evergreen forests are well stratified. They are having a multi-layered continuous canopy; growing in layers; 5 layers. The stratification results from competition between species for favourable locations for the sunlight. First layer: uppermost canopy of the tallest trees. The tall trees grow so close together that their crowns interlock to form a continuous canopy, likes an umbrella or crown which blocks out the sunlight to the next layers. They are in an average height of 30m– 60m. Second layer: This layer is at a height of 25m-30m. Third layer: Have lower and smaller trees, height of 15-20m. Fourth layer: It is the shrub layer, also some stunted plants and trees of less than 5m height are there. Fifth layer: It is the ground layer having herbaceous plants and ferns. Tropical evergreen rain forest biome accounts for the largest number of plant species. The fora is highly diverse here; one square kilometre may contain as many as 100 different tree species. Tree is the most significant floral member, second is the Creepers (climbers) like herbaceous plant climber, lianas and epiphytes (they do not need to have their roots on the surface). They are forest of tall and large trees like ebony, mahagony, rosewood, palms; and creepers like vines, lianas, epiphytic

54 orchids; bromeliads, shrubs, herbs, ferns, mosses, etc. Like the vegetation, animal life in this region is also found in abundance and variety. The most of the animals found are arboreal animals (creatures, which spend the majority of their lives in trees). Some examples of animals in the evergreen forest are howler monkeys, brocket deer, lemur, elephants, one horned rhinoceros, bats, sloth, scorpions, snails, oatimundis, agoutis, curassows, tinamous, plenty of birds, humming birds, butterflies, lizards, silky ant eaters, woolly oppassum, kinkajous, armadillos, jaguars, owls, parrots, parakeets, tree frog, etc. The primary ecological productivity of the tropical rain forest is the highest of all biome type of the world. It accounts 40 percent of the total net productivity of the world, approximately 5000 dry grams per square meter per year. They are found in South America, West Africa, Australia, Southern India, and Southeast Asia. 4.4.1.3 TEMPERATE FORESTS The forest found in the temperate region, about 48 N latitude. Temperate forests occur in eastern North America, northeastern Asia, and western and central Europe. Well-defined seasons with a distinct winter characterize this forest biome. The temperature ranges from 20 – 30 C. Rainfall is evenly distributed throughout the year about an average of75-150cm. The soil is fertile, enriched with decaying litter. It has deep soil layers, rich in nutrients, so is good for agriculture. Climate and amount of sunlight can vary tremendously between each season. Temperate forests have moderately dense broadleaved trees – mostly deciduous & some evergreen; with less diversity of plant species. Trees adapt to varied climate by becoming dormant in winter. Deciduous forest has more diversity than that of coniferous forest, but less diversity of plant species than that of tropical rain forest. Deciduous forests also grow in layers but not as much that of evergreen. More sunlight reaches the ground compared to a rainforest so more ground dwelling plants can see there. The main plant species are Oak, Beech, Maple, hickory, hemlock, basswood, cottonwood, Elm, Willow, spring flowering herbs, etc. The main fauna are: Squirrels, rabbits, skunks, birds, black bears, mountain lions, deer, bobcat, timber wolf, fox, Bald Eagles, raccoon, elks, White tailed deers, coyotes, American buffalos, beavers, wolves, Cougar, owl, rodent, opossum. 4.4.1.4 TAIGA OR BOREAL FOREST The taiga is the biome of the needle leaf forest. A lot of coniferous trees grow in the taiga. Cold-tolerant evergreen conifers like Pine, Fir, Spruce and Larch are the major trees seen here. The roots are long to anchor trees. The needles are long, thin and waxy. Low sunlight and poor soil keep plants from growing on forest floor. Taiga has a thin soil cover and poor in nutrients and acidic. The seasons are divided into short moist rainy moderately warm summers and long cold snowfall dry winter. They have a very low temperature. The precipitation is mostly snowfall and is ranging 40–100 cm. extreme annual variation of temperature ranging between -40C to 25C. The animals are adapted for cold winters. The main fauna are: Caribou, moose, timber wolf, lynx, bears, wolverines, capercaillies, red squirrels, crossbill, pine marten, mink, beaver, woodpeckers, owl, hawks, bears, deer, hares, bats etc. It is also called as temperate coniferous forest, because of a few species of temperate deciduous trees have also developed in this biome. E.g., Aldar, Birch and Poplar. Boreal forests, or taiga, represent the world's largest terrestrial biome. Found only in Northern Hemisphere, occurring between 50 and 60 N latitudes just below the tundra biome. And it stretches over Eurasia and North America, parts of Siberia, Alaska, Canada and Scandinavia. The average net primary productivity is 800 dry grams per square meter per year.

55 4.4.1.5 GRASS LANDS Grassland biomes are large, lands of grasses, flowers and herbs. Latitude, soil and local climates for the most part determine what kinds of plants grow in particular grassland. The rainfall is less here, that not enough to support a forest, but it is more than that of the desert. Due to the less precipitation, drought and fire prevent large forests from growing. The soil of most grassland is also too thin and dry for trees to survive. Grassland biomes can be found in the middle latitudes, in the interiors of continents. There are two real seasons: a growing season and a dormant (not growing-too cold) season. There are mainly two types of grassland biomes; Tropical (savanna) and temperate grasslands. 4.4.1.6 SAVANNA (TROPICAL GRASSLANDS) It is a variety of grassland with scattered shrubs and individual isolated trees (deciduous). The trees are having a flat crown, umbrella shaped. Savanna can be found between tropical deciduous rainforest and desert biome. Savanna is found in the tropics, near equator. Savannas cover Africa (generally central and east Africa) and large areas of Australia, South America (Venezuela, Brazil, Columbia), and India. Climate is the most important factor in creating a savanna. Savannas are always found in warm hot climates where the annual rainfall is from about 50 – 125 cm per year. It has only 2 very different seasons; a dry and warm one and a rainy (wet) hot one. In tropical grasslands the length of the growing season is determined by how long the rainy season lasts. Amount of precipitation supports tall grasses but only occasional trees. It appears greenish and well-nourished in the rainy season and turns in to yellow in dry season. The soil has porous with a thin layer of humus (the organic portion of soil created by partial decomposition of plant or animal matter), which provides vegetation with nutrients. Savanna contains the greatest number of grazing animals on Earth. Plants of the savannah are highly specialised to the long period of drought. They have long tap roots, thick barks to resist annual fire, trunks that can store water, and the leaves that can drop off during the dry season to conserve water. Many plants have thorns and sharp leaves to protect against predation. The main floras are Acacia, baobab, bottle trees, grass, etc. Most of the animals on the savannah have long legs or wings for long migrations. The animals are adapted for short rainy season, they migrate as necessary. They reproduce during rainy season and ensure more young survive. The fauna are Hawks, buzzards, Kangaroo, Giraffes, zebras, buffalos, elephants, antelopes, gazells, marsupials, uanaco, mice, moles, snakes and worms, Lion, leopards, cheetah, jackals, hyenas, gophers, ground squirrels, termites, beetles, ostrich, etc. Average net primary productivity is 900 dry grams per square meter per year. 4.4.1.7 TEMPERATE GRASSLANDS Temperate grasslands are characterized as having grasses as the dominant vegetation. Trees and large shrubs are absent. Temperate grasslands have hot summers and cold winters. The amount of rainfall is less in temperate grasslands than in savannas. The annual average is about 50-90cm. The amount of annual rainfall influences the height of grassland vegetation, with taller grasses in wetter regions. In the temperate grasslands the length of the growing season is determined by temperature. The soil of the temperate grasslands is deep and dark, with fertile upper layers. The rotted roots hold the soil together and provide a food source for living plants. Some non-woody plants, specifically a few hundred species of flowers, grow among the grasses. The various species of grasses include purple needle-grass, blue grama, buffalo grass, and galleta. Flowers include asters, blazing stars, coneflowers, goldenrods, sunflowers, clovers, psoraleas, and wild indigos. The appearance of the temperate

56 grasslands varies with seasons. In spring, the grass appear, green, fresh and blooming with small, colourful flowers. The light rainfall that comes in late spring and early summer greatly stimulates their growth and there is plenty for the animals to graze. In summer, there is so much heat and evaporation that the grass is scorched. The bluish-green grass turns yellow and soon brown. Towards autumn, the grass withers and dies, but the roots remain alive and lie dormant throughout the cold winter. The average net primary productivity is 600 dry grams per square meter per year. The fauna found here are gazelles, zebras, rhinoceroses, wild horses, lions, wolves, prairie dogs, jack rabbits, deer, mice, coyotes, foxes, skunks, badgers, blackbirds, grouses, meadowlarks, quails, sparrows, hawks, owls, snakes, grasshoppers, leafhoppers, and spiders. The temperate grass lands are found in South Africa, Hungary, the pampas of Argentina and Uruguay, the steppes of the former Soviet Union, and the plains and prairies of central North America. Temperate grasslands can be further subdivided; prairies and steppes. They are somewhat similar. Prairies are grasslands with tall grasses about 11 feet. 4.4.1.8 STEPPES The Steppe biome is a dry, cold, grassland that is found in all of the continents except Australia and Antarctica. It is mostly found in the USA, Mongolia, Siberia, Tibet and China. Steppes occur in the interiors of North America and Europe. There isn't much humidity in the air because Steppe is located away from the ocean and close to mountain barriers. The Steppe biome is usually found between the desert and the forest. Steppe has warm summers and really cold winters. All the Steppes experience long droughts and violent winds due to few trees. The steppe is differing only in the density and quality of the grass. Their greatest difference from the tropical savanna is that they are practically treeless and the grasses are much shorter. The grasses are greater than 30cm tall. They include blue grama and buffalo grass, cacti, sagebrush, spear grass, and small relatives of the sunflower. 4.4.1.9 DESERT These are the driest places on earth. Deserts cover about one fifth of the Earth's surface and occur where rainfall is less than 25cm. Evaporation rates regularly exceed rainfall rates. The environment, so lacking in moisture and so excessive in heat, is most unfavourable for plant growth. Desert soil is rich in nutrients with little or no organic matter. Even though nutrients are present in the soil due to the less rainfall the productivity is less. Most desert shrubs have well-spaced long roots to gather moisture, and search for ground water. Plants have few or no leaves and are either waxy, leathery, hairy or needle-shaped to reduce the loss of water through transpiration. Some of them are entirely leafless, with pricks or thorns. Others like the cacti have thick succulent stems to store up water for long droughts. Major deserts on earth: sahara, thar, Kalahari, Arabian, namib, Iranian, Turkestan, takia makan gobi, Australian, Patagonian, Atacama, north American. Desert Biomes can be classified as follows: 4.4.1.10 HOT AND DRY DESERT In these types of deserts seasons are generally warm throughout the year and very hot in the summer. The winters usually bring little rainfall. The average rainfall is less than 1. 5 cm. Some years are even rainless. Inland Sahara also receives less than 1.5 cm a year. The mean annual temperature range is 20-45 C. Most Hot and Dry Deserts are near the Tropic of Cancer or the Tropic of Capricorn. E.g., Sahara, Kalahari, Marusthali, Rub-el-Khali. The four major North American deserts of this type are the Chihuahuan, Sonoran, Mojave and Great Basin. The

57 plants need some adaptations to survive. Some of them are the ability to store water for long periods of time and the ability to stand the hot weather. Plants are mainly ground hugging shrubs, the leaves are with water conserving characteristics. Some examples of plant are Turpentine Bush, Prickly Pears, and Brittle Bush, yuccas, ocotillo, false mesquite, sotol, ephedras and agaves. The animals include small nocturnal (active at night) animals. Some examples of the animals are Borrowers, kangaroo rats, Mourning Wheatears, and Horned Vipers. 4.4.1.11 SEMI ARID DESERT Semi-arid desert are found in the marginal areas of hot deserts. They are having a temperature of 21-38 C. The summer is moderately long and dry, like hot deserts. The winters normally bring low concentrations of rainfall. The average rainfall ranges from 2-4 cm annually. Semiarid plants include: Creosote bush, bur sage, white thorn, cat claw, mesquite, brittle bushes, lyciums, and jujube. The animals include the kangaroo rats, rabbits, and skunks; lizards and snakes; burrowing owls and the California thrasher. The major deserts of this type include the sagebrush of Utah, Montana and Great Basin. They also include the North America, Newfoundland, Greenland, Russia, Europe and northern Asia. 4.4.1.12 COSTAL DESERT These deserts occur in moderately cool to warm areas. A good example is the Atacama of Chile. The temperature range is 15-35 C. The cool winters of coastal deserts are followed by moderately long, warm summers. The average rainfall measures 8-13 cm in many areas. The plants living in this type of desert include the salt bush, buckwheat bush, black bush, rice grass, little leaf horsebrush, black sage, and chrysothamnus. Animals include: coyote, badger, toads, great horned owl, golden eagle, bald eagle, lizards, snakes, insects etc. 4.4.1.13 COLD DESERT They are found near to the tundra regions. Cold deserts are near the Arctic part of the world. The temperature range is 2-25 C. These deserts are characterized by cold winters with snowfall and high overall rainfall. The precipitation is of 15-26cm. They have short, moist, and moderately warm summers. The animals in Cold deserts also have to burrow but in this case to keep warm, not cool. Widely distributed animals are jack rabbits, kangaroo rats, kangaroo mice, pocket mice, grasshopper mice, and antelope ground squirrels, badger, kit fox, and coyote. 4.4.1.14 TUNDRA The word tundra means a barren land. The ground is permanently frozen 25-100cm down so that trees can’t grow there. The tundra is the world’s coldest and driest biomes. They have little precipitation, poor nutrients, short growing seasons and low biotic diversity. Temp rarely higher than 10 C. They are bitterly cold and covered with snow and ice. They have short growing seasons. Very short warm season that is very wet. Many insects are there during warm season. Below a thin layer of tundra soil is its permafrost, a permanently frozen layer of ground. Only certain small plants such as mosses, shrubs, sedges, lichens, and grasses can grow. The plants here are growing close to the ground. And they are having shallow roots to absorb the limited water resources. The animals are shrews, hares, rodents, wolves, arctic foxes, polar bears, lemmings, wolverine, reindeer, deer, harp seal, penguins of Antarctica, muskox. Black flies, deer fies, mosquitoes and noseeums (tiny biting midges) can make the tundra a miserable

58 place to be in the summer. Migratory birds like the harlequin duck, sandpipers and plovers are found in tundra. The average net primary productivity is 140 dry grams per square meter per year. Tundra Biomes can be classified as follows: 4.4.1.15 ARCTIC TUNDRA Arctic tundra is located in the northern hemisphere, encircling the North Pole. The growing season ranges from 50 to 60 days. The average winter temperature is -34°C. The average summer temperature is 3-12°C which enables this biome to sustain life. Yearly precipitation, including melting snow, is 15 to 25 cm. There is no deep root system of vegetation. They are having low shrubs, sedges, reindeer mosses, liverworts, grasses, 400 varieties of flowers, crustose and foliose lichen. The animals are: lemmings, voles, caribou, arctic hare, squirrels, arctic foxes, wolves, polar bears, Migratory birds: ravens, snow buntings, falcons, loons, sandpipers, terns, snow birds, gulls. It occupies the northern fringe of Canada, Alaska, European Russia, Siberia and island group of Artic Ocean. 4.4.1.16 ALPINE TUNDRA Alpine tundra is located on mountains throughout the world at high altitude, above the tree line and just below the snow line of the mountain. In the summer average temperature ranges from 10-15 C. In the winter the temperature are below freezing. The winter season can last from October to May. The summer season may last from June to September. The growing season is approximately 180 days. The major vegetation's are tussock grasses, dwarf trees, small-leafed shrubs, heaths. Animals living are pikas, marmots, mountain goats, sheep, elk, grouse like birds, springtails, beetles, grasshoppers, butterflies, etc Alpine animals have to deal with two types of problems; the cold and too much high UV rays. This is because there are fewer atmospheres to filter UV rays from the sun light. There are only warm-blooded animals in the Alpine biome. Alpine animals adapt to the cold by hibernating, migrating to lower warmer areas, or insulating their bodies with layers of fat. Alpine animals also have larger lungs, more blood cells and haemoglobin because of the increase of pressure and lack of oxygen at higher altitudes. 4.4.1.17 HIGHLAND ICY ALPINE BIOME Alpine biome describes an ecosystem that does not contain trees due to its high altitude. These biomes are found in mountainous regions across the globe. Their elevation normally ranges between 10,000 feet (3,000 meters) and the area where a mountain's snow line begins. Alpine biomes are home to only about 200 plant species, as their dynamic conditions are not favorable for plant growth. These regions are characterized by cold and windy conditions, as well as harsh sunlight. Moreover, there's a minimal supply of carbon dioxide for photosynthesis at high altitudes. Let's take a deeper look at alpine biome, including its climate, geographical location, as well as various flora and fauna you can find there. The climate of alpine biomes is somewhat dynamic. You can't describe the climate of this kind of biome using a simple climate scheme. Temperatures normally drop by about 10 o C for every 1000 meters as you go up a mountain. The biome experiences a long, cold winter season, lasting about nine months. Summer temperatures normally range from 40 to 60 o F. However, these temperatures can normally drop from warm to freezing within a day. Precipitation varies considerably in alpine biomes, but they're usually fairly dry. In fact, the regions receive about one foot (30 cm) of precipitation annually. Nevertheless, snow may

59 remain on the ground for an extended period of time, thanks to the consistently low temperatures. Alpine biomes occur at high altitudes within any latitude worldwide. Parts of montane grassland and shrubland ecosystems across the globe include alpine biome. Extensive areas of alpine biome are found in the following regions: the Himalayas in Asia, the Scottish Highlands, the Scandinavian Mountains, American Cordillera in North and South America, the Rift Mountains of Africa, Carpathian and Pyrenees Mountains in European, the Caucasus Mountains, a substantial extent of the Tibetan Plateau. Alpine biome occupies summits and slopes of high mountains. It can also be found in high- mountain ridges above timberline. The treeline normally occurs at high altitude on warmer equator-facing slopes. In light of the fact that alpine region is found only on mountains, the biome is characterized by a rugged and wrecked landscape, with rock-strewn, snowcapped peak, and cliffs. Other remarkable features include talus slopes. It's worth noting that some areas of this biome feature gently rolling to virtually flat terrain. Across various locations, the treeling rises about 75 meters as you move one degree south from 70 o N to 50 o N, and 130 meters a degree as you move from 50 o N to 30 o N. The treeline virtually remains constant between 30 o N and 20 o S, at 3,500 meters to 4,000 meters. The alpine biome is characterized by unfavourable conditions for plants to thrive, including strong winds, unfavourably low temperatures, low carbon dioxide levels, and strong sunlight. With low carbon dioxide, plants have a hard time carrying out photosynthesis. As a result of the windy weather, alpine biomes are characterized by small groundcover plants. These plants take longer to grow and reproduce. They shield themselves from the cold and windy conditions by staying as close to the ground as possible. Moreover, these plants decompose slowly after they die, thanks to the low temperatures. This results in poor soil conditions. Most plants that are found in alpine biomes are adapted to thrive in rocky and sandy soil. You should also realize that plants in the alpine biome have an anti-freeze chemical, which coats and protects the plants from the low temperatures. This ensures the plants don't die from freezing. They also have specialized root system. The roots don't grow vertically downward but rather spread and grow horizontally. This kind of root growth prevent the roots from getting to the permafrost soil, which would result in the death of the plants due to water loss. It's also worth noting that alpine plants have limited transpiration. Transpiration is the process by which plants lose water through their leaves. Limited transpiration, therefore, ensures that alpine plants don't dry out as a result of excessive water loss. These plants need all the water they can get in a bid to survive the cold, dry alpine conditions. Here are some of the plants that thrive in alpine biomes: Bear Grass, Moss Campion, Pygmy Bitterroot, Wild potato, Bristlecone pine etc. Animals that live in the alpine biome should be adapted to contend with two types of problems: 1. the cold, 2. high UV light exposure. This region is home to many warm-blooded animals and a couple of insect species. But how do these animals deal with the cold? They normally hibernate, mover to warmer regions, or insulate their bodies with layers of fur and fat. Moreover, these animals normally have short legs, ears, and tails, which helps in minimizing heat loss. They also boast larger lungs and a higher number of blood cells. The blood of alpine animals has the capability to work with lower oxygen levels that are typical of high elevations. Here are some of the animals you can find in alpine biome: Elk, Sheep, Mountain goats, Snow

60 leopard, Alpaca, Yak, Chinchilla, Ptarmigan bird, Snowshoe rabbit, Himalayan Tahr, Marmot etc. 4.5 Summary • Biomes are geographically extensive ecosystems that occur throughout the world wherever environmental conditions are suitable for their development. The same biome may occur in far-flung places, even on different continents, and in such cases, it will be similar in structure and function but will usually be dominated by different species. • Plants are main components of terrestrial ecosystems as they are primary producers. Almost all terrestrial life if based on the types of plants found in the area. • The major types of biomes are; forest, grassland, tundra, desert and aquatic. 4.6 Questions/ Self-Assessment questions MCQ types questions 1. Which type of trees is found in a temperate forest? a) Deciduous b) Evergreen c) Ginko d) Palm 2. What are the key features of the Tundra? a) cold winter, thin acidic soil, evergreen trees b) treeless, permafrost, cold dark winters c) long cool summers, short dark winters, migrating animals d) many evergreen trees, short moist summers, long snowy winters 3. The desert and tundra are alike because they both have a) high precipitation b) low precipitation c) the same organisms d) sandy soil 4. The greatest biodiversity on earth is found in the __________ biome. a) Taiga b) Grassland c) Tropical deciduous forest d) Tropical rain forest 5. This biome is also known as the "taiga". a) tropical rainforest b) alpine tundra c) temperate deciduous forest d) coniferous forest Short answer type questions 1. What is a biome? What is main abiotic factor defining biomes? 2. What is the typical vegetation and typical fauna of the tundra? 3. How can the abundance and diversity of living organisms in tropical forests be explained? 4. What are the grasslands of North America and of South America respectively called?

61 5. Which terrestrial vertebrate group is extremely rare in deserts? What is desert biome of India? Long answer type questions 1. Write short note on different types of forest biomes. 2. Describe different types of desert biomes with their floral and faunal features. 3. Discuss about alpine biomes and its biotic diversity. 4.7 Select Readings/ Suggested Readings Breckle, S.W. 2002. Walter's Vegetation of the Earth. The Ecological Systems of the Geo- Sphere, 4th ed. Springer-Verlag, Berlin, Germany. Heywood, V.H. (ed.). 1995. Global Biodiversity Assessment. Cambridge University Press, Cambridge, UK. Odum, E.P. and G.W. Barrett. 2004. Fundamentals of Ecology. Brooks Cole, Florence, KY. Woodward, S.L. 2003. Biomes of the Earth: Terrestrial, Aquatic, and Human-Dominated. Greenwood Press, Oxford, UK.

62 5 Community Ecology 5.1 Objectives 5.2 Introduction 5.3 Concept of Community 5.4 Community structure 5.5 Factors influencing the structure of communities 5.6 Community dynamics 5.7 Interspecific interactions 5.8 Species diversity in community ecology 5.9 Summary 5.10 Questions/ Self-Assessment questions 5.11 Selected Readings/ Suggested Readings 5.1 Objectives • To learn about community structure and influencing factors. • Describe the interspecific interaction and competitive exclusion principle. • Define different symbiotic relationships between species. • Elucidate species diversity in community ecology. • To learn about intermediate disturbance hypothesis. • A brief note on island equilibrium model 5.2 Introduction Communities are complex systems that can be characterized by their structure (the number and size of populations and their interactions) and dynamics (how the members and their interactions change over time). Understanding community structure and dynamics allows us to minimize impacts on ecosystems and manage ecological communities we benefit from. This chapter will introduce the concept of community, its structure and dynamics. We will examine ecological interactions between populations of different species and interspecies interaction. Lastly, we will discuss about species diversity and population equilibrium in a community. 5.3 Concept of Community

A group of populations of different species living close enough to interact is called a biological community. Ecologists define the boundaries of a particular community to fit their research questions: They might study the community of decomposers and other organisms living on a rotting log, the benthic community in Lake Superior, or the community of trees and shrubs in Banff National Park in Alberta.

Some key relationships in the life of an organism are its interactions with individuals of other species in the community. These interspecific interactions include competition, predation, herbivory, symbiosis (including parasitism, mutualism, and commensalism), and facilitation.

63 In this section, we will define and describe each of these interactions, recognizing that ecologists do not always agree on the precise boundaries of each type of interaction. We will use the symbols + and - to indicate how each interspecific interaction affects the survival and reproduction of the two species engaged in the interaction. For example, predation is a +/- interaction, with a positive effect on the survival and reproduction of the predator population and a negative effect on that of the prey population. Mutualism is a +/+ interaction because the survival and reproduction of both species are increased in the presence of the other. A 0 indicates that a population is not affected by the interaction in any known way. Historically, most ecological research has focused on interactions that have a negative effect on at least one species, such as competition and predation. However, positive interactions are ubiquitous, and their contributions to community structure are the subject of considerable study today. 5.4 Community structure Different ecological communities can be pretty different in terms of the types and numbers of species they contain. For instance, some Arctic communities include just a few species, while some tropical rainforest communities have huge numbers of species packed into each cubic meter. One way to describe this difference is to say that the communities have different structures. Community structure is essentially the composition of a community, including the number of species in that community and their relative numbers. It can also be interpreted more broadly, to include all of the patterns of interaction between these different species. A community's structure can be described by its species richness, which is the number of species present, and species diversity, which is a measure of both species richness and species evenness (relative numbers). Community structure is influenced by many factors, including abiotic factors, species interactions, level of disturbance, and chance events. Some species, such as foundation species and keystone species, play particularly important roles in determining their communities' structure. 5.5 Factors influencing the structure of communities The structure of a community is the result of many interacting factors, both abiotic (non-living) and biotic (living organism-related). Here are some important factors that influence community structure: • The climate patterns of the community's location. • The geography of the community's location. • The heterogeneity (patchiness) of the environment. • The frequency of disturbances, or disruptive events. • Interactions between organisms. A community's structure can also be shaped by the chance events that happened during its history. For instance, suppose that a single seed blows into the dirt of a particular area. If it happens to take root, the species may establish itself and, after some period of time, become dominant (excluding similar species). If the seed fails to sprout, another similar species may instead be the lucky one to establish itself and become dominant.

64 5.6 Community

dynamics Community dynamics are the changes in community structure and composition over time, often following environmental disturbances such as volcanoes, earthquakes, storms, fires, and climate change. Communities with a relatively constant number of species are said to be at equilibrium. The equilibrium is dynamic with species identities and relationships changing over time, but maintaining relatively constant numbers. Following a disturbance, the community may or may not return to the equilibrium state. Succession describes the sequential appearance and disappearance of species in a community over time after a severe disturbance. Details about it could be find in chapter 2. 5.7 Interspecific interactions
Interspecific
competition is a -/- interaction that occurs when individuals of different species compete for a resource that limits their growth and survival. Weeds growing in a garden compete with garden plants for soil nutrients and water.
What happens in a community when two species compete for limited resources? In 1934, Russian ecologist G. F. Gause studied this question using laboratory experiments with two closely= related species of ciliated protists, Paramecium aurelia and Paramecium caudatum. He cultured the species under stable conditions, adding a constant amount of food each day. When Gause grew the two species separately, each population grew rapidly and then leveled off at the apparent carrying capacity of the culture.
But when Gause grew the two species together, P. caudatum became extinct in the culture. Gause inferred that P. aurelia had a competitive edge in obtaining food. He concluded
that two species competing for the same limiting resources cannot coexist permanently in the same place.
In the absence of disturbance, one species will use the resources more efficiently and reproduce more rapidly than the other. Even a slight reproductive advantage will eventually lead to local elimination of the inferior competitor, an outcome called competitive exclusion.
We can use the niche concept to restate the principle of competitive exclusion: Two species cannot coexist permanently in a community if their niches are identical. However, ecologically similar species can coexist in a community if one or more significant differences in their niches arise through time. Evolution by natural selection can result in one of the species using a different set of resources.
The differentiation of niches that enables similar species to coexist in a community is called resource partitioning. Closely related species whose populations are sometimes allopatric and sometimes sympatric (geographically overlapping) provide more evidence for the importance of competition in structuring communities. In some cases, the allopatric populations of such species are morphologically similar and use similar resources. By contrast, sympatric populations, which would potentially compete for resources, show differences in body structures and in the resources they use. This tendency for characteristics to diverge more in sympatric than in allopatric populations of two species is called character displacement.
65
Table 5-1: Different Interspecific Interaction in a community.
Interspecific Interaction Description Competition (-/-)
Two or more species compete for a resource that is in short supply. Predation (+/-) One species,
the predator, kills and eats the other, the prey. Predation has led to diverse adaptations, including mimicry. Herbivory (+/-) An herbivore eats part of a plant or alga. Plants have various chemical and mechanical defences against herbivory, and herbivores have specialized adaptations for feeding. Symbiosis Individuals of two or more species live in close contact with one another. Symbiosis includes parasitism, mutualism, and commensalism. Parasitism (+/-) The parasite derives its nourishment from a second organism, its host, which is harmed. Mutualism (+/+) Both species benefit from the interaction. Commensalism (+/0) One species benefits from the interaction, while the other is unaffected by it. Amensalism (-/0) It is a type of biological interaction where one species causes harm to another organism without any cost or benefits to itself.
Facilitation (+/+ or 0/+) Species have positive effects on the survival and reproduction of other species without the intimate contact of a symbiosis. 5.8
Species diversity in community ecology
The species diversity of a community—the variety of different kinds of organisms that make up the community—has two components. One is
species richness, the number of different species in the community. The
other is the relative abundance of the different species, the proportion each species represents of all individuals in the community. Imagine two small forest communities, each with 100 individuals distributed among four tree species (A, B, C, and D) as follows: Community 1: 25A, 25B, 25C, 25D Community 2: 80A, 5B, 5C, 10D The species richness is the same for both communities because they both contain four species of trees, but the relative abundance is very different. You would easily notice the four types of trees in community 1, but without looking carefully, you might see only the abundant species A in the second forest. Most observers would intuitively describe

community 1
as the more diverse of the two communities. Ecologists use many tools to quantitatively compare the diversity of different communities across time and space. They often calculate indexes of diversity based on species richness and relative abundance. One widely used index is Shannon diversity (H): H = -(P A lnP A + P B lnP B + P C lnP C + ...) Where A, B, C . . . are the species in the community, p is the C
relative abundance of each species, and ln is the natural logarithm.
A higher value of H indicates a more diverse
66 community. Let's use this equation to calculate the Shannon diversity index of the two communities. For community 1, p = 0.25 for each species, so H = -4(0.25 ln 0.25) = 1.39 For community 2, H = - [0.8 ln 0.8 + 2(0.05 ln 0.05) + 0.1 ln 0.1] = 0.71 These calculations confirm our intuitive description of
community 1 as more diverse.
Determining the number and relative abundance of species in a community is easier said than done. Many sampling techniques can be used, but since most species in a community are relatively rare, it may be hard to obtain a sample size large enough to be representative. It is also difficult to census the highly mobile or less visible or accessible members of communities, such as microorganisms, nematodes, deep-sea creatures, and nocturnal species. The small size of microorganisms makes them particularly difficult to sample, so ecologists now use molecular tools to help determine microbial diversity. Measuring species diversity is often challenging but is essential for understanding community structure and for conserving diversity.
Higher-diversity communities are often more resistant to invasive species,
which are organisms that become established outside their native range.
Energetic hypothesis, suggests that the length of a food chain is limited by the inefficiency of energy transfer along the chain.
The energetic hypothesis predicts that food chains should be relatively longer in habitats of higher photosynthetic production, since the starting amount of energy is greater than in habitats with lower photosynthetic production. The dynamic stability hypothesis, proposes that long food chains are less stable than short chains. Population fluctuations at lower trophic levels are magnified at higher levels, potentially causing the local extinction of top
predators. In a variable environment, top predators must be able to recover from environmental shocks (such as extreme winters) that can reduce the food supply all the way up the food chain. The longer a food chain is, the more slowly top predators can recover from environmental setbacks. This hypothesis predicts that food chains should be shorter in unpredictable environments.
Another factor that may limit food chain length is that carnivores in a food chain tend to be larger at successive trophic levels. The size of a carnivore and its feeding mechanism put some upper limit on the size of food it can take into its mouth. And except in a few cases, large carnivores cannot live on very small food items because they cannot procure enough food in a given time to meet their metabolic needs.
Among the exceptions are baleen whales, huge suspension feeders with adaptations that enable them to consume enormous quantities of krill and other small organisms.
Dominant species in a community are the species that are the most abundant or that collectively have the highest biomass. As
a result, dominant species exert a powerful control over the occurrence and distribution of other species.
For example, the dominance of sugar maples in an eastern North American forest community has a major impact on abiotic factors such as shading and soil nutrient availability, which in turn affect which other species live there.
In contrast to dominant
species, keystone species are not usually abundant in a community. They exert strong control on community structure not by
numerical might but by their pivotal ecological roles, or niches. A sea star, in maintaining the diversity of an intertidal community
is an example of keystone species.
67
The intermediate disturbance hypothesis states that
moderate levels of disturbance foster greater species diversity than do low or high levels of disturbance.
High levels of disturbance reduce diversity by creating environmental stresses that exceed the tolerances of many species or by disturbing the community so often that slow-growing or slow-colonizing species are excluded. At the other extreme, low levels of disturbance can reduce species diversity by allowing competitively dominant species to exclude less competitive ones. Meanwhile, intermediate levels of disturbance can foster greater species diversity by opening up habitats for occupation by less competitive species. Such intermediate
disturbance

levels rarely create conditions so severe that they exceed the environmental tolerances or recovery rates of potential community members.

In 1807, naturalist and explorer Alexander von Humboldt described one of the first patterns of species richness to be recognized, the species-area curve: All other factors being equal,

the larger the geographic area of a community, the

more species it has.

The likely explanation for this pattern is that larger areas offer a greater diversity of habitats and microhabitats than smaller areas. In conservation biology, developing species-area curves for the key taxa in a community helps ecologists predict how the potential loss of a certain area of habitat is likely to affect the community's diversity. Figure 5-1: Effect of size of island and distance of island from mainland on community size.

MacArthur and Wilson's model is called the island equilibrium model because

an equilibrium will eventually be reached where the rate of species immigration equals the rate of species extinction. The number of species at this equilibrium point is correlated with the island's size and distance from the mainland.

Like any ecological equilibrium, this species

equilibrium

is dynamic; immigration and extinction continue, and the exact species composition may change over time. MacArthur and Wilson's studies of the diversity of plants and animals on many island chains support the prediction that species richness increases with island size, in keeping with the island equilibrium model. Species counts also fit the prediction that the number of species decreases with increasing remoteness of the island. 5.9

Summary • A community is a group of organisms in the same environment that interact with one another.

68 • The main types of interspecific interactions include competition (-/-), predation (+/-), mutualism, (+/+), commensalism (+/0), and parasitism (+/-). •

The principle of

competitive exclusion states that two species competing for the same resources cannot

coexist. •

The

tendency for characteristics to diverge more in sympatric than in allopatric populations of two species is called character displacement. •

The intermediate disturbance hypothesis states that

moderate levels of disturbance foster greater species diversity than do low or high levels of disturbance. 5.10

Questions/ Self-Assessment questions MCQ type question 1. What type of species interaction is the following: a killer whale kills and eats a seal. a) Commensalism b) Predation c) Mutualism d) Competition 2. What type of species interaction is the following: two bears fighting over the same mate. a) Predation b) Competition c) Mutualism d) Parasitism 3. Name the species interaction: a mosquito feeds on human blood & transfers a disease. a) Predation b) Competition c) Mutualism d) Parasitism 4. ______

is a series of changes that occur in a community over time

after disturbances. a) community succession b) evolution c) tertiary succession d) guild formation 5.

According to the competitive exclusion principle, two species cannot continue to occupy the same:

a) Habitat b) Niche c) Territory d) Range Short answer type question 1. What is competitive exclusion principle? Give an example. 2. What is character displacement? Give an example. 3. What is intermediate disturbance hypothesis?

69 4. Briefly describe island equilibrium model. 5. What is resource partitioning? Long answer type question 1. What is a community? What is the main influencing factor of community structure? 2. Describe different types of interspecific interaction with suitable example. 3. Elucidate species diversity in community and dynamic stability hypothesis. 5.11 Selected Readings/ Suggested Readings 1. Fundamentals of Ecology by Eugene Odum 2. Ecology: Theories & Applications by Peter Stiling 3. Elements of Ecology by Smith & Smith 4. Ecology: Principles and Applications by JL Chapman and MJ Reiss 5. Ecology by Ricklefs & Miller

70 6 Biological Diversity 6.1 Objectives 6.2 Introduction 6.3 Types of Biodiversity 6.4 Loss of biodiversity 6.5 Threats to biodiversity 6.6 Biodiversity hotspot in India 6.7 Mega Biodiversity countries 6.8 Extinct, rare, endangered, threatened flora and fauna of India 6.9 Strategies for biodiversity conservation 6.10 Conservation of biodiversity 6.11 Bio-piracy in India 6.12 Bio-piracy and the difficulties in protecting traditional knowledge 6.13 Summary 6.14 Questions/ Self-Assessment questions 6.15 Select Readings/ Suggested Readings 6.1 Objectives • To learn about different aspects of biodiversity – components, loss, threats. • Brief account on biodiversity hotspot of India and megadiverse countries. • To get informed about Extinct, rare, endangered, threatened flora and fauna of India • Discussion about conservation strategies in India • To know about in-situ and ex situ conservation. • Elucidate bio-piracy in India 6.2 Introduction The word biodiversity is a modern contraction of the term biological diversity. Diversity refers to the range of variation or variety or differences among some set of attributes; biological diversity thus refers to variety within the living world or among and between living organisms. ''Biodiversity'' is a relatively new compound word, but biological diversity (when referring to the number of species) is not. Over the last decade its definition has taken a more reductionist turn. Possibly the simplest definition for biodiversity, lacking in specificity or context, is merely the number of species. Yet many have argued that biodiversity does not equate to the number of species in an area. The term for this measure is species richness (Fiedler and Jain, 1992), which is only one component of biodiversity. Biodiversity is also more than species diversity (simply called diversity by some authors), which has been defined as the number of species in an area and their relative abundance (Pielou, 1977).

71 6.3 Types of Biodiversity Various authors have proposed specific and detailed elaborations of this definition. Gaston and Spicer (1998) proposed a three-fold definition of ''biodiversity''— ecological diversity, genetic diversity, and organismal diversity—while others conjoined the genetic and organismal components, leaving genetic diversity and ecological diversity as the principal components. These latter two elements can be linked to the two major ''practical'' value systems of direct use/genetics and indirect use/ecological described by Gaston and Spicer (1998). Other workers have emphasized a hierarchical approach or hierarchies of life systems. 6.3.1 Genetic diversity Genetic diversity is reliant on the heritable variation within and between populations of organisms. New genetic variation arises in individuals by gene and chromosome mutations, and in organisms with sexual reproduction it can be spread through the population by recombination. It has been estimated that in humans and fruit flies alike, the number of possible combinations of different forms of each gene sequence exceeds the number of atoms in the universe. Other kinds of genetic diversity can be identified at all levels of organization, including the amount of DNA per cell and chromosome structure and number. Selection acts on this pool of genetic variation present within an interbreeding population. Differential survival results in changes of the frequency of genes within this pool, and this is equivalent to population evolution. Genetic variation enables both natural evolutionary change and artificial selective breeding to occur (Thomas, 1992). Only a small fraction (>1%) of the genetic material of higher organisms is outwardly expressed in the form and function of the organism; the purpose of the remaining DNA and the significance of any variation within it are unclear (Thomas, 1992). Each of the estimated 10 9 different genes distributed across the world's biota does not make an identical contribution to overall genetic diversity. In particular, those genes that control fundamental biochemical processes are strongly conserved across different taxa and generally show little variation, although such variation that does exist may exert a strong effect on the viability of the organism; the converse is true of other genes. A large amount of molecular variation in the mammalian immune system, for example, is possible on the basis of a small number of inherited genes (Thomas, 1992). 6.3.2 Species diversity Historically, species are the fundamental descriptive units of the living world and this is why biodiversity is very commonly, and incorrectly, used as a synonym of species diversity, in particular of ''species richness,'' which is the number of species in a site or habitat. Discussion of global biodiversity is typically presented in terms of global numbers of species in different taxonomic groups. An estimated 1.7 million species have been described to date; estimates for the total number of species existing on earth at present vary from 5 million to nearly 100 million. A conservative working estimate suggests there might be around 12.5 million. When considering species numbers alone, life on earth appears to consist mostly of insects and microorganisms. The species level is generally regarded as the most natural one at which to consider whole-organism diversity. While species are also the primary focus of evolutionary mechanisms, and the origination and extinction of species are the principal agents in governing biological diversity, species cannot be recognized and enumerated by systematists with total precision. The concept of what a species is differs considerably among groups of organisms. It is for this reason, among others, that species diversity alone is not a satisfactory basis on which

72 to define biodiversity. Another reason why a straightforward count of the number of species provides only a partial indication of biological diversity concerns the concept of degree or extent of variation that is implicit within the term biodiversity. By definition, organisms that differ widely from each other in some respect contribute more to overall diversity than those that are very similar. The greater the interspecific differences (e.g., by an isolated position within the taxonomic hierarchy), then the greater contribution to any overall measure of global biological diversity. Thus, the two species of Tuatara (genus Sphenodon) in New Zealand, which are the only extant members of the reptile order Rhynchocephalia, are more important in this sense than members of some highly species-rich family of lizards. A site with many different higher taxa present can be said to possess more taxonomic diversity than another site with fewer higher taxa but many more species. Marine habitats frequently have more different phyla but fewer species than terrestrial habitats, that is, higher taxonomic diversity but lower species diversity. By this measure, the Bunaken reef off the north coast of Sulawesi has the highest biodiversity on earth. Current work is attempting to incorporate quantification of the evolutionary uniqueness of species into species-based measures of biodiversity. The ecological importance of a species can have a direct effect on community structure, and thus on overall biological diversity. For example, a species of tropical rain forest tree that supports an endemic invertebrate fauna of a hundred species makes a greater contribution to the maintenance of global biological diversity than does a European alpine plant that may have no other species wholly dependent on it. 6.3.3 Ecosystem diversity While it is possible to define what is in principle meant by genetic and species diversity, it is difficult to make a quantitative assessment of diversity at the ecosystem, habitat, or community level. There is no unique definition or classification of ecosystems at the global level, and it is difficult in practice to assess ecosystem diversity other than on a local or regional basis, and then only largely in terms of vegetation. Ecosystems are further divorced from genes and species in that they explicitly include abiotic components, being partly determined by soil/parent material and climate. To get around this difficulty, ecosystem diversity is often evaluated through measures of the diversity of the component species. This may involve assessment of the relative abundance of different species as well as consideration of the types of species. The more that species are equally abundant, then the more diverse that area or habitat. Weight is given to the numbers of species in different size classes, at different trophic levels, or in different taxonomic groups. Thus, a hypothetical ecosystem consisting only of several plant species would be less diverse than one with the same number of species but that included animal herbivores and predators. Because different weightings can be given to these different factors when estimating the diversity of particular areas, there is no one authoritative index for measuring ecosystem diversity. This obviously has important implications for the conservation ranking of different areas. In examining beta diversity (i.e., the change in species composition between areas), the only reliable predictor of community similarity is to compare the species composition of the site immediately adjacent. 6.4 Loss of biodiversity Species extinction is a natural process that occurs without the intervention of humans since, over geological time, all species have a finite span of existence. Extinctions caused directly or indirectly by humans are occurring at a rate that far exceeds any reasonable estimates of background extinction rates, and to the extent that these extinctions are correlated with habitat

73 perturbation, they must be increasing. Quantifying rates of species extinction is difficult and predicting future rates with precision is impossible. The documentation of definite species extinctions is only realistic under a relatively limited set of circumstances, for example, where a described species is readily visible and has a well-defined range that can be surveyed repeatedly. Unsurprisingly, most documented extinctions are of species that are easy to record and that inhabit sites that can be relatively easily inventoried. The large number of extinct species on oceanic islands is not solely an artifact of recording, because island species are generally more prone to extinction as a result of human actions. Most global extinction rates are derived from extrap- olations of measured and predicted rates of habitat loss, and estimates of species richness in different habitats. These two estimates are interpreted in the light of a principle derived from island biogeography, which states that the size of an area and of its species complement tend to have a predictable relationship. Fewer species are able to persist in a number of small habitat fragments than in the original unfragmented habitat, and this can result in the extinction of species (MacArthur and Wilson, 1967). These estimates involve large degrees of uncertainty, and predictions of current and future extinction rates should be interpreted with considerable caution. The pursuit of increased accuracy in the estimation of global extinction rates is not crucial. It is more important to recognize in general terms the extent to which populations and species that are not monitored are likely to be subject to fragmentation and extinction (Temple, 1986). Loss of biodiversity in the form of domesticated animal breeds and plant varieties is of little significance in terms of overall global diversity, but genetic erosion in these populations is of particular human concern in so far as it has implications for food supply and the sustainability of locally adapted agricultural practices. For domesticated populations, the loss of wild relatives of crop or timber plants is of special concern for the same reason. These genetic resources may not only underlie the productivity of local agricultural systems but may also, when incorporated into breeding programs, provide the foundation of traits (disease resistance, nutritional value, hardiness, etc.) that are of global importance in intensive systems and that will assume even greater importance in the context of future climate change. Erosion of diversity in crop gene pools is difficult to demonstrate quantitatively, but can be indirectly assessed in terms of the increasing proportion of world cropland planted to high-yielding, but genetically uniform, varieties. Genetic modification of organisms, varieties, or cultivars for food production, pharmaceuticals, and other products, which has caused concern in some countries but not others, may also contribute to the loss of biodiversity. Humans exterminate species either directly by hunting, collection, and persecution or indirectly through habitat destruction and modification. Overhunting is perhaps the most obvious direct cause of extinction in animals, but it is undoubtedly far less important than the indirect causes of habitat modification in terms of overall loss of biodiversity. Hunting selectively affects the targeted species, as well as plant and animal species whose populations are subsequently affected either negatively or positively, and so it has important implications for the management of natural resources. Genetic diversity in a hunted population is liable to decrease as a result of the same factors. The genetic diversity represented by populations of crop plants or livestock is also likely to decline as a result of mass production, for the desired economics of scale demand high levels of uniformity. Sustained human activity will affect the relative abundance of species and in extreme cases may lead to extinction. This may result from the habitat being made unsuitable for the species (e.g., clear-felling of forests or severe pollution of rivers) or through the habitat becoming fragmented (discussed earlier). Fragmentation divides previously contiguous populations of species into small sub-
74 populations. If these are sufficiently small, then chance processes lead to higher probabilities of extinction within a relatively short time. Major changes in natural environments are likely to occur within the next century as a result of changes in global climate and weather patterns. These will cause greatly elevated extinction rates. 6.5 Threats to biodiversity Scientists have named five main threats to biodiversity. Knowing what they are and how they work can help you identify ways your company's practices might be contributing to declines in biodiversity, as well as areas where you can change. Figure 6-1: Major threats to Biodiversity 1. Land and water use change: Both our lands and our seas contain many different ecosystems, and these are affected by business actions. For example: when developers drain and fill in marshes or wetlands in order to build housing, they take away the land that captures excess water during storms. The consequences can be drastic. Ecosystem conversion and ecosystem degradation contribute to habitat fragmentation. Habitat loss from exploitation of resources, agricultural conversion, and urbanization is the largest factor contributing to the loss of biodiversity. The consequent fragmentation of habitat results in small isolated patches of land that cannot maintain populations of species into the future. Scientists report that the effect of habitat fragmentation on biodiversity may not be fully realized for decades after habitat is degraded. Therefore, habitat connectivity must be considered in current management practices to prevent the devastating effects of fragmentation on biodiversity. Maintaining the connectivity of the landscape could offset their impacts on biodiversity. The corridor concept proposes that refuges connected by corridors will have higher immigration rates than isolated patches of natural habitat. This can offset extinction by promoting gene flow and preventing inbreeding. Corridors composed of naturally occurring or restored strips of land that connect large habitat patches may facilitate the movement of species between patches, and decrease the effects of threats to biodiversity. Habitat patches connected

75 by corridors must always be large enough to maintain populations of species, especially for large-bodied vertebrates. 2. Invasive species: Global trade brings species from their home ecosystems to other parts of the world, where there are often no predators to eat them and keep their numbers in check. The warming climate allows dangerous species such as disease-carrying mosquitos to thrive in new latitudes. Alien species often throw their new habitats severely out of balance. For instance, the brown rat, which originated in central Asia and has invaded almost every part of the world, has driven hundreds of species extinct. Infestation by alien species, such as the Codling Moth, is also a major threat to ecosystems. The intentional and inadvertent introductions of a wide variety of species to ecosystems in which they do not belong have resulted in ecosystems that differ radically in structure and function from those originally present. Exotic species are typically introduced into ecosystems without their co-evolved predators and parasites, which enables an alien invader to out-compete native species with similar ecological requirements. The interactions between native species are altered or destroyed by these exotic species, and can result in the loss of native biodiversity. 3. Pollution: Pollution of air, soil, and water poses a serious problem to many ecosystems. Tiny bits of plastic suspended in ocean water build up inside fish, birds, and other marine species. Industrial toxins kill many species in rivers and lakes. Air pollution makes its way into soil, leaves, and water. It all adds up to fewer species, less diversity, and weakened ecosystems. Atmospheric and hydrologic pollution have far- reaching negative effects on biodiversity. Pollution from burning fossil fuels such as oil, coal and gas can remain in the air as particle pollutants or fall to the ground as acid rain. Acid rain, which is primarily composed of sulfuric and nitric acid, causes acidification of lakes, streams and sensitive forest soils, and contributes to slower forest growth and tree damage at high elevations. In addition, chemical pollutants such as pesticides and herbicides leach into soils and watersheds. Species' sensitivity to pollution is variable. However, many species are vulnerable to the indirect effects of pollution through the concentration of toxic chemicals in top predators of food chains and disruption of predator-prey interactions. 4. Climate change: We're already seeing hotter temperatures, warmer oceans, and more severe weather events. Many species can't adjust to these conditions, and their numbers crash. Carbon dioxide released from burning fossil fuels and biomass, deforestation, and agricultural practices contributes to greenhouse gases, which prevent heat from escaping the earth's surface. With the increase in temperature expected from increasing greenhouse gases, there will be higher levels of air pollution, greater variability in weather patterns, and changes in the distribution of vegetation in the landscape. Some species will not be able to adapt to these changes in the environment and will become extinct. However, it is expected that many plant and animal species will attempt to disperse to higher latitudes and altitudes as the temperature increases. Therefore, any barriers in the landscape, such as highways and urban areas that prevent movement to more hospitable environments, will result in loss of biodiversity.

76 5. Overexploitation: Activities such as logging, farming, and fishing can be done sustainably, but they are often done in ways that overexploit a resource. When too many species, or even just a few important species, are taken out of the ecosystem, the whole network of life in that area can collapse. Think of a rock wall with too many rocks taken out, or a spider web with too many strands cut. Overall, people have been taking far more from nature than it can afford. For example, 70% of fish stocks in the ocean are currently being overfished. A 2016 study suggested that the oceans could be empty of fish by 2050. 6.6 Biodiversity hotspot in India The term 'biodiversity hotspot' was coined by Norman Myers (1988). He recognized 10 tropical forests as "hotspots" on the basis of extraordinary level of plant endemism and high level of habitat loss, without any quantitative criteria for the designation of "hotspot" status. Two years later, he added eight more hotspots, and the number of hotspots in the world increased to 18 (Myers 1990). Subsequently, the Conservation International in association with Myers made the first systematic update of the hotspots, and introduced the following two strict quantitative criteria, for a region to qualify as

a hotspot: i) It must contain at least 1,500 species of vascular plants (< 0.5% of the world's total) as endemics;

ii) It has to have lost $\geq$ 70% of its original native habitat. The first systematic update of the hotspots, which involved an extensive global review, introduced seven new hotspots on the basis of the newly defined criteria and authentic new data, thus the number of hotspots has been increased to 25 (Mittermeier & al., 1999; Myers & al., 2000). The second systematic update revisited the hotspot regions and redefined several hotspots based on the distribution of species, threats, and changes in the threat status of these regions, which resulted in addition of nine more hotspots thus the number of hotspots expanded to 34 (Mittermeier &t al., 2004). The "Forests of East Australia" harbouring at least 2,144 endemic vascular plant species in an area with just 23% of its original vegetative cover remaining was identified as the 35th biodiversity hotspot (Williams & al., 2011; Mittermeier & al., 2011). In February 2016, the "North American Coastal Plain" meeting the criteria of hotspot, was recognized as the 36th global biodiversity hotspot. Therefore, according to Conservation International (https://www.conservation.org), at present, there are 36 biodiversity rich areas in the world that have been qualified as

hotspots, which represent just 2.5% of earth's land surface, but support over 50% of the world's endemic plant species, and nearly 43% of bird, mammal, reptile and amphibian species as endemics. India, the seventh largest country in the world by geographical area (constitutes 2.4% of the total geographical area of the world) with varied physiographic divisions, climatic regimes, and ecological habitats exhibits a rich floral diversity, and harbours nearly 8% of the globally

77 known flora, of which 28% of floral elements are endemic to the country (Mao & al., 2020). India is one of the 17 mega diversity countries in the world (Williams, 2001). According to a recent estimation the country harbours a total of 18,800 taxa of angiosperms, 82 taxa of Gymnosperms, 1307 taxa of Pteridophytes, 2786 taxa of Bryophytes, besides 15447 taxa of Fungi, 7434 taxa of Algae, 2917 taxa of Lichens and 1239 species of microbes (Viruses and Bacteria), which represent 8% of total recorded plant species (including algae, fungi, lichens, viruses and bacteria) of the world (Mao & al., 2020). India has four biodiversity hotspots namely Himalaya, Indo-Burma (Northeastern India and Andaman Islands), Sundalands (Nicobar Islands) and Western Ghats (and Sri Lanka) (https://www.conservation.org). The ecosystem profiles of these four hotspot regions are provided in detail below. Figure 6-2: Biodiversity hotspots in India

78 1. Himalaya: Includes the entire Indian Himalayan region [Jammu and Kashmir, Himachal Pradesh, Uttarakhand, northern part of West Bengal (Darjeeling), Sikkim, northern part of Assam and Arunachal Pradesh] and that falling in Pakistan, Tibet, Nepal, Bhutan, China and Myanmar. Overall, the Himalayas comprises North-East India, Bhutan, Central and Eastern parts of Nepal. These Himalayan Mountains are the highest in the world and hosts some of the highest peaks of the world including Mount Everest and K2. It also includes some of the major rivers of the world like Indus and Ganga. Himalayas hosts almost 163 endangered species including one-horned rhinoceros, wild Asian water buffalo and as many as 45 mammals, 50 birds, 12 amphibians, 17 reptiles, 3 invertebrates and 36 plant species. 2. Indo-Burma: Myanmar, Thailand, Vietnam, Laos, Cambodia and southern China; also included the entire northeastern India (Mizoram, Manipur, Nagaland, Meghalaya, and Tripura), and Andaman group of Islands, Bangladesh and Malaysia, while originally defined by Mittermeier & al. (2004). This region consists of various countries including North-Eastern India (to the south of the Brahmaputra River), Myanmar, and China's Yunnan provinces, Lao People's Democratic Republic, Vietnam, Cambodia, and Thailand. Almost 13,500 plant species can be spotted in the region, half of which are endemic and cannot be found in any other place in the world. Although this region is quite rich in its biodiversity, the situation has been worsening over the past few decades. 3. Sundaland: Indonesia, Malaysia, Singapore, Brunei and Philippines; also included Nicobar group of Islands while originally defined by Mittermeier & al. (2004). This region lies in South-East Asia and includes Thailand, Singapore, Indonesia, Brunei, and Malaysia. Nicobar region represents India in this hotspot. UNESCO declared this region as the world biosphere reserve in 2013. These islands have a rich terrestrial as well as marine ecosystem including mangroves, seagrass beds, and coral reefs. 4 . Western Ghats and Sri Lanka: Includes the entire Western Ghats [Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra and Gujarat] and Sri Lanka. These hills are found along the western edge of peninsular India. As the region is mountainous and oceanic, it receives a good amount of rainfall. Around 77% of the amphibians and 62% of the reptiles are endemic. Moreover, the region is also home to around 450 species of birds, 140 mammals, 260 reptiles and 175 amphibians. 6.7 Mega Biodiversity countries Megadiverse Countries is a term used to refer to the world's top biodiversity rich countries. This country-focused method raises national awareness for biodiversity conservation in nations with high biological diversity. The mega-diverse countries are those that house the largest indices of biodiversity, including a large number of endemic species. This concept was first proposed in 1988 by Russell Mittermeier and is now used to raise awareness to the protection of natural biodiversity, and particularly in the countries where this is more abundant and threatened. 6.7.1.1 The Megadiversity country concept is based on four premises: a) The biodiversity of each and every nation is critically important to that nation's survival.

79 b) Biodiversity is by no means evenly distributed on our planet, and some countries, especially in the tropics, harbour far greater concentrations of biodiversity than others. c) Some of the most species rich and biodiverse nations also have ecosystems that are under the most severe threat. d) To achieve maximum impact with limited resources, conservation efforts must concentrate heavily (but not exclusively) on those countries richest in diversity and endemism and most severely threatened. The identified Megadiverse Countries are: India, Brazil, Madagascar, Colombia, Ecuador, Peru, Venezuela, United States of America, Mexico, Democratic Republic of Congo, South Africa, Malaysia, Indonesia, Philippines, Papua New Guinea, China, Australia. Figure 6-3: Megadiverse Countries shown in world map. These countries declared to set up a Group of Like-Minded Megadiverse Countries as a mechanism for consultation and cooperation so that their interests and priorities, related to the preservation and sustainable use of biological diversity, could be promoted. They also declared that they would call on those countries that had not become Parties to the Convention on Biological Diversity, the Cartagena Protocol on Biosafety, and the Kyoto Protocol on climate change to become parties to these agreements. 6.8 Extinct, rare, endangered, threatened flora and fauna of India As per BSI, 18 species of plants — four non-flowering and 14 flowering — have gone extinct. The notable among them are Lastreopsis wattii, a fern in Manipur discovered by George Watt in 1882 and three species from the genus Ophiorrhiza (Ophiorrhiza brunonis, Ophiorrhiza caudate and Ophiorrhiza radican), all discovered from peninsular India. Corypha taliera

80 Roxb. a palm species discovered in Myanmar and the Bengal region by William Roxburgh is also extinct. Among mammals, the Asiatic cheetah (Acionyx jubatus), Indian aurochs (Bos primigenius namadicus) and the Sumatran rhinoceros (Dicerorhinus sumatrensisi) are considered extinct in India. The pink-headed duck (Rhodonessa caryophyllaceai) is feared extinct since 1950 and the Himalayan quail (Ophrysia supercililios) was last reported in 1876. The flora of India is one of the richest in the world due to the country's wide range of climate, topology, and environment. There are over 15,000 species of flowering plants in India, which account for 6% of all plant species in the world. Many plant species are being destroyed, however, due to their prevalent removal. Roughly 1/4 of all plant species in the world are at risk of being endangered or going extinct. The combination of global warming and habitat destruction is the sole reason for the disappearance of many plants. Though there are thousands of interesting and unusual plants, here are some common plants which have become rare and endangered species in the past 30 years due to habitat destruction. Table 6-1: Some common plants which have become rare and endangered species in the past 30 years due to habitat destruction. Plant Common name Region Status Polygala irregularis Milkwort Gujarat Rare Lotus corniculatus Bird's foot Gujarat Rare Amentotaxus assamica Assam catkin yew Arunachal Pradesh Threatened Psilotum nudum Moa, skeleton, fork fern, and whisk fern Karnataka Rare Diospyros celibica Ebony tree Karnataka Threatened Actinodaphne lawsonii Kerala Threatened Acacia planifrons Umbrella tree, kudai vel Tamil Nadu Rare Abutilon indicum Indian mallow, thuthi, and athibalaa Tamil Nadu Rare Chlorophytum tuberosum Musli Tamil Nadu Rare Chlorophytum malabaricum Malabar lily Tamil Nadu Threatened Nymphaea tetragona Jammu & Kashmir Endangered Belosynapsis vivipara Spider wort Madhya Pradesh Endangered Colchicum luteum Himachal Pradesh Threatened Pterospermum reticulatum Malayuram, Malavuram Kerala and Tamil Nadu Threatened Ceropegia odorata Jeemikanda Gujrat, Rajasthan, Maharastra Endangered Globally threatened list of the Indian fauna with categories and criteria assigned by IUCN, from the gobal fauna and Flora, and have assessed their conservation status under the various schedules of the Indian Wildlife (Protection) Act 1972, appendices of Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) and of

81 Convention of Migratory Species of Wild Animals (CMS) vis-a-vis trends in population status for the 648 species which is approximately 8.91%: of the world's total number of threatened faunal species. The Indian Red List includes 212 Species of Mammals. 143 Birds, 34 Reptiles, 148 Amphibians. 78 Pisces and 33 Invertebrate species of the 648 Threatened Indian Species 183 species are endemic that significantly makes 28.24% of the threatened Indian fauna, which is a very high ratio and the threats to the endemic species is a cause of concern. The data of the threatened Indian species reveals 44 species as Critical, 109 as Endangered. 195 as Vulnerable, 63 as Lower Risk near Threatened, 91 as Near Threatened, 9 as Lower Risk Conservation dependent and 134 as Data Deficient. 6.8.1.1 Critically endangered fauna of India- (a) Birds - Jerdon's Courser (Rhinoptilus bitorquatus), Forest Owlet (Heteroglaux blewitti), White-bellied Heron (Ardea insignis), White-backed Vulture (Gyps bengalensis), Slender-billed Vulture (Gyps tenuirostris), Long-billed Vulture (Gyps indicus), Himalayan Quail (Ophrysia superciliosa), Siberian Crane (Grus leucogeranus), Sociable Lapwing (Vanellus gregarius), Spoon-billed Sandpiper (Eurynorhynchus pygmeus), Bengal Florican (Houbaropsis bengalensis) (b) Mammals - Pygmy hog (Porcula salvania), Andaman White-toothed Shrew (Crocidura andamanensis), Jenkin's Shrew (Crocidura jenkinsi), Nicobar Shrew (Crocidura nicobarica), Large Rock-rat (Cremnomys elvira), Malabar Civet (Viverra civettina), Namdapha Flying Squirrel (Biswamoyopterus biswasi) (c) Reptiles - Gharial (Gavialis gangeticus), Leatherback turtles (Dermochelys coriacea), Four-toed river terrapin or River terrapin (Batagur baska), Hawksbill Turtle (Eretmochelys imbricata), Red-crowned Roof Turtle (Batagur kachuga) (d) Amphibia - Gliding Frog (Rhacophorus pseudomalabaricus), Fejervarya murthii, Indirana gundia, Philautus sanctisilvaticus, Raorchestes shillongensis (e) Fish - Knifetooth Sawfish (Anoxypristis cuspidata), Ganges Shark (Glyphis gangeticus), Pondicherry Shark (Carcharhinus hemiodon), Largetooth Sawfish (Pristis microdon), Deccan Labeo (Labeo potail) The Zoological Survey of India, Kolkata published a booklet titled "Critically Endangered Animal Species of India" in March 2011. The booklet provides details of fauna which are critically endangered and on the verge of extinction. The findings of the status survey of rare and endangered species of fauna have been published by the Zoological Survey of India for the last 15 years as mentioned in Annexure A. The Botanical Survey of India has published four volumes of Red Data Book of Indian Plants, (Eds. Jain & Rao, 1984; Nayar & Sastry 1987 – 1990) and Red List of Threatened Vascular Plant Species in India (Rao et al. 2003), which provide information on 1236 species belonging to different threatened categories like Critically Endangered, Endangered, Vulnerable, etc. For protection of the interests of flora and fauna, the Government has established a country- wide protected area network (678 Protected Areas (PAs) including 102 National Parks, 515 Wildlife Sanctuaries, 4 Community Reserves, and 57 Conservation Reserves in different biogeographic regions), which primarily covers habitats of threatened flora and fauna. Moreover, 9 of the 18 Biosphere Reserves in India are part of the World Network of Biosphere Reserves of UNESCO. Specific areas are designated by the Govt. of India as Ecologically Sensitive Areas (ESAs), which are protected under the Environment (Protection) Act 1986

82 (EPA). Several other steps to conserve/protect the wildlife and species of flora and fauna undertaken by the government. 6.9 Strategies for biodiversity conservation India is a signatory to several major international conventions relating to conservation and management of wildlife. Some of these are Convention on Biological Diversity, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on the Conservation of Migratory Species of Wild Animals etc. Financial and Technical assistance is provided to State/Union Territory Governments for protection and Management of Protected Areas as well as other forests under various Centrally Sponsored Schemes. Indian Government has taken various biodiversity protection steps. Important measures include: 1. The Central Government has enacted the Wild Life (Protection) Act, 1972. The Act, inter alia, provides for the creation of Protected Areas for the protection of wildlife and also provides for punishment for hunting of specified fauna specified in the schedules I to IV thereof. 2. Wetland (Conservation and Management) Rules 2010 have been framed for the protection of wetlands, in the States. 3. The Centrally Sponsored Scheme of National Plan for Conservation of Aquatic Eco- System also provides assistance to the States for the management of wetlands including Ramsar sites in the country. 4. Wildlife Crime Control Bureau has been established for control of illegal trade in wildlife, including endangered species. 5. Wildlife Institute of India, Bombay Natural History society and Salim Ali Centre for Ornithology and Natural History are some of the research organisations undertaking research on conservation of wildlife. 6. The Indian Government has banned the veterinary use of diclofenac drug that has caused the rapid population decline of Gyps vulture across the Indian Subcontinent. Conservation Breeding Programmes to conserve these vulture species have been initiated at Pinjore (Haryana), Buxa (West Bengal) and Rani, Guwahati (Assam) by the Bombay Natural History Society. 7. The Centrally Sponsored Scheme 'Integrated Development of Wildlife Habitats' has been modified by including a new component namely 'Recovery of Endangered Species' and 16 species have been identified for recovery viz. Snow Leopard, Bustard (including Floricans), Dolphin, Hangul, Nilgiri Tahr, Marine Turtles, Dugong, Edible Nest Swiftlet, Asian Wild Buffalo, Nicobar Megapode, Manipur Brow-antlered Deer, Vultures, Malabar Civet, Indian Rhinoceros, Asiatic Lion, Swamp Deer and Jerdon's Courser. 8. Under the 'Recovery of Endangered Species' component of the Centrally Sponsored Scheme 'Integrated Development of Wildlife Habitats' for the recovery of endangered species viz. Hangul in Jammu and Kashmir, Snow Leopard in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and Arunachal Pradesh, Vulture in Punjab, Haryana and Gujarat, Swiftlet in Andaman and Nicobar Islands, Nilgiri Tahr in Tamil Nadu, Sangai Deer in Manipur, the government has to spend lakhs of rupees.

83 9. Protected Areas, viz, National Parks, Sanctuaries, Conservation Reserves and Community Reserves all over the country covering the important habitats have been created as per the provisions of the Wild Life (Protection) Act, 1972 to provide better protection to wildlife, including threatened species and their habitat. 10. Financial and technical assistance is extended to the State Governments under various Centrally Sponsored Schemes, viz, 'Integrated Development of Wildlife Habitats', 'Project Tiger' and 'Project Elephant' for providing better protection and conservation to wildlife. 11. The Central Bureau of Investigation (CBI) has been empowered under the Wild Life (Protection) Act, 1972 to apprehend and prosecute wildlife offenders. 12. The State Governments have been requested to strengthen the field formations and intensify patrolling in and around the Protected Areas. 6.9.1 Important Indian Acts and policies related to Environment and Bio Diversity 6.9.1.1 Acts Fisheries Act 1897, Indian Forests Act 1927, Mining and Mineral Development Regulation Act 1957, Prevention of cruelty to animals 1960, Wildlife protection act 1972, Water (prevention and control of pollution) act 1974, Forest Conservation Act 1980, Air (prevention and control of pollution) act 1981, Environment Protection Act 1986, Biological Diversity Act 2002, Scheduled Tribes and other traditional forest dwellers (recognition of rights) act 2006. 6.9.1.2 Policies National Forest Policy, National Conservation Strategy and Policy statement on Environment and Development, National Policy and macro-level action strategy on Biodiversity, National Biodiversity Action Plan (2009), National Agriculture Policy, National Water Policy, National Environment Policy (2006). 6.10 Conservation of biodiversity Humans have been directly or indirectly dependent on biodiversity for sustenance to a considerable extent. However, increasing population pressure and developmental activities have led to large scale depletion of the natural resources. Conservation is the protection, preservation, management, or restoration of wildlife and natural resources such as forests and water. Through the conservation of biodiversity and the survival of many species and habitats which are threatened due to human activities can be ensured. There is an urgent need, not only to manage and conserve the biotic wealth, but also restore the degraded ecosystems. Conservation can broadly be divided into two types: 1. In-situ conservation 2. Ex-situ conservation

84 Figure 6-4: Biodiversity conservation 6.10.1 In-Situ Conservation Strategies: In situ conservation means 'on-site conservation'. Here, the plant or animal species are protected in their natural habitat. This is carried on by two methods: (i) Either by protecting or cleaning up the habitat itself. (ii) By defending the species from predators. Here stress is laid upon protection of total ecosystem. This leads to declaration of 'Protected Areas'. For protecting such areas, legal or other effective strategies are used. 6.10.1.1 Protected Areas in India: These include: a) National Parks b) Sanctuaries, and c) Biosphere Reserves. a) National Parks: A national park is an area which is strictly reserved for the betterment of the wildlife and where activities like forestry, grazing or cultivation are not permitted. In these parks, even private ownership rights are not allowed. There are about 66 national parks (in 1988) in India spread over an area of 3398814 square kilometres or nearly 1 per cent of the country's geographical area. Some National Parks of India: 1. Kaziranga National Park, District Sibsagar (Assam) – Rhinoceros, elephant, wild buffalo, bison, tiger, leopard, sloth, bear, sambhar, swamp deer, barking deer, wild boar, gibbon, python and birds like pelican, stork and ring tailed fishing eagles. This is a famous National Park of famous one-horned rhinoceros of India. 2. Sundarbans (Tiger Reserve) 24 Pargana (West Bengal) – Tiger, wild boar, deer, dolphin, estuarine, crocodile. Biodiversity Conservation In-situ Protected areas * National Parks * Sanctuaries * Biosphere Reserve Sacred forest and lakes Ex-situ * Seed banks & gene banks * Captive breeding * Animal translocation and rehabilitaion *Tissue culture banks * Cryopreservation of gamets and embryo * Botanical and zoological gardens

85 3. Hazaribagh National Park, Hazaribagh (Bihar) – Tiger, leopard, hyaena, wild boar, gaur, sambhar, nilgai, chital, sloth, bear, peafowl. 4. Corbett National Park, Nanital (Uttarkhand) – Tiger, elephant, panther, sloth, bear, wild boar, nilgai, sambhar, chital, crocodile, python, king cobra, peafowl, partridge. This is the first National Park of India which is famous for tigers. 5. Gir National Park, District Junagarh (Gujrat) – Asiatic lion, panther, striped hyaena, sambhar, nilgai, chital, 4-horned antelope, chinkara, wild boar, langur, python, crocodile, green pigeon, partridge. This National Park is famous for Asiatic lions. 6. Kanha National Park, Mandla and Balaghat (Madhya Pradesh) – Tiger, panther, chital, chinkara, barking deer, blue bull, deer, langur, wild boar, black buck, nilgai, wild dog, sloth bear, sambhar, crocodile, grey horn bill, egret, peafowl. 7. Tandoba National Park, Chandrapur (Maharashtra) – Tiger, sambhar, sloth bear, bison, chital, chinkara, barking deer, blue bull, four-horned deer, langur, pea-fowl, crocodile. 8. Bandipur National Park, District Mysore (Karnataka) – Elephant, tiger, leopard, sloth bear, wild dog, chital, panther, barking deer, langur, porcupine, gaur, sambhar, malabar squirrel, green pigeon. 9. Desert National Park, Jaisalmer (Rajasthan) – Great Indian Bustard, black buck, chinkara. 6.10.1.2 Sanctuaries: A sanctuary is a protected area which is reserved for the conservation of only animals and human activities like harvesting of timber, collection of minor forest products and private ownership rights are allowed so long as they do not interfere with the well- being of animals. There are about 392 (As on October, 1992) and 421 (As in 1993) sanctuaries in India (368 sanctuaries in 1988) which cover about 107,310 square kilometres or 3.2 per cent of country's geographical area. Some important sanctuaries of India are listed below: 1. Annamalai Sanctuary, Coimbatore (Tamil Nadu) – Elephant, tiger, panther, gaur, sambhar, spotted deer, sloth bear, wild dog, barking deer. 2. Jaldapara Sanctuary, Madarihat (West Bengal) – Rhino, elephant, tiger, leopard, gaur, deer, sambhar, different kinds of birds. 3. Keoladeo Ghana Bird Sanctuary, Bharatpur (Rajasthan) – Siberian crane, storks, egrets, herons, spoon bill, etc. Drier parts of this marshy sanctuary have spotted deer, black buck, sambhar, wild boar, blue bull, Indian rock python. This sanctuary is famous for birds. 4. Sultanpur Lake Bird Sanctuary, Gurgaon (Haryana) – Crane, saras, spotbill, duck, drake, green pigeon, wild bear, crocodile, phython. 5. Bir Moti Bagh Wildlife Sanctuary, Patiala (Punjab) – Nilgai, wild boar, hog deer, black buck, blue bull, jackal, pea-fowl, partridge, sparrow, myna, pigeon, dove. 6. Shikari Devi Sanctuary, Mandi (Himachal Pradesh) – Black bear, snow leopard, flying fox, barking deer, musk deer, chakor, partridge. 7. Dachigam Sanctuary, Srinagar (Jammu & Kashmir) – Hangul or Kashmir stag, musk deer, snow leopard, black bear, brown bear.

86 8.

Mudumalai Wildlife Sanctuary, Nilgiri (Tamil Nadu) – Elephant, gaur, sambhar, chital, bar-king deer, mouse deer, four horned antelope, langur, giant squirrel, flying squirrel, wild dog, wild cat, civet, sloth bear, porcupine, phython, rat snake, monitor lizard, flying lizard. 9.

Nagarjuna Sagar Sanctuary, Guntur, Kamool and Nalgonda (Andhra Pradesh) – Tiger, panther, wild bear, chital, nilgai, sambhar, blackbuck, foz, jackal, wolf, crocodile. 10. Periyar Sanctuary (Kerela) – Elephants, gaur, leopard, sloth, bear, sambhar, bison, black langur, hornbill, egret. It is famous for animals. 11. Chilka Lake Bird Sanctuary, Balagaon (Orissa) – An oasis of birds like water fowls, ducks, cranes, golden plovers, sand pipers, flamingoes. 12. Manas Wildlife Sanctuary, Kamprup (Assam) – Tiger, panther, rhino, gaur, wild buffalo, sambhar, swamp deer, golden langur, wild dog, wild boar. 6.10.1.3 Biosphere Reserves: Under MAB (Man and Biosphere) Programme, UNESCO has established a number of biospheres reserves in the world. The concept of Biosphere Reserves was launched by MAB in 1975 for dealing with the conservation of ecosystems and the genetic resources contained therein. Under MAB programme, UNESCO has studied the impact of human interference and pollution on biotic and abiotic environments and conservation strategies for the present as well as future. A biosphere reserve is a specified area iii which multiple use of the land is permitted by dividing it into certain zones, each zone being specified for a particular activity. Zones of a Biosphere Reserve: A biosphere reserve is basically divided into three zones: 1. Core Zone: It lies at centre where no human activity is allowed. It is legally protected. 2. Buffer Zone: In this zone limited human activities are allowed. It surrounds core area. 3. Manipulative Zone (Transition Zone): In this zone multiple human activities are allowed but ecology is not permitted to be disturbed. It is the outermost part of biosphere reserve. Biosphere Reserves in India: In India, there are 14 biosphere reserves. The first biosphere reserve of the world was established in 1979. Till May 2005, there were 425 Biosphere Reserves located in 95 countries. The number assigned to a biosphere reserve is based on its date of declaration. The purpose of declaration of biosphere reserve is to conserve bio-diversity in-situ along with its supporting system. Biosphere reserves with human beings as its integral parts are examples of natural biomes. First biosphere reserve established in India, was Nilgiri Biosphere Reserve (1986). Nanda Devi Biosphere Reserve was established in 1988. Date of notification of Nilgiri Biosphere reserve is 01.8.1986 with area of 5520 km2 and cover the states of Kerala, Kamataka and Tamil Nadu. Dibru-Saikhowa Biosphere reserve is present

87 in Dibrugarh and Tinsukia districts of Assam. Sunderbans Biosphere reserve with an area of 9630 km2 covers part of delta of Ganga and Brahmputra river system in West Bengal. Panchmarhi covers an area of 4926 km2 and lies in Madhya Pradesh. Kanchanjanga Biosphere reserve with an area of 2619 km is present in Sikkim. Manas Biosphere reserve is in Assam. Nokrek Biosphere reserve is in Meghalaya. Nanda Devi Biosphere reserve with an area of 5860 km2 is present in Uttaranchal Gulf of Mannar Biosphere reserve is in Tamil Nadu. Significance: The concept of Biosphere Reserves is of immense value for conserving the gene- pool resources of flora and fauna in the country and to serve as bench-marks for future studies. The concept of Biosphere Reserve has the following objectives: i. To conserve for present and future human race use, the diversity and integrity of biotic communities of plants and animals within natural ecosystems and to safeguard the genetic diversity of species on which their continuing evolution depends. ii. To provide areas for ecological and environmental research. iii. To provide facilities for education and training. iv. To promote economic development. Sacred Forests and Sacred Lakes: Some forest patches are being protected by tribals due to religious sanctity are called sacred forests. Such forests have been found to be most undisturbed and they are usually surrounded by most degraded land scapes. Such sacred forests in India are present in states like Karnataka, Maharashtra, Kerela and Meghalaya. In Sikkim, Khecheopalri lake is declared sacred lake by people, thus protecting the aquatic flore and fauna. 6.10.2 Ex-Situ Conservation Strategies: Such strategies include establishment of botanical gardens, zoos, conservation strands and gene, pollen, seed, seedling, tissue culture and DNA banks. These facilities not only provide housing and care for endangered species, but also have educational and recreational values for the society. Few noteworthy points of ex-situ conservation are: a) Seed Gene Bank or Germplasm Bank: This is the easiest way to store the germ plasm of plants at low temperature. The term seed bank also refers to cryogenic laboratory facility in which the seeds of some species can be kept viable for long period. Germplasm can also be preserved by in vitro culturing where cutting of plants and maintained under controlled conditions. Genetic variability can also be preserved by field gene bank under normal growing conditions. The gene banks are used to store living sperms, eggs or embryos. b) Cryopreservation: This type of in vitro conservation is done at very low temperature i.e., -196°C in liquid nitrogen. This may be done with very rapid cooking (in storing seeds) or by gradual cooling and

88 simultaneous dehydration (in tissue culture). Cryopreservation is highly successful in crops like potato. c) Tissue culture bank: Cryopreservation of disease-free meristems is very helpful. Long term culture of excised roots and shoots are maintained. Meristem culture is very popular in plant propagation as it's a virus and disease-free method of multiplication. d) Captive breeding: The method involves capture, maintenance, and captive breeding on long term basis of individuals of the endangered species which have lost their habitat permanently or certain highly unfavourable conditions are present in their habitat. e) Botanical Gardens: In more than 1500 botanical gardens and arboreta (botanical gardens where particular shrubs and trees are grum) in world. In such gardens more than 80,000 species are found. Many botanical gardens have the facilities of seed banks, tissue culture and other latest ex-situ technologies. f) Zoological Gardens: In world, there are about 800 zoos. Such zoos have about 3000 species of vertebrates. Some zoos have undertaken captive breeding programmes. 6.10.2.1 Limitations of Ex-Situ Conservation: i) It stops the natural evolution and adaptations processes. In cryogenic preservation of specimens, adaptations processes come to halt altogether. ii) Ex-situ conservation strategies are highly expensive. iii) If fails to recreate the habitat as a whole. A species may adapt to changed environmental conditions due to genetic variation of a species, its symbiotic counter parts or other elements. iv) Seed banks are not effective for few plant species with recalcitrant seeds do not show viability for long time. 6.10.2.2 Advantages of ex-situ preservation: i) It is useful for declining population of species. ii) Endangered animals on the verge of extinction are successfully breeded. iii) Threatened species are breeded in captivity and then released in the natural habitats. iv) Ex-situ centres offer the possibilities of observing wild animals, which is otherwise not possible. v) It is extremely useful for conducting research and scientific work on different species. Table 6-2: Some of the major Differences between In-situ and ex-situ Conservation are as follows In situ Conservation Ex situ Conservation It is conservation of endangered species in their natural habitats. It is conservation of endangered species outside their natural habitats. The endangered species are protected from predators. The endangered species are protected from all adverse factors.

89 The depleting resources are augmented. They are kept under human supervision and provided all the essentials. The population recovers in natural environment. Offspring produced in captive breeding are released in natural habitat for acclimatization. 6.11 Bio-piracy in India Since the last two decades multinational corporations are profiting by patenting the indigenous knowledge and resources of Indian hotspots and associated communities. Bio- piracy is hampering the livelihoods of communities and farmers who have invested their time, care, hard work and knowledge in restoring their heritage. An account of various medicinal plants like turmeric, neem, basmati rice, ashwagandha, pudina, kalmegh, aloe-vera, karela, jamun and brinjal have been given, which are victimized by bio-piracy and where India have successfully put forward its perspective in the international courts and came forth as a winner. This is the ripe time where genuine efforts are required from government, Non Government Organization (NGO)'s, scientists and publishers to restrict highly ambitious pharmaceutical and biotechnological firms to escort our national wealth. There is a dire need of modification or amendments in international and national rules in order to safeguard national interests and to negate the privatization of international knowledge and resources. So far, the best solution provided by India has been the construction of databases and traditional knowledge archives - Traditional Knowledge Digital Library (TKDL) to endorse the preservation, promotion, dissemination and exercising suitable use of traditional knowledge as 'Prior art'. India is a land of traditions and here knowledge is acquired over centuries unknown. India supports about 15% of world's population owing to its unique geographical location and diverse cultures. Our traditional knowledge (TK) is an integral part of our cultural identity and has been playing a vital role in our day to day life from time immemorial as traditional knowledge is the only means of livelihood in rural areas. Besides India, about 80% population of developing countries depend on medicines obtained from traditional plants to meet their health care needs. Local communities of a particular country imbibe traditional knowledge regarding medicinal values of plants and the same is passed on with incremental improvements over generation. Although, a part of this knowledge is documented but its interpretation is cumbersome because of the involvement of local script used. Due to this unsynchronized documentation of traditional knowledge, patents are often granted to facilitate those persons who traditionally don't owe this knowledge but reap massive profits, there by leading to conflicts in the market interests of the parties involved as the original stakeholders of the traditional knowledge are dissatisfied as no profit flows back to them. Bio-piracy implies any attempt to acquire proprietary rights over biological resources and its associated indigenous knowledge, or upon product(s) based on them, neglecting the consent and contribution of the bearers of such resources and knowledge. Put differently, bio piracy is defined as a process in which living resources or traditional knowledge and practices are

90 patented, thus applying intellectual property restrictions to their use. These practises will lead to inequality between the developed countries (supported by transnational corporations) and developing countries (dependent solely on their indigenous resources). The issue of bio-piracy is touching threatening horizons because the western countries are toying with the patents of crucial traditional and indigenous products of the progressing nations. Recently, Ayurveda has captured the interest and excitement of the western part of globe, especially Europe and United States. The ayurvedic knowledge is gaining global attraction as well as adoption due to the awareness regarding the adverse effects of allopathy leading to bio piracy. The Convention on Biological Biodiversity has added up a synergistic effect to the problem by providing a tool of free accession in the hands of multinational companies to the indigenous natural resources and after screening the indispensable resource, gets the exclusive rights for such plants and debaring the natives of their rights of cultural and traditional use. Similarly, Geographical Indications (GIs) are under serious threats from bio-pirates as domestic regulations of individual nations are inefficient in international markets without suitable rectifications in TRIPS where commodities are moving beyond borders. Bio pirates carry out their operations under a veil of legality i.e., the international patent system. They make the fields and forests of developing countries their target and apply for exclusive rights in the form of patents- the Intellectual Property Rights (IPR) Protection. An invention should be novel, useful and non-obvious to be patentable but in countries like Japan, United States and Europe, patents are granted for plant varieties which are hardly novel. As stated by the United Nations Human Development Report of 1999 “the current patent system is leading to the silent theft of centuries of knowledge from the developing to developed countries” demands amendments in the current patent law. With these modern generous policies, the supremacy of rural India is under threat. TRIPS has opened the channels for multinational corporations based on agro-business to involve themselves in bio piracy, geographical indication and genetically modified (GM) seed dominance, thus a set back to our rural and traditional localities. The companies are manipulating the IPR’s according to their own advantage, thus making the patents ineffective which in turn put the traditional farmers on a defensive side. A big chunk of farmers have lost their right to grow and possess control over the production cycles leading to indebtness, disempowerment and posing as a danger to their survival. India has aggressively commenced its struggle against bio-piracy and is successful in revoking a number of patents around the world. The following is an account of ayurvedic drugs against which India has opposed and emerged as a winner. 6.12 Bio-piracy and the difficulties in protecting traditional knowledge While bio-piracy is inherently an act of appropriation of traditional knowledge by individuals and corporations for commercial gain, there are existing difficulties in protecting such knowledge that allow attempts at appropriation. These include: 1. Collective Resource: Intellectual Property Rights (IPR) provide protection to individual ownership of knowledge but traditional knowledge usually belongs to a community or a tribe who have been practising it for generations.

91 2. Criteria of novelty in IPR: Most traditional knowledge is not based on scientific methods of assessment and evolves organically with the help of communities as a response to new challenges and needs. The evolution of such knowledge across generations means that the novelty or innovative factor is non-existent. Thus, such knowledge fails to meet the criteria of novelty required for IPR patents. 3. Limited protection under IPR: Traditional knowledge requires protection for an indefinite period simply because it is associated with the living practices of an indigenous population. These practices may also be vulnerable to appropriation (Bijoy: 2007). At present, the Indian Patents Act does not allow for evergreening of patents. 4. Problem of benefit-sharing: When it comes to sharing monetary and other benefits after commercialisation of a traditional practice through a legal procedure, it is sometimes difficult to identify the beneficiary. For instance, in the mid-1990s, scientists at the Tropical Botanic Garden and Research Institute (TBGRI) developed and patented a drug called "Jeevani". The development of the drug borrowed heavily from the medicinal knowledge of the energising properties of Arogyapacha herb, from the Kani tribe in Kerala. Although TBGRI ended up signing a benefit-sharing agreement with a trust with members from the Kani tribe, not all Kani people agree with the arrangement claiming traditional rights on beneficial properties of the herb (Bijoy 2007). 5. Lack of documentation: Traditional knowledge is usually a product of learning through experience and oral traditions passed over centuries. It may have been generated, transmitted, and strengthened through rituals, songs, oral history, human interactions, ceremonies, languages, experiences, and practices. These traditions are often inaccessible to the patentee or the concerned authority due to the lack of formal documentation. 6. Language Barriers: Even in cases where it is documented, traditional knowledge exists in vernacular languages, which may act as a barrier when it comes to it being universally accessible. 6.12.1 Institutional efforts at preserving traditional knowledge Over the years there have been several national and international policies/conventions to secure the rights of source countries as well as indigenous populations over traditional knowledge. At the national level, one such intervention is the Traditional Knowledge Digital Library (TKDL) which was created to overcome the problem of documentation and availability of information about traditional knowledge in the public domain (Tarunika and Tamilselvi 2018: 1256). TKDL is a collaborative project between the Council of Scientific and Industrial Research (CSIR), Ministry of Science and Technology and the Ministry of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy (AYUSH). It documents traditional knowledge from existing literature in a digitised format, in five international languages, viz. English, French, German, Spanish and Japanese (James 2018). It allows access to this information to patent offices around the world under an access agreement. Although there is no specific legislation for the protection of traditional knowledge in India, the pre-existing legal framework for IPR as well as other acts provide for protection of traditional knowledge through various provisions: 1. The Indian Patents (Amendment) Act 1970: The Act has provisions for mandatory disclosure of source and geographical origin of the biological material used in the invention while applying for patents. Provisions include non-disclosure or wrongful

92 disclosure of known traditional knowledge as grounds for opposition and for revocation of the patents, if granted. 2. The Trade Marks Act 1999: Trademarks can be used to secure protection for the Indian System of Medicine practices since the Trade Marks Act extends to services as well. 3. The Geographical Indications of Goods (Registration and Protection) Act 1999: The Act facilitates protection of collective rights of rural and indigenous communities and their traditional knowledge (Tarunika and Tamilselvi 2018: 1256). By registering an item which is the product of traditional knowledge, as GI, it can be protected indefinitely by renewing the registration when it expires after a period of ten years. 4. Biological Diversity Act 2002 (NBD): The Act establishes a three-tier institutional structure for biodiversity governance in India - National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs) and Biodiversity Management Committees (BMCs). The Act makes applications for IPRs of products/inventions that use traditional knowledge subject to approval by competent authorities. Under the Act, BMCs prepare People's Biodiversity Registers (PBR) in consultation with local communities. PBRs contain comprehensive information on availability and knowledge of local biological resources, their medicinal or any other use or any other traditional knowledge associated with them. 5. Protection of Plant Varieties and Farmers Rights Act 2001 (PPVFR): Among other provisions for recognition of traditional knowledge of farmers, it stipulates benefit- sharing, recognition, and reward (through a Gene Fund) for farmers engaged in the conservation of genetic resources of plants. At the international level, measures for protection of traditional knowledge range from a mix of binding as well as non-binding agreements. The Convention on Biological Diversity (CBD) was the first move towards international dialogue on the protection of biodiversity and TK protection (Ministry of Environment, Forest and Climate Change 2019). Subsequently, the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) 2007 provides indigenous peoples "the right to maintain, control, protect and develop their intellectual property over their cultural heritage, traditional knowledge, and traditional cultural expressions" (United Nations 2007: 23). Under the Declaration, states have to provide "redress through effective mechanisms...developed in conjunction with indigenous peoples, with respect to their cultural, intellectual, religious and spiritual property taken without their free, prior and informed consent or in violation of their laws, traditions and customs.". Additionally, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) was adopted by the FAO in 2004. Through an innovative multilateral system of access and benefit sharing, the treaty allows citizens of signatory countries to use the resources provided, as long as they use them for non-commercial purposes and that they do not acquire IP rights over such resources (Food and Agriculture Organization). However, most prominently under the World Trade Organisation (WTO), the Trade Related Aspects of Intellectual Property Rights (TRIPS) agreement as it stands does not extend protection to traditional knowledge. As a result, proponents of protection of traditional knowledge have missed a key opportunity to benefit from the effective implementation and enforcement mechanism of the WTO. India is prone to Bio-piracy because of its being the earth's richest biodiversity. Bio-piracy provides scarce biological resources to the monopoly control of corporations thus depriving

93 local communities the benefits of its use. It creates market monopolies and excludes the original stakeholders (farmers) from their rightful share to local, national, and global markets. In order to restrict bio-piracy there is a desperate need to make amendments in TRIPS, Biodiversity Bill, Seed Bill and Patent Bill as these are enforced in a hurry to comply with global changes. Ayurvedic courses should be upgraded to accommodate patent awareness among professional, academicians and researchers. GIs should also address the rights of our farmers to use, save, exchange, and improve their seeds for domestic production or protection of our indigenous knowledge. Bio-piracy is a serious tool used by highly desirous pharmaceutical and biotechnological firms which should be restricted and opposed and demands attention and efforts from government, Non-government organizations, scientists and publishers in public and national interests. An attempt has been made in this article to support the developing countries who are victim of bio-piracy by the highly covetous developed countries who are toying with the traditional knowledge of the indigenous residents under the veil of legality-the international Patent System. 6.13 Summary • A measure of variety at the genetic, species, and ecological levels is called biodiversity. • The main direct cause of biodiversity loss is land use change. • The five main threats to biodiversity are habitat loss, pollution, overexploitation, invasive species, and climate change. • India hosts four biodiversity hotspots: the Himalayas, the Western Ghats, the Indo- Burma region and the Sundaland. • Megadiverse countries are those which contain the majority of the planet's natural wealth. Only 17 nations are home to between 60 and 80% of life on Earth. • There are primarily two methods of biodiversity conservation: (a) In-situ Conservation (b)Ex-situ Conservation. • When traditional knowledge is used without permission by the researchers, or exploit the cultures they are drawing from – it's called biopiracy. Indian government takes a strong stance on protecting its ancient knowledge from being patented by other countries. 6.14 Questions/ Self-Assessment questions MCQ type questions 1. Spoon-billed Sandpiper is a _______ bird of India. a) Endangered b) Rare c) Vulnerable d) Critically Endangered 2. One horned Rhinoceros found on a) Sunderban b) Bandhabgarh c) Kaziranga d) Nilgiri 3. Which extinct in India mammal recently brought back to India from Africa a) Dodo

94 b) Cheetah c) Water buffalo d) Sumatran rhinoceros 4. Khecheopalri lake is a a) Ramsar site b) Wasteland c) Sacred lake d) Picnic spot 5. Biodiversity hotspot has been lost _____ of original native habitat a) ≥ 30% b) ≥ 70% c) ≥ 50% d) ≥ 90% Short answer type questions 1. What are the different types of biodiversity? What are the reasons behind the loss of biodiversity? 2. Distinguish between In-Situ and Ex-Situ approaches of conservation of biodiversity. 3. Why certain regions have been declared as biodiversity hot spots by environmentalists of the world? Name any two hot spot regions of India. 4. What is megadiverse countries? Name them all. 5. What is Cryopreservation, Germplasm bank and Tissue bank? Long answer type questions 1. What are the difficulties in protecting biopiracy in India? What are the institutional efforts at preserving traditional knowledge? 2. Give brief account on different In-situ and Ex situ conservation strategies with suitable Indian example. 3. What are the major threats to biodiversity? Give one example of Extinct, rare, endangered, threatened flora and fauna of India. 6.15 Select Readings/ Suggested Readings Agrawal, K. C. (2009). Biodiversity: Concept, Conservation and Management. ISBN: 81- 89153-05-6. Botanical Survey of India (BSI) report (2006). Plant Biodiversity in India. Botkin, D. B.; Keller, E. A. (2010). Environmental Science. ISBN-13: 978-0470520338. Central Zoo Authority (CZA) report (2011). Important zoo in India. www.cza.nic.in Chaturvedi, Mahendra (2010). Biodiversity and Conservation. ISBN: 978-93-80388-03-8. Convention on International Trade in Endangered Species of Wild Fauna and For a (CITES)www.cites.org ENVIS. Environmental Information system. www.envis.nic.in
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2 Course: Energy and Environment Contents Netaji Subhas Open University P.G. Environmental Science PGES CC104

1 Unit 1: Energy Resource 1.1 Objectives 1.2 Introduction 1.3 Concept of Renewable & Non-renewable Resource 1.4 Conventional and Nonconventional energy resources 1.5 Energy use pattern in India 1.6 Summary 1.7 Questions/ Self-Assessment questions 1.8 Select Readings/ Suggested Readings 1.1 Objectives Learners will get knowledge about the • Concept of the energy resource • Detailed knowledge about the conventional and nonconventional energy resource • Also learn about the energy use pattern in India 1.2 Introduction

Energy is required for all activities. It is needed to cook, to provide light and heat, to propel vehicles and to drive machinery in industries. Energy can be generated from fuel minerals like coal, petroleum, natural gas, uranium and from electricity. Energy resources can be classified as conventional and non-conventional sources. Conventional sources include: firewood, cattle dung cake, coal, petroleum, natural gas and electricity (both hydel and thermal). Non-conventional sources include solar, wind, tidal, geothermal, biogas and atomic energy. Firewood and cattle dung cake are most common in rural India. According to one estimate more than 70 per cent energy requirement in rural households is met by these two; continuation of these is increasingly becoming difficult due to decreasing forest area. Moreover, using dung cake too is being discouraged because it consumes most valuable manure which could be used in agriculture. 1.3

Concept of Renewable & Non-renewable Resource The term energy resource refers to any material that can be used as a basis or source of energy. Energy resources are used to generate electricity and other forms of power for human use. There are two kinds of energy resources - Renewable Energy Resources and Non-Renewable Energy Resources. Renewable energy is energy supplied from natural inexhaustible sources and non- renewable energy is energy supplied from sources that exist in a limited amount on Earth. Some

2 examples of Renewable energy resources are hydro, wind, solar, biomass, geothermal etc. and of non-renewable energy are coal, petroleum etc. The sun is the main source of energy on Earth. Other energy sources include coal, geothermal energy, wind energy, biomass, petrol, nuclear energy, and many more. Energy is classified into various types based on sustainability as

renewable sources of energy and non-renewable

sources of energy. 1.3.1.1

What is Energy? The classical description of energy is the ability of a system to perform work, but as energy exists in so many forms, it is hard to find one comprehensive definition. It is the property of

an object that can be transferred from one object to another or converted to different forms but cannot be created or destroyed. There are numerous sources of energy.

In the next few sections, let us discuss the about different

sources of energy in detail. 1.3.2 Sources

of Energy Sources of energy can be classified into: • Renewable Sources • Non-renewable

Sources 1.3.2.1 Renewable sources of energy Renewable sources of energy

are

available plentiful in nature

and are sustainable. These resources of energy can be naturally replenished and are safe for

the environment. Examples of renewable sources of energy are: Solar energy, geothermal energy, wind energy, biomass, hydropower and tidal energy. 1.3.2.2 Non-renewable sources of energy A non-renewable

resource is a natural resource that is found underneath the earth. These type of energy resources do not replenish at the same speed at which it is used. They take millions of years to replenish. The main examples of non-renewable resources are coal, oil and natural gas. Examples of non-renewable sources of energy are: Natural gas, coal, petroleum, nuclear energy and hydrocarbon gas liquids. a. Table 1-1: Difference Between Renewable and Non-renewable

Sources of Energy Renewable Non-renewable The resources that can be renewed once they are consumed are called renewable sources of energy. The resources that cannot be renewed once they are consumed are called non-renewable sources of energy. These resources do not cause any environmental pollution. These resources cause environmental pollution. Renewable resources are inexhaustible. Non- Renewable resources are exhaustible.

3 Renewable resources are not affected by human activities. Non- Renewable resources are affected by human activities.

Examples of Renewable resources- Air, water and solar energy. Examples of

Non-renewable resources- natural gas, coal and nuclear

energy. 1.3.3

What is renewable energy? Renewable energy is energy derived from natural sources that

are

replenished at a higher rate

than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us. Fossil fuels - coal, oil and gas - on the other hand, are non-renewable resources that take hundreds of

millions of years to form. Fossil fuels, when burned to produce energy, cause harmful greenhouse gas emissions, such as carbon dioxide. Generating renewable energy creates far lower emissions than burning fossil fuels. Transitioning from fossil fuels, which currently account for the lion’s share of

emissions, to renewable energy is key to addressing the climate crisis.

Renewables are now cheaper in most countries, and generate three times more jobs than fossil fuels. Here are a few common sources of renewable energy: a) Solar Energy Solar energy is the most abundant of all energy resources and can even be harnessed in cloudy weather. The rate at which solar energy is intercepted by the Earth is about 10,000 times greater than the rate at which humankind consumes energy. Solar technologies can deliver heat, cooling, natural lighting, electricity, and fuels for a host of applications. Solar technologies convert sunlight into electrical energy either through photovoltaic panels or through mirrors that concentrate solar radiation. Although not all countries are equally endowed with solar energy, a significant contribution to the energy mix from direct solar energy is possible for every country. The cost of manufacturing solar panels has plummeted dramatically in the last decade, making them not only affordable but often the cheapest form of electricity. Solar panels have a lifespan of roughly 30 years, and come in variety of shades depending on the type of material used in manufacturing. b) Wind Energy Wind energy harnesses the kinetic energy of moving air by using large wind turbines located on land (onshore) or in sea- or freshwater (offshore). Wind energy has been used for millennia, but onshore and offshore wind energy technologies have evolved over the last few years to maximize the electricity produced - with taller turbines and larger rotor diameters.

4 Though average wind speeds vary considerably by location, the world's technical potential for wind energy exceeds global electricity production, and ample potential exists in most regions of the world to enable significant wind energy deployment. Many parts of the world have strong wind speeds, but the best locations for generating wind power are sometimes remote ones. Offshore wind power offers tremendous potential. c) Geothermal Energy Geothermal energy utilizes the accessible thermal energy from the Earth's interior. Heat is extracted from geothermal reservoirs using wells or other means. Reservoirs that are naturally sufficiently hot and permeable are called hydrothermal reservoirs, whereas reservoirs that are sufficiently hot but that are improved with hydraulic stimulation are called enhanced geothermal systems. Once at the surface, fluids of various temperatures can be used to generate electricity. The technology for electricity generation from hydrothermal reservoirs is mature and reliable, and has been operating for more than 100 years. d) Hydropower Hydropower harnesses the energy of water moving from higher to lower elevations. It can be generated from reservoirs and rivers. Reservoir hydropower plants rely on stored water in a reservoir, while run-of-river hydropower plants harness energy from the available flow of the river. Hydropower reservoirs often have multiple uses - providing drinking water, water for irrigation, flood and drought control, navigation services, as well as energy supply. Hydropower currently is the largest source of renewable energy in the electricity sector. It relies on generally stable rainfall patterns, and can be negatively impacted by climate-induced droughts or changes to ecosystems which impact rainfall patterns. The infrastructure needed to create hydropower can also impact on ecosystems in adverse ways. For this reason, many consider small-scale hydro a more environmentally-friendly option, and especially suitable for communities in remote locations. e) Ocean Energy Ocean energy derives from technologies that use the kinetic and thermal energy of seawater - waves or currents for instance - to produce electricity or heat. Ocean energy systems are still at an early stage of development, with a number of prototype wave and tidal current devices being explored. The theoretical potential for ocean energy easily exceeds present human energy requirements. f) Bioenergy Bioenergy is produced from a variety of organic materials, called biomass, such as wood, charcoal, dung and other manures for heat and power production, and agricultural crops for liquid biofuels.

5 Most biomass is used in rural areas for cooking, lighting and space heating, generally by poorer populations in developing countries. Modern biomass systems include dedicated crops or trees, residues from agriculture and forestry, and various organic waste streams. Energy created by burning biomass creates greenhouse gas emissions, but at lower levels than burning fossil fuels like coal, oil or gas. However, bioenergy should only be used in limited applications, given potential negative environmental impacts related to large-scale increases in forest and bioenergy plantations, and resulting deforestation and land-use change. 1.4 Conventional and Nonconventional energy resources 1.4.1 Natural Sources of Energy During the stone age, it was wood. During the iron age, we had coal. In the modern age, we have fossil fuels like petroleum and natural gas. So how do we choose

the source

of energy? Good sources of energy should have the following qualities: • Optimum heat production per unit of volume/mass used • Easy to transport • Least Polluting • Economical 1.4.1.1

Types of Natural Sources of Energy There are two types of natural sources of energy classified by their popularity and use, • Conventional

Sources of Energy • Non-Conventional Sources of Energy Table 1-2: Difference Between Conventional and Non-Conventional Sources of Energy

Conventional Non-conventional

These resources

are exhaustible. These resources are inexhaustible. These resources cause pollution as they emit smoke and ash. These resources are usually pollution-free. These resources are very expensive to be maintained, stored and transmitted. These resources are less expensive

for
local use and can easily be maintained. Examples- coal, natural gas, petroleum, and water power. Examples- solar, biomass, wind, biogas, and tidal, geothermal.
6 1.5
Energy use pattern in India The way and total use of energy may be defined as its pattern. In general energy is classifies into two main groups: renewable and non-renewable. Renewable energy is the cleanest sources of energy and non-renewable sources are not environmentally friendly source of energy. Over 80%of India's energy needs are met by three fuels: coal, oil and solid biomass. Coal has underpinned the expansion of electricity generation and industry, and remains the largest single fuel in the energy mix. Energy demand in rural areas is on a steady rise. India is the fourth largest energy consumer in the world. The present energy use is mostly in the areas of domestic cooking and lighting, agriculture, transport and industrial sectors. India’s energy basket has a mix of all the resources available including renewables. The largest energy source is coal, followed by petroleum and traditional biomass. According to the 2011 Census, the household-level data indicates that only 55.3 per cent of rural homes used electricity as the primary source for lighting. Energy access, with about one fourth of the population lacking access to electricity and energy security, with the country relying on imports for a considerable amount of its energy use, particularly for crude petroleum are key challenges that the country faces with respect to energy. Wide disparity in energy use pattern between the haves and have-nots, urban and rural and men and women are also a cause of concern. 1.5.1 Present status of energy use in India In India, of the 121 crore Indians, 83.3 crore live in rural areas while 37.7 crore stay in urban areas. Energy availability, access and affordability are vital if our country is to keep its pace of development. 99.92 % of villages in India are fully electrified. To know the details, click here. During 2018-19, the per capita electricity consumption in India is 872.87 kilowatt-hour (Kwh). According to the official data the total installed capacity of the country stood at 3,70,348 MW, as on April 2020. Thermal power plants constitute 62.8 % of the installed capacity and hydropower about 12.4. There are 21 nuclear power reactors in the country with a total installed capacity of 6780 MW. The peak power deficit was 0.5 % during December 2019. Active LPG domestic connections (as of March 2020) was 27.87 crore. According to NSO’s 76th round survey on ‘Drinking Water, Sanitation, Hygiene and Housing Condition’, among the households living in houses, about 93.9 percent of the households in the rural areas and about 99.1 percent of the households in the urban areas had electricity for domestic use. Among the households living in houses, about 48.3 percent of the households in the rural areas and about 86.6 percent of the households in the urban areas used LPG as fuel for cooking. Increased energy conservation, improved energy efficiency and enhanced energy production from renewable sources can definitely lead India in general and rural areas in particular to become self- sustainable communities. Energy Consumption in India India's per capita commercial energy consumption, increased from 9% of global average in 1965 to 19.4% in 2000 (TERI, 2000). In 1998-99, commercial energy consumption in India was estimated at 195.11 MT of oil equivalent, indicating a 75% growth over

7 a decade. However, India’s per capita consumption of commercial energy continues to be much lower than the global average of about 1684 Kg of oil equivalent and is 5-10% that of developed countries like; Japan, France and the USA. In India, commercial energy demand grew at six percent (CMIE, 2001). Energy Consumption by Sources: Overall Production and Consumption India is both a major energy producer and consumer. India currently ranks as the world’s eleventh greatest energy producer, accounting for about 2.4% of the world’s total annual energy production, and as the world’s sixth greatest energy consumer, accounting for about 12 3.3% of the world’s total annual energy consumption. Despite its large annual energy production, India is a net energy importer, mostly due to the large imbalance between oil production and consumption. 1.5.1.1 Petroleum India's proved oil reserves are currently estimated (January 2005) at about 5 billion barrels, or about 4.5% of the world total. Most of these reserves lie offshore near Mumbai and onshore in Assam state. However, exploration is still happening, and India's off-shore and on-shore basins may contain as much as 11 billion barrels. India presently ranks as the 25th greatest producer of crude oil, accounting for about 1% of the world’s annual crude oil production. About 30% of India's energy needs are met by oil, and more than 60% of that oil is imported. A strong growth in oil demand has resulted in India’s annual petroleum consumption increasing by more than 75% from what it was a decade ago. India is currently the world's sixth greatest oil consumer, accounting for about 2.9% of world's total annual petroleum consumption. An historical summary of petroleum production and consumption in India is shown in 1.5.1.2 Natural Gas India's natural gas reserves are currently estimated (as of January 2005) at about 29-32 trillion cubic feet (tcf), or about 0.5% of the world total. Most of these reserves lie offshore northwest of Mumbai in the Arabian Sea and onshore in Gujarat state. India does not yet rank in the top 20 of the world's greatest natural gas consumers, but that will soon change. Natural gas has experienced the fastest rate of increase of any fuel in India's primary energy supply; demand is growing at about 4.8% per year and is forecast to rise to 1.2 tcf per year by 2010 and 1.6 tcf per year by 2015. 1.5.1.3 Coal India's has huge proven coal reserves, estimated (as of January 2005) at more than 90 billion tons, or about 10% of the world's total. Most of these reserves are relatively high ash bituminous coal and are located in Bihar, West Bengal, and Madhya Pradesh states. At the current level of production and consumption, India's coal reserves would last more than two hundred years. India is currently the third-largest coal-producing country in the world (behind China and the United States), and accounts for about 8.5% of the world's annual coal production. India is also currently the third-largest coal consuming country (behind the China and the United States), and accounts for nearly 9% of the world's total annual coal consumption. More than half of India’s energy needs are met by coal, and about 70% of India's electricity generation is now fueled by coal. The annual demand for coal has been steadily increasing over the past decade, and is now nearly 50% greater than it was a decade ago. Even though India is able to satisfy most of its country's coal demand through domestic production, less than 5% of its reserves is coking coal used by the steel industry. As a result, India's steel industry imports coking coal, mainly from Australia and New Zealand, to
8 meet about 25% of its annual needs. An historical summary of coal production and consumption in India is shown in Table 1-3. b. Table 1-3: Coal Production and Consumption in India, 1996-2005 (in millions of tons) Year 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 Production 295.56 311.96 323.63 319.93 326.58 337.94 352.60 367.29 389.20 412.95 Bituminous 273.41 289.32 300.40 296.51 304.10 313.69 327.79 341.27 361.24 382.61 Lignite 22.15 22.64 22.23 23.42 22.48 24.25 24.81 26.02 27.96 24.34 Consumption 332.2 358.5 362.9 375.4 406.1 413.6 430.6 430.6 N/A N/A Note: components may not add to total due to rounding Source: GOI, 2006 Electricity India is presently the sixth-greatest electricity generating country and accounts for about 4% of the world's total annual electricity generation. India is also currently ranked sixth in annual electricity consumption, accounting for about 3.5% of the world's total annual electricity consumption. Overall, India's need for power is growing at a prodigious rate; annual electricity generation and consumption in India have increased by about 64% in the past decade, and its projected rate of increase for electricity consumption is one of the highest in the world. Electricity consumption in India has more than doubled in the last decade. The primary energy supply in the country is coal- dominant, with the power sector accounting for about 40 percent of primary energy and 70 percent of coal consumption (CMIE, 2000). The Indian power sector is characterized by large demand- supply gap. Faced with unreliable power supply, many industries have invested in on-site power generation that now accounts for more than 10 percent of total capacity (CMIE, 2000). 1.6 Summary 1.7 Questions/ Self-Assessment questions Short questions: 1. What is Conventional Energy? Give example. 2. What is Non-conventional Energy? Give example. 3. What is nonconventional energy? Descriptive questions: 1. What is the major difference between renewable and
non-renewable sources of energy? 2. What is the major
difference between conventional and non-conventional sources of energy? 3.
What is the current of Energy
utilization of India? 4. What are the drawbacks of non-conventional energy sources?

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11 Unit 2: Non-Renewable and Conventional Energy Resource 2.1 Objectives 2.2 Introduction 2.3 Classification and composition of Fossil fuels 2.4 Physicochemical characteristics and Energy Content of coal, Petroleum and natural gas 2.5 Summary 2.6 Questions/ Self-Assessment questions 2.7 Select Readings/ Suggested Readings 2.1 Objectives After reading this chapter students will get a clear idea regarding • The classification of the fossil fuels • Composition of the fossil fuels • Physicochemical property and energy content of different conventional fossil fuel i.e., coal, petroleum and natural gas. 2.2 Introduction
Energy is the basis of all processes that take place around us and is the most critical factor influencing the development of society. Energy is a phenomenon without which life is inconceivable
today. Without energy, we could not use most of the production facilities and household appliances, set vehicles in motion and we would not have heat and light. If we look at today's world through the prism of the main and priority areas on which we should focus, then there is certainly a question of ensuring low-cost and sustainable forms of energy. Yes, it is necessary to find, transform and utilise these forms of energy, but it is necessary to do it ecologically. So, let us try to extend the phenomenon of energy into the phrase "energy and environment". How has the humankind changed in the last 100 years? How have production technologies changed during that time? How has the range of manufactured products changed over that period? How has the people's view of the need for energy and its use at their work and in their daily life changed? And how has our environment changed in the context of energy production and subsequent manufacturing activity? How long will the basic fossil fuels last? Will we be able to replace these fuels completely? These are the questions we could answer at length, but also with a simple and short sentence: "We live in dynamic times – with high energy consumption". Those who see the threat of basic energy sources depletion and climate change associated with greenhouse gas emissions know the meaning and the importance of finding new forms of energy. Some traditional energy sources are being gradually consumed and are increasingly expensive.

12 Therefore, we have searched for alternative forms of energy sources for decades. Maybe it is appropriate to ask a question, whether it would not be better to find and develop such technologies and products that would require minimum energy instead of searching for alternative forms of energy sources. Or to implement effective energy saving, which represents the cheapest "source of energy". Energy sources

Non-renewable and renewable energy sources are used in various technological processes in the production of the required forms of energy. The non-renewable energy sources include mainly fossil fuels based on coal and hydrocarbons. Fossil fuels may be present in solid (

e.g., coal), liquid (e.g., petroleum products) or gaseous (e.g., natural gas) form. Fossil fuel energy Coal, petroleum, and natural gas are called Fossil fuel as these are formed by the decomposition of the remains of dead plants and animals buried under the earth for a long time. These are non- renewable sources of energy, which, if exhausted, cannot be replenished in a short time. Their reserves are limited and are considered very precious. These should be used with care and caution to let them last long. These are also contributing to the global environmental pollution. Wood was dominant source of energy in the pre-industrialization era. It gave way to coal and coke. Use of coal reached a peak in the early part of the twentieth century. Oil gets introduced at that time and has taken a substantial share from wood and coal. Wood is no more regarded as a conventional source. Hydroelectricity has already growth to a stable level in most of the developed countries. 8 A brief account of the various important sources of energy and their future possibilities is given below. The percentage use of various sources for the total energy consumption in the world are Coal 32.5% Oil 38.3% Gas 19.0% 92% Uranium 0.13% Hydro 2.0% Wood 6.6% Dung 1.2% 8% Waste 0.3% (i) Coal: India now ranks third amongst the coal-producing countries in the world. Coal is the most abundant fossil fuel in India till date and coal has been the mainstay of India's energy supply for many years. Production of coal has increased from about 71 MT (million tones) in the early 19705 to 407 MT in 2005-06 (MOC 2007). Indian coal is of poor quality and has high ash content Since the advent of industrialization coal has been most common source of energy. In the last three decades, the world switched over from coal to oil as a Major source of energy because it is simpler and cleaner to obtain useful energy from oil. Coal is a complex mixture of compounds of carbon, hydrogen and oxygen. Small amounts of nitrogen and Sulphur compounds are also present in coal. It is mainly available in Bihar, West Bengal, Orissa and Madhya Pradesh. The big coal mines in our country are at Jharia and Bokaro in Biharand at Raniganj in West Bengal. It is considered as the backbone of the energy sector for its use in industry, transportation and electric power generation. According to estimates coal is abundant. It is enough to last for 200 years. However, it is low in calorific value and its transportation is expensive. Coal is pollutant and when burnt it produces CO 2 and CO. Extensive use of coal as a source of energy is likely to disturb the ecological balance of CO 2 since global warming will takes place due to large proportions of

13 carbon dioxide produced by burning large quantities of coal. Coal: Proved reserves at end of 2005 in MT. (ii) Petroleum Oil: The 40% of the energy needs of the world are fed by oil It is a dark coloured, viscous and foul smelling crude oil. The petroleum means rock oil. It is normally found under the crust of earth trapped in rocks. The crude oil is a complex mixture of several solid liquid gaseous hydrocarbons mixed with water, salt and earth particles. It is a natural product obtained from oil wells. With today's consumption and a resource amount of 250,000 million tons of oil, it would suffice for about 100 years unless more oil is discovered. Some of the crude oil producing locations in our country are: (i) Ankleshwar and Kalol in Gujarat (ii) Rudrasagar and Lakwa in Assam; and (iii) Bombay high (off-shore area) The oil wells of Bombay high are producing about 22 million tons of crude petroleum oil per year, which is little less than half of the total requirement of the country. The efforts are also being made to search oil well in off- shore deltas to Godavari, Kaveri, and Rajasthan. The indigenous production of crude oil has increased from 6.82 MT in 1970/71 to 34.227 MT in 2007-08 (MoPNG 2008). However, during the last 15 years, domestic production of crude oil has remained almost stagnant, thereby leading to increased import of crude oil. During 2007-08, the country's crude oil import was 122.67 MT, valued at Rs. 2727 billion, resulting in an import dependency of about 75%. Oil: Proved reserves at end of 2005 in TMB India (iii) Natural gas: It consists about 95% Methane and rest ethane and propane. It occurs deep under the crust of the earth either alone or a long with oil above the petroleum deposits. It is a product of petroleum mining. The gas is available in Tripura, Jaisalmer, off-shore areas of Bombay High and in the Krishna – Godavari delta. It is used as a domestic and industrial fuel. The natural gas is now also available as CNG (Compressed Natural Gas) a substitution of petrol in automobiles. Gas is incompletely utilized at present and huge quantities are burnt off in the oil production process because of the non-availability of ready market. The reason may be the high transportation cost of the gas. To transport gas is costlier than transporting oil. The production of natural gas increased from 1.4 B.C.M. (billion cubic meters) in 1970/71 to 32.274 BCM in 2007-08. The demand for natural gas is more than the demand hence to bridge this gap, India is importing natural gas in liquefied form, commonly referred to as LNG (liquefied natural gas). Natural Gas: proved reserves at end of 2005 in TCM. 2.3 Classification and composition of Fossil fuels According to the law of conservation of energy, energy can never actually be "consumed"; it can only be changed from one form to another.

Fossil fuels, coal, oil and natural gas are the result of anaerobic decay of dead plants and animals laid down hundreds of millions of years ago, most of which took place well before the dinosaurs strode the earth. Fossil fuels slowly formed as further geological layers compressed and heated

14 the dead organic matter. The energy content of fossil fuels results from the transformation of sunlight into vegetation and the chemical transformation brought about by anaerobic cooking at high pressures and temperatures over geological times. Fossils are the remains of creatures that lived long ago. So, fossils include organic matter buried beneath layers of rocks. A fuel is a source of energy. Without fossil fuels, most people could not drive their cars. They could not turn on their lights or heat their homes. This is because most of the energy needed to do these things comes from fossil fuels. The energy in fossil fuels originally came from the Sun. Plants use the energy in sunlight to make their own food. The energy in plants passes to the animals that eat the plants. (You can learn about these processes in the lesson Food Webs.) Some energy remains in plants and animals that die and become fossil fuels. Burning the fossil fuels releases the energy for humans to use 2.3.1 Composition of Fossil fuel 2.3.1.1 Natural Gas Natural gas is a (mostly) combustible gas found underground. While primarily composed of methane (70-90%) the gas from each well has a different composition and the value of the other components affects the value of the gas. The gas from wells that are rich in methane is called dry and wells that have a considerable amount of higher hydrocarbons produce wet gas. The higher hydrocarbons have value above that of methane so stripping them out is important. Some wells are sour because their gas has hydrogen sulfide which must be removed before the gas can be used for heating or generating electricity. c. Table 2-1: Composition of Natural Gas Gas Molecular Formula Composition Methane CH 4 70-95% Ethane C 2 H 6 0-20% Carbon Dioxide CO 2 0-8% Nitrogen N 2 0-5% Hydrogen Sulfide H 2 S 0-5% Propane C 3 H 8 Traces Butane C 4 H 10 Traces Rare Gases He (also Ne) 0-3% (only in Texas) 2.3.1.2 Hydrocarbon content Natural gas is a hydrocarbon mixture consisting primarily of saturated light paraffins such as methane and ethane, both of which are gaseous under atmospheric conditions. The mixture also may contain other hydrocarbons, such as propane, butane, pentane, and hexane. In natural gas

15 reservoirs even, the heavier hydrocarbons occur for the most part in gaseous form because of the higher pressures. They usually liquefy at the surface (at atmospheric pressure) and are produced separately as natural gas liquids (NGLs), either in field separators or in gas processing plants. Once separated from the gas stream, the NGLs can be further separated into fractions, ranging from the heaviest condensates (hexanes, pentanes, and butanes) through liquefied petroleum gas (LPG; essentially butane and propane) to ethane. This source of light hydrocarbons is especially prominent in the United States, where natural gas processing provides a major portion of the ethane feedstock for olefin manufacture and the LPG for heating and commercial purposes. 2.3.1.3 Nonhydrocarbon content Other gases that commonly occur in association with the hydrocarbon gases are nitrogen, carbon dioxide, hydrogen, and such noble gases as helium and argon. Nitrogen and carbon dioxide are non-combustible and may be found in substantial proportions. Nitrogen is inert, but, if present in significant amounts, it reduces the heating value of the mixture; it must therefore be removed before the gas is suitable for the commercial market. Carbon dioxide is removed in order to raise heating value, reduce volume, and sustain even combustion properties. Often natural gases contain substantial quantities of hydrogen sulfide or other organic sulfur compounds. In this case, the gas is known as "sour gas." Sulfur compounds are removed in processing, as they are toxic when breathed, are corrosive to plant and pipeline facilities, and are serious pollutants if burned in products made from sour gas. However, after sulfur removal a minute quantity of a noxious mercaptan odorant is always added to commercial natural gas in order to ensure the rapid detection of any leakage that may occur in transport or use. Because natural gas and formation water occur together in the reservoir, gas recovered from a well contains water vapour, which is partially condensed during transmission to the processing plant. 2.3.1.4 Coal Composition The composition of coal can be analyzed in two ways. The first is reported as a close analysis (moisture, volatile matter, fixed carbon and ash) or a final analysis (ash, carbon, hydrogen, nitrogen, oxygen and sulfur). A typical bituminous coal may have a final analysis on a dry, ash- free basis of 84.4% carbon, 5.4% hydrogen. d. Table 2-2: ASH Composition, weight percent Ash Composition Weight Percent SiO 2 20-40 Al 2 O 3 10-35 Fe 2 O 3 5-35 CaO 1-20 MgO 0.3-4 TiO 2 0.5-2.5 Na 2 O & K 2 O 1-4 SO 3 0.1-12

16 2.4 Physicochemical characteristics and Energy Content of coal, Petroleum and natural gas 2.4.1 Coal Characteristics and Properties Many of the properties of coal vary with factors such as its composition and the presence of mineral matter. Different techniques have been developed to examine the properties of coal. These are X-ray diffraction, scanning and transmission electron microscopy, infrared spectrophotometry, mass spectroscopy, gas chromatography, thermal analysis, and electrical, thermal analysis, and electrical, optical and magnetic measurements. 2.4.1.1 Intensity Knowing the physical properties of coal is important in the preparation and use of coal. For example, coal density ranges from about 1.1 to about 1.5 megagrams per cubic metre, or grams per cubic centimeter. Coal is slightly denser than water and significantly less dense than most rocks and mineral matter. Density differences make it possible to improve the quality of a coal by removing most of the rock matter and sulfide-rich particles through heavy liquid separation. 2.4.1.2 Porosity Coal density is controlled in part by the presence of pores that persist throughout charring. Pore sizes and pore distribution are difficult to measure; however, pores appear to have three size ranges: a) Macropores (diameter greater than 50 nanometres), b) Mesopores (2 to 50 nanometres in diameter), and c) Micropores (diameter less than 2 nanometres). One nanometer equals 10–9 metres. Most of a coal's effective surface area- about 200 square meters per gram- is found in the pores of the coal, not on the outer surface of a piece of coal. The presence of pore space is important in coke production, gasification, liquefaction and high surface area carbon production to purify water and gases. For safety reasons, coal pores may contain significant amounts of adsorbed methane, which can be released during mining operations and form explosive mixtures with air. The risk of explosion can be reduced by adequate ventilation or prior removal of coalbed methane during mining. 2.4.1.3 Reflectivity An important property of coal is its reflectivity (or reflectivity), that is, its ability to reflect light. Reflectivity is measured by shining a monochromatic light beam (with a wavelength of 546 nanometers) onto a polished surface of vitrinite macerals in a charcoal sample and measuring the percentage of reflected light with a photometer. Vitrinite is used as its reflectivity gradually changes with increasing degree. Fusinite reflections are very high due to its coal origin and

17 liptinites tend to disappear with increasing degrees. Although very little of the incident light is reflected (ranging from a few tenths of a percent to 12 percent), the value increases with degrees and can be used to grade most coals without measuring the percentage of volatile matter present. 2.4.1.4 Other features Other properties such as hardness, grindability, ash fusion temperature, and free swelling index (a visual measurement of the amount of swelling that occurs when a coal sample is heated in a closed crucible) can affect coal mining and preparation. as well as the way a coal is used. Hardness and grindability determine the types of equipment used for mining, crushing and grinding, in addition to the amount of power consumed in their operations. Ash fusion temperature affects furnace design and operating conditions. The free swelling index provides preliminary information on the suitability of a coal for coke production. 2.4.1.5 Energy Content The ultimate energy source of coal is the sun because the energy stored within dead plant matter is what yields coal. Coal is burned in the presence of atmospheric oxygen. This increased temperature allows a chemical reaction between the fuel (carbon in the coal) and the oxygen in the atmosphere to occur which forms Carbon dioxide (CO 2). Since coal also contains hydrogen atoms the combustion will form some water vapour as a product (H 2 O). The production of CO 2 is leading to climate change; however, it is the production of CO 2 that makes coal such a useful fuel. CO 2 represents the lowest possible energy state of a carbon atom in Earth's oxygen containing atmosphere, therefore the transition from the fuel (carbon in coal) and atmospheric oxygen into CO 2 allows for the maximal amount of energy to be extracted from the fuel. The energy content of coal varies along with its maturity (older is better), as seen in the table below anthracite has the highest energy content of all the coal types. Table 2-3: Energy content in different type of coals Type of coal Energy content (MJ/Kg) Anthracite 31 - 36 Bituminous 25 - 35 Sub-bituminous 19 - 30 Lignite 12 - 20 2.4.2 Composition of Petroleum Petroleum contains four classes of compound: alkanes, cycloalkanes, aromatics, and heteroatomic compounds with one or more atoms of nitrogen, sulfur, and/or oxygen. In petroleum chemistry and technology, alkanes are called paraffins; cycloalkanes, naphthenes; and the heteroatomic

18 compounds are lumped together as NSOs. Cycloalkanes, aromatics, and NSOs can all have one or more alkyl side chains. Petroleum or crude oil is a complex mixture of hydrocarbons and other chemicals. The composition varies widely depending on where and how the petroleum was formed. In fact, chemical analysis can be used to fingerprint the source of petroleum. However, raw petroleum or crude oil has characteristic properties and composition. 2.4.2.1 Hydrocarbons in Crude Oil There are four main types of hydrocarbons found in crude oil. 1. Paraffins (15-60%) 2. Naphthenes (30-60%) 3. Aromatics (3-30%) 4. Asphaltics (Remainder) The hydrocarbons primarily are alkanes, cycloalkanes, and aromatic hydrocarbons. 2.4.2.2 Elemental Composition of Petroleum Although there is considerable variation between the ratios of organic molecules, the elemental composition of petroleum is well-defined: 1. Carbon - 83 to 87% 2. Hydrogen - 10 to 14% 3. Nitrogen - 0.1 to 2% 4. Oxygen - 0.05 to 1.5% 5. Sulfur - 0.05 to 6.0% 6. Metals - > 0.1% The most common metals are iron, nickel, copper, and vanadium. 2.4.2.3 Petroleum Color and Viscosity The color and viscosity of petroleum vary markedly from one place to another. Most petroleum is dark brown or blackish in color, but it also occurs in green, red, or yellow. 2.4.2.4 Physicochemical properties of petroleum Petroleum exhibits a wide range of physical properties and several relationships can be made between various physical properties (Speight, 2001). Whereas properties such as viscosity, density, boiling point, and color of petroleum may vary widely, the ultimate or elemental analysis varies, as already noted, over a narrow range for a large number of petroleum samples. The carbon content is relatively constant, while the hydrogen and heteroatom contents are responsible for the major differences between petroleum samples. Coupled with the changes brought about to the

19 feedstock constituents by refinery operations, it is not surprising that petroleum characterization is a monumental task. The physical and chemical characteristics of crude oils and the yields and properties of products or fractions prepared from them vary considerably and are dependent on the concentration of the various types of hydrocarbons and minor constituents present. Some types of petroleum have economic advantages as sources of fuels and lubricants with highly restrictive characteristics because they require less specialized processing than that needed for production of the same products from many types of crude oil. Others may contain unusually low concentrations of components that are desirable fuel or lubricant constituents, and the production of these products from such crude oils may not be economically feasible. 2.4.2.5 Energy Content Table 2-4: Energy content in some commonly used energy sources Energy Source Unit Energy Content (Btu) Electricity 1 Kilowatt-hour 3412 Butane 1 Cubic Foot (cu.ft.) 3200 Coal 1 Ton 28000000 Crude Oil 1 Barrel - 42 gallons 5800000 Fuel Oil no.1 1 Gallon 137400 Fuel Oil no.2 1 Gallon 139600 Fuel Oil no.3 1 Gallon 141800 Fuel Oil no.4 1 Gallon 145100 Fuel Oil no.5 1 Gallon 148800 Fuel Oil no.6 1 Gallon 152400 Diesel Fuel 1 Gallon 139000 Gasoline 1 Gallon 124000 Natural Gas 1 Cubic Foot (cu.ft.) 950 - 1150 Heating Oil 1 Gallon 139000 Kerosene 1 Gallon 135000 Pellets 1 Ton 16500000 Propane LPG (Liquid Petroleum Gas) 1 Gallon 91330 Propane gas 60 o F 1 Cubic Foot (cu.ft.) 2550 Residual Fuel Oil 1) 1 Barrel - 42 gallons 6287000 Wood - air dried 1 Cord 20000000 Wood - air dried 1 pound 8000

20 1) Residual Fuel Oil - The liquid or semi-liquid, high-boiling fraction of residue from the distillation of crude oil. • 1 Gallon (U.S.) = 3.785x10 -3 m 3 = 3.785 dm 3 (liter) • 1 ft 3 = 0.02832 m 3 • 1 barrel (US, oil) = 1.33 barrel (US, liq) = 5.61458 cu foot = 42 gallons (US, liq) = 158.9873 liter • 1 lb m = 0.4536 kg • 1 ton (short) = 2000 lbs = 907 kg 2.4.3 Physico- chemical properties of Natural Gas Natural Gas is a fossil fuel. It occurs naturally and approximately consists of 95% hydrocarbon methane, the other 5% consists of nitrogen, carbon dioxide, helium or hydrogen sulfide. It takes millions of years for it to form. The gas is formed when layers of decaying plants and animals are buried under the earth’s surface and are exposed to intense heat and pressure for millions of years. Plants originally obtain energy from the sun and store in the form of chemical bonds in the gas. And thus, the formation of this gas occurs. 2.4.3.1 Properties of Natural Gas The following are the properties of Natural Gas: • The state of matter of this energy resource is gaseous. • It doesn’t have any color and is a tasteless gas. • It is free of any kind of toxic, there is no smoke on burning and it has high calorific value. • The gas is odorless. However, a chemical called mercaptan is added to it in small amounts to give it distinctive smell of eggs. This helps to find out any gas leaks. • It is a combustible gas and a fossil fuel. • It’s a mixture of simple hydrocarbon compounds. • It contains primarily methane, along with small amounts of ethane, butane, pentane, and propane. 1.1.1.1 British Thermal Unit (Btu) The unit of heat in the imperial system - the BTU - is • The amount of heat required to raise the temperature of one pound of water through 1 o F (58.5 o F - 59.5 o F) at sea level (30 inches of mercury). • 1 Btu (British thermal unit) = 1055.06 J = 107.6 kpm = 2.931 10 -4 kWh = 0.252 kcal = 778.16 ft lb f = 1.05510 10 ergs = 252 cal = 0.293-watt hours An item using one kilowatt-hour of electricity will generate 3412 Btu

21 • The by-products of this gas are water vapor and carbon dioxide. • Air is 60% heavier than natural gas. • It has a low flammability range and a high ignition temperature. • Generally, it is transported through pipes. • It occurs naturally in the rocks beneath the earth's surface, in sedimentary rocks that are porous. 2.5 Summary 2.6 Questions/ Self-Assessment questions Short questions: 1. What are the sources of non-renewable energy sources? 2. What is Energy content of Anthracite and Lignite? 3. Describe Btu. Descriptive questions: 1. write down the composition of natural gas. 2. Composition of petroleum. 3. What are the basic properties of Natural Gas? 2.7 Select Readings/ Suggested Readings • Norman, J. Hyne (2001). Nontechnical guide to petroleum geology, exploration, drilling, and production (2nd ed.). Tulsa, OK: Penn Well Corp. ISBN 978-0-87814-823-3. • Ollivier, Bernard; Magot, Michel (January 1, 2005). Petroleum Microbiology. Washington, DC: American Society of Microbiology. doi:10.1128/9781555817589. ISBN 978-1-55581-758-9. • Speight, James G. (1999). The Chemistry and Technology of Petroleum (3rd ed.). New York: Marcel Dekker. ISBN 978-0-8247-0217-5.

22 Unit 3: Unit 3: Non-conventional energy sources 3.1 Objectives 3.2 Introduction 3.3 Principle, Importance and basic Mechanism of Generation 3.3.1 Hydropower 3.3.2 Wind power 3.3.3 Tidal Energy 3.3.4 Geothermal Energy 3.3.5 OTEC 3.4 Summary 3.5 Questions/ Self-Assessment questions 3.6 Select Readings/ Suggested Readings 3.1 Objectives Students will learn about • Different types of the nonconventional energy sources • Basic mechanism of energy generation from nonconventional energy sources • They also learn about the importance of the nonconventional energy sources 3.2 Introduction Energy is the primary and most universal measure of all kinds work by human beings and nature. Everything what happens the world is the expression of flow of energy in one of its forms. Energy is the major input to drive the life cycle and improve it. Energy consumption is closely related to the progress of the mankind. In future, improvement in the living standard of the mankind, industrialization of the developing countries and the global demand for energy will increase with every growing population. The development of infrastructure plays a significant role to sustain economic growth. The power sector is one of the major significant constituents of infrastructure. In general, India is dependent on conventional sources of energy like thermal, hydro and nuclear.

Non-conventional sources are also known as renewable sources of energy. Examples of non- conventional sources of energy include solar energy, bioenergy, tidal energy and wind energy.

Can you imagine a car that runs on water? Or one that runs on the power of the Sun? Well, the truth is you might have to get used to such wacky ideas. The planet is rapidly running out of conventional fuels, and non-conventional sources of energy are becoming our future. And in order to operate them

23 let us learn more about non-conventional sources of energy. Natural resources like wind, tides, solar, biomass, etc. generate energy which is known as "non-conventional resources". These are pollution free and hence we can use these to produce a clean form of energy without any wastage. 3.2.1 Why do we need non-conventional energy resources? As the consumption of energy grows, the population depends more and more on fossil fuels such as coal, oil and gas day by day. There is a need to secure the energy supply for future since the prices of gas and oil keep rising by each passing day. So, we need to use more and more renewable sources of energy. For the effective exploitation of non-conventional sources, there has been an establishment of a separate department namely "Department of non-conventional sources of energy" by the government of India. In India, the Department of Non-Conventional Energy Sources (DNES) was created in the Ministry of Energy in the year of 1982 to look after all the aspects relating to new and renewable energy. The Department was upgraded into a separate Ministry of Non-Conventional Energy Sources (MNES) in 1992 and was rechristened as Ministry of New and Renewable Energy (MNRE) in October, 2006. As per the information furnished by MNRE, starting with the 9th Plan, there has been consistent increase in pace of renewable energy development. Reportedly, India's renewable energy installed capacity has grown at an annual rate of 23%, rising from about 3900 MW in 2002-03 to about 24000 MW in 2011-12. Energy generated by using wind, solar, small hydro, tides, geothermal heat and biomass is known a non-conventional energy. All these sources are renewable process of energy generation and do not cause environmental pollution. Our country has been endowed with adequate natural resources. 3.2.1.1 Advantages of Non-Conventional Energy Technologies • Non-conventional/renewable energy is an indigenous source available in considerable quantities to all developing nations and capable, in principle of having a significant local, regional or national economic impact. • There is a great scope of research and development in non-conventional/renewable energy sectors regarding its future development and scientific utilization. • The power plants based on renewable do not have any fuel cost and hence negligible running cost. • Renewable have low energy density and more or less there is no pollution or ecological balance problem. Provide energy in environmentally benign manner. • The use of non-conventional/renewable energy could help to conserve foreign exchange and generate local employment if conservation technologies are designed, manufactured, assembled and installed locally. • Short gestation period and low investment.

24 3.3 Principle, Importance and basic Mechanism of generation 3.3.1 Hydropower Hydropower, or hydroelectric power, is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity. Hydropower currently accounts for 31.5% of total U.S. renewable electricity generation and about 6.3% of total U.S. electricity generation. While most people might associate the energy source with the Hoover Dam—a huge facility harnessing the power of an entire river behind its wall—hydropower facilities come in all sizes. Some may be very large, but they can be tiny, too, taking advantage of water flows in municipal water facilities or irrigation ditches. They can even be “damless,” with diversions or run-of-river facilities that channel part of a stream through a powerhouse before the water rejoins the main river. Whatever the method, hydropower is much easier to obtain and more widely used than most people realize. In fact, all but two states (Delaware and Mississippi) use hydropower for electricity, some more than others. For example, in 2020 about 66% of the state of Washington’s electricity came from hydropower. Hydropower technologies generate power by using the elevation difference, created by a dam or diversion structure, of water flowing in on one side and out, far below, on the other. The Department of Energy's "Hydropower 101" video explains how hydropower works and highlights some of the research and development efforts of the Water Power Technologies Office (WPTO) in this area. The benefits of hydropower have been recognized and harnessed for thousands of years. In addition to being a clean and cost-effective form of energy, hydropower plants can provide power to the grid immediately, serving as a flexible and reliable form of backup power during major electricity outages or disruptions. Hydropower also produces a number of benefits outside of electricity generation, such as flood control, irrigation support, and water supply. 3.3.2 Wind power Wind power or wind energy is mostly the use of wind turbines to generate electricity.

Wind power is a popular, sustainable, renewable energy source that has a much smaller impact on the environment than burning fossil fuels.

Historically, wind power has been used in sails, windmills and windpumps but today it is mostly used to generate electricity.

Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network.

New onshore (on-land)

wind farms are cheaper than new coal or gas plants,

but

expansion of wind power is being hindered by fossil fuel subsidies.

Onshore wind farms have a greater visual impact on the landscape than some other power stations. Small onshore wind farms

can feed some energy into the grid or provide power to isolated off-grid locations. Offshore wind farms deliver more energy per installed capacity with less fluctuations and have less visual impact. Although there is less offshore wind power at present and construction and maintenance costs are higher, it is expanding.

Offshore wind power currently has a share of about 10% of new installations.

25 Wind power is

variable renewable energy, so power-management techniques are used to match supply and demand, such as: wind hybrid power systems, hydroelectric power or other dispatchable power sources, excess capacity, geographically distributed turbines, exporting and importing power to neighboring areas, or grid storage. As the proportion of wind power in a region increases the grid may need to be upgraded.

Weather forecasting allows the electric-power network to be readied for the predictable variations in production that occur.

In 2021, wind supplied over 1800 TWh of electricity, which was over 6% of world electricity and about 2% of world energy. With about 100 GW added during 2021, mostly in China and the United States, global installed wind power capacity exceeded 800 GW. To help meet the Paris Agreement goals to limit climate change, analysts say it should expand much faster - by over 1% of electricity generation per year.

Regions in the higher northern and southern latitudes have the highest potential for wind power. In most regions, wind power generation is higher in nighttime, and in winter when PV output is low. For this reason, combinations of wind and solar power are suitable in many countries. 3.3.2.1

Principle and Mechanism of Action Wind turbines work on a simple principle: instead of using electricity to make wind—like a fan— wind turbines use wind to make electricity. Wind turns the propeller-like blades of a turbine around a rotor, which spins a generator, which creates electricity. A wind turbine turns wind energy into electricity using the aerodynamic force from the rotor blades, which work like an airplane wing or helicopter rotor blade. When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this causes the rotor to spin. The rotor connects to the generator, either directly (if it's a direct drive turbine) or through a shaft and a series of gears (a gearbox) that speed up the rotation and allow for a physically smaller generator. This translation of aerodynamic force to rotation of a generator creates electricity. Figure 3-1: Graphical representation of Wind power generation and distribution 26 3.3.2.2 Importance of Wind power The world is warming due to human-created climate change. Climate scientists have sounded the alarm for decades. We're already seeing many of the catastrophic effects such as rising sea levels, massive hurricanes, severe drought, and more. While some of the changes can't be reversed, there's still hope. The key? Reduce greenhouse gases. That can be done by reducing human dependence on fossil fuels and turning to renewable energy sources, like wind energy. What makes wind energy important? Here are ten reasons: 1. Wind energy has a small carbon footprint A carbon footprint includes all greenhouse gases and not just carbon dioxide. Humans create carbon footprints by burning fossil fuels. What's the carbon footprint of a wind turbine? We need to consider what results during the creation process of the turbine, too, and not just when it's up and running. Researchers calculate the pollution generated by a wind turbine's life cycle. A Yale Climate Connections blog compiled data from the last few years and found that while it varies, wind turbines overall produce far less carbon dioxide than coal and natural gas power plants. 2. Wind energy doesn't create pollution When fossil fuels burn, they release nitrogen oxides into the atmosphere. This leads to things like acid rain and smog, which are very harmful to the environment. Wind energy doesn't have that problem! Turbines don't emit toxic chemicals or other pollutants into the air. 3. Wind energy doesn't harm human health As a result of pollution, fossil fuels are responsible for around 1 in 5 deaths worldwide. In 2018, fossil fuel emissions killed 8.7 million people. This is a higher death toll than previously thought, highlighting just how important other sources of energy are. Because it doesn't generate pollution, wind energy is much better for human health. In another study described on The Conversation, Jonathan Buonocore and colleagues found that a 1,100-megawatt wind farm off the New Jersey coast could save 13 lives a year! 4. Wind energy uses less water Wind energy is already good for the water supply because it doesn't pollute, but it also doesn't use much water. When combined with solar thermal and photovoltaic sources, wind power could reduce the United States' energy water consumption by a whopping 97%. That water can then be used for other purposes, like growing food. 5. Wind energy creates jobs Wind energy isn't only good for the environment, it's good for the economy. In the United States, wind energy supports a domestic supply chain, which means it has the potential to support 600,000+ jobs by 2050. Globally, an analysis by the Global Wind Energy Council found that 3.3 million new wind power jobs can be created over the next five years, thanks to the expansion of the industry. 6. Wind energy saves money Generating electricity can be expensive. Thankfully, renewable energies are the cheapest energy sources. According to a report from the International Renewable Energy Agency (IRENA), almost

27 ⅔ of the wind and solar projects built in 2020 will generate cheaper electricity than the world's cheapest new coal plants. The cost of wind farms continues to fall, so the old argument against wind power ("it costs too much") no longer holds up. 7. Wind energy is good for areas that need reliable electricity Many places – including remote areas and communities that live "off the grid" – need reliable electricity. In fact, about 13% of the world's population doesn't have reliable electricity. Things are gradually getting better thanks to renewable energy. In 2018, there was a big increase in access mostly due to solar and wind power in China. For electricity access to be equitable around the world, however, there needs to be more committed to wind energy. 8. Wind energy is good for farmers Things have been rough for farmers for quite some time. Climate change is a big reason for that. Wind energy could help. Wind developers pay farmers to lease their land, which is an excellent cash opportunity, especially for struggling farmers. Research from Iowa State University shows wind farms may even help crops grow better. How? Wind blowing across corn and soybean fields warded off pathogens and drew carbon dioxide from the soil for plants to use. 9. Wind energy leads to energy independence A big benefit of wind energy is that it's generated domestically. When countries replace fossil fuels with renewables like wind power, they don't need imported fuel sources. This strengthens national security, lowers spending, and creates more local jobs. In short, it leads to stronger economic freedom. 10. Wind energy is becoming more popular Wind energy is growing year by year. In 2020, the United States installed more wind energy than any other energy source. That same year, wind turbines created about 8.4% of all utility-scale electricity generation. What about wind energy on the world stage? According to the Global Wind Energy Council, offshore and onshore wind power generated 743 gigawatts at the end of 2020. That's enough to avoid 1.1 billion tonnes of CO 2 . China produces the most wind energy with the United States in second place. 3.3.3 Tidal Energy Tidal energy is a form of power produced by the natural rise and fall of tides caused by the gravitational interaction between Earth, the sun, and the moon. Tidal currents with sufficient energy for harvesting occur when water passes through a constriction, causing the water to move faster. Tidal energy is a form of power produced by the natural rise and fall of tides caused by the gravitational interaction between Earth, the sun, and the moon. Tidal currents with sufficient energy for harvesting occur when water passes through a constriction, causing the water to move faster. Using specially engineered generators in suitable locations, tidal energy can be

28 converted into useful forms of power, including electricity. Other forms of energy can also be generated from the ocean, including waves, persistent ocean currents, and the differences in temperature and salinity in seawater. Suitable locations for capturing tidal energy include those with large differences in tidal range, which is the difference between high tide and low tides, and where tidal channels and waterways become smaller and tidal currents become stronger. As worldwide demand for clean electricity, renewable fuels, and critical materials for energy and industrial processes grows, it is crucial to identify and secure sustainable energy resources beyond what is currently available. Researchers recognize the vast potential of the ocean to produce reliable, renewable energy for a variety of uses. The Water Power Technologies Office of the Department of Energy (DOE) estimates that energy from waves, tides, and ocean currents have the combined potential to generate enough electricity to power millions of homes. Because water is denser than air, tidal energy is more powerful than wind energy, producing exponentially more power at the same turbine diameter and rotor speed. Tidal power is also more predictable and consistent than wind or solar energy, both of which are intermittent and less predictable. This makes tidal energy an intriguing renewable energy source to pursue. The challenge is in making it commercially feasible to capture and convert the energy into usable power at scale, as well as finding uses of tidal energy where costs are less sensitive than national grid electricity. To fully harness tidal energy as a significant and ongoing source of clean energy, it is critical that researchers explore ways to assist in developing technologies and methods that increase its viability for broad commercial application. The industry is largely just emerging, with complex barriers to overcome before it can sustainably grow and thrive. 3.3.3.1 Working principle of Tidal power plants Tide or wave is periodic rise and fall of water level of the sea. Tides occur due to the attraction of sea water by the moon. Tides contain large amount of potential energy which is used for power generation. When the water is above the mean sea level, it is called flood tide. When thewater level is below the mean level it is called ebb tide. The arrangement of this system is shown in figure. The ocean tides rise and fall and water can be stored during the rise period and it can be discharged during fall. A dam is constructed separating the tidal basin from the sea and a difference in water level is obtained between the basin and sea. During high tide period, water flows from the sea into the tidal basin through the water turbine. The height of tide is above that of tidal basin. Hence the turbine unit operates and generates power, as it is directly coupled to a generator.

29 Figure 3-2: High tide During low tide period, water flows from tidal basin to sea, as the water level in the basin is more than that of the tide in the sea. During this period also, the flowing water rotates the turbine and generator power. Figure 3-3: Low tide The generation of power stops only when the sea level and the tidal basin level are equal. For the generation of power economically using this source of energy requires some minimum tide height and suitable site. Kislaya power plant of 250 MW capacity in Russia and Rance power plant in France are the only examples of this type of power plant. 3.3.3.2 Importance of Tidal energy • Tidal energy represents a significant opportunity to increase the world's renewable power generation capacity. As countries continue to develop, and the global population and its reliance on energy grows, so does the demand on power systems to provide additional clean energy resources. Tidal energy could potentially supply a significant percentage of future electricity needs if barriers, including robustness of devices, environmental challenges, and the cost-effectiveness of its commercial application, can be successfully navigated. • Tidal energy is best captured in areas with high tidal ranges and strong currents. There are several ways to harness it.
30 • Tidal turbines can be installed in places with strong tidal activity, either floating or on the sea floor, individually or in arrays. They look and operate much like wind turbines, using blades to turn a rotor that powers a generator, but must be significantly more robust given their operating environment and, as tidal turbines are much smaller than large wind turbines, more turbines are required to produce the same amount of energy. Multiple tidal demonstration projects are under way in the United States. • Turbines placed in tidal streams capture energy from the current, and underwater cables transmit it to the grid. Tidal stream systems can capture energy at sites with high tidal velocities created by land constrictions, such as in straits or inlets. When fully operational, the MeyGen project in Scotland will be the largest tidal stream generating station in the world, with up to 398 MW generation capacity. • Tidal barrages are like dams built across tidal rivers, bays, and estuaries to form a tidal basin. Turbines inside the barrage enable the basin to fill during incoming tides and release through the system during outgoing tides, generating electricity in both directions. It operates much like a river dam in capturing the power in surrounding water. Two of the world's largest tidal power stations are barrages in South Korea and France, with 254 MW and 240 MW electricity generation capacity, respectively. The next largest in Canada has much lower generation capacity at 20 MW. • Tidal lagoons are like barrages in using man-made retaining walls to partially contain a large volume of incoming tidal water, with embedded turbines to capture its energy. They also rely on a large tidal range to generate power. Unlike barrages, tidal lagoons could be placed along natural coastline for continuous power generation as the tide changes and designed to minimize their environmental footprint. Though the energy output from tidal lagoons is unproven, with no current examples in operation, a few are under development in China, North Korea, and the United Kingdom. Due to the environmental challenges, they pose, tidal barrages and lagoons are not the focus of tidal energy development efforts in most areas of the world. • The predominant application for tidal energy has been the generation of electricity for use on shore via the national power grid. There is also potential value in tidal energy to serve the needs of other existing or emerging ocean industries (e.g., aquaculture, ocean mineral mining, oceanographic research, or military missions), as captured in DOE's Powering the Blue Economy Initiative. The "blue economy" is defined as the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs, while preserving the health of ocean ecosystems. • Tidal energy is a clean, renewable, sustainable resource that is underutilized and represents significant opportunity to meet growing global energy needs, both now and in the future. Water is hundreds of times denser than air, which makes tidal energy more powerful than wind. It is more efficient than wind or solar energy due to its relative density and produces no greenhouse gases or other waste, making it an attractive renewable energy source to pursue.

31 • Also beneficial is the relative predictability and reliability of continuous tides, especially compared to other renewable energy sources like wind and solar, which are affected by the variability and uncertainty of atmospheric forcing. Low tide and high tide cycles are easy to predict and rarely experience unexpected changes. To realize the benefits of tidal energy on a commercial scale, it will be important for researchers to identify new technologies and methods that significantly lower installation and maintenance costs, reduce environmental effects, and increase the suitability of more locations. There are a few tidal projects in operation; however, the industry is growing slowly due to barriers to entry and lack of supply chain. 3.3.4 Geothermal energy Geothermal power plants use steam to produce electricity. The steam comes from reservoirs of hot water found a few miles or more below the earth's surface. The steam rotates a turbine that activates a generator, which produces electricity. Geothermal Electricity Production Basics Geothermal power plants use steam to produce electricity. The steam comes from reservoirs of hot water found a few miles or more below the earth's surface. The geothermal energy in the form of heat energy can be used to generate electricity economically and efficiently. It is a renewable source of energy and is inexhaustible like solar or wind energy. Though the amount of thermal energy within the earth is very large, useful resources of geothermal energy are very limited due to feasibility to access and extract heat. 3.3.4.1 Geothermal Power Plant Working Principle Normally the thermal energy available inside the earth is at a depth of more than 80 km. The average temperature gradient in the earth's surface is 30 O C /km depth. Therefore, for power generation to attain temperatures up to 300 O C, a hole has to be drilled in earth's surface of about 10 km depth. However, there are few sites in the world where this energy can be extracted at the depth of 0.5 to 3 km. The sites from where the thermal energy can be extracted are known as geothermal fields. The earth's interior having the mass of hot liquids, gases and steam are cooling slowly and the temperature of the earth's core is about 4000 O C. Below the solid crust of the earth, the molten mass which is known as magma is still in the process of cooling. The hot magma near the earth's surface causes hot gasses, hot springs, and geysers. We can utilize these hot gases and hot water to generate electricity.

32 There are different types of geothermal resources. Those geothermal resources, in which the water is heated by contact with the hot rocks are known as hydrothermal resources. These are being used to generate electricity presently since the technology for commercial utilization of other geothermal sources is not available. There are three main types of geothermal energy plants that are used to utilize geothermal energy and generate power. • Dry Steam System • Flash Steam System • Binary Cycle System a. Geothermal Energy Plant Based on Dry Steam System It is a most common system. This system is used where geothermal resources deliver steam with little or no water. In this system, pressure and temperatures of the steam reaching to the earth's surface are limited to 8 bar and 200 o C. The block diagram of a dry steam power plant is shown in Figure 3.3. Dry steam is extracted from the geothermal field. It contains some water and solid particles. These are removed in a centrifugal separator. Pure and dry steam is then fed to a steam turbine. The steam turbine drives an electrical generator coupled to it and generates electricity. The exhausted steam from the turbine is condensed in a condenser. The condensate is then re- injected into the ground.

33 Figure 3-4: Geothermal Energy Plant Based on Dry Steam System b. Geothermal Energy Plant based on Flash Steam System Flash steam plants differ from dry steam because they extract hot water, rather than steam, directly to the surface. The hot water is extracted from the geothermal field from a depth of about 1 km at about 40 bar. Then hot water reaches to the wellhead at low pressure. It is a throttling process due to which hot water is converted into a two-phase mixture having the steam of low quality and is fed to a flash chamber cum brine separator. In the flash chamber, hot water flashes into steam. It results in dry steam; pure and dry steam is fed to a steam turbine and brine is collected from the bottom. The steam turbine drives an electrical generator coupled to it and generates electricity. The hot brine is re-injected into the ground along with the steam condensate from the condenser.

34 Figure 3-5: Geothermal Energy Plant based on Flash Steam System c. Binary Cycle System This system is used where geothermal resources deliver hot fluid in the temperature range of 90 O C to 170 O C. This temperature is not sufficient for the production of steam. In order to utilize this geothermal heat, an organic compound of low boiling temperature like isobutene is used under pressure in a primary heat exchanger. In this system, the water or steam from geothermal resource never comes in direct contact with the turbines. Instead, water from below the earth is pumped through a heat exchanger where it heats a second liquid (isobutene). The geothermal fluid is re-injected to the ground after extracting heat.

35 The isobutene vapor, generated in the primary heat exchanger, is passed through a turbine where it expands. The mechanical power of the turbine is converted into electrical power by a generator. The exhaust of the turbine is passed through a regenerator (heat exchanger) where it is cooled and then condensed in the condenser. The returned condensate is heated in the regenerator by the exhaust vapor of the turbine. Figure 3-6: Binary Cycle System 3.3.4.2 Geothermal Energy Advantages and Disadvantages Advantages: • It is a reliable source of energy and is available throughout the year. • It is independent of weather conditions. • No thermal storage is required. • Capital and generation cost is low as compared to conventional thermal power plants.

36 • Needs a very small land area. Disadvantages: • It is a low-grade heat energy since the temperatures are limited to 150 O C • The geothermal fluids are corrosive and abrasive in nature due to the presence of salts. Therefore, the life of the plant is low as compared to conventional power plants. • The geothermal fluids also bring dissolved gases like H 2 S, CO 2 , NH 3 and other solvents which cause air and land pollution if not discharged into the ground properly. • Continuous extraction of these fluids may affect the stability of land and may trigger earthquakes also. 3.3.5 OTEC Ocean thermal energy conversion (OTEC) is a process or technology for producing energy by harnessing the temperature differences (thermal gradients) between ocean surface waters and deep ocean waters. Energy from the sun heats the surface water of the ocean. Non-conventional sources are turning out to be significant sources of energy for humanity. With global warming a certainty, it is imperative that we turn to non-polluting and renewable sources of energy. One such source of energy is Ocean Thermal Energy Conversion (OTEC). 3.3.5.1 Ocean Thermal Energy (OTE) • Ocean thermal energy conversion is an electricity generation system. • Ocean Thermal Energy, also called Ocean Thermal Energy Conversion (OTEC), refers to using the temperature difference between the deep parts of the sea, which are cold and the shallow parts of the sea, which are cold, to run a heat engine and produce useful work. • The deeper parts of the ocean are cooler because the heat of sunlight cannot penetrate very deep into the water. • Here the efficiency of the system depends on the temperature difference. • Greater the temperature difference, the greater the efficiency. • The temperature difference in the oceans between the deep and shallow parts is maximum in the tropics, 20 O C to 25 O C. • Tropics receive a lot of sunlight which warms the surface of the oceans, increasing the temperature gradient.

37 Figure 3-7: Ocean Thermal Energy [Source: Byju's] • The energy source of OTEC is abundantly available, free, and will be so for as long as the sun shines and ocean currents exist. • Estimates suggest that ocean thermal energy could contain more than twice the world's electricity demand. • This makes it necessary for us to give it a closer look. 3.3.5.2 Types of Ocean Thermal Energy Conversion Systems a. Closed Cycle: • Closed cycle Ocean Thermal Energy Conversion systems use a working fluid with a low boiling point, Ammonia, for example, and use it to power a turbine to generate electricity. • Warm seawater is taken in from the surface of the oceans and cold water from the deep at 5 o C. • The warm seawater vaporises the fluid in the heat exchanger, turning the generator's turbines. • The fluid now in the vapour state is brought in contact with cold water, which turns it back into a liquid. • The fluid is recycled in the system, which is why it is called a closed system.

38 Figure 3-8: Close cycle Ocean Thermal Energy Conversion Systems b. Open Cycle: • Open cycle OTEC directly uses the warm water from the surface to make electricity. • The warm seawater is first pumped into a low-pressure chamber, where it undergoes a drop in boiling point due to the pressure drop. • This causes the water to boil. • This steam drives a low-pressure turbine which is attached to an electrical generator. • The advantage this system has over a closed system is that, in the open cycle, desalinated water is obtained in the form of steam. o Since it is steam, it is free from all impurities. o This water can be used for domestic, industrial, or agricultural purposes. Ocean Thermal Energy (OTEC) is a real candidate as one of the future sources of energy. Its environmental impact is negligible. The mixing of deep and shallow seawater brings up nutrients from the seafloor. The deepwater is rich in nitrates, which can also be used in agriculture.

39 Figure 3-9: Open cycle Ocean Thermal Energy Conversion Systems 3.3.5.3 Importance of Ocean Thermal Energy Conversion 3.3.5.4 Immense Resource OTEC is solar power, using the oceans as a thermal storage system for 24-hour production. Unlike other renewable energies, the maximum available energy from OTEC is not limited by land, shorelines, water, environmental impact, human impact, etc. Baseload Power OTEC produces electricity continuously, 24 hours a day throughout the entire year. Intermittent renewable energy sources are not baseload and often require storage of their energy during peak production hours for later consumption. Large, baseload OTEC plants could actually start to replace fossil-fuel-fired power plants without compromising grid stability. Dispatchable Power OTEC is dispatchable, meaning that its power can be ramped up and down quickly (in a matter of seconds) to compensate for fluctuating power demand or supply from intermittent renewables. For this reason, OTEC is complementary to other renewables like solar and wind, and could enable further penetration on the grid while helping to maintain its stability. Security OTEC offers the opportunity of tapping an immense energy resource that is not controlled by other nations. Renewable Believed to be sustainable at four or more times current total global electrical energy production. Low Risk

40 Conventional Closed Cycle OTEC is a low-risk. Clean Energy OTEC has the potential of being a very clean alternative energy – unique for a firm power source capable of providing massive energy needs. The environmental risk with OTEC is very low. Offshore OTEC production occurs offshore. Land resources are not needed other than for on-shore landing. OTEC is not competing for other vital resources such as food and fresh water. 3.4 Summary 3.5 Questions/ Self-Assessment questions Short questions: 1. Benefits of hydropower. 2. What is High tide and Low tide? 3. What is geothermal energy? 4. What is OTEC? Descriptive questions: 1. Why do we need non-conventional energy resources? 2. Principal mechanism of wind power. 3. What are the Benifits of Wind power? 4. Advantages and disadvantages of geothermal energy. 3.6 Select Readings/ Suggested Readings Renewable Energy Resources by John Twidell and Tony Weir, 3 rd Ed, Routledge Publishers Non-Conventional Energy Resources by Prof. D S Chauhan and Dr. S K Srivastava, New Age International (P) Ltd Publishers https://ncert.nic.in/textbook/pdf/jess105.pdf
https://en.wikipedia.org/wiki/Wind_power#cite_note-abbess-10
41 Unit 4: Solar Energy 4.1 Objectives 4.2 Introduction 4.3 Sun as a source of energy 4.4 Theory of Generation of solar energy 4.5 Solar Collector 4.6 Photovoltaic Modules 4.7 Solar Pond 4.8 Summary 4.9 Questions/ Self-Assessment questions 4.10 Select Readings/ Suggested Readings 4.1 Objectives • To learn bout the importance and utilization of solar energy • To know about different types of solar collectors • To learn about the mechanism of solar pond 4.2 Introduction In today's climate of growing energy needs and increasing environmental concern, alternatives to the use of non-renewable and polluting fossil fuels have to be investigated. One such alternative
is solar energy. Solar energy is quite simply the energy produced directly by the sun
and collected elsewhere, normally the Earth. The sun creates its energy through a thermonuclear process that converts about 650,000,000 tons of hydrogen to helium every second. The process creates heat and electromagnetic radiation. The heat remains in the sun and is instrumental in maintaining the thermonuclear reaction. The electromagnetic radiation (including visible light, infra-red light, and ultra-violet radiation) streams out into space in all directions. Only a very small fraction of the total radiation produced reaches the Earth. The radiation that does reach the Earth is the indirect source of nearly every type of energy used today. The exceptions are geothermal energy, and nuclear fission and fusion. Even fossil fuels owe their origins to the sun; they were once living plants and animals whose life was dependent upon the sun.

42 Due to the nature of solar energy, two components are required to have a functional solar collects the radiation that falls on it and converts a fraction of it to other forms of energy (either electricity and heat or heat alone). The storage unit is required because of the non-constant nature of solar energy; at certain times only a very small amount of radiation will be received. At night or during heavy cloud cover, for example, the amount of energy produced energy generator. These two components are a collector and a storage unit. The collector simply by the collector will be quite small. The storage unit can hold the excess energy produced during the periods of maximum productivity, and release it when the productivity drops. In practice, a backup power supply is usually added, too, for the situations when the amount of energy required is greater than both what is being produced and what is stored in the container. 4.3 Sun as a source of energy Tides are driven by gravitational energy and plate tectonics by the heat generated by the radioactive decay of elements in the Earth's mantle, but the energy driving the atmosphere, oceans, and living organisms is supplied by the Sun. To a limited extent this energy can also be harnessed directly to perform useful work for humans. Solar heat can be used directly to warm buildings and water, desalinate water, and cook food. Sunlight can be converted into electricity. Electrical power can also be generated from wind and sea waves and, because the atmospheric circulation responsible for wind and wind-driven waves is driven by solar heat, these are also forms of solar energy. The outer layer of the Sun, which is what we see and the region from which the Sun radiates, is at a temperature of about 6000 K and it radiates energy at 73.5×10 W from every square metre of its visible surface (the photosphere; being entirely gaseous, the Sun has no solid surface). The figure can be calculated because the Sun behaves as a 'black body'. This is a body that absorbs all the energy falling on it and radiates energy at the maximum rate possible; the rate is calculated by using Stefan's law and is proportional to the absolute temperature raised to the fourth power. The Sun radiates in all directions and the Earth, being a very small target at a distance of 150 million km, intercepts 0.0005 per cent of the total. At the top of the Earth's atmosphere this amounts to about 1360 W m, a value known as the 'solar constant'. Solar output is not as constant as this name suggests. Between 1981 and 1984, it decreased by 0.07-2 per cent (Hidore and Oliver, 1993, p. 166). This is a small deviation, but a decrease of about 0.1 per cent sustained over a decade would be sufficient to produce major climatic effects and a 5 percent decrease might trigger a major glaciation. Cyclical variations in the Earth's rotation and orbit also alter the solar constant. These are believed to be the major cause of large-scale climatic change, and variations in solar output, marked by changes in sunspot activity, are linked to less dramatic changes, such as the Little Ice Age, a period when average temperatures were lower than at present which lasted from about 1450 to 1880. Some scientists believe that the recent climatic warming and rise in atmospheric carbon dioxide concentration are both wholly due to the marked increase in energy output of the Sun since about 1966 (Calder, 1999). Radiant heat and light are both forms of electromagnetic radiation, varying only in their wavelengths, and the Sun radiates across the whole electromagnetic spectrum. According to Wien's law, the wavelength at which a body radiates most intensely is inversely proportional to its temperature, so the hotter the body the

43 shorter the wavelength at which it radiates most intensely. This is not surprising, because electromagnetic radiation travels only at the speed of light (beyond the Earth's atmosphere, in space, about 300000 km s) and the only way its energy can increase is by reducing the wavelength. Very short-wave (high-energy) gamma (10 -14 –10 -8 μm) and X (10 -10 μm) solar radiation is absorbed in the upper atmosphere and none reaches the surface. Radiation with a wavelength between 0.2 and 0.4 μm is called 'ultraviolet' (UV); at wavelengths below 0.29 μm, most UV is absorbed by stratospheric oxygen (O 2) and ozone (O 3). The wavelengths between 0.4 and 0.7 μm are what we see as visible light, with violet at the short-wave end of the spectrum and red at the long-wave end. These are the wavelengths at which the Sun radiates most intensely, with an intensity peak at around 0.5 μm in the green part of the spectrum. It is the part of the spectrum to which our eyes are sensitive, for the obvious reason that the most intense radiation is also the most useful, although some animals have eyes receptive to slightly shorter or longer wavelengths. Sunlight can be concentrated. A device developed in Israel by the commercial arm of the Weizmann Institute of Science and Boeing uses highly reflective mirrors (heliostats) to track the Sun and reflect sunlight to another reflector on top of a central tower. This reflector redirects the sunlight to a matrix of concentrators, which increase the intensity of the light 5000 to 10000 times, compared with the sunlight reaching the surface outside the facility. The concentrated light is fed to a receiver, called 'Porcupine' because it contains hundreds of ceramic pins arranged in a geometric pattern. Compressed air flowing across the pins is heated and channeled to gas turbines that generate electrical power. The prototype plant was installed late in 1999. 4.4 Theory of Generation of solar energy When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow. 4.5 Solar Collector A solar collector is a device that collects and/or concentrates solar radiation from the Sun. These devices are primarily used for active solar heating and allow for the heating of water for personal use. These collectors are generally mounted on the roof and must be very sturdy as they are exposed to a variety of different weather conditions. The use of these solar collectors provides an alternative for traditional domestic water heating using a water heater, potentially reducing energy costs over time. As well as in domestic settings, a large number of these collectors can be combined in an array and used to generate electricity in solar thermal power plants. 4.5.1 Types of Solar Collectors There are many different types of solar collectors, but all of them are constructed with the same basic premise in mind. In general, there is some material that is used to collect and focus energy from the Sun and use it to heat water. The simplest of these devices uses a black material

44 surrounding pipes that water flows through. The black material absorbs the solar radiation very well, and as the material heats up the water it surrounds. This is a very simple design, but collectors can get very complex. Absorber plates can be used if a high temperature increase isn't necessary, but generally devices that use reflective materials to focus sunlight result in a greater temperature increase. 4.5.1.1 Flat Plate Collectors These collectors are simply metal boxes that have some sort of transparent glazing as a cover on top of a dark-colored absorber plate. The sides and bottom of the collector are usually covered with insulation to minimize heat losses to other parts of the collector. Solar radiation passes through the transparent glazing material and hits the absorber plate. This plate heats up, transferring the heat to either water or air that is held between the glazing and absorber plate. Sometimes these absorber plates are painted with special coatings designed to absorb and retain heat better than traditional black paint. These plates are usually made out of metal that is a good conductor - usually copper or aluminum. 4.5.1.2 Evacuated Tube Collectors This type of solar collector uses a series of evacuated tubes to heat water for use. These tubes utilize a vacuum, or evacuated space, to capture the suns energy while minimizing the loss of heat to the surroundings. They have an inner metal tube which acts as the absorber plate, which is connected to a heat pipe to carry the heat collected from the Sun to the water. This heat pipe is essentially a pipe where the fluid contents are under a very particular pressure. At this pressure, the "hot" end of the pipe has boiling liquid in it while the "cold" end has condensing vapour. This allows for thermal energy to move more efficiently from one end of the pipe to the other. Once the heat from the Sun moves from the hot end of the heat pipe to the condensing end, the thermal energy is transported into the water being heated for use. 4.5.1.3 Line Focus Collectors These collectors, sometimes known as parabolic troughs, use highly reflective materials to collect and concentrate the heat energy from solar radiation. These collectors are composed of parabolically shaped reflective sections connected into a long trough. A pipe that carries water is placed in the center of this trough so that sunlight collected by the reflective material is focused onto the pipe, heating the contents. These are very high-powered collectors and are thus generally used to generate steam for Solar thermal power plants and are not used in residential applications. These troughs can be extremely effective in generating heat from the Sun, particularly those that can pivot, tracking the Sun in the sky to ensure maximum sunlight collection. 4.5.1.4 Point Focus Collectors These collectors are large parabolic dishes composed of some reflective material that focus the Sun's energy onto a single point. The heat from these collectors is generally used for driving Stirling engines. Although very effective at collecting sunlight, they must actively track the Sun across the sky to be of any value. These dishes can work alone or be combined into an array to gather even more energy from the Sun.

45 Point focus collectors and similar apparatuses can also be utilized to concentrate solar energy for use with Concentrated photovoltaics. In this case, instead of producing heat, the Sun's energy is converted directly into electricity with high efficiency photovoltaic cells designed specifically to harness concentrated solar energy. 4.6 Photovoltaic Modules The solar technology which has the greatest potential for use throughout the world is that of solar photo voltaic cells which directly produce electricity from sunlight using photovoltaic (PV) (also called solar) cells. Solar cells use the sun's light, not its heat, to make electricity. PV cells require little maintenance, have no moving parts, and essentially no environmental impact. They work cleanly, safely and silently. They can be installed quickly in small modules, anywhere there is sunlight. Solar cells are made up of two separate layers of silicon, each of which contains an electric charge. When light hits the cells, the charges begin to move between the two layers and electricity is produced. PV cells are wired together to form a module. A module of about 40 cells is enough to power a light bulb. For more power, PV modules are wired together into an array. PV arrays can produce enough power to meet the electrical needs of a home. Over the past few years, extensive work has been done in decreasing PV technology costs, increasing efficiency, and extending cell lifetimes. Many new materials, such as amorphous silicon, are being. Tested to reduce costs and automate manufacturing. PV cells are commonly used today in calculators and watches. They also provide power to satellites, electric lights, and small electrical appliances such as radios and for water pumping, highway lighting, weather stations, and other electrical systems located away from power lines. Some electric utility companies are building PV systems into their power supply networks. PV cells are environmentally benign, i.e., they do not release pollutants or toxic material to the air or water, there is no radioactive substance, and no catastrophic accidents. Some PV cells, however, do contain small quantities of toxic substances such as cadmium and these can be released to the environment in the event of a fire. Solar cells are made of silicon which, although the second most abundant element in the earth's crust, has to be mined. Mining creates environmental problems. PV systems also of course only work when the sun is shining, and thus need batteries to store the electricity. CASE STUDIES In 1981, a plane called 'The Solar Challenger' flew from Paris to England in 5 hours, 20 minutes. It had 16,000 solar cells glued to the wings and tail of the Plane and they produced enough power to drive a small electric motor and propeller. Since 1987, every three years theres a World Solar challenge for solar operated vehicles in Australia where the vehicles cover 3000 kms. • The world's first solar-powered hospital is in Mali in Africa. Being situated at the edge of the Sahara Desert, Mali receives a large amount of sunlight. Panels of solar cells supply the power needed to run vital equipment and keep medical supplies cool in refrigerators.

46 • Space technology required solar energy and the space race spurred the development of solar cells. Only sunlight can provide power for long periods of time for a space station or long-distance spaceship. • Japanese farmers are substituting PV operated insect killers for toxic pesticides. • In recent years, the popularity of building integrated photovoltaics (BIPV's) has grown considerably. In this application, PV devices are designed as part of building materials (i.e., roofs and siding) both to produce electricity and reduce costs by replacing the costs of normal construction materials. There are more than 3,000 BIPV systems in Germany and Japan has a program that will build 70,000 BIPV buildings. 4.7 Solar Pond A solar pond is a solar energy collector, generally fairly large in size, that looks like a pond. This type of solar energy collector uses a large, salty lake as a kind of a flat plate collector that absorbs and stores energy from the Sun in the warm, lower layers of the pond. These ponds can be natural or man-made, but generally speaking the solar ponds that are in operation today are artificial. The key characteristic of solar ponds that allow them to function effectively as a solar energy collector is a salt-concentration gradient of the water. This gradient results in water that is heavily salinated collecting at the bottom of the pond, with concentration decreasing towards the surface resulting in cool, fresh water on top of the pond. This collection of salty water at the bottom of the lake is known as the "storage zone", while the freshwater top layer is known as the "surface zone". The overall pond is several meters deep, with the "storage zone" being one or two meters thick. These ponds must be clear for them to operate properly, as sunlight cannot penetrate to the bottom of the pond if the water is murky. When sunlight is incident on these ponds, most of the incoming sunlight reaches the bottom and thus the "storage zone" heats up. However, this newly heated water cannot rise and thus heat loss upwards is prevented. The salty water cannot rise because it is heavier than the fresh water that is on top of the pond, and thus the upper layer prevents convection currents from forming. Because of this, the top layer of the pond acts as a type of insulating blanket, and the main heat loss process from the storage zone is stopped. Without a loss of heat, the bottom of the pond is warmed to extremely high temperatures - it can reach about 90°C. If the pond is being used to generate electricity this temperature is high enough to initiate and run an organic Rankine cycle engine. It is vital that the salt concentrations and cool temperature of the top layer are maintained in order for these ponds to work. The surface zone
is mixed and kept cool by winds and heat loss by evaporation. This top zone must also be flushed continuously with fresh water
to ensure that there is no accumulation of salt in the top layer, since the salt from the bottom layer diffuses through the saline gradient over time. Additionally, a
solid salt or brine mixture must be added to the pond frequently to make up for

any upwards salt loses.

47 4.7.1 Applications The heat from solar ponds can be used in a variety of different ways. First, since the heat storing abilities of solar ponds are so great, they are ideal for use in heating and cooling buildings as they can maintain a fairly stable temperature. These ponds can also be used to generate electricity either
by driving a thermo-electric device or some organic Rankine engine cycle - simply a turbine powered by evaporating a fluid (in this case a fluid with a lower boiling point). Finally, solar ponds can be used for desalination purposes as the low cost of this thermal energy can be used to remove the salt from water for drinking or irrigation purposes. 4.7.2 Benefits and Drawbacks One benefit of using these ponds is that they have an extremely large thermal mass. Since these ponds can store heat energy very well, they can generate electricity during the day when the Sun is shining as well as at night. Despite being a source of energy, there are numerous thermodynamic limitations as a result of the relatively low temperatures achieved in these ponds. Because of this, the solar-to-electricity conversion is fairly inefficient - generally less than 2%. As well, large amounts of fresh water are necessary to maintain the right salt concentrations all through the pond. This is an issue in places where fresh water is hard to come by, especially in desert environments. These ponds also do not work well at high latitudes as the collection surface is horizontal and cannot be tilted to collect more sunlight. 4.8 Summary 4.9 Questions/ Self-Assessment questions Short questions: 1. What is solar Collector? 2. What is PV cell? 3. What is Solar Pond? 4. Benefits of soler energy. Descriptive questions: 1. Describe different types of solar collectors. 2. Benefits and draw back of the solar pond. 3. How does solar cell work?

48 4.10 Select Readings/ Suggested Readings 1. G. Boyle. Renewable Energy: Power for a Sustainable Future, 2nd ed. Oxford, UK: Oxford University Press, 2004. 2. Fundamentals and Applications of Renewable Energy by Mehmet Kanoglu, Yunus A. Cengel, John M. Cimbala 3. Introduction to Environmental Engineering and Science by Gilbert M. Masters 4. A.Akbarzadeh, J.Andrews, P.Golding.(August 12, 2015). Solar Ponds [Online]. Available: http://www.eolss.net/sample-chapters/c08/e6-106-08.pdf 5. ↑ Created internally by a member of the Energy Education team. Adapted from: G. Boyle. Renewable Energy: Power for a Sustainable Future, 2nd ed. 6. K. Goutham, C.Krishna. (August 12, 2015). Solar Pond Technology [Online]. Available: http://www.ijergs.org/files/documents/Solar-Pond-Technology-2.pdf
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49 Unit 5: Nuclear Energy 5.1 Objectives 5.2 Introduction 5.3 Fission and Fusion Reactions 5.4 Nuclear Fuels 5.5 Common physical forms of nuclear fuel 5.6 Less-common fuel forms 5.7
Accident tolerant fuels 5.8 Spent nuclear fuel 5.9 Fuel behaviour and post-irradiation examination 5.10 Radioisotope decay fuels 5.11
Fusion fuels 5.12 Nuclear Fuel cycles 5.13 Nuclear Reactor: Principle and Types 5.14 Summary 5.15 Questions/ Self-Assessment questions 5.16 Select Readings/ Suggested Readings 5.1 Objectives • To learn about the fission and fusion reaction • To know the nuclear fuels • To learn about the nuclear energy operation. • To learn about different types of nuclear reactors 5.2 Introduction In the late 1930s, we discovered that some particularly large atoms found in nature can be split into two (or fission), releasing a shocking amount of energy as heat. Because the energy emerges from the atomic nucleus, we call it nuclear energy. When these atoms are arranged properly in a machine called a nuclear reactor, each splitting nucleus can induce its neighbors to split in turn, creating a controlled chain reaction. Reactors can convert the released nuclear heat into electricity, shaft horsepower (to power ships), building heating, desalinated water, hydrogen, and many other things useful to human civilization.

50 Today, about 430 commercial nuclear power plants worldwide produce around 400 GW of electricity, enough to power 400 million average households. About one-fifth of the USA's electricity comes from nuclear power, which represents about half of the country's zero-carbon electricity. Nuclear energy is controversial due to concerns about radiation. Public support varies geographically, but nuclear is generally among the least popular forms of energy. 5.3 Fission and Fusion Reactions Nuclear fusion and nuclear fission are different types of reactions that release energy due to the presence of high-powered atomic bonds between particles found within a nucleus. In fission, an atom is split into two or more smaller, lighter atoms. Fusion, in contrast, occurs when two or smaller atoms fuse together, creating a larger, heavier atom. Table 5-1: Nuclear Fission versus Nuclear Fusion comparison chart Nuclear Fission Nuclear Fusion Definition Fission is the splitting of a large atom into two or more smaller ones. Fusion is the fusing of two or more lighter atoms into a larger one. Natural occurrence of the process Fission reaction does not normally occur in nature. Fusion occurs in stars, such as the sun. By-products of the reaction Fission produces many highly radioactive particles. Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that. Conditions Critical mass of the substance and high-speed neutrons are required. High density, high temperature environment is required. Energy Requirement Takes little energy to split two atoms in a fission reaction. Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion.

51 Nuclear Fission Nuclear Fusion Energy Released The energy released by fission is a million times greater than that released in chemical reactions, but lower than the energy released by nuclear fusion. The energy released by fusion is three to four times greater than the energy released by fission. Nuclear weapon One class of nuclear weapon is a fission bomb, also known as an atomic bomb or atom bomb. One class of nuclear weapon is the hydrogen bomb, which uses a fission reaction to "trigger" a fusion reaction. Energy production Fission is used in nuclear power plants. Fusion is an experimental technology for producing power. Fuel Uranium is the primary fuel used in power plants. Hydrogen isotopes (Deuterium and Tritium) are the primary fuel used in experimental fusion power plants. Nuclear fusion is the reaction in which two or more nuclei combine, forming a new element with a higher atomic number (more protons in the nucleus). The energy released in fusion is related to E = mc 2 (Einstein's famous energy-mass equation). On Earth, the most likely fusion reaction is Deuterium–Tritium reaction. Deuterium and Tritium are isotopes of hydrogen. Figure 5-1: Fusion of deuterium with tritium creating helium-4, freeing a neutron, and releasing 17.59 MeV of energy. 2 1 Deuterium + 3 1 Tritium = 4 2 He + 1 0 n + 17.6 MeV Nuclear fission is the splitting of a massive nucleus into photons in the form of gamma rays, free neutrons, and other subatomic particles. In a typical nuclear reaction involving 235 U and a neutron:
52 235 92 U + n = 236 92 U followed by 236 92 U = 144 56 Ba + 89 36 Kr + 3n + 177 MeV 5.4
Nuclear Fuels
Nuclear fuel is material used in nuclear power stations to produce heat to power turbines. Heat is created when nuclear fuel undergoes nuclear fission.
Most nuclear fuels contain heavy fissile actinide elements that are capable of
undergoing and sustaining nuclear fission. The three most relevant fissile isotopes are uranium-233, uranium-235 and plutonium-239. When the unstable nuclei of these atoms are hit by a slow-moving neutron, they frequently split, creating two daughter nuclei and two or three more neutrons. In that case, the neutrons released go on to split more nuclei. This creates
a self-sustaining chain reaction that is controlled in a nuclear reactor, or uncontrolled in a nuclear weapon.
Alternatively, if the nucleus absorbs the neutron without splitting, it creates a heavier nucleus with one additional neutron.
The processes involved in mining, refining, purifying, using, and disposing of nuclear fuel are collectively known as
the nuclear fuel cycle. Not all types of nuclear fuels create power from nuclear fission; plutonium-238
and some other elements are used to produce small amounts of nuclear power by radioactive decay in radioisotope thermoelectric generators and other
types of atomic batteries.
Nuclear
fuel has the highest energy density of all practical
fuel
sources. 5.4.1 Oxide fuel
For fission reactors, the fuel (typically based on uranium) is usually based on the metal oxide; the oxides are used rather than the metals themselves because the oxide melting point is much higher than that of the metal and because it cannot burn, being already in the oxidized state. 5.4.1.1
Uranium dioxide
Uranium dioxide is a black semiconducting solid. It can be made by heating uranyl nitrate
to form UO 3. This is then converted by heating with hydrogen to form UO 2 . It can be made from enriched uranium hexafluoride by reacting with ammonia to form a solid called ammonium diuranate, This is then heated (calcined) to form UO 3 and U 3 O 8 which is
then
converted by heating with hydrogen or ammonia
to form UO 2 . The UO 2 is mixed with an organic binder and pressed into pellets, these pellets are then fired at a much higher temperature (in H 2 /Ar) to sinter the solid. The aim is to form a dense solid which has few pores. The thermal conductivity of uranium dioxide is very low compared with that of zirconium metal, and it goes down as the temperature goes up. Corrosion of uranium dioxide in water is controlled by similar electrochemical processes to the galvanic corrosion of a metal surface.
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While exposed to the neutron flux during normal operation in the core environment a small percentage of the Uranium-238 in the fuel absorbs excess neutrons and is transmuted into U-239. U-239 rapidly decays into Neptunium-239 which in turn rapidly decays into Plutonium-239. The small percentage of Plutonium-239 has a higher neutron cross section than Uranium-235. As the Plutonium-239 accumulates the chain reaction shifts from pure Uranium-235 at initiation of the fuel use to a ratio of about 70% Uranium-235 and 30% Plutonium-239 at the end of the 18 to 24 month fuel exposure period. 5.4.2 Mixed oxide (

MOX) Mixed oxide, or MOX fuel, is a blend of plutonium and natural or depleted uranium which behaves similarly (though not identically) to the enriched uranium feed for which most nuclear reactors were designed. MOX fuel is an alternative to low enriched uranium (LEU) fuel used in the light water reactors which predominate nuclear power generation. Some concern has been expressed that used MOX cores will introduce new disposal challenges, though MOX is itself a means to dispose of surplus plutonium by transmutation. Reprocessing of commercial nuclear fuel to make MOX was done in the Sellafield MOX Plant (England). As of 2015, MOX fuel

is made in France, and to a lesser extent in Russia, India and Japan. China plans to develop fast breeder reactors (

see CEFR) and reprocessing. The Global Nuclear Energy Partnership, was a U.S. proposal in the George W. Bush Administration

to form an international partnership to see spent nuclear fuel reprocessed in a way that renders the plutonium in it usable for nuclear fuel but not for nuclear weapons. Reprocessing of spent commercial-reactor nuclear fuel has not been permitted in the United States due to nonproliferation considerations. All of the other reprocessing nations have long had nuclear weapons from military-focused "research"-reactor fuels except for Japan.

Normally, with the fuel being changed every three years or so, about half of the Pu-239 is 'burned' in the reactor, providing about one third of the total energy. It behaves like U-235 and its fission releases a similar amount of energy. The higher the burn-up, the more plutonium in the spent fuel, but the lower the fraction of fissile plutonium. Typically, about one percent of the used fuel discharged from a reactor is plutonium, and some two thirds of this is fissile (C 50% Pu-239, 15% Pu-241). Worldwide, some 70 tonnes of plutonium contained in used fuel is removed when refueling reactors each year. 5.4.3

Metal fuel Metal fuels have the advantage of a much higher heat conductivity than oxide fuels but cannot survive equally high temperatures.

Metal fuels have a long history of use, stretching from the Clementine reactor in 1946 to many test and research reactors. Metal fuels have the potential for the highest fissile atom density. Metal fuels are normally alloyed, but some metal fuels have been made with pure uranium metal. Uranium alloys that have been used include uranium aluminum, uranium zirconium, uranium silicon, uranium molybdenum, and uranium zirconium hydride (UZrH). Any of the aforementioned fuels can be made with plutonium and other actinides as part of a closed nuclear fuel cycle. Metal fuels have been used in water reactors and liquid metal fast breeder reactors, such as EBR-II.

54 5.4.4

TRIGA fuel TRIGA fuel is used in TRIGA (Training, Research, Isotopes, General Atomics) reactors. The TRIGA reactor uses UZrH fuel, which has a prompt negative

fuel temperature coefficient of reactivity,

meaning that as the temperature of the core increases, the reactivity decreases—so it is highly unlikely for a meltdown to occur. Most cores that use this fuel are "high leakage" cores where the excess leaked neutrons can be utilized for research.

That is, they can be used as a neutron source.

TRIGA fuel was originally designed to use highly enriched uranium, however in 1978 the U.S. Department of Energy launched its Reduced Enrichment for Research Test Reactors program, which promoted reactor conversion to low-enriched uranium fuel. A total of 35 TRIGA reactors have been installed at locations across the US. A further 35 reactors have been installed in other countries. 5.4.5 Actinide fuel In a fast neutron reactor, the minor actinides produced by neutron capture of uranium and plutonium can be used as fuel. Metal actinide fuel is typically an alloy of zirconium, uranium, plutonium, and minor actinides. It can be made inherently safe as thermal expansion of the metal alloy will increase neutron leakage. 5.4.6

Molten plutonium Molten plutonium, alloyed with other metals to lower its melting point and encapsulated in tantalum, was tested in two experimental reactors, LAMPRE I and LAMPRE II, at Los Alamos National Laboratory in the 1960s. "LAMPRE experienced three separate fuel failures during operation." 5.4.7

Non-oxide

ceramic fuels Ceramic fuels other than oxides have the advantage of high heat conductivities and melting points, but they are more prone to swelling than oxide fuels and are

not understood as

well. 5.4.7.1 Uranium nitride This is often the fuel of choice for reactor designs that NASA produces, one advantage is that UN has a better thermal conductivity than UO 2 . Uranium nitride has a very high melting point. This fuel has the disadvantage that unless 15 N was used (in place of the more common 14 N) that a large amount of 14 C would be generated from the nitrogen by the (n,p) reaction. As the nitrogen required for such a fuel would be so expensive it is likely that the fuel would have to be reprocessed by pyro-processing to enable the 15 N to be recovered. It is likely that if the fuel was processed and dissolved in nitric acid that the nitrogen enriched with 15 N would be diluted with the common 14 N.

Fluoride volatility is a method of reprocessing that does not rely on nitric acid, but it has only been demonstrated in relatively small scale installations whereas the established PUREX process is used commercially for about a third of all spent nuclear fuel (the rest being largely subject to a "once through fuel cycle"). All nitrogen-fluoride compounds are volatile or gaseous at room temperature and could be fractionally distilled from the other gaseous products (including recovered uranium hexafluoride) to recover the initially used nitrogen. If the fuel could be processed in such a way as to ensure low contamination with non-radioactive carbon (not a
55 common fission product and absent in nuclear reactors that don't use it as a moderator) then Fluoride volatility could be used to separate the C produced by producing carbon tetrafluoride. C is proposed for use in particularly long-lived low power nuclear batteries called diamond battery. 5.4.7.2
Uranium carbide Much of what is known about uranium carbide is in the form of pin-type fuel elements for liquid metal fast reactors during their intense study during the 1960s and 1970s. However, recently there has been a revived interest in uranium carbide in the form of plate fuel and most notably, micro fuel particles (such as TRISO particles). The high thermal conductivity and high melting point makes uranium carbide an attractive fuel. In addition, because of the absence of oxygen in this fuel (during the course of irradiation, excess gas pressure can build from the formation
of
O 2 or other gases) as well as the ability to complement a ceramic coating (a ceramic-ceramic interface has structural and chemical advantages), uranium carbide could be the ideal fuel candidate for certain Generation IV reactors such as the gas-cooled fast reactor.
While the neutron cross section of carbon is low, during years of burnup, the predominantly C will undergo neutron capture to produce stable C as well as radioactive C. Unlike the C produced by using Uranium nitrate, the C will make up only a small isotopic impurity in the overall carbon content and thus make the entirety of the carbon content unsuitable for non-nuclear uses but the C concentration will be too low for use in nuclear batteries without enrichment. Nuclear graphite discharged from reactors where it was used as a moderator presents the same issue. 5.4.8
Liquid fuels
Liquid fuels are liquids containing dissolved nuclear fuel and have been shown to offer numerous operational advantages compared to traditional solid fuel approaches. Liquid-fuel reactors offer significant safety advantages due to their inherently stable "self-adjusting" reactor dynamics. This provides two major benefits: - virtually eliminating the possibility of a run-away reactor meltdown, - providing an automatic load-following capability which is well suited to electricity generation and high-temperature industrial heat applications. Another major advantage of some liquid core designs is their ability to be drained rapidly into a passively safe dump-tank. This advantage was conclusively demonstrated repeatedly as part of a weekly shutdown procedure during the highly successful 4-year
Molten Salt Reactor Experiment.
Another huge advantage of the liquid core is its ability to release xenon gas which normally acts as a neutron absorber
135
Xe is the strongest known neutron poison and is produced both directly and as a decay product of 135 I
as a fission product) and causes structural occlusions in solid fuel elements (leading to
the
early replacement of solid fuel rods with over 98% of the nuclear fuel unburned, including many long-lived actinides). In contrast, Molten Salt Reactors (MSR) are capable of retaining the fuel mixture for significantly extended periods, which not only increases fuel efficiency dramatically but also incinerates the vast majority of its own waste as part of the normal operational characteristics.
A downside to letting the 135 Xe escape instead of allowing it to capture neutrons converting it to the basically stable and chemically inert 136 Xe, is that it will quickly decay to the highly chemically reactive long lived radioactive 135 Cs, which behaves similar to other alkali metals and can be taken up by organisms in their metabolism.
56 5.4.9 Molten salts Molten salt fuels are mixtures of actinide salts (e.g., thorium/uranium fluoride/chloride) with other salts, used in liquid form above their typical melting points of several hundred degrees C. In some
molten salt-fueled reactor designs, such as the liquid fluoride thorium reactor (LFTR),
this fuel salt is also the coolant; in other designs, such as the stable salt reactor, the fuel salt is contained in fuel pins and the coolant is a separate, non-radioactive salt. There is a further category of molten salt-cooled reactors in which the fuel is not in molten salt form, but a molten salt is used for cooling.
Molten salt fuels were used in the LFTR known as
the Molten Salt Reactor Experiment, as well as other liquid core reactor experiments. The liquid fuel for the molten salt reactor was
a mixture of lithium, beryllium, thorium and uranium fluorides:

LiF-BeF 2 -ThF 4 -UF 4 (72-16-12-0.4 mol%). It had a peak operating temperature of 705 °C in the experiment, but could have operated at much higher temperatures since the boiling point of the molten salt was in excess of 1400 °C. 5.4.10 Aqueous solutions of uranyl salts The aqueous homogeneous reactors (AHRs) use a solution of uranyl sulfate or other uranium salt in water.

Historically, AHRs have all been small research reactors, not large power reactors. An AHR known as the Medical Isotope Production System is being considered for production of medical isotopes. 5.4.11

Liquid metals or alloys The Dual fluid reactor has a variant DFR/m which works with eutectic liquid metal alloys, e.g., U-Cr or U-Fe. 5.5

Common physical forms of nuclear fuel Uranium dioxide (UO 2) powder is compacted to cylindrical pellets and sintered at high temperatures to produce ceramic nuclear fuel pellets with a high density and well-defined physical properties and chemical composition. A grinding process is used to achieve a uniform cylindrical geometry with narrow tolerances. Such fuel pellets are then stacked and filled into the metallic tubes.

The metal used for the tubes depends on the design of the reactor. Stainless steel was used in the past, but most reactors now use a zirconium alloy

which, in addition to being highly corrosion-resistant, has low neutron absorption. The tubes containing the fuel pellets are sealed:

these tubes are called fuel rods.

The finished fuel rods are grouped into fuel assemblies that are used to build up the core of

a power reactor.

Cladding is the outer layer of the fuel rods, standing between the coolant and the nuclear fuel. It is made of a corrosion-resistant material with low absorption cross section for thermal neutrons, usually Zircaloy or steel in modern constructions, or magnesium with small amount of aluminium and other metals for the now-obsolete Magnox reactors. Cladding prevents radioactive fission fragments from escaping the fuel into the coolant and contaminating it.

Besides the prevention of radioactive leaks this also serves to keep the coolant as non-corrosive as feasible and to prevent reactions between chemically aggressive fission products and the coolant. (e.g., The highly

57 reactive alkali metal Caesium which reacts strongly with water, producing hydrogen, and which is among the more common fission products [a]) 5.5.1

PWR fuel

Pressurized water reactor (PWR) fuel consists of cylindrical rods put into bundles. A uranium oxide ceramic is formed into pellets and inserted into Zircaloy tubes that are bundled together. The Zircaloy tubes are about 1 centimetre (0.4 in)

in diameter, and the fuel cladding gap is filled with helium gas to improve heat conduction from the fuel to the cladding. There are about 179– 264 fuel rods per fuel bundle and about 121 to 193 fuel bundles are loaded into a reactor core. Generally, the fuel bundles consist of fuel rods bundled 14×14 to 17×17. PWR

fuel bundles are about 4 m (13 ft) long. In PWR fuel bundles, control rods are inserted through the top directly into the fuel bundle. The fuel bundles usually are enriched several percent in 235 U. The uranium oxide is dried before inserting into the tubes to try to eliminate moisture in the ceramic fuel that can lead to corrosion and hydrogen embrittlement. The Zircaloy tubes are pressurized with helium to try to minimize pellet-cladding interaction which can lead to fuel rod failure over long periods. 5.5.2 BWR fuel In boiling water reactors (BWR), the fuel is similar to PWR fuel except that the bundles are "canned". That is, there is a thin tube surrounding each bundle. This is primarily done to prevent local density variations from affecting neutronics and thermal hydraulics of the reactor core. In modern BWR fuel bundles, there are either 91, 92, or 96 fuel rods per assembly depending on the manufacturer. A range between 368 assemblies for the smallest and 800 assemblies for the largest BWR in the U.S. form the reactor core. Each BWR fuel rod is backfilled with helium to a pressure of about 3 standard atmospheres (300 kPa). 5.5.3 CANDU fuel CANDU fuel bundles

are about 0.5 metres (20 in) long and 10 centimeters (4 in) in diameter.

They consist of sintered (UO 2) pellets in zirconium alloy tubes, welded to zirconium alloy end plates. Each bundle weighs roughly 20 kilograms (44 lb), and a typical core loading is on the order of 4500–6500 bundles, depending on the design. Modern types typically have 37 identical fuel pins radially arranged about the long axis of the bundle, but in the past several different configurations and numbers of pins have been used. The CANFLEX bundle has 43 fuel elements, with two element sizes. It is also about 10 cm (4 inches) in diameter, 0.5 m (20

in) long and weighs about 20 kg (44 lb) and replaces the 37-

pin standard bundle. It has been designed specifically to increase fuel performance by utilizing two different pin diameters. Current CANDU designs do not need enriched uranium to achieve criticality (due to

the lower neutron absorption in their heavy water moderator compared to light

water), however, some newer concepts call for low enrichment to help reduce the size of the reactors.

The Atucha nuclear power plant in Argentina, a similar design to the CANDU but built by German KWU was originally designed for non-enriched fuel but since switched to slightly enriched fuel with a 235 U content about 0.1 percentage points higher than in natural uranium.
58 5.6
Less-common fuel forms Various other nuclear fuel forms find use in specific applications, but lack the widespread use of those found in BWRs, PWRs, and CANDU power plants. Many of these fuel forms are only found in research reactors, or have military applications. 5.6.1 Magnox fuel
Magnox (magnesium non-oxidising) reactors are pressurised, carbon dioxide–cooled, graphite- moderated reactors using natural uranium (i.e., unenriched) as fuel and Magnox alloy as fuel cladding. Working pressure varies from 6.9 to 19.35
bars (100.1
to 280.6 psi) for the steel pressure vessels, and the two reinforced concrete designs operated at 24.8 and 27
bars (24.5
and 26.6 atm). Magnox alloy consists mainly of magnesium with small amounts of aluminium and other metals— used in cladding unenriched uranium metal fuel with a non-oxidising covering to contain fission products. This material has the advantage of a low neutron capture cross-section, but has two major disadvantages: • It limits the maximum temperature, and hence the thermal efficiency, of the plant. • It reacts with water, preventing long-term storage of spent fuel under water -
such as in a
spent fuel pool. Magnox fuel incorporated cooling fins to provide maximum heat transfer despite low operating temperatures, making it expensive to produce. While the use of uranium metal rather than oxide made
nuclear
reprocessing
more straightforward and therefore cheaper, the need to reprocess fuel a short time after removal from the reactor meant that the fission product hazard was severe. Expensive remote handling facilities were required to address this issue. 5.6.2
TRISO fuel
Tristructural-isotropic (TRISO) fuel is a type of micro-particle fuel. A particle consists of a kernel of UO X fuel (sometimes UC or UCO),
which has been coated with four layers of three isotropic materials
deposited through fluidized chemical vapor deposition (FCVD).
The four layers are a porous buffer layer made of carbon
that absorbs fission product recoils, followed by a dense inner layer of protective
pyrolytic carbon (PyC), followed by a ceramic layer of SiC to retain fission products at elevated temperatures and to give the TRISO particle more structural integrity, followed by a dense outer layer of PyC. TRISO particles are
then encapsulated into cylindrical or spherical graphite pellets.
TRISO fuel particles are designed not to crack due to the stresses from processes (such as differential thermal expansion or fission gas pressure) at temperatures
up to 1600 °
C, and therefore can contain the fuel in the worst of accident scenarios in a properly designed reactor. Two such reactor designs are
the
prismatic-block gas-cooled reactor (such as the GT-MHR)
and the pebble-bed reactor (PBR).
Both of these reactor designs are high temperature gas reactors (HTGRs). These are also the basic reactor designs of very-
high-temperature reactors (VHTRs), one of the six classes of reactor designs in the Generation IV initiative
that is attempting to reach even higher HTGR outlet temperatures. TRISO fuel particles were originally developed in the United Kingdom as part of the Dragon
reactor
project. The inclusion of the SiC as diffusion barrier was first suggested by D. T. Livey.
59
The first nuclear reactor to use TRISO fuels was the
Dragon reactor
and the first powerplant was the THTR-300. Currently, TRISO fuel compacts are being used in some experimental reactors,

such as
the HTR-10 in China and the High-temperature engineering test reactor in Japan. Spherical fuel elements utilizing a TRISO particle with a UO 2 and UC solid solution kernel
are being used in the Xe-100 in the United States. 5.6.3 QUADRISO fuel In QUADRISO particles a burnable neutron poison (europium oxide or erbium oxide or carbide) layer surrounds the fuel kernel of ordinary TRISO particles to better manage the excess of reactivity. If the core is equipped both with TRISO and QUADRISO fuels, at beginning of life neutrons do not reach the fuel of the QUADRISO particles because they are stopped by the burnable poison.
During reactor operation, neutron irradiation of the poison causes it to "burn up" or progressively transmute to non-poison isotopes, depleting this poison effect and leaving progressively more neutrons available for sustaining the chain-reaction. This mechanism compensates for the accumulation of undesirable neutron poisons which are an unavoidable part of the fission products, as well as normal fissile fuel "burn up" or depletion.
In
the generalized QUADRISO fuel concept the poison can eventually be mixed with the fuel kernel or the outer pyrocarbon. The QUADRISO [9] concept was conceived at Argonne National Laboratory. 5.6.4
RBMK
fuel
RBMK reactor fuel was used in Soviet-designed and built RBMK-type reactors. This is a low- enriched uranium oxide fuel. The fuel elements in an RBMK are 3 m long each, and two of these sit back-to-back on each fuel channel, pressure tube. Reprocessed uranium from Russian VVER reactor spent fuel is used to fabricate RBMK fuel. Following the Chernobyl accident, the enrichment of fuel was changed from 2.0% to 2.4%, to compensate for control rod modifications and the introduction of additional absorbers. 5.6.5
CerMet fuel CerMet fuel consists of ceramic fuel particles (usually uranium oxide) embedded in a metal matrix. It is hypothesized that this type of fuel is what is used in United States Navy reactors. This fuel has high heat transport characteristics and can withstand a large amount of expansion. 5.6.6
Plate-type fuel
Plate-type fuel has fallen out of favor over the years. Plate-type fuel is commonly composed of enriched uranium sandwiched between metal cladding. Plate-type fuel is used in several research reactors where a high neutron flux is desired, for uses such as material irradiation studies or isotope production, without the high temperatures seen in ceramic, cylindrical fuel.
It is currently used in the Advanced Test Reactor (ATR) at Idaho National Laboratory,
and the nuclear research reactor at the University of Massachusetts Lowell Radiation Laboratory. 5.6.7 Sodium-bonded fuel Sodium-bonded fuel consists of fuel that has liquid sodium in the gap between the fuel slug (or pellet) and the cladding. This fuel type is often used for sodium-cooled liquid metal fast reactors.
60 It has been used in EBR-I, EBR-II, and the FFTF. The fuel slug may be metallic or ceramic. The sodium bonding is used to reduce the temperature of the fuel. 5.7
Accident tolerant fuels Accident tolerant fuels (ATF) are a series of new nuclear fuel concepts, researched in order to improve fuel performance under accident conditions, such as loss-of-coolant accident (LOCA) or reaction-initiated accidents (RIA). These concerns became more prominent after the Fukushima Daiichi nuclear disaster in Japan, in particular regarding light-water reactor (LWR) fuels performance under accident conditions. The aim of the research is to develop nuclear fuels that can tolerate loss of active cooling for a considerably longer period than the existing fuel designs and prevent or delay the release of radionuclides during an accident. This research is focused on reconsidering the design of fuel pellets and cladding, as well as the interactions between
the two. 5.8
Spent nuclear fuel Used nuclear fuel is a complex mixture of the fission products, uranium, plutonium, and the transplutonium metals. In fuel which has been used at high temperature in power reactors it is common for the fuel to be heterogeneous; often the fuel will contain nanoparticles of platinum group metals such as palladium. Also, the fuel may well have cracked, swollen, and been heated close to its melting point. Despite the fact that the used fuel can be cracked, it is very insoluble in water, and is able to retain the vast majority of the actinides and fission products within the uranium dioxide crystal lattice.
The radiation hazard from spent nuclear fuel declines as its radioactive components decay, but remains high for many years. For example, 10 years after removal from a reactor, the surface dose rate for a typical spent fuel assembly still exceeds 10,000 rem/hour, resulting in a fatal dose in just minutes. 5.8.1
Oxide fuel under accident conditions
Two main modes of release exist, the fission products can be vaporised or small particles of the fuel can be dispersed. 5.9
Fuel behavior and post-irradiation examination

Post-Irradiation Examination (PIE) is the study of used nuclear materials such as nuclear fuel. It has several purposes. It is known that by examination of used fuel that the failure modes which occur during normal use (and the manner in which the fuel will behave during an accident) can be studied. In addition information is gained which enables the users of fuel to assure themselves of its quality and it also assists in the development of new fuels. After
major accidents the core (or what is left of it) is normally subject to PIE to find out what happened. One site where PIE is done is the ITU which is the EU centre for the study of highly radioactive materials.
61
Materials in a high-radiation environment (such as a reactor) can undergo unique behaviors such as swelling and non-thermal creep. If there are nuclear reactions within the material (such as what happens in the fuel), the stoichiometry will also change slowly over time. These behaviors can lead to new material properties, cracking, and fission gas release.
The thermal conductivity of uranium dioxide is low; it is affected by porosity and burn-up. The burn-up results in fission products being dissolved in the lattice (such as lanthanides), the precipitation of fission products such as palladium, the formation of fission gas bubbles due to fission products such as xenon and krypton and radiation damage of the lattice. The low thermal conductivity can lead to overheating of the center part of the pellets during use. The porosity results in a decrease in both the thermal conductivity of the fuel and the swelling which occurs during use. 5.10
Radioisotope decay fuels 5.10.1 Radioisotope battery An atomic battery (also called a
nuclear battery or radioisotope battery) is
a device which uses the radioactive decay to generate electricity. These systems use radioisotopes that produce low energy beta particles or sometimes alpha particles of varying energies. Low energy beta particles are needed to prevent the production of high energy penetrating bremsstrahlung radiation that would require heavy shielding. Radioisotopes such as plutonium-238, curium-242, curium-244 and strontium-90 have been used.
Tritium, nickel-63, promethium-147, and technetium-99 have been tested. There are two main categories of atomic batteries: thermal and non-thermal. The non-thermal atomic batteries, which have many different designs, exploit charged alpha and beta particles. These designs include the direct charging generators, betavoltaics, the optoelectric nuclear battery, and the radioisotope piezoelectric generator. The thermal atomic batteries on the other hand, convert the heat from the radioactive decay to electricity. These designs include thermionic converter, thermophotovoltaic cells, alkali-metal thermal to electric converter, and the most common design, the radioisotope thermoelectric generator.
5.10.2 Radioisotope thermoelectric generator A radioisotope thermoelectric generator (RTG) is a simple electrical generator which converts heat into electricity from a radioisotope using an array of thermocouples. 238 Pu has become the most widely used fuel for RTGs, in the form of plutonium dioxide. It has a half-life of 87.7 years, reasonable energy density, and exceptionally low gamma and neutron radiation levels. Some Russian terrestrial RTGs have used 90 Sr this isotope has a shorter half-life and a much lower energy density, but is cheaper. Early RTGs, first built in 1958 by the U.S. Atomic Energy Commission, have used 210 Po. This fuel provides phenomenally huge energy density, (a single gram of polonium-210 generates 140 watts thermal) but has limited use because of its very short half-life and gamma production, and has been phased out of use for this application.
62 5.10.3 Radioisotope heater unit (RHU)
A radioisotope heater unit (RHU) typically provides
about 1 watt of heat each, derived from the decay of a few grams of plutonium-238. This heat is given off continuously for several decades. Their function is to provide highly localised heating of sensitive equipment (such as electronics in outer space). The Cassini–Huyges orbiter to Saturn contains 82 of these units (in addition to its 3 main RTGs for power generation). The Huygens probe to Titan contains 35 devices. 5.11 Fusion fuels
Fusion fuels
are fuels to use in hypothetical Fusion power reactors. They
include deuterium (2 H) and tritium (3
H) as well as helium-3 (3 He). Many other elements can be fused together,
but the larger electrical charge of their nuclei means that much higher temperatures are required. Only the fusion of the lightest elements is seriously considered as a future energy source.
Fusion of the lightest atom, 1 H hydrogen, as is done in the Sun and stars, has also not been considered practical on Earth.
Although the energy density of fusion fuel is even higher than fission fuel, and fusion reactions sustained for a few minutes have been achieved, utilizing fusion fuel as a net energy source remains only a theoretical possibility. 5.11.1
First-generation fusion fuel Deuterium and tritium are both considered first-generation fusion fuels;
they are the easiest to fuse, because the electrical charge on their nuclei is the lowest of all elements. The three most commonly cited nuclear reactions that could be used to generate energy

are: $^2H + ^3H \rightarrow n$ (14.07 MeV) + ^4He (3.52 MeV) $^2H + ^2H \rightarrow n$ (2.45 MeV) + ^3He (0.82 MeV) $^2H + ^2H \rightarrow p$ (3.02 MeV) + ^3H (1.01 MeV) 5.11.2 Second-generation fusion fuel Second-generation fuels require either higher confinement temperatures or longer confinement time than those required of first-generation fusion fuels,
but generate fewer neutrons. Neutrons are an unwanted byproduct of fusion reactions in an energy generation context, because they are absorbed by the walls of a fusion chamber, making them radioactive. They cannot be confined by magnetic fields, because they are not electrically charged.
This group consists of deuterium and helium-3. The products are all charged particles, but there may be significant side reactions leading to
the production of neutrons. $^2H + ^3He \rightarrow p$ (14.68 MeV) + ^4He (3.67 MeV) 5.11.3 Third-generation fusion fuel Third-generation fusion fuels produce only charged particles in the primary reactions, and side reactions are relatively unimportant.
Since a very small amount of neutrons is produced, there would be little induced radioactivity in the walls of the fusion chamber. This is often seen as the
Neutron Neutron Proton Proton
63
end goal of fusion research. ^3He has the highest Maxwellian reactivity of any 3rd generation fusion fuel. However, there are no significant natural sources of this substance on Earth. $^3He + ^3He \rightarrow 2p + ^4He$ (12.86 MeV) Another potential aneutronic fusion reaction is the proton-boron reaction: $p + ^{11}B \rightarrow 3\,^4He$ (8.7
MeV) Under
reasonable assumptions, side reactions will result in about 0.1% of the fusion power being carried by neutrons. With 123 keV, the optimum temperature for this reaction is nearly ten times higher than that for the pure hydrogen reactions, the energy confinement must be 500 times better than that required for the D-T reaction, and the power density will be 2500 times lower than for D-
T. 5.12
Nuclear Fuel
cycles A nuclear fuel cycle is the path that nuclear fuel (Uranium, Thorium, Plutonium, etc.) takes as it is used to generate power in a nuclear reactor. They describe where the material comes from and where it ends up. Different fuel cycles range from very simple to fairly complicated. We describe several of these below. 5.12.1 Once Through Cycle The simplest fuel cycle is the once-through cycle. It is the de-facto standard in most operating nuclear power plants, with a few exceptions in Europe and Asia. Uranium is mined, enriched, used in a reactor (where it becomes radioactive nuclear waste), and then stored until it is no longer dangerously radioactive. While this cycle is cheap, there are two major problems with it. Firstly, the waste is radioactive for hundreds of thousands of years. No one has been able to design a repository that is convincingly capable of storing material for that long. Secondly, Uranium is not the most abundant element on Earth, and in this kind of cycle, the global supply of cheap uranium could run low within 200 years. So much for sustainability! There are some deep-burn once- through cycles out there that have good sustainability properties though. 5.12.2 Closed Fuel Cycle Closing the fuel cycle involves recycling the nuclear waste as new fuel. Since the main component of nuclear waste is Uranium-238 (which can be transmuted to Plutonium, especially with advanced breeder reactors), we can get more energy out of the waste than in a once-through cycle. The recycling plant separates the good stuff from the bad stuff. The bad stuff is mostly fission products, the atoms that a Uranium atom becomes after it splits in the fission process. These fission products mostly decay to safe levels within 300-500 years, which is significantly shorter than standard nuclear waste. So, by closing the fuel cycle with standard reactors, we address the issue of nuclear waste identified in the once-through cycle. In this case, nuclear waste is a tractable problem. But most of the reactivity is coming from the mine, since standard reactors burn most of the fissile nuclide, U-235. Also, the reprocessing technology is expensive and separates out pure Plutonium, which could possibly be stolen, bringing a rogue entity closer to having a nuclear weapon. For these reasons, the USA does not currently recycle. There are ways to solve these issues.
Proton Proton

64 5.12.3 Breeder Fuel Cycle Breeder reactors can create as much or more fissile material (atoms that readily split) than they use. These special reactors are designed to have extra neutrons flying around, so that some can convert U-238 to Pu-239 (see above) and the others can run the reactor. Often, these special reactors are deemed "fast" reactors because the neutrons are moving through the reactor at higher speeds, on average. In a full breeder fuel cycle, we get the maximum use of the Uranium resources on Earth, and what we already know exists can last tens of thousands of years. The cycle has cost and proliferation concerns associated with any closed cycle. Additionally, we have significantly less operational experience with breeder reactors, so we would need to train builders and operators for such a machine. Using a Thorium cycle instead of a Uranium-Plutonium cycle may allow breeding in less exotic reactors. Using this kind of fuel cycle, nuclear power can truly be considered sustainable. 5.13 Nuclear Reactor: Principle and Types A nuclear reactor is a system that contains and controls sustained nuclear chain reactions. Reactors are used for generating electricity, moving aircraft carriers and submarines, producing medical isotopes for imaging and cancer treatment, and for conducting research. Fuel, made up of heavy atoms that split when they absorb neutrons, is placed into the reactor vessel (basically a large tank) along with a small neutron source. The neutrons start a chain reaction where each atom that splits releases more neutrons that cause other atoms to split. Each time an atom splits, it releases
large amounts of energy in the form of heat. The heat is
carried out of the reactor by coolant, which is most commonly just plain water. The coolant heats up and goes off to a turbine to spin a generator or drive shaft. Nuclear reactors are just exotic heat sources. 5.13.1 Main components • The core of the reactor contains all of the nuclear fuel and generates all of the heat. It contains low-enriched uranium (>5% U-235), control systems, and structural materials. The core can contain hundreds of thousands of individual fuel pins. • The coolant is the material that passes through the core, transferring the heat from the fuel to a turbine. It could be water, heavy-water, liquid sodium, helium, or something else. In the US fleet of power reactors, water is the standard. • The turbine transfers the heat from the coolant to electricity, just like in a fossil-fuel plant. • The containment is the structure that separates the reactor from the environment. These are usually dome-shaped, made of high-density, steel-reinforced concrete. Chernobyl did not have a containment to speak of. • Cooling towers are needed by some plants to dump the excess heat that cannot be converted to energy due to the laws of thermodynamics. These are the hyperbolic icons of nuclear energy. They emit only clean water vapor. It captures the essence of the system well. The water coming into the condenser and then going right back out would be water from a river, lake, or ocean. It goes out the cooling towers. As you can see, this water does not go near the radioactivity, which is in the reactor vessel.
65 5.13.2 Types of Reactors There are many different kinds of nuclear fuel forms and cooling materials can be used in a nuclear reactor. As a result, there are thousands of different possible nuclear reactor designs. Here, we discuss a few of the designs that have been built before, but don’t limit your imagination; over a million other reactor designs are possible. Dream up your own! Or, for fun you can try our Random Reactor Concept Generator or see a list of over a million options. 5.13.2.1 Pressurized Water Reactor The most common type of reactor. The PWR uses regular old water as a coolant. The primary cooling water is kept at very high pressure so it does not boil. It goes through a heat exchanger, transferring heat to a secondary coolant loop, which then spins the turbine. These use oxide fuel pellets stacked in zirconium tubes. They could possibly burn thorium or plutonium fuel as well. Pros: • Strong negative void coefficient — reactor cools down if water starts bubbling because the coolant is the moderator, which is required to sustain the chain reaction • Secondary loop keeps radioactive stuff away from turbines, making maintenance easy. • Very much operating experience has been accumulated and the designs and procedures have been largely optimized. Cons: • Pressurized coolant escapes rapidly if a pipe breaks, necessitating lots of back-up cooling systems. • Can’t breed new fuel — susceptible to "uranium shortage" 5.13.2.2 Boiling Water Reactor Second most common, the BWR is similar to the PWR in many ways. However, they only have one coolant loop. The hot nuclear fuel boils water as it goes out the top of the reactor, where the steam heads over to the turbine to spin it. Pros: • Simpler plumbing reduces costs • Power levels can be increased simply by speeding up the jet pumps, giving less boiled water and more moderation. Thus, load-following is simple and easy. • Very much operating experience has been accumulated and the designs and procedures have been largely optimized.

66 Cons: • With liquid and gaseous water in the system, many weird transients are possible, making safety analysis difficult • Primary coolant is in direct contact with turbines, so if a fuel rod had a leak, radioactive material could be placed on the turbine. This complicates maintenance as the staff must be dressed for radioactive environments. • Can't breed new fuel — susceptible to "uranium shortage" • Does not typically perform well in station blackout events, as in Fukushima. 5.13.2.3 Canada Deuterium-Uranium Reactors (CANDU) CANDUs are a Canadian design found in Canada and around the world. They contain heavy water, where the Hydrogen in H2O has an extra neutron (making it Deuterium instead of Hydrogen). Deuterium absorbs many fewer neutrons than Hydrogen, and CANDUs can operate using only natural uranium instead of enriched. Pros: • Require very little uranium enrichment. • Can be refueled while operating, keeping capacity factors high (as long as the fuel handling machines don't break). • Are very flexible, and can use any type of fuel. Cons • Some variants have positive coolant temperature coefficients, leading to safety concerns. • Neutron absorption in deuterium leads to tritium production, which is radioactive and often leaks in small quantities. • Can theoretically be modified to produce weapons-grade plutonium slightly faster than conventional reactors could be. 5.13.2.4 Sodium Cooled Fast Reactor These reactors are cooled by liquid sodium metal. Sodium is heavier than hydrogen, a fact that leads to the neutrons moving around at higher speeds (hence fast). These can use metal or oxide fuel, and burn a wide variety of fuels. Pros: • Can breed its own fuel, effectively eliminating any concerns about uranium shortages 67 • Can burn its own waste • Metallic fuel and excellent thermal properties of sodium allow for passively safe operation — the reactor will shut itself down safely without any backup-systems working (or people around), only relying on physics. Cons: • Sodium coolant is reactive with air and water. Thus, leaks in the pipes results in sodium fires. These can be engineered around but are a major setback for these reactors. • To fully burn waste, these require reprocessing facilities which can also be used for nuclear proliferation. • The excess neutrons used to give the reactor its resource-utilization capabilities could clandestinely be used to make plutonium for weapons. • Positive void coefficients are inherent to most fast reactors, especially large ones. This is a safety concern. • Not as much operating experience has been accumulated. We have only about 300 reactor-years of experience with sodium cooled reactors. 5.13.2.5 Molten Salt Reactor Molten Salt Reactor's (MSRs) are the internet's favorite reactor. They are unique so far in that they use fluid fuel. Pros: • Can constantly breed new fuel, eliminating concerns over energy resources • Can make excellent use of thorium, an alternative nuclear fuel to uranium • Can be maintained online with chemical fission product removal, eliminating the need to shut down during refueling. • No cladding means less neutron-absorbing material in the core, which leads to better neutron efficiency and thus higher fuel utilization • Liquid fuel also means that structural dose does not limit the life of the fuel, allowing the reactor to extract very much energy out of the loaded fuel. Cons: • Radioactive gaseous fission products are not contained in small pins, as they are in typical reactors. So, if there is a containment breach, all the fission gases can release instead of just the gases from one tiny pin. This necessitates things like triple-redundant containments, etc. and can be handled.

68 • The presence of an online reprocessing facility with incoming pre-melted fuel is a proliferation concern. The operator could divert Pa-233 to provide a small stream of nearly pure weapons-grade U-233. Also, the entire uranium inventory can be separated without much effort. In his autobiography, Alvin Weinberg explains how this was done at Oak Ridge National Lab: "It was a remarkable feat! In only 4 days all of the 218 kg of uranium in the reactor were separated from the intensely radioactive fission products and its radioactivity reduced five billion-fold." • Very little operating experience, though a successful test reactor was operated in the 1960s 5.13.2.6 High Temperature Gas Cooled Reactor HTGRs use little pellets of fuel backed into either hexagonal compacts or into larger pebbles (in the prismatic and pebble-bed designs). Gas such as helium or carbon dioxide is passed through the reactor rapidly to cool it. Due to their low power density, these reactors are seen as promising for using nuclear energy outside of electricity: in transportation, in industry, and in residential regimes. They are not particularly good at just producing electricity. Pros: • Can operate at very high temperatures, leading to great thermal efficiency (near 50%!) and the ability to create process heat for things like oil refineries, water desalination plants, hydrogen fuel cell production, and much more. • Each little pebble of fuel has its own containment structure, adding yet another barrier between radioactive material and the environment. Cons: • High temperature has a bad side too. Materials that can stay structurally sound in high temperatures and with many neutrons flying through them are hard to come by. • If the gas stops flowing, the reactor heats up very quickly. Backup cooling systems are necessary. • Gas is a poor coolant, necessitating large amounts of coolant for relatively small amounts of power. Therefore, these reactors must be very large to produce power at the rate of other reactors. • Not as much operating experience 5.14 Summary

69 5.15 Questions/ Self-Assessment questions Short questions 1. What is nuclear fission reaction? 2. What called nuclear fuel? 3. what are the common physical forms of nuclear fuel? 4. Nuclear fuel cycle? 5. What is CANDU? Descriptive questions 1. What is the difference between nuclear fission and fusion reaction? 2. describe different types of nuclear fuel. 3. What are the main components of nuclear reactor 4. what are the pros and cons of boiling water reactor? 5.16 Select Readings/ Suggested Readings 1. Energy, Environment Ecology and Society by Dr. Pushpendra 2. Introduction to Environmental Engineering and Science by Gilbert M. Masters 3. Nuclear Reactor Engineering by Dr. G Vaidyanathan 4. Nuclear Energy: Principles, Practices, and Prospects by David Bodansky 5. Nuclear Energy: What Everyone Needs to Know by Charles D. Ferguson

70 Unit 6: Bioenergy 6.1 Objectives 6.2 Introduction 6.3 Biomass Characteristics 6.4 Production of Energy from Biomass 6.5 Problems and Prospects 6.6 The pros of biomass energy 6.7 The cons of biomass energy 6.8 Summary 6.9 Questions/ Self-Assessment Questions 6.10 Selected Readings/ Suggested Readings 6.1 Objectives • To learn about different characteristics of biomass • To know the ways of production of energy from biomass • Pros and cons of biomass energy 6.2 Introduction Bioenergy is one of many diverse resources available to help meet our demand for energy. It is a form of renewable energy that is derived from recently living organic materials known as biomass, which can be used to produce transportation fuels, heat, electricity, and products. Bioenergy is a form of renewable energy generated when we burn biomass fuel. Biomass fuels come from organic material such as harvest residues, purpose-grown crops and organic waste from our homes, businesses and farms. Examples include burning wood to create heat, using biodiesel and ethanol to fuel vehicles, and using methane gas and wood to generate electricity. More recently, developed forms of bioenergy use materials called "biomass," such as sugar cane, grasses, straw, soybeans, and corn. Bioenergy, while still responsible for the release of carbon into the atmosphere, is considered less harmful than the burning of fossil fuels, as it utilizes and releases carbon currently in our modern cycle, whereas fossil fuels release carbon that has been stored away for long periods of time. Biopower technologies convert renewable biomass fuels into heat and electricity using processes like those used with fossil fuels. There are three ways to harvest the energy stored in biomass to produce biopower: burning, bacterial decay, and conversion to a gas or liquid fuel.

71 Demand for bioenergy production will increase, but must be achieved sustainably Modern bioenergy is the largest source of renewable energy globally, accounting for 55% of renewable energy and over 6% of global energy supply. The Net Zero Emissions by 2050 Scenario sees a rapid increase in the use of bioenergy to displace fossil fuels by 2030. Use of modern bioenergy has increased on average by about 7% per year between 2010 and 2021, and is on an upward trend. More efforts are needed to accelerate modern bioenergy deployment to get on track with the Net Zero Scenario, which sees deployment increase by 10% per year between 2021 and 2030, while simultaneously ensuring that bioenergy production does not incur negative social and environmental consequences. In accordance with these sustainability considerations, there is no expansion of cropland for bioenergy nor conversion of existing forested land into bioenergy crop production in the Net Zero Scenario. Total global bioenergy uses in 2030 under the Net Zero Scenario is only about 20% higher than in 2021, although this by itself is quite misleading. Over 35% of the bioenergy used in 2021 was from biomass for traditional cooking methods – practices that are unsustainable, inefficient, polluting and linked to 5 million premature deaths in 2021 alone. The use of this traditional biomass falls to zero by 2030 in the Net Zero Scenario in order to achieve the UN Sustainable Development Goal 7 on Affordable and Clean Energy. Modern bioenergy usage, which excludes traditional uses of biomass, nearly doubles from about 42 EJ in 2021 to 80 EJ in 2030. 6.3 Biomass Characteristics Several characteristics affect the performance of biomass fuel, including the heat value, moisture level, chemical composition, and size and density of the fuel. These characteristics can vary noticeably from fuel to fuel. In addition, natural variations of a given fuel type can be significant. Biomass is a promising option for providing locally produced, renewable energy in Pennsylvania. While it is not unusual for homes in the state to be heated with firewood, other forms of biomass fuel are not as common and commercial-scale use of biomass fuel is very limited. A person who plans to use biomass for fuel or design equipment for biomass heat needs to understand the performance characteristics of biomass in order to avoid possible problems and utilize the biomass effectively. Biomass can be a source of liquid fuel (e.g., biodiesel) or gaseous fuel (e.g., "wood gas"), but the most common use is as a solid fuel (e.g., wood, biomass pellets). This fact sheet presents some of the more important characteristics of solid biomass fuel and explains their significance. 6.3.1 Heat Value The heat value, or amount of heat available in a fuel (kJ/kg), is one of the most important characteristics of a fuel because it indicates the total amount of energy that is available in the fuel. The heat value in a given fuel type is mostly a function of the fuel's chemical composition. The heat value can be expressed in one of two ways: the higher heating value or the lower heating value. The higher heating value (HHV) is the total amount of heat energy that is available in the

72 fuel, including the energy contained in the water vapor in the exhaust gases. The lower heating value (LHV) does not include the energy embodied in the water vapor. Generally, the HHV is the appropriate value to use for biomass combustors, although some manufacturers may utilize the LHV instead, which can lead to confusion. Some species of biomass tend to have more energy per unit of mass than others. However, the variation between species is often no greater than the natural variations found within one species or another. The heat content of a fuel type can vary significantly depending on the climate and soil in which the fuel is grown, as well as other conditions. As a result, the energy content of a biomass fuel should be thought of as a range rather than a fixed value. Figure 1 shows the typical range of some common fuels. 6.3.2 Moisture Content Fresh, "green" wood is often about half water, and many leafy crops are primarily water. A low moisture level in the fuel is usually preferable because high-moisture fuels burn less readily and provide less useful heat per unit mass (much of the energy in wet fuel is used to heat and vaporize the water). Extremely dry fuel, however, can cause problems such as dust that fouls equipment or can even be an explosion hazard. The moisture content in a fuel can be calculated by one of two methods: wet basis or dry basis. In the case of wet-basis calculations, the moisture content is equal to the mass of water in the fuel divided by the total mass of the fuel. In the case of dry-basis calculations, the moisture content is equal to the mass of water in the fuel divided by the mass of the dry portion of the fuel. It is important to know which type of calculation is being used, as the two values can be quite different in magnitude. For example, a 50 percent wet-basis moisture level is the same as a 100 percent dry- basis moisture level. The practical maximum moisture level for combusting fuel is about 60 percent (wet basis), although most commercial equipment operates tolerably well with fuels that only have up to about 40 percent moisture. 6.3.3 Composition In addition to heat content, other differences in fuel performance are related to composition of the various biofuels. The three most significant compositional properties are (1) ash content, (2) susceptibility to slagging and fouling, and (3) percent volatiles. Ash content (the mass fraction of uncombustible material) is an important parameter, with grasses, bark, and field crop residues typically having much higher amounts of ash than wood. Systems that are designed to combust wood can be overwhelmed by the volume of ash if other biofuels are used, which can reduce the combustion efficiency or clog the ash handling mechanisms. Slagging and fouling are problems that occur when the ash begins to melt, causing deposits inside the combustion equipment. Ash ideally remains in a powdery form at all times. However, under some conditions, the combustion ash can partially melt, forming deposits on the combustor surfaces (fouling) or hard chunks of material in the base of the combustion chamber (slagging/clinkering). Certain mineral components in biomass fuels, primarily silica, potassium, and chlorine, can cause these problems to occur at lower temperatures than might be expected.

73 Many studies have observed that the high mineral content in grasses and field crops can contribute to fouling and clinkering--a potentially expensive problem for a combustion system. The timing of harvest can affect this property, with late harvested crops having noticeably lower ash content (Adler et al., 2006). Dirt in the fuel also adds to the mineral content and associated clinkering and fouling problems; therefore, fuel should be kept free of soil and other contaminants. Slagging and fouling can be minimized by keeping the combustion temperature low enough to prevent the ash from fusing. Alternately, some biomass combustion equipment uses an opposite approach--it is designed to encourage the formation of clinkers but is able to dispose of the hardened ash in an effective manner. 6.3.4 Fuel Size and Density The size and density of the biomass fuel particles is also important. They affect the burning characteristics of the fuel by affecting the rate of heating and drying during the combustion process. Fuel size also dictates the type of handling equipment that is used. The wrong size fuel will have an impact on the efficiency of the combustion process and may cause jamming or damage to the handling equipment. Smaller-sized fuel is more common for commercial-scale systems because smaller fuel is easier to use in automatic feed systems and also allows for finer control of the burn rate by controlling the rate at which fuel is added to the combustion chamber. Fuel size and density are probably the most over-looked factors affecting fuel performance and should be given careful consideration when selecting a fuel type. Several characteristics affect the performance of biomass fuel, including the heat value, moisture level, chemical composition, and size and density of the fuel. These characteristics can vary noticeably from fuel to fuel. In addition, natural variations of a given fuel type can be significant. Combustion equipment can and should be designed to handle this range of properties. 6.4 Production of Energy from Biomass

Although biomass is a term that is closely associated with ecology, it can also be defined and described in terms of energy. The biomass energy is one of the primary sources of energy for many activities. It is considered as the source of renewable energy since the primary source of this energy is plenty in this world. Most biomass comprises carbon, hydrogen, oxygen, nitrogen, and other alkali metals, which provide a large amount of energy when burnt. Organic materials like agricultural wastes, wood, and municipal wastes can be recycled for the production of biofuels. Definition of Biomass in terms of energy Definition of Biomass could be, the energy that is generated from biomass is called biomass energy. All organic matter that can produce energy when reactions are done with it can produce biomass energy. These can be wood, leaves, pellets, fecal wastes, and other organic matters. Technically speaking, biomass energy was discovered back during the ages when humans used to live in caves. Marco Polo, in the 13 th century, described the use of biomass for the production of fuel after taking inspiration from the Chinese who used to cover sewage tanks to generate biogas.

74 Biomass energy can be both renewable and non-renewable. The first source of energy in the production of biomass is the sun. The plants convert solar energy by photosynthesis into chemical energy as food and subsequently uses it in their growth, which is later converted to fuel. The energy derived from biomass can be processed directly by burning to produce heat, or converted directly into electricity, or can also be processed to produce biofuels in an indirect manner. 6.4.1 Plants that are a rich source of Biomass energy and hence considered for Biofuel production There are several plants that can be considered as a rich source of biomass energy and hence are often considered for the production of biofuels. Some of them include wheat, switchgrass, sunflower, cottonseed, mustard oil, corn, canola, sugarcane, soy plants, jatropha, palm oil, and many more. These plants are often cultivated in large fields for the production of biofuels. 6.4.2 Ways to produce Biomass energy- Thermal conversion One of the primitive ways of producing biomass energy is to burn the organic material and utilize the heat energy produced from it. The thermal conversion of biomass involves heating the feedstock so that energy is released, the feedstock is dehydrated, or the biomass is stabilized. The common source of biomass feedstock is the municipal solid wastes and also waste from lumber mills and paper factories. The different processes of thermal conversion are direct firing, pyrolysis, co-firing, gasification, as well as anaerobic decomposition. Before the biomass is burnt, they are needed to be dried. The chemical process of drying biomasses is called torrefaction. In this process, the biomass is heated to a temperature of 200 to 320ºC. The biomass not only loses all its moisture, and also loses the ability to absorb it. After torrefaction, the biomass is converted into a black dry material, which is then compressed to form briquettes. Briquettes are highly hydrophobic, thus enabling them to be kept in moist places. Also, the briquettes have high energy density and can easily be burnt by direct firing or co-firing. 6.4.3 Ways to produce Biomass energy- Biofuel Biomass is considered a renewable source of biofuels like biodiesel and ethanol. Such biofuels are used to power vehicles and machines in several countries like Austria, Sweden, and the United States of America. Ethanol is produced by the fermentation process of biomasses that are rich in carbohydrates, such as corn, wheat, and sugarcane. Biodiesel can be made by combining this ethanol with animal fat, vegetable oil, and recycled cooking fat. Biofuels do not produce as much energy and, therefore, not as effective as gasoline. However, they can be mixed with gasoline, and this mixture can be used to power automobiles and pieces of machinery used in several industries. By using such mixture, the emission of harmful gases, as observed in the case of fossil fuels, is greatly minimized.

75 6.4.4 Ways to produce Biomass energy- Biochar Biochar is a byproduct of the pyrolysis process of biomasses. It is considered to be a valuable source of energy for agriculture and other environmental uses. When biomass rots or burns, it releases large amounts of carbon dioxide and methane into the atmosphere. However, such emissions are prevented, and the process of charring these biomasses can retain the carbon content. When these biochars are added back to the soil, they can still absorb carbon from the surroundings. They can act as sequestered carbon sinks, which is beneficial for maintaining the quality of the soil it has been found that addition of biochars to the soil helps in increasing the quality and quantity of agricultural production. 6.4.5 Ways to produce Biomass energy- Black liquor Black liquor is a toxic byproduct in the production of paper from wood. Till the 1930s, this black liquor is considered as an industrial waste product and was dumped into the nearby water bodies. However, later it was found that the black liquor can retain almost 50% of the carbon content of the source material. Later it was used as a power source in several mills with the help of the recovery boiler. It was also tried to be gasified so that it can be used to generate electricity. 6.4.6 Ways to produce Biomass energy- Hydrogen fuel cells Hydrogen fuel cells are produced from biomass that is rich in hydrogen. These hydrogen atoms are chemically extracted from the biomasses and are used in batteries for generating powers and fuel machines and vehicles. These cells are mainly used for automobiles driven in remote locations, like wilderness areas or in spacecraft. Hydrogen fuel cells can be considered as an alternative source of energy for vehicles. In current times, these cells are used as a source of power for boats, buses, submarines, and forklifts. Testings are going on for their usage in airplanes as well. All living organisms can be considered as a rich source of energy. Most of our energy sources are carbon, hydrogen, and oxygen, and all these atoms make up the carbohydrate, which is an integral part of all living organisms. Biomass can be converted to different forms of energy, which can then be used in different ways like as fuel for automobiles, as a source of power for different industries, and to generate electricity. 6.5

Problems and Prospects The existing challenges of biomass supply chain related to different feedstock can be broadly classified into operational, economic, social and policy and regulatory challenges.

76 6.5.1 Operational Problems Feedstock unavailability: Inefficient resource management and the government non-intervention approach are the key factor hindering the expansion of the biomass industry. Regional and seasonal availability of biomass and storage problem: The seasonal variation results in the fuel price. As the energy density of biomass is low, acquisition of land for harvesting and storage is difficult. Pressure on transport section: Because of biomass moisture, transporting wet biomass from the plantation to the production site becomes energetically unfavorable and costly with increasing distance. Inefficiency of conversion facility, core technology and equipment shortage: Technical barriers were resulted from the lack of standards on bioenergy systems and equipment, especially where the energy sources are so diverse. Appropriate pretreatment required to prevent biodegradation and loss of heating value, not only increases the production cost but also in equipment's investment. Immature industry chain: It is virtually impossible to get long term contracts for consistent feedstock supply in reasonable price. The low ability to gain profits is also a reason that many upstream firms lack driving forces in the technology reform. 6.5.2 Economic problems Feedstock acquisition cost: The biomass resources are scattered and in order to reduce the cost of transportation, biomass projects are eager to occupy land close to the source, leading to centralization of biomass projects. Limiting financing channels and high investment and capital cost: Because of decentralized capital, poor profitability, frequent fluctuations of international crude oil prices and high market risk, seldom investors took an initiative part in the biomass power generation industry. The biomass power generation is subjected to constraints of excessive investment and high operating costs. Biomass pre-treatment technologies have extra costs, which scattered farmers and small- scale fuel companies may not be able to afford. 6.5.3 Social Problems Conflicting decision: Decision making on selection of supplier, location, routes & technologies is crucial and needs proper communication. By strengthening leadership and implementing the

77 responsibilities, the stakeholders should be made fully aware of the economic, environmental and social wealth of resource utilization. Land use issues: Land use issues leads to the loss of ecosystems preservation and the homes of indigenous people. Impact on the environment: The biomass plantation depletes nutrients from soil, promote aesthetic degradation and increase the loss of biodiversity. Other social impacts will result from installation of energy farms within rural areas like increased need of services, increased traffic, etc. The potential negative social impacts appear strong enough to ignore the benefit of new and permanent employment generation. 6.5.4 Policy and Regulatory Problems Policies: At present, the government is subsidizing the domestic fuel price which in turn makes the electricity generating cost from conventional sources lower than the power production cost from renewable fuels. System: There are no specific rules to regulate the work of utilization of biomass resource, and there are no specific penalties for not using behavior that should be comprehensively used. Regulation: There is no special mechanism to manage the development of biomass resources industry and no specialized department to manage the implementation of relevant national standards and policies. 6.6 The pros of biomass energy a. Renewable As the availability of biomass sources such as plants, manure and waste may not diminish compared to finite fossil fuels, the alternative source of energy is considered by many as a renewable form of energy. Trees and crops can be replanted to offset those that are removed – although effective agricultural and land management is essential to ensure resources do not become depleted faster than they are used. Other organic materials such as food and animal waste are constantly being produced, and on a much shorter timescale than it takes for trees to be cultivated. b. Reduced dependence on fossil fuels As biomass sources can be converted to fuels and electricity, they can help in reducing the dependence on fossil fuels. The global energy system is shifting its focus away from fossils like coal, oil and gas as measures are taken to address climate change, meaning new sources of energy are needed to fill the gap.

78 While renewable technologies like wind and solar will likely dominate the future energy mix, biomass-fired power generation has also emerged in this transitional period. Many former coal plants are in the process of converting their existing equipment to run on biomass feedstocks. Meanwhile, biofuels will be important alternative energy carriers to fuels like diesel and petroleum, to be used in transport, heating and some industrial processes. c. Carbon neutral There is some debate about whether or not biomass can in fact be considered a carbon-neutral source of energy. The argument in favour is due to the fact that, although carbon emissions are released when burning, plant material like trees actually remove CO2 from the atmosphere during their lifetime through photosynthesis. The balance of this equation largely comes down to sustainable and responsible crop management. If biomass power plants can be equipped with effective carbon capture and storage technologies, there is an extra dimension to claims of carbon neutrality – and some companies have even made bold claims for becoming carbon-negative using this technique. There is another aspect to consider too. As the International Energy Agency says: "The full supply chain must be considered, and all emissions associated with the production, processing, transport and use of bioenergy need to be included." d. Waste reduction Generating energy from organic waste materials can greatly help in waste management, which has become a major issue in many countries. A number of waste-to-electricity power plants have been developed around the world, which can provide an alternative destination for discarded biomass materials, rather than being sent to landfills. There is a growing availability of animal and plant waste, as production and consumption levels continue to rise, and finding ways to re-use these materials will be an important aspect of future sustainability goals. 6.7 The cons of biomass energy a. Emissions Like fossil fuels, biomass releases carbon dioxide emissions upon combustion.

79 While there is an argument for carbon balancing – due to the carbon dioxide that is removed from the atmosphere by trees and plants during their lifetimes via photosynthesis – these are nevertheless emissions that could be avoided if other renewable sources like wind or solar were used instead. In addition to CO 2 , burning biomass fuels results in the release of various other harmful gases such as carbon monoxide, NOx (nitrogen oxides), and VOCs (volatile organic compounds), which all contribute to air pollution. b. Deforestation Providing the feedstock used in biomass power plants – frequently in the the form of wood pellets – requires large areas of forest and woodland to be cut down. Proponents will argue that all trees are replaced with new ones, that can grow, remove carbon, and be used for future energy needs – but this cycle requires strict adherence to sustainable land management and responsible agriculture throughout the supply chain. And as biomass power stations grow in number, demand for these materials will multiply accordingly – exerting greater pressure on a natural resource that is already under threat from other industries. There are biodiversity considerations too, because while an area of forest might be replaced to grow anew over time, the wildlife and ecosystems that are displaced by these actions are faced with a more immediate challenge that is not solved by planting young trees. c. Cost The construction and operating costs of a biomass energy plant can be expensive in relation to traditional forms of power generation. Storage facilities require huge space, as harnessing energy from biomass involves numerous different processes. Also, extraction of biomass materials can be an expensive task due to a great variability in sources – while the high-water content in many biomass materials can increase the costs of transportation. d. Other issues The seasonality of biomass supply and a wide variability in available sources present a potential challenge for biomass energy plants.

80 Facilities must be able to cope with the ups and downs associated with the changing of the seasons, which can vary greatly. Energy generation from biomass containing multiple components may also not have the same efficiency compared to the usage of single source. 6.8 Summary 6.9 Questions/ Self Assessment Questions Short questions: 1. What is bioenergy? 2. what is biochar? 3. What is Hydrogen fuel cell? Descriptive questions: 1. Elaborate different characteristics of biomass. 2. How to produce biomass energy from biofuel? 3. What are the definite problems of bioenergy production? 4. Benefits of biomass energy? 6.10 Selected Readings/ Suggested Readings Adler, P., M. Sanderson, A. A. Boateng, P. J. Weimer, and H. J. G. Jung. "Biomass Yield and Biofuel Quality of Switchgrass Harvested in Fall or Spring." Agron. J. 98 (2006): 1518-25. Bain, R., W. Amos, M. Downing, and R. Perlack. Biopower Tech nical Assessment: State of the Industry and Technology. National Renewable Energy Laboratory Report # NREL/TP- 510-33123. Golden, Colo.: National Renewable Energy Laboratory, 2003. Bergman, R., and T. M. Maker. Fuels for Schools: Case Study in Darby, Montana. General Technical Report FPL-GTR-173. Madison, Wis.: USDA Forest Service, Forest Products Laboratory, 2007. Demirbas, A. "Calculation of Higher Heating Values of Biomass Fuels." Fuel 76, no. 5 (1997): 431-34. Dinkelbach, L. Thermochemical Conversion of Willow from Short Rotation Forestry. European Union Project Report ECN-C-00-028, 2000. Dobie, J., and D. Wright. Conversion Factors for the Forest Products Industry in Western Canada. West. For. Prod. Lab. Inf. Rep. VP-X-97. Canadian Forest Service, 1972.

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Course: Environmental Pollution, Degradation and Control Contents UNIT 1: Air Pollution
Netaji Subhas Open University P.G. Environmental Science PGES-CC-201
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Summary 1.16 Questions/ Self-Assessment questions 1.17 Select Readings/
Suggested Readings 1.1 Objectives After successfully completing this unit, you will be able to: ➢
learn about the different air pollution sources, ➢ understand different types of

pollutants and their transmission, ➢ outline different inorganic, particulate, organic and bio-pollutants ➢ know the atmospheric stability and pollutant dispersion mechanism, ➢ learn about acid rain phenomenon and its associated problems, ➢ understand the different adverse effects of air pollution, ➢ comprehend the control mechanism of air pollution, ➢ understand the ambient air quality standards and legislation. 1.2 Introduction The biosphere's main component, the atmosphere, is a dynamic system that continuously ingests a variety of particles from both natural and artificial sources, including solids, liquids,

2 and gases. These substances scatter through the air, interact chemically and physically with one another, and move around. The majority of these components eventually end up in a repository like the ocean or a receptor like a person. Yet, some chemicals, like helium, escape the biosphere. Others, like carbon dioxide, may enter the atmosphere more quickly than they could enter a reservoir, slowly accumulating in the air. 78.09% nitrogen and 20.94% oxygen make up the volume of pure, dry air. The remaining 0.97% of the atmosphere is made up of a gaseous combination of carbon dioxide, helium, argon, krypton, nitrous oxide, and xenon, as well as very minute amounts of a few additional organic and inorganic gases whose concentrations in the atmosphere change with time and location. Through both natural and artificial activities that take place on earth, different quantities of pollutants are constantly released into the atmosphere. Man has dubbed these compounds "pollutants" for the fraction of them that interacts with the environment to cause toxicity, sickness, aesthetic distress, physiological impacts, or environmental destruction. Generally speaking, human activity is the main contributor to pollution, and as the population grows, so do the associated pollution issues. With the discovery of fire, man's impact on nature saw its first major alteration. In his cave, prehistoric man lit a fire for lighting, cooking, and heating. At this period, the issue of air pollution first emerged. "

Air pollution means the presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odor, smoke, or vapour, in quanti-ties, with characteristics, and of durations such as

to be injurious to human, plant, or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property." -

Engineers Joint Council (U.S.A.) "Air pollution is the presence in ambient atmosphere of substances, generally result-ing from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property." - Indian Standards Institution IS-4167 (1966). "Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well-being of the individual or causes damage to property." - American Medical Association Since

3 1.3 Types of Air Pollutants Air pollution may come from numerous human activities like industrial processes or it may come from the natural world. The by-products of internal combustion, such as the reactions in gasoline and diesel engines, or by-products of external combustion, such as smoke, dust, and sulphur oxides, can also be considered industrial pollutants. Moreover, the emissions may be main pollutants or secondary pollutants. The numerous pollution sources can also be roughly divided into fixed sources and mobile ones. In the pages that follow, each of these is explained in further depth. Air pollutants can be classified as follows a. Based on where the pollutants came from. They are divided into two categories: primary pollutants and secondary pollutants. i. Principal air pollutants are those released from known sources directly. Primary air contaminants include: 1. Less than 100 μm diameter particles, 2. Large particles (diameter higher than 100 μm), 3. Sulfur compounds, 4. Nitrogen oxides 5. Carbon monoxide, 6. Halogen substances 7. Organic substances 8. Radioactive substances, 9. Finer aerosols contain metal, charcoal, tar, glue, pollen, microorganisms, and other particles. ii. Secondary air pollutants are those that are released into the atmosphere as a result of interactions between two or more main pollutants or as a result of chemical reactions with regular atmospheric elements, either with or without photoactivation. Secondary air pollution examples include: 1.Ozone, 2. Formaldehyde, 3. PAN (peroxy acetyl nitrate), 4. Smog that is photochemical, 5. When water droplets are present in the atmosphere, sulphur dioxide and dissolved oxygen combine to form acid mists (H_2SO_4). b. On the basis of physical state, air pollutants are categorized into three types: i. Solid air pollutants: Carbon particles, etc. ii. Liquid air pollutants: H_2SO_4, HNO_3, etc. iii. Gaseous air pollutants: CO, NOx, SOx c. Based on how contaminants enter the atmosphere and their form, the sources are divided into three categories: point, line, and area/volume sources. They come in both instantaneous and continuous varieties.

4 i. Point Source – It is the continuous emission of pollutants into the atmosphere from a single spot, such as the stack of a power station. The point at which pollution is not continuously emitted is known as an instantaneous source. Examples include volcanic eruptions. ii. Line Source—This type of emission is described as the entry of pollutants into the atmosphere through a source that has a line shape, such as automobile exhaust pollution, which emits pollutants continuously. An instantaneous line source of pollution is a line- shaped source, such as an aeroplane spraying pesticides, through which the emission of pollutants is not continuous. iii. Area/Volume Source – It is the continual release of pollutants into the atmosphere from an area or volume source, such as the industrial city core. An instance of an instantaneous area/volume source is the blasting of a poison gas tank, where the discharge of contaminants is not continuous. d. Depending on the chemistry of the contaminants. They are divided into two categories: i) organic pollutants and ii) inorganic pollutants. (i) Organic Pollutants - PAN (Peroxy Acetyl Nitrate) and hydrocarbons are examples of pollutants that are made up of organic elements and exhibit features of organic molecules. (ii) Inorganic Pollutants - The pollutants that are made of substances that resemble inorganic substances, such as CO, SO 2 , and NO 2 , are referred to as inorganic pollutants. e. Based on the state of matter in which they are found in the atmosphere they are divided into two categories: i) gaseous pollutants and (ii) particulate pollutants. (i) Particulate pollutant: These are the tiny, finely divided solid and liquid particles that are produced during combustion and found in the atmosphere. Their sizes range from 500 nm to 0.0002 nm. They are primarily transported through smoke, dust, etc. because of their extremely reactive chemical characteristics. (ii) Gaseous Pollutants - Gaseous pollutants are pollutants that exist in the form of gases, such as Carbon-di-Oxide, Sulfur-di-Oxide, etc.

5 f. Based on the origin, air contaminants are classified into two types: i. Natural contaminants: e.g., natural fog, pollen grains, bacteria, and products of volcanic eruption. ii. Aerosols (particulates): e.g., dust, smoke, mists, fog and fumes. iii. Gases and vapors 1.3.1 Natural Contaminants Pollen is a significant natural contaminant because some people find its distinctive qualities annoying. Gymnosperm and angiosperm male gametophytes called pollen grains are released into the atmosphere by weeds, grasses, and trees. Many pollen grains are released due to wind pollination. While the majority of pollen grains carried by air are between 10 and 50 (microns) in size, some have been discovered to range in size from 5 to 100 um. Because they trigger allergic reactions in sensitive people, airborne contaminants are important from a pollution perspective. Many people experience hay fever or asthma. While the majority of patients have a straightforward form of hay fever, where symptoms go away at the pollen season. 1.3.2 Aerosols/Particulate Pollutants The dispersion of microscopic-sized solid or liquid particles in gaseous medium, such as dust, smoke, or mist, is referred to as an aerosol. A colloidal system with a gas as the dispersion medium and a solid or liquid as the dispersed phase is known as an aerosol. When anything is suspended in the air, the term "aerosol" is employed. The word no longer applies once it has settled, whether due to its weight, agglomeration, or impact on a surface made of solid or liquid. Hence, particulate matter only constitutes an air pollution when it takes the form of an aerosol. Nonetheless, both as an aerosol (which reduces visibility) and as settled or deposited waste, it is an annoyance (soiling of surfaces, corrosions). In terms of particle size, particle density, and their significance as pollutants, aerosols vary greatly. They typically have dimensions between 0.01 o and 100 µm, or less. The different aerosols are listed below. a. Dust: Solid particles that are primarily larger than those present in colloids and capable of momentarily suspending in air or other gases make up dust. They don't typically flocculate until there are electrostatic forces at play, and when gravity is at play, they don't diffuse but instead settle. Dust is created when organic and inorganic materials are crushed, ground, etc. They typically have a diameter of over 20, however some are smaller. Fly ash from chimneys ranges from 80 to 3; cement is between 150 and 10; and foundry dust is between 200 and 1. The majority of dust particles fall to the ground as they are, but those that are five microns or smaller usually form stable suspensions. b. Smoke: Finely fragmented particles created by imperfect mixing make up smoke. It primarily comprises of carbon particles and other flammable substances. The particles

6 are often smaller than 1 in size. Oil smoke particles range in size from 1.0-0.03 p, while coal smoke particles range in size from 0.2-0.01 µm. c. Mists: This phrase describes a low concentration dispersion of sizable liquid particles. It refers to a light dispersion of tiny water droplets hanging in the atmosphere in meteorology. The size of naturally occurring mist particles, which ranges from 500 to 40, is relatively enormous. The fragments might combine. Mist is a suspension of liquid droplets that is created when vapour condenses. They range from 40 to 500 microns in size. d. Fog: Visible aerosols with a liquid-like dispersion phase are referred to as fog. Condensation-based formation is typically suggested. It is the dispersion of water or ice in the atmosphere close to the earth's surface that causes visibility to drop to less than km in meteorology. The size of the particles in natural fog ranges from 40 to 1.0. e. Fumes: These are solid particles with a size range of 0.03 to 1 microns that are produced by condensation from the gaseous state, usually after volatilization from melted materials, and frequently in conjunction with a chemical process like oxidation. Fumes sometimes agglomerate and flocculate. f. Smog: The photochemical reaction between particulate matter and water molecules creates smog, which is a suspension of smoke particles and condensed liquid droplets. g. Haze: It is a type of air pollution brought on by the presence of very small particles of dust in the atmosphere. In terms of Coefficient of Haze (COH), it is as follows: COH = 100 (log), or transmittance at 100%. 1.4 Important Gaseous Pollutants The gases in air pollution are as follows: 1.4.1 Oxides of sulphur One of the main components of air pollution is this. Often abbreviated as SOx, this combination. The components of SOx are SO 2 , (97 to 99%), and SO 3 , (1 to 3%). It is a heavy, water-soluble gas that is colourless and has an offensive smell. Quickly dispersing oxidising agent that produces acid. React with minerals, metals, and organic substances. Reacts with water to generate H 2 SO 4 . Volcanic activity and other natural sources, over which humans have no influence, are responsible for over 67% of the SOx pollution in the world. The remaining 33% of SO2 emissions are caused by human activity, including fuel combustion, coal-fired power plants, transportation, refineries, metallurgical processes like the smelting of sulphide ores, and chemical plants like those that produce sulfuric acid. Urban and industrial regions are where the majority of man-made SOx pollution is found. The burning of fuels, particularly coal, is the principal source of sulphur dioxide. As a result, the sulphur content of the fuel used to generate electricity and heat buildings determines how much of it is present in the atmosphere. Fuels range in sulphur content from under 1% for high-quality anthracite to over 4% for bituminous coal.

7 Most crude petroleum products have sulphur content of less than 1%; a handful have up to 5%. Sulfur compounds are frequently concentrated in the heavier fractions throughout the refining process. Sulfur is also present in fuel gases, but only in trace amounts. Flue gases contain sulphur dioxide, which accounts for virtually all of the sulphur in liquid and gaseous fuels and around 80% of the sulphur in coal. The inorganic sulphur that is still present in coal and so persists in the ash. Sulfur dioxide levels in flue gases typically vary from 0.05 to 0.25 percent, but they can occasionally reach 0.4%. Metal-lurgical processes are another frequent source of sulphur dioxide in the environment. The main component of several ores, including zinc, copper, and lead, is sulphur. Sulfur dioxide is released from these ores during smelting in stack concentrations of 5–10%. (SO2). Nonetheless, this can be recovered as sulfuric acid. Sulfuric acid facilities and paper mills are two examples of the several industries that release sulphur dioxide into the atmosphere. The amounts are typically small, making control measures simple to implement. Municipal incinerators and open burning of waste both release some sulphur dioxide into the sky. Photochemical smog is created when photolytic and catalytic processes involving ozone, NOx, and hydrocarbons convert SO2 to SO3 in atmospheric air. SO2 can be oxidised in the presence of catalysts like NOx, metal oxides, soot, and dust. When the atmosphere is normally humid, SO3 combines with water vapour to form H2SO4, aerosol particles, which result in the so-called "acid rain" that will be covered later. SO 2 + O 3 → SO 3 + O_2 SO 3 + H_2O → H_2SO 4 → (H_2SO 4)n SO_2+ ½ O2 + H 2 O → (Catalyst such as metal oxide, soot etc.) H_2SO4 → aerosol (H_2SO4)n Controlling SOx emissions caused by human activity is envisioned along these lines: (1) Taking away SOx from polluted gases into the atmosphere can be achieved by using chemical scrubbers like (a) lime stone or (b) citric acid are advised. 2 CaCO, + 2SO 2 +O_2 → 2 CaSO 4 , + CO_2 (2) Sulfur removal from fuels for combustion: Coal washeries can grind and wash coal to remove pyrite sulphur. Unfortunately, it is difficult to extract sulphur from charcoal that has been biologically bonded. A specific class of microorganisms that can transform organically bound sulphur into soluble form is being created through biotechnology research. (3) Using fuels with little sulphur.

8 (4) generating power from alternative energy sources and preventing the construction of thermal power facilities that rely on fossil fuels. Effects: Quick absorption and irritation of the upper respiratory tract are the biochemical consequences. reacts with the molecules that make up cells, like enzymes. The H.SO that is produced lowers pH, hinders enzyme activity, and obliterates several useful molecules. causes bronchial spasms, shortness of breath, decreased lung clearance, reduced pulmonary function, and increased susceptibility to infection. 1.4.2 Nitrogen oxides Next to sulphur dioxide,
nitrogen oxides are perhaps the second most prevalent atmospheric pollutants in many cities. Only nitric oxide and nitrogen dioxide,
which are produced by a variety of human activities and are categorised as pollutants, are two
of the seven nitrogen oxides (N 2 O, NO, NO 2 , NO 3 , N 2 O 3 , N 2 O 4 , N 2 O 5).

They are typically listed as "total oxides of nitrogen," or "NO," in atmospheric analyses. Out of the seven potential nitrogen oxides, only N 2 O, NO, and NO 2 are significant atmospheric components. NO, NO 2 , and N 2 O make up the majority of NOx. NO is a colourless gas that has a negligible water solubility. NO 2 is a reddish- brown gas that is an oxidising agent and relatively water soluble. It may combine with water to generate HNO 3 , a strong oxidising agent that can react with practically all metals and many organic compounds. Inhalation of NO 2 can enter the respiratory system. Moreover, it contributes to ozone synthesis in the atmosphere. N 2 O, NO, and NO 2 have background atmospheric values of 0.25 ppm, 0.1 to 2 ppm, and 0.5 to 4 ppm, respectively. Although N2O concentrations are higher in the atmosphere, NO and NO 2 are more important from the perspective of air pollution, and they are typically referred to as NO. High temperatures (between 1210 and 1765°C), which are typically reached in the combustion processes involving air, are favourable for the production of NO from N 2 and O 2 . NO does not dissociate when the combustion products are quickly cooled (quenched). High temperatures (1100°C) also encourage the oxidation of NO to NO 2 , but the amount of NO2 produced is typically less than 0.5% of the total NOx present. The effluents from companies where nitric acid is produced or employed in chemical reactions often have the highest concentration of nitrogen oxides in gaseous emissions. In automotive exhaust, the concentration is the second highest. Then follow the effluents from big power plants and, to a lesser extent, those from furnaces and burners with low heat. As was previously mentioned, photolytic reactions in the environment also produce NO2. Here are a few of the possible
reactions: N 2 + O 2 → [1210-1765 °C) 2NO 2NO+ O_2 → 2NO 2 NO 2 + hv → NO+O O_2+ hv → 398 nm 2O + O* O+ O_2+ M → 242 nm O3 + M
9 03+NO → (third body) NO 2 +O 2 O3 + NO → N_2 0, $+0_2$ 4NO 2 + 2H 2 O + O 2 - → 4HNO, Alternative Mechanism for Nitric Acid formation (a) O 3 + NO_2 → NO 3 + O_2 (b) NO + NO 2 → N 2 O 5 (c) N_2O 5 + H_2O → 2HNO 3 Both spontaneous and artificial nitrogen fixation from the environment as well as nitrogen molecules found in organic matter can result in the formation of nitrates of nitrogen. About 5 x 10' tonnes of NOx are released globally each year from artificial sources, which is only marginally less than the amount released by bacterial activity in the environment. Nitrogen oxides are created through the burning of organic materials including coal, oil, and natural gas. Hence, NOx is released into the atmosphere through sources like as coal-fired power stations, incinerators, furnace stacks, and other similar sources. Some of the N in the air is converted to NO when fuels are burned in the presence of air. The temperature of the flame and the rate at which the combustion products cool or are quenched affect how much NO is produced. The generation of NO is aided by higher flame temperatures and quick cooling of the combustion products. NO and NO 2 , respectively, spend an average of 4 days and 3 days in the atmosphere. In the atmosphere, they go through a variety of photochemical and chemical processes that result in the creation of HNO, which precipitates as nitrates during rain or as dust. In comparison to rural locations, urban areas may have 10 to 100 times more NOx from man- made sources. Even in metropolitan regions, the ambient NOx levels change according on the time of day and the amount of traffic. Photo-chemical smog is created as a result of chemical and photo-chemical processes involving NO 2 , hydrocarbons, and sunlight. Using two stage catalytic converters can reduce the NOx from vehicle emissions, as was covered in the prior section. Similar to this, a two-stage combustion method can cut NOx emissions from power plants by 90%. It is possible to ignite the fuel at a reasonably high temperature using just approximately 90% of the necessary stoichiometric air, resulting in the formation of a negligible amount of NO in these circumstances. The fuel can then burn completely in the extra air at a relatively low temperature. NO does not form in these circumstances. Biochemical effects: oxidises lipids within cells, combines with haemoglobin to form connections that decrease the effectiveness of oxygen delivery. some cellular enzyme systems are disrupted. Greater concentrations and extended exposures could result in pulmonary fibrosis, an inflammation of the lung tissues that could ultimately result in death. causes some actions of nitric acid that are comparable to those of H2SO4 that were previously described. If NO2 enters the bloodstream, it can combine with haemoglobin to generate other compounds.

10 1.4.3 Hydrogen Sulphide The gas hydrogen sulphide has a bad odour. Anaerobic biological degradation processes on land, in marshes, and in the water are some of the origins of its natural emission. Natural water springs and volcanoes both release some hydrogen sulphide. The Kraft pulp sector, which uses a sulphide method to make paper, is one of the main emitters of hydrogen sulphide. Other industrial sources of hydrogen sulphide include chemical factories, coke ovens, viscose rayon facilities, and petroleum refineries. The strong scents of methyl mercaptan (CH3 SH), dimethyl sulphide (CH3-S-CH3), dimethyl disulphide (CH3 SS CH3), and their higher molecular homologs make these sulphur compounds and others of interest in the study of air pollution. Certain pulp mills, oil refineries, and chemical industrial facilities release combinations of pollutants, including mercaptans. 1.4.4 Hydrogen Fluoride The production of phosphate fertilisers, the aluminium sector, brick manufacturing, pottery production, and ferro-enamel works are the main producers of fluorides. Other metallurgical processes, such zinc foundries and open-hearth steel furnaces, also release small amounts. The burning of coal, which typically contains 0.01% fluorine, also releases small amounts. Even at extremely low quantities of 0.001-0.10 ppm by volume, hydrogen fluoride is a significant air pollutant. When present at these concentrations, hydrogen fluoride causes more harm to plants and animals than it does to people. For enterprises producing aluminium and phosphate fertilisers, the regulation of such emissions is essential due to the high level of toxicity of fluorine compounds. 1.4.5 Hydrogen chloride with chlorine The element chlorine itself, hydrogen chloride, chlorine-containing organic molecules like perchlorethylene, and inorganic chlorides are all present in contaminated atmospheres. The last compound is a solid and is therefore found in particulate form, whereas the previous compounds are gases. The production of chlorine or its usage in the synthesis of other chemicals are the most frequent sources of chlorine in the atmosphere. Equipment malfunction can occasionally cause chlorine to escape into the atmosphere since chlorine is utilized in swimming pools, sewage treatment facilities, and water purification facilities. Several industrial chemical processes produce hydrogen chloride, but because it is so easily recovered, very little of it ends up in the environment. The principal impacts of chlorine and its derivatives include irritation of the respiratory system, corrosion caused by hydrogen chloride, and harm to vegetation.

11 1.4.6 Combustible Oxide The primary source of

carbon monoxide, an odourless and colourless gas, is the incomplete combustion of carbonaceous materials. It is a very dangerous gas that is typically categorised as an asphyxiant.

Combustion, mainly from car exhausts, is the main cause of carbon monoxide in the environment. Yet, relatively little carbon monoxide is present in the gaseous emissions from well adjusted, correctly functioning equipment, with the exception of motor cars and other internal combustion engines. Automobile exhausts are by far the most significant generator

of carbon monoxide in the atmosphere, even if other industrial processes such as electric and blast furnaces, some petroleum refining operations, gas producing plants, and coal mines are also potential contributors. 1.4.7

Ozone Ozone is a light blue gas with some water solubility, instability, and a sweetish odour. a very reactive oxidising chemical that can combine with rubber and other materials as well as numerous organic molecules found in organisms and tissues. Plants, animals, and people can all be harmed by O and PAN. Although the source of the ozone that is found in the air is unknown, it is most likely a combination of sunlight and combustion. Ozone is toxic and odorous. Under natural circumstances, it is very prevalent in the high atmosphere. Biochemical effects: Oxidize the components of cells. The creation of free radicals results in the toxicity of PAN and ozone. The generated free radicals may harm DNA, changing cellular genetic integrity as a result. After inhalation and absorption in the lungs, the harmful effects of ozone become apparent and result in fluid buildup in the lungs (pulmonary edoema), damage to the capillaries in the lungs, and, in the case of prolonged or high exposure levels, fatality. The eyes and respiratory system become irritated by both 0 and photochemical smog. The sulphydryl groups on enzymes are attacked by free radicals produced by oxygen and other photochemical oxidants, which also renders enzymes like isoctric dehydrogenase, malic dehydrogenase, and glucose-6-phosphate dehydrogenase inactive. These enzymes are heavily involved in the citric acid cycle and the production of cellular energy. Several enzymes involved in the synthesis of cellulose and lipids in plants may similarly be inhibited by O3. Cysteine is one of the sulfur-containing amino acids that PAN attacks most vigorously. 1.4.8 Aldehydes They are created from the burning of fuels like gasoline, diesel, fuel oil, and natural gas. Aldehydes are created when motor fuel and lubricant oils undergo incomplete oxidation. There is a possibility that lower aldehydes exist in the environment at levels comparable to sulphur dioxide. They might also develop in the atmosphere as a result of photochemical reactions. The eyes are irritated by formaldehyde.

12 1.4.9 Chemical Vapors Many chemical substances, such as paraffins, olefins, acetylenes, aromatic hydrocarbons, chlorinated hydrocarbons, etc. are among these pollutants. They are created through petroleum operations, home incinerators, and combustion processes, particularly in autos. Also, it's likely that they cause changes in the atmosphere that lead to the development of smog. 1.4.10 Radioactive Gases The nuclear power plant and associated fuel management facilities are a significant producer of radioactive gases and particulates. Other sources include experimental accelerators, atmospheric nuclear bomb tests, and the use of radioactive isotopes in industry, agriculture, and medicine. Nuclear fuel reprocessing facilities are a further source of radioactive particles and gases that are becoming more significant. 1.4.11 Smog Smoke and fog are two adjectives that are synonymous with smog. Smog can be either coal- or photochemical-induced. Only heavily populated sections of metropolitan cities, like Los Angeles, have photochemical haze. It happens when the air movement is constrained and there are poor meteorological conditions. When certain hydrocarbons and oxidants interact, hazardous peroxy acetyl nitrate is produced under the effect of sunlight, which is the source of smog (PAN). Nitrogen oxides, PAN, hydrocarbons, carbon monoxide, and ozone make up the majority of its components. It impairs visibility, irritates the eyes, harms plants, and causes rubber to fracture. When the temperature is below 10°C and the weather is calm, coal-fired power plants produce fog that blankets urban areas at night or on chilly days (December 1952). Fly ash, sulphur compounds, and smoke make up this fog. Long-term smog exposure may increase the risk of death, especially in the elderly and those with a history of chronic bronchitis, asthma, bronchopneumonia, or other lung or heart disorders. 1.5 Sources of Air Pollution Natural and human-made pollution make it impossible to find clean air in the natural world. Natural processes, such as volcanic activity, vegetation decomposition, and forest fires, continuously emit gases into the atmosphere, including CO, $SO2$, and $H2S$. In addition, winds, volcanic eruptions, and other similar natural disturbances disperse minute particles of solids or liquids throughout the air. Man-made pollutants, such as gases, mists, and particulates that emerge from the chemical and biological processes that humans use, are in addition to these "natural pollutants." When compared to background air concentrations, the latter are found in

13 quite high concentrations. At altitudes more than 2000 feet, these contaminants hardly ever exist. Concentrations of air pollutants in the atmosphere disrupt the dynamic equilibrium in the atmosphere and thereby affect man and his environment. Air pollution sources are generally classified into two categories namely anthropogenic and natural sources. Many significant natural sources that contribute to air pollution include the following: 1 . Large amounts of toxic gases, such as SO 2 , H 2 S, CO, and others, will be released during volcanic eruptions, producing air pollution. 2 . Air pollution from CO and CO 2 emissions is a result of natural forest fires. 3 . Vast volumes of CO 2 are released into the atmosphere by green plants through evapo- transpiration. 4 . Other sources of air pollution include forest fires and interactions between natural gas emissions. 5 . Winds and storms will release solid particles into the air, generating air pollution. 6 . Hydrocarbons, CO, and CO 2 produce air pollution when natural gas is forced out of borewells. 7. CO and CH 4 gases are produced during seed germination, marsh gas production, organic matter breakdown, and bio-degradation. These gases persist in the atmosphere and contribute to air pollution. 7 . Pollen grains from flowers, dust, and natural organic and inorganic decomposition are formed and discharged into the air, making it unclean and harmful to human health. Anthropogenic sources mean man-made sources. The following man-made sources cause air pollution: a. Combustion of fossil fuels: The organic materials that produce energy during combustion include coal, natural gas, petroleum, wood, and oil, among others. These substances are also known as "fossil fuels." Air pollution results from burning fossil fuels like coal, wood, and oil. when black smoke is created during the burning of coal, wood, and oil. Unburned black carbon particles as well as toxic chemicals like CO and SO 2 are present in this smoke. Oils and coal both have sulphate as an impurity. Hence, SO 2 and CO 2 gases will be released during the burning of coal and oil. As a result of the atmospheric persistence of CO, CO 2 , SO 2 , and unburned carbon particles from the burning of fossil fuels, the air becomes contaminated. b. Population explosion: The most major source of air pollution is the increasing expansion of the population day by day. Population growth causes greenhouse gas emissions and global warming. As a result, sou level will result. As a result, the ice caps and glaciers will be visible in low-lying places of the globe. Food grain production will decline as a result of global warming. According to estimates, due to an increase in CO2 concentration that melts ice caps, the sea level may rise by 200 feet by the year 2050, flooding major towns and low-lying areas. c. Transportation: Vehicles are regarded as the principal mode of transportation, including cars, trucks, motorcycles, taxis, buses, lorries, aeroplanes, and scooters. Air pollution is

14 brought on by the CO, NO 2 , and NO gases emitted by internal combustion engines in vehicles including cars, buses, trucks, and aeroplanes. The internal combustion engine that burns gasoline as a fuel can emit pollutants as seen in the diagram below. Let's assume that the fuel utilised in car engines is gasoline. Hydrocarbons are one of the key components of gasoline. These hydrocarbons are known as octanes because their general chemical formula is C8H8. In an automobile engine, gasoline burns quickly. Due to the limited burning duration, incomplete combustion of gasoline results in CO 2 , CO, H 2 O vapour, alcohol, acid, and unburned carbon. d. Deforestation: Deforestation is the term used to describe the indiscriminate removal of plants, trees, and debris from jungles and forests. In nature, forests have a specific place. Forests are seen as a gift from nature to all living things. The equilibrium of CO2 and O 2 concentrations in the environment is mostly maintained by plants. e. Industrialization: Due to the current population explosion, the need for rapid industrialization has become imperative. Basically, the living community's support system is its industry. Sources of various industries, such as chemical industries, paper mills, cotton mills, metal extraction plants, petroleum refineries, oil refining factories, plastic, rubber, mica industries, nuclear reactors, soap industries, drug industries, etc., to be started become a necessary activity based on regional needs. These industries release a variety of harmful substances into the atmosphere. These gases contaminate the air. Around 20% of air pollution is attributable to the aforementioned businesses. f. Agricultural Activities: Due to the rapid population growth, more agricultural land needs to be planted in order to provide for the minimum level of living standards. Fertilizers must be used in order to produce a large yield. The crop may experience several diseases during the ripening stage, which are brought on by various pests. Several kinds of "biocides" such pesticides, insecticides, herbicides, and rodenticides must be used to eradicate these pests. This utility for biocides pollutes the air. This is due to the fact that when these harmful compounds are sprayed on crops, some of them are transported by the wind to various locations. As a result, the air that contains "biocides" is dangerous for both humans and other animals. Here are a few examples of specific things that contribute to air pollution: 1 . Chlorine (Cl 2) gas is released into the air from a bleaching powder manufacturing facility. 2 . Businesses that extract metals from sulphide ores, such as Fe, Cu, and Zn, create SO 2 gas, which pollutes the air. 3 . The smoke that is emitted into the atmosphere by factories contains gases that pollute the air, such as CO 2 , CO, SO 2 , H 2 S, NO 2 , and NO. 4 . Different industries' dust pollution of the air. 5 . In 1952, London's haze claimed the lives of nearly 3000 individuals as a result of the buildup of 1.3 ppm S0 2 pollutants in the atmosphere. 6 . Methyl iso cyanate (MIC) vapour released into the cool winter atmosphere due to explosion from MIC tanks of Union carbide pesticide factory during the preparation of

15 carbaryl or sevin, turned the city into a poisonous gas chamber. The Bhopal gas tragedy, which occurred on 3-12-1984, was regarded as the worst disaster in history and occurred in Bhopal, India. 18000 people died as a result, while 100,000 more were hurt. For numerous generations, the surviving will continue to experience genetic harm. 7 . Ozone deflection is brought on by nitrogen oxides (NOx), pollutants released from numerous plants. 8 . Air pollution is brought on by the radioactive waste that nuclear reactors release. High intensity gamma radiations are created during the enrichment of radioactive materials used in laboratories and hospitals. 9 . More than 2100 million tonnes of particulate matter are thought to reach the atmosphere each year. 10 .By 2047, there would be 30 crore tonnes of solid trash, 45 crore tonnes of ash waste, and other waste that contributes to air pollution. Additionally, anthropogenic sources are two types i.e., stationary sources and non- stationary sources. Stationary sources include fossil fuel smoke stacks and biomass power plants, manufacturing facilities (factories), furnaces and other methods of waste incineration (incinerators as well as open and uncontrolled fires of unmanaged trash). Stationary sources again divided into two categories that is area sources and point sources. Examples of area sources includes residential heating, on site incineration, open burning, evaporative losses, institutional & commercial heating coal oil and gas. Examples of point sources include power plants, industrial processing, etc. On the other hand, non-stationary sources, also called mobile sources, includes facilities like motor vehicles, trains (especially diesel locomotives and DMUs), marine boats, and aircraft are. Non-stationary sources again divided into two categories that is area sources and line sources. Examples of area sources includes port vessels, railyard locomotives, etc. Examples of line sources include highway vehicles, channel vessels, etc. 1.6 Pollutants Transportation and Dispersion Mean wind flow and atmospheric turbulence both affect how chemical contaminants are dispersed in the atmosphere. The friction of the ground surface, actual obstructions to wind flow, and the vertical temperature profile of the lower atmosphere are a few examples of the elements that cause turbulence. The level of turbulence in the atmosphere is described by the stability class. Stability typically refers to the lower portions of the atmosphere, where contaminants are released, when discussing air quality. Although the concept of discrete stability classes simplifies the complexity of the atmosphere, it has proven effective in research that aim to forecast future events. A stable atmosphere is characterised by air that is colder on the ground than it is in the atmosphere, by slow-moving winds, and as a result, by little turbulence. Long distances can be

16 travelled in a largely undamaged state by a pollution plume that has been released into a stable lower layer of the atmosphere. On the other side, a high level of turbulence indicates an unstable atmosphere. An unstable environment may cause a visible plume to take on the recognisable looping pattern that turbulent eddies produce. The "neutral" stability class is a middle turbulence class between stable and unstable circumstances. The edges of a visible plume released into a neutral stability situation may stretch out in a V-shape, giving the plume the appearance of a cone. A layer of the atmosphere is referred to as an inversion when temperature rises with height as opposed to falling, as is typically the case. This inversion layer acts as a cap, stopping any further upward dispersion of chemical contaminants. As a result, pollutant levels will increase below the cap and a protracted period of such a pollutant buildup is commonly referred to as a stagnation event during which smog might form. It has been common practise to erect taller stacks in order to lower emissions at a particular location. When pollutants are released from a source with a tall stack, the concentrations at ground level are typically lower than when the same quantity of pollutants are released from a source with a short stack. The ability of pollutants discharged from tall stacks, above the inversion layer, to travel great distances has been a problem despite the fact that a traditional method to air pollution prevention has been to build a taller stack. However, sources with the same stack height might have various effects based on the plume rise above the stack, which is influenced by the exit velocity of the emissions, the temperature of the emissions, and other factors. The term "effective stack height" refers to the sum of the physical stack height and plume rise over the stack. Pollutants produced in the atmosphere or released into it eventually run out. Two other typical depletion mechanisms are dry deposition and washout, in addition to chemical transformation, which depletes precursors. Dry deposition is the term used to describe the removal of both particles and gases from the ground surface. When rain or snow falls on the ground, water droplets and snow pick up particles and gases in the atmosphere and remove them from the environment through washouts. Precipitation must form within the clouds in order for wet deposition to really remove contaminants from the atmosphere. The pollutant mass remains in the atmosphere until there are no cloud components larger than around 100 microns in diameter, primarily due to the very small cloud drops' insignificant rates of fall. Pollutant separation between water phases prevents the transmission of cloud water acidity to big particles, which do precipitate quickly. The majority of precipitation in mid- latitude storms is begun by the production of ice particles in the cold, upper reaches of the clouds. The acidity of precipitation typically tends to be significantly lower than that of the cloud water that remains aloft, in part due to such microphysical phenomena and in part due to non-uniform distributions of contaminants within the clouds. The result of all of these consequences is that the air can become highly polluted, as evidenced by the quality of life in some inner-city neighbourhoods. Identification of the contaminants in the atmosphere, through precise sample techniques, is a critical issue where precision and dependability are a need.

17 1.7 Atmospheric Stability and Temperature Inversions In well-mixed, dry air, the temperature drops by roughly 3.3°F (about 1.8°C) for every 1000 feet (300 m) of elevation gain. The value given is the typical lapse rate, which is the term for this vertical temperature gradient. A dense cold stratum of air at ground level is covered by lighter, warmer air at higher altitudes when the reverse or negative lapse rate occurs. The term "inversion" refers to this process. Inversions limit vertical air circulation, which causes pollutants to accumulate in the thicker air at ground level and below the inversion layer. As a result, the atmosphere remains stable and there is very little turbulence or mixing during temperature inversion. In these circumstances, air pollutants do not disperse. Autumn and winter are when inversions are most common, and the buildup of smoke and other pollutants makes pollution much worse by keeping the sun's rays from warming the ground and the air around it. Because the temperature at ground level is below the dew point of the air's water vapour, fog is frequently linked to inversions. When horizontal air flow is constrained, inversions are more likely to occur in narrow valleys. Visibility is significantly decreased and pollutants are at their highest during inversions. 1.7.1 Types of Inversions a. Radiation inversion: This phenomenon typically happens at night when the earth radiates heat away, cooling the air that comes into touch with it. Fog will form in wet air when the temperature is below the dew point. Once warmer air has covered the cool air stratum, upward movement is halted until the following morning, the sun heats the lower air. Because to the longer nights, this kind of inversion occurs more frequently in the winter than in the summer. Such inversions may regularly occur in valley locations due to the surrounding high ground's restriction of horizontal air flow. In India, inversions end shortly after daybreak due to the tremendous sunlight heating of the ground. Yet, the presence of fog or mist at the same time as an inversion lengthens its duration by preventing sunlight from reaching the ground. b. Inversion of subsidence It appears at low elevations and frequently lasts for several days. It is brought on by the air in anticyclones sinking or subsiding (high pressure areas surrounded by low pressure areas). Around the location, the air progressively lowers at a rate of around 1000 m each day. The air is heated and compressed as it sinks, creating a warm, dense layer. This serves as a cover to stop pollutants from rising. The inversion height can range from the level of the ground to 1600 metres. Extreme pollution happens when the distance is smaller than 200 m. Subsidence inversion and radiation inversion can sometimes happen at the same time. This occurrence is referred to as "double inversion." 1.7.2 Adiabatic Lapse Rate The upward lift of air pollutants released into the atmosphere, and consequently their ultimate dispersion and dilution, are significantly influenced by the change in air temperature with height. The term "adiabatic lapse rate" refers to the pace at which a parcel of dry air rises in a hydrostatically stable atmosphere and gently expands to lower the atmospheric pressure without exchanging heat. 0.98°C/100 m is the dry adiabatic lapse rate. A smoke plume will rise

18 into the atmosphere under adiabatic lapse rate circumstances due to its low density due to the greater temperature until it meets air of a similar density. The lapse rate, however, may frequently be more or lower than the adiabatic rate due to external heating or cooling factors. The super adiabatic lapse rate (rate greater than adiabatic) and the negative lapse rate are the two circumstances that are most crucial from the point of air pollution (inversion). During a sunny summer day, the sun's rapid heating of the earth warms the air close to the surface, causing the lapse rate to become super-adiabatic. The atmosphere is believed to be in an unstable equilibrium at this point, and there is a noticeable vertical mixing of the air as a result. This is a situation where contaminants spread out quickly. 1.7.3 Mixing Height The mixing height is the fourth and key meteorological characteristic. It can be described as the height above the surface of the planet where relevant contaminants will travel mostly due to atmospheric turbulence. It usually has something to do with one or more of the three wind-related variables: wind speed, wind turbulence, and wind direction. In other cases, it might be connected to all three. After air pollutants are released into the sky, the weather has complete control over how they will behave going forward, or how they will disperse. The vertical extent of the mixing varies throughout the day, seasonally, and is also influenced by topographical characteristics. The amount of atmosphere that can be used to reduce the pollution concentration increases with vertical extent. The Maximum mixing depth (MMD), or convective mixing layer depth, is determined by thermal buoyancy effects. Mean maximum mixing depths (MMMD) are the average MMD values that are available for a month. The temperature of an air parcel increases when it is heated by solar radiation at the surface of the earth. The air packet will climb inside the local atmosphere after heating until its temperature reaches the ambient temperature there. The height at which the air parcel and its surroundings reach equilibrium determines the maximum mixing depth or the top of the convective mixing layer. When solar energy at the earth's surface warms an air parcel. In reality, the MMD is calculated using the actual temperature profile of the atmosphere many kilometres above the surface of the globe. Temperature readings are communicated back from various altitudes using a balloon that is launched into the air. They are plotted against height and are referred to as radiosonde measurements. On this plot, a dry adiabatic temperature line is also drawn, beginning at the highest surface temperature recorded for that particular month. The MMD is the height at which this dry adiabatic line crosses the radiosonde readings. Although morning measurements are also commonly performed, temperature sounding data are typically taken at night. The MMD readings are typically lower at night and higher during the day. The value may be practically nil during a severe inversion at night, whereas values between 2000 and 5000 metres are typical during the day. The mean MMD varies seasonally, reaching its lowest point in the winter (December and January) and its highest point in the summer (May and June). When the MMD value is below 1500 metres, it has been observed that large urban air pollution episodes regularly happen. Although readings below threshold are very typical in many metropolitan areas, there is frequently a high risk for air pollution episodes. It is important to

19 check that the MMD values are at least 2000 metres before situating an industry. Similar to the minimum surface, the minimum mixing depth, which typically occurs before sun rise, is calculated by adding 5°C. 1.8 Plume Behavior The term "plume" describes the direction and size of the gaseous effluents that are emitted from a source, typically a stack, into the sky. Localized air stability determines how a plume released from any stack behaves. Typical circumstances like those in Fig. 3.5 are typically found in the lower atmosphere (less than 300 m above ground). Because of the combined effects of buoyancy and velocity on plume rise, effluents from tall stacks are frequently injected to an effective height of several hundred metres above ground. The daily differences in air stability and the long-term alterations brought on by seasonal changes are further factors influencing plume behavior. The vertical temperature and wind profiles affect the geometric shapes of stack plumes, and vice versa. By observing the plume, one may determine the stability condition and the atmosphere's ability to disperse particles. The environmental lapse rate determines a plume's behavior and dispersion throughout its entirety (ELR). According to Fig. 6.1,

a portion of air expelled from a stack into the environment follows the Dry Adiabatic Lapse Rate (DALR)

and reaches a temperature of about 16°C (depending on surface temperature and altitude). Nonetheless, the ambient temperature will be around 25°C. As a result, in the warmer and lighter environment, the denser parcel of air cannot rise upward. Consequently, the most unfavorable circumstance for the dispersion of contaminants in the atmosphere is inversion. The temperature in the environment would drop at a quicker pace in a super-adiabatic atmosphere (n< 1.4), say 1.5°C/100 m, compared to the plume temperature, which would drop at the typical rate of 1°C/100 m. As a result, the temperature of

a plume or parcel of air expelled from a stack is higher than

the ambient temperature. Due to its reduced density, the air parcel is therefore continuously lifted aloft. Such an atmosphere is referred to be an unstable atmosphere since it has good pollution dispersion and low ground level concentrations. The impact of temperature profile (also known as environmental lapse rate) and wind speed on the dispersion of pollutants released from a stationary source of smoke stack is depicted in Figure 6.1. It should be noted that the environmental lapse rate (ELR), which is typically positive at roughly 6.6°C/km, turns negative under exceptional circumstances, such as when an inversion occurs. Adiabatic lapse rate (ALR) is a term used to describe the rate at which the temperature falls in an ascending parcel of air as it slowly expands in a decreasing ambient pressure. The stability of the atmosphere is determined by the ratio of ELR to ALR in magnitude. The spread of the plume is closely tied to the vertical temperature gradient, as illustrated on the left side of the picture, and several patterns of plume behaviour under various meteorological conditions are shown in Table 1.1.
20 a. Looping: This kind of plume has a wavy appearance. Rapid mixing results in a highly unstable atmosphere where it happens. High concentrations may develop close to the stack if the plume reaches the ground, however the high degree of turbulence aids in the plume's quick dispersion. Highly unstable (ELR < ALR) During warm seasons with bright skies, it is related to turbulent air. Despite the fact that looping happens in unstable environments that are conducive to complete mixing, taller stacks might be required to avoid making contact with the ground too soon. b. Coning: This kind of plume has a cone-like shape. When the wind speed is more than 32 km/h, this occurs in an atmospheric environment that is almost neutral (adiabatic condition). Yet, the plume travels farther to the ground than looping. Neutral or near neutral (wind < 32 kmph. Weakly stable, ELR > ALR) The environment is neutral or only marginally stable when the ambient lapse rate is sub- adiabatic. As a result of the limited vertical mixing, there is a higher chance that the area will experience air pollution issues. Coning is the term for the typical plume in such circumstances. The visible plume has a horizontal axis and a cone shape of about 10 degrees. Compared to a looping plume, it disappears longer downwind. Coning happens when there are strong to moderate winds with gloomy skies, either during the day or at night. Unlike to looping, the majority of the pollutant concentration in coning is carried quite far downwind before substantially reaching ground level. c. Fanning: It is a specific kind of plume that is released when there is a severe inversion. In these circumstances, the plume will primarily extend horizontally and very little to none vertically. As a result, it is challenging to forecast ground level concentrations in this area. Strongly stable (ELR negative) Large negative lapse rates (inversion and isothermal lapse rate) cause a "fanning plume," which causes a severe surface inversion to occur far above the stack height. There is very little turbulence and the winds are light, and the atmosphere is remarkably stable. The plume typically appears at night and in the early hours of the morning when the earth is being cooled by emitted radiation. For several kilometres downwind, a fanning plume may appear as a small horizontal fan with no vertical spreading. Warm wastewater causes the plume to climb gradually before drifting horizontally. The plume disperses very slowly and concentrates in a high altitude at a comparatively far distance downwind. Despite the possibility of turbulence, there is a limited likelihood of ground impact. d.
Lofting: When there is a significant lapse rate above a surface inversion,
lofting takes place. The inversion layer is not penetrated by downward diffusion under these circumstances, despite rapid upward diffusion. These circumstances prevent emissions from rising to the surface. Stable, but inversion above plume source. In the late afternoon and early evening, when the sky is clear, "lofting" rules. When
the sun has set, radiation from the surface causes an inversion layer to form close to the ground. A lofting plume will become a fanning plume as the inversion
layer deepens. The plume has a well-defined bottom and diffuses to the top in the shape of loops or cones. The winds in the upper layer are moderately turbulent and significant, but they have minimal effect on the winds in the layer below. The likelihood of ground contact during lofting is limited unless the inversion layer is shallow. Since there is little chance of contaminants coming into contact with the ground, it is regarded as the ideal setting for dispersion.
21 e. Fumigation: When the air becomes unstable, pollutants that are high in the air are quickly transported to the ground level. Stable, inversion aloft, but inversion layer above plume source. Fumigation plumes develop when a stable air layer is located just above the plume's discharge point and an unstable air layer is located directly beneath the plume. It happens when an inversion transitions to a normal state and when there is a sea wind in the late morning or early afternoon. Except when there is a sea breeze, it stays for a maximum of 30 minutes. In that case, it stays for several hours. A negative temperature gradient from the base upward forms as a result of the morning sun heating
the ground. Large amounts of stack gas will be carried downwind to the surface
once the newly developed unstable layer reaches the height of the stack.

Although there is simply thermal turbulence in the bottom layer, the winds are light to moderate both above and below. Concentrations at ground level are high, particularly when the plume has stagnated above. Fumigation typically forms in the summer and is more common when there are no clouds and little breeze. The typical beginning is when a fanning plume fragments into a looping plume. f. Trapping: The term is used to describe circumstances in which a plume is stuck between two inversions and can only spread to a certain vertical height. The lofting plume is the preferred method for reducing air pollution. From the perspective of ground level pollution concentrations, the fumigating and trapping plumes are extremely important. Stable, inversion both above and below the source. With an unstable atmosphere sandwiched between the two inversion layers and occurring in a stable atmosphere, it can only spread up to a certain vertical height. Any season, any time of day, may see it happen. When linked to subsidence inversions, it can endure for several weeks, as it did in Los Angeles, whereas when linked to warm frontal inversions, it only lasts a few hours. One of the worst pollution crises exists right now. g. Neutral Plume: Until it hits air with a density akin to the plume itself, it has a tendency to rise straight into the atmosphere. If the wind speed is greater than 10 m/sec and the cloud cover blocks both the solar radiation during the day and the terrestrial radiation at night, it frequently converts to coning. Neutral or near neutral (ELR~ALR) When choosing where to take air samples, it can be helpful to observe these apparent smoke plumes. Understanding plume characteristics is also useful for addressing invisible pollution. Nonetheless, caution should be exercised to prevent optical illusions when witnessing a plume (for example, a plume may be visible for several kilometres yet not extend upward for a small fraction of a kilometre). This may be accomplished by simultaneously or consecutively viewing the plume from two sites that are at right angles to one another.
22 Figure 1-1: Different types of Plume Behavior Table 1-1: Demonstrates the diverse characteristics of plumes Type Description of visible plume Dispersion and ground contact Associated wind and turbulence Temperature profile and stability Typical Occurrence Looping Irregular loops dissipate in patches and relatively Disperses rapidly with distance, large probability of high concentrations Light winds with intense thermal turbulence. Adiabatic or super adiabatic lapse rate. Unstable.
During day time with clear or partly cloudy skies and intense
23
rapidly with distance. sporadically at ground relatively close to the stack. Inverted and isothermal lapse rate. Very stable. solar heating. Coning Cone shaped with horizontal axis, dissipates further down-wind than looping plume. Disperses less rapidly with distance than looping plume, large probability of ground contact some distance down- wind. Concentration less but persists longer than looping plumes. Moderate to strong winds. Turbulence largely mechanical rather than thermal. Lapse rate between dry adiabatic and isothermal. Neutral or stable. During windy conditions, day or night. Layer type cloudiness favored in day. Fanning Narrow horizontal fan. No vertical spread for kms down- wind.
If effluent is warm, plume rises slowly, then drifts horizontally. Disperses slowly, con- centration aloft high at relatively great distance downwind, small pro- bability of ground contact, though
increase in turbulence can result in ground contact, Light winds. Very little turbulence. Adiabatic lapse rate at stack top and above. Inverted below stack. Lower layer stable, upper layer neutral or unstable. At night and in the early morning, any sea- son, usually favorite- ed by light winds. Lofting Loops or cones with well defined bottom.. Diffuses to top. Probability of ground contact is small unless inversion layer is
shal- Moderate winds and considerable turbilence aloft, very light winds, Adiabatic or super adiabatic lapse rate at stack top and below. During change from lapse to inversion condition, usually near
24 low,
considered to be
the best condition for dispersion since pollutants are dispersed in upper air with small probability of ground contact. and little turbulence in layer below. sunset on fair days. Fumigation Fan or cone with well defined cone and dragged or diffused bottom. Large probability of ground contact in relatively high concentration. especially after plume has stagnated aloft. Winds light to moder- ate aloft and light be- low. Thermal turbulence in lower layer, little turbulence in upper layer. Isothermal or inverted lapse rate above. Lower layer. unstable or neutral upper layer stable. During change from inversion to lapse condition, may Occur with sea breeze in late morning- ing or early after- noon. 1.9 Gaussian Plume Model A mathematical simulation of the physics and chemistry driving the transport, dispersion, and transformation of pollutants in the atmosphere is known as an atmospheric dispersion model. In addition, it entails estimating downwind air pollution concentrations using data on pollutant emissions and atmospheric composition. The most popular methods for determining the effects of nonreactive contaminants are gaussian models. The most people utilize it. In the Gaussian Dispersion Model, it is assumed that molecular diffusion accounts for the majority of the plume dispersion, pollutant concentrations in the plume are regularly distributed (double Gaussian distribution), both horizontally and vertically, and the spread and shape of the plume change depending on the weather.

25 1.9.1 Development of Gaussian Dispersion Model Imagine a point source in the air that continuously releases a pollutant at a rate Q (kg/s). The wind is blowing continually at a speed of U (m/s) and in the direction x (measured in metres from the source). The plume expands as it moves in the x direction, resulting in local concentrations C(x,y,z) (kg/m3) that form distributions with "Gaussian" or "normal" forms in planes parallel to the x direction at every point in space. The profile shape in the lateral, or y, direction is determined by While moving vertically, or in the z direction, it is indicated by The Gaussian distributions' parameters y and z (m), which represent the spread of the plume in the y and z directions, respectively, are standard deviations. They grow as you move away from the source by x. The area under the distribution, determined by integration of the functions given above between plus and minus infinity, is equal to unity.

26 The function describing the form of the distribution in three dimensions—a sort of pollutant "hill"—is obtained by multiplying these two-dimensional shape distributions together. Every point's concentration is provided by As a result, the concentration is determined by multiplying the shaping function by the rate of emission from the source, which is then divided by the wind speed. This distribution measures y and z typically from the x-axis, which is also sometimes referred to as the plume's centre line. The source will typically be elevated above the ground in practise (for example the exit of a chimney). Hence, in order to measure the z coordinate from the ground, we must change it. Where, H is the center-line effective height of the plume (m) Hs stands for height above ground (m) h (m) is initial plume rising, z is a coordinate that represents a position in the plume as measured vertically from the ground (m) Hence, the new vertical coordinate is (z-H) with respect to the plume axis.

27 This equation still has to be changed in one more way. Contrary to a plume that spreads in free air, most plumes are released near to the ground, as in the case of the chimney in the image above. So, when the plume goes downwind from the source, it will eventually "strike" the earth as it spreads downward (as well as above). There is no way the plume can keep extending into the ground! As opposed to that, it is "reflected" back into the air above the ground. Through the use of a fake "mirror-image" source (Si = S) with the same strength (Qi = Q) and location at the same height from the ground (hs), the influence of the ground boundary is quantitatively accounted for in the concentration equation. As a result, at every position P, both the genuine source (S) and the hypothetical source (S) contribute to the concentration C(x, y, z) (Si). The vertical distance between P and the true plume's centre is (z-H). P is located (z+H) vertical distance from the imagined source's centre. For both sources, the lateral distance (y) into the page is the same. As a result, P's overall concentration is

28 We can simplify the equation by putting z=0 if just ground-level concentrations are needed, such as when determining how much exposure crops or people have to the contaminant. These results The highest level of concentration is reached when The concentration fluctuates in proportion to 1/(σy . σz) at far-off locations when z is significantly bigger than H. Since both z=0 and y=0, the equation is further simplified if just concentrations at ground level on the center-line of the plume (in the x-axis direction) are required. As a result, Using the fundamental equation, we can calculate the concentration (C) at any location if we know the rate of emission from the source (Q), the predominant wind speed and direction (x), and the height of the centre of the plume above ground (H) (x,y,z). To accomplish this, though, we must first learn about the plume spread by getting values for σy and σz. There are numerous formulae and semi-empirical expressions that can be used to calculate σy and σz under various atmospheric stability scenarios. When the source is high above the ground (as at the top of a chimney), a good approximation in areas close to the source is σy = Iy . x and σz = Iz . x

29 where Iy and Iz are, respectively, the turbulence intensities (turbulence speed fluctuations) in the y and z directions. It has been discovered that, under neutral air conditions, Iy and Iz may be calculated as spanning a range of heights corresponding to the vertical plume dispersion, centred at about hs. where "ln" stands for the natural log, "hs" for release height, and "zo" for aerodynamic roughness, all of which indicate various topographic ground conditions (see notes on atmospheric boundary layers). Both this straightforward model for turbulence intensities and the estimates we used previously in the course for Ix, Iy, and Iz may be applied in practise. The following typical values apply to broad cases of various atmospheric conditions: Thermal stratification Lateral intensity (Iy) Vertical intensity (Iz) Extremely unstable 0.40 - 0.55 0.15 - 0.55 Moderately unstable 0.25 - 0.40 0.10 - 0.15 Near neutral 0.10 - 0.25 0.05 - 0.08 Moderately stable 0.08 - 0.25 0.03 - 0.07 Extremely stable 0.03 - 0.25 0 - 0.03 As atmospheric conditions become increasingly unstable, it may be observed that the turbulence intensities, particularly the vertical wind speed fluctuations, rise. The plume rise (h) is an additional aspect that must be taken into account in practise. This is the center-line plume's course or trajectory from the time it leaves the source. The quantity of buoyancy and vertical momentum in the first plume at the source, as well as the atmospheric conditions, all affect the course of the plume. The variation in plume rise due to buoyancy forces is x 2/3 . The plume rise varies with x 1/3 due to momentum forces. So, the forces that control the plume will determine the trajectory's shape. According to atmospheric conditions, the chimney plume can ascend to a maximum level between h = 0.2 hs and h = 0.6 hs above the source, depending on the turbulence intensities, especially if they are buoyant. An approximate expression for the end plume increase, if the initial plume momentum dominates, is

30 where D is the source's diameter, such as the diameter of a chimney's exit (m) W is the plume's initial vertical velocity (in m/s). In reality, the initial vertical velocity frequently resembles the current wind speed. Hence, the final plume rise is in the range of 9m for a standard chimney diameter of, let's say, 3m. Many times, the value of the plume rise is so negligible in comparison to the size of the plume and the magnitude of the release height that the plume centre line may be assumed to be horizontal for convenience. 1.10 Acid Rain Mankind has long treasured rain since only adequate and timely rainfall makes healthy crops and copious water sources feasible. Summer downpours renew people. The aquifers are refilled and the groundwater is purified during spring rains. The air is purified by winter snow and autumn rain. In general, rain evokes feelings of optimism, vigour, and promise for the future. In some places of the world, however, simple rainfall has acquired a dangerous complexity over the past several decades. In these areas, where the atmosphere is contaminated with nitrogen and sulphur oxides (SOx), rain must travel through it (NOx). Sulfuric acid, nitric acid, and water are frequently produced as a result of the pouring rain and snow reacting with these oxide pollutants. This is referred to as acid rain or acid precipitation. Due to the reaction of atmospheric CO2 with water to form carbonic acid, rain typically has a pH of 5.6 to 5.7. Nonetheless, although not being extremely acidic, this modest quantity of acidity is sufficient to dissolve minerals in the earth's crust and make them accessible to plant and animal life. The natural sources of acidity in rain also include various air components from volcanic eruptions, forest fires, and other similar natural events. Even so, typical rainfall is able to digest the massive amounts of acids that nature produces each year to the point that they do little to no known harm. However, the contributions of SOx, NOx, etc. from anthropogenic activities upset this acid equilibrium and turn naturally occurring, moderately acidic rain into precipitation, having significant negative effects on the environment. Hence, any sort of precipitation with a pH below 5.6 is considered acid rain. The pH of typical rain is little around 6, which makes it mildly acidic. The mild carbonic acid that results from the dissociation of dissolved carbon dioxide is what causes this natural acidity. Sulfur from volcanic eruptions, impurities in fossil fuels, and nitrogen from the air combine with oxygen to generate sulphur dioxide and nitrogen oxides, which are what is known as "acid rain." They dissipate into the atmosphere, where they combine with water to generate soluble sulfuric and nitric acids, which then fall as rain. In addition, some hydrochloric acid is created. Gas phase chemistry of acid rain

31 By a tri-molecular interaction with the hydroxyl radical, sulphur dioxide is oxidised in the gas phase: SO_2+OH+M → $HOSO_2$+M HOSO2+02 → HO2 + SO3 In the presence of water sulfur trioxide is converted rapidly to sulfuric acid: SO3 + H2O+M → H2SO4 + M Nitric acid is formed by the reaction of OH with nitrogen dioxide: NO_2+OH+M → HNO3 +M Sulfur dioxide dissolves in water, then, like CO2, hydrolysis in a series of equilibrium reactions: SO 2 (g) + H_2O ↔ SO_2 H_2O SO_2 H_2O ↔ H + + HSO 3 - HSO 3 ↔ H + + SO 3 2- 1.10.1 Sources of Acid Rain As mentioned in the earlier sections, a sequence of photochemical reactions and chemical reactions catalysed by other species in the environment cause SOx and NOx emissions into the atmosphere to finally be transformed into H2SO4 and HNO3 droplets. With bases such particulate lime, NH, etc., these acid droplets are partially neutralised. Acidic precipitation, often known as "Acid Rain," is created by these salts, the residual H2SO4 and HNO3 droplets, HCI, and HCl emissions from both natural and man-made sources. Following species were discovered through analysis of acid rain samples: H, NH, Na, K, Ca, Mg, SO, NO and Ct. The three acids all contribute to acid rain in roughly the same proportions. H2SO4<HNO3<HCL Acid rain may occur far from the sources of the pollution, perhaps even 500 to 1000 kilometres away. 1.10.2 Effects of Acid Rain Because of the significant SOx and NOx emissions into the atmosphere from large industrial locations, acid rain is one of the main effects of air pollution. The more time SO and NO spend in the atmosphere, the more likely it is that one of the many photochemical and catalytic chemical reactions will result in their oxidation to H2SO and HNO3. Acid showers have the potential to seriously harm a variety of materials and terrestrial ecosystems, including water, fish, plants, stone, steel, paint, soil, and people. Effects on materials and terrestrial ecosystems 1 Pitting and mechanical weakening caused by the acidic components' attack on architectural and structural materials, as well as priceless ancient statues carved from marble, limestone, sandstone, etc. According to reports, acid rain damage caused stone statue deformation and

32 deterioration in nations like Greece and Italy. If appropriate steps are not taken, architectural landmarks like the Taj Mahal in our nation will be threatened in a similar way. 2 Soil acidification and its consequences on soil fauna, microbial life, and nitrogen fixing. Moreover, there are indirect repercussions from changes in soil chemistry brought on by soil acidification, which lowers forest production. 3 Damage to crops and forests from foliar growth, nutrition loss from leaves, and modifications to seed germination traits. Injury to tissues of young, growing plants and the photosynthesis process, which impedes plant growth and jeopardises their survival. 4 Acidification, a decline in alkalinity, and the mobilisation of metals like aluminium are potential repercussions on aquatic systems. 5 There are also other biological consequences on aquatic life, such as altered species compositions in plankton, flora, and invertebrates, a drop in fish and amphibian productivity, skeletal abnormalities, and higher fish mortality rates. 6 Corrosion of steel, zinc, paints made of oil, and automotive coatings. 7 Potential impacts on people. Skin, hair, and lungs could be impacted. Acid rain's heavy metal emissions could also pose a harm to human health. Increases in heavy metal concentrations and acidification of drinking water reservoirs may go beyond acceptable levels for public health and have harmful impacts. Acid rain's effects on aquatic systems The loss in fish population, which is particularly detrimental to recreational fishing, is the most significant impact of acid rain on aquatic systems. Economic impact is the indirect result on tourism. The decline of specific zooplankton, algae, and aquatic plant species, which upsets the lake's overall food chain and could lead to ecological imbalances, are other aquatic impacts of acid rain. These include effects on humans who consume fish that have higher metal concentrations in their flesh. Trout and Atlantic salmon are particularly sensitive to low pH levels, which interfere with their reproductive activities and frequently result in skeletal malformations, as studies have amply shown. Fish and maybe other delicate biota, such planktonic crustaceans, are frequently killed by high aluminium concentrations in acidifying water. Aluminum concentrations are quite low in lakes that are alkaline or nearly neutral. But, as the pH falls, the previously insoluble aluminium that is present in very high amounts in rocks, soils, and sediments from rivers and lakes starts to dissolve. At low concentrations (between 0.1 and 1 mg/l), aluminium is remarkably toxic to a variety of aquatic life once it is in solution. Although the content of aluminium rises exponentially below a pH of 4.5 to 4.7, fish poisoning starts to occur at this pH. Aluminum that is free and ionic occurs primarily below 4.2 and is exceedingly hazardous. The hydroxyl forms prevail at a pH of about 5.0, and the toxicity decreases above and below this pH. At pH 5.0, aluminium concentrations of 0.2 mg/l or above harm fish gills and cause brown trout and whitesucker gills to secrete mucus. The gills appear to be plugged by the slimy mucus, leading to breathing issues. Moreover, the semipermeable gill membranes, which allow for the exchange of gases and salts, lose some of their fundamental integrity. In light of this, it appears that aluminium may also be a significant hazardous component in water with a pH of 5.0 and for sure at 4.0, in addition to an increase in H+ ions as a cause of fish deaths and population decreases. For the protection of their external skeletons, some groups of biota, such

33 as the molluscs (animals with shells, such as snails, limpets, mussels, and oysters), heavily rely on calcium. They cannot thrive in such water because acidic water easily dissolves calcium carbonate and prevents these organisms from absorbing calcium. Effects on forests Our woodlands are under a sneaky, perhaps fatal threat from acid rain. It has been demonstrated that somewhat acidic rain can harm seedlings (pH 4.6). Researchers are starting to examine how acid rain affects a tree's susceptibility to disease and insects. Although there is no direct evidence of acid rain harming foliage directly, the abrupt and spectacular loss and dieback of trees in Central Europe is a driving force behind such worries. Effects on trees: Depending on the country's geography and the acidity of the rain, acid rain's effects on trees can range from mild to severe. Acidic precipitation, acidic fog, and acidic mist harm leaves and needles' surfaces, lessen a tree's resistance to cold, and prevent plant germination and reproduction. As a result, the tree's vitality and capacity for regeneration are diminished. Effects on crops: There is no conclusive proof that acid rain has yet injured agricultural leaves in the field, despite the fact that many crop species appear to be far more sensitive to direct foliar damage than many tree species. Groundwater and drinking water quality Surface water percolates through the soil and bedrock to the water table, where it slowly builds up as groundwater. According to scientific data, some locations are experiencing groundwater acidification and the subsequent metal contamination that results from this. Lead, copper, and zinc are the main metals of concern because they may seep from water pipelines and containers, and aluminium because it comes from the bedrock itself. Corrosion of water pipes Water pipes deteriorate from acidic water. Naturally, this increases the need for pipe repair, but it also increases the danger that individuals could directly consume metals that have leached from pipe walls. Older homes continue to have lead pipes, which are also typical in older homes in Britain and Ireland. Another common use is for high-zinc galvanised pipes. Below pH 5.0, as well as with rising temperature, copper solubility increases significantly. Acidic water inside hot water pipes makes them particularly prone to dissolving. Effects on buildings, materials and paint Many airborne contaminants, such as acid rain, damage stone structures, statues, and monuments. Steel, paint, plastics, cement, masonry, galvanised steel, limestone, sandstone, and marble are among the building materials that are susceptible to harm. Sulfur dioxide and its byproducts are widely acknowledged to be the primary single corrosive agent of construction materials. Sandstones and limestones are frequently used as building materials for statues and monuments. Both corrode more quickly in city air that is high in sulphur than in rural air that is low in sulphur. The calcium carbonate in sandstone or limestone reacts with sulphur pollutants when they are dumped on the surface, turning it into the easily soluble calcium sulphate (gypsum), which is washed away in the rain.
34 1.10.3 Remedial and Control Measures of Acid rain Reducing SOx and NOx emissions is the only workable solution to the acid rain issue. For this, the following three standard alternatives are taken into account: 1 . Energy conservation results in less fuel consumption and hence fewer SOx and NOx emissions. It is also being researched how to conserve through increased thermal insulation and more effective fuel use. 2 . The desulfurization and denitrification of fuels used in stack gases, increasing usage of fuels with low sulphur content naturally occurring, or application of technologies that lower SOx and NOx emissions Currently, and possibly for some time to come, the only effective management methods are desulfurization and the deployment of low NO- producing technology. 3 . Future remedies to this issue might include substituting other alternative energy sources for fossil fuels. By using methods like coal cleaning, coal gasification, and desulfurization of liquid fuels, as well as by removing the sulphur content during combustion as in fluidized-bed combustion, as well as by removing the sulphur emissions after combustion as in stack or flue gas desulfurization systems of scrubbers, it is possible to reduce SOx emissions. The development of these strategies will determine SOx, control from conventional fuel sources in the future. The design of the furnace and burners can be changed, as well as the operating conditions, to reduce NOx emissions from stationary combustion sources. Currently, it is possible to modify combustion by employing two-stage combustion, carefully regulating airflow, injecting water during burning, recirculating flue gases, and/or changing the architecture of firing chambers. With equipment like a 3-way system that simultaneously decreases carbon monoxide, hydrocarbons, and NOx, as well as lowering engine combustion temperatures, it is possible to reduce NOx emissions from mobile combustion sources. 1.11 Bio-Pollutants Bacteria, viruses, cat saliva, home dust, mites, cockroaches, and pollen are examples of biological pollutants. Living beings produce or cause biological pollutants. Some kinds of asthma, allergic rhinitis, and hypersensitivity pneumonitis are brought on by certain biological pollutants. The air is a common way for infectious diseases like the flu, measles, and chicken pox to spread. Toxins that cause illness are released by moulds and mildew. Sneezing, wet eyes, coughing, shortness of breath, dizziness, tiredness, fever, and stomach issues are examples of biological pollution' health effects.

35 1.11.1 Sources 1. Pollens, which come from plants, 2. Pollens, which come from plants, 3. viruses, which are spread by people and animals, 4. mould 5. bacteria, which is spread by people, animals, soil, and plant debris, 6. household pets, which are sources of saliva and animal dander (skin flakes), cockroach, rodent, and other pest or insect droppings, 7. viruses, and bacteria 8. Rat and mouse urine contains a protein that is a strong allergen. It has the potential to fly when it dries. 9. Contaminated central air handling systems can grow mould, mildew, and other biological contaminants, which can subsequently spread throughout the house. 1.11.2 Effects of Bio-pollutants Only after repeated exposure to a particular biological allergen do allergic responses develop. Yet, that response could happen right away after a subsequent exposure or after several exposures spread out over time. As a result, individuals who previously experienced relatively minor allergic reactions or none at all may find that they are suddenly extremely sensitive to certain allergens. Certain illnesses, such as humidifier fever, are linked to toxins produced by bacteria that can flourish in sophisticated building ventilation systems. These illnesses are also linked to microorganisms that thrive in humidifiers and residential HVAC systems. Disease- causing biological agents in the indoor air are especially dangerous to children, the elderly, those with breathing issues, allergies, and lung conditions. Asthma can be brought on by mould, dust mites, pet dander, and bug droppings or dead bodies. A sizeable fraction of the population can develop allergic reactions to biological pollutants like mould and pollen. It is recognised that certain diseases can be spread through the air, including influenza, measles, staphylococcus infections, and Legionella. 1.11.3 Control of Bio-pollutants Maintenance of the heating and cooling systems as well as general excellent housekeeping are crucial. Good air circulation and enough ventilation are also beneficial. Moisture management is essential for controlling mould. If there is mould, remove the mould and any extra water or moisture. Mold, dust mites, and cockroaches can all be managed by keeping the relative humidity between 30% and 60%. Control insect and animal allergens by using integrated pest management. There are methods for treating cooling towers that can lower Legionella and other microbial levels. Install and operate outdoor-ventilated exhaust fans in bathrooms and kitchens, and vent clothes dryers outside. The moisture that accumulates from daily activities can be greatly reduced by these procedures. There are quiet exhaust fans available on the market, which is a crucial factor for some people. Using exhaust fans in the kitchen and bathroom also has the advantage of
36 lowering the amount of organic pollutants that are vaporised from hot water used in showers and dishwashers. Ventilate the crawl space and attic to keep moisture from accumulating. Water condensation on building materials can be avoided by keeping humidity levels in these regions below 50%. Whether utilising cool mist or ultrasonic humidifiers, clean equipment as directed by the manufacturer and top it with fresh water every day. These humidifiers have the potential to spread biological pollutants and result in illnesses including humidifier fever and hypersensitivity pneumonitis. Moreover, evaporation trays in refrigerators, dehumidifiers, and air conditioners should be cleaned frequently. Water-damaged carpets and building materials must be thoroughly cleaned and dried (within 24 hours, if possible), or removal and replacement may be an option. Mold and bacteria can grow on carpets and in construction materials that have been flooded. Complete biological contamination removal from such materials is quite challenging. Keep your home tidy. Although they cannot be completely removed, household dust mites, pollens, animal dander, and other allergens can be decreased with routine cleaning. Allergy sufferers should wear allergen-proof mattress covers, wash bedding in hot (130° F) water, and stay away from dust-collecting room furniture, especially if they can't be washed in hot water. Also, allergic people should leave the house while it is being vacuumed because this might actually raise the amount of mite allergens and other biological contaminants in the air. It might also be beneficial to use central vacuum systems that are vented to the outside or vacuums with high-efficiency filters. Reduce biological contaminants in basements by taking appropriate action. The basement floor drain should be cleaned and sanitised frequently. Finishing a basement below ground level is not advised unless all water leaks are repaired, external ventilation is installed, and sufficient heat is provided to prevent condensation. Keep animals that cause allergies away from your home: Avoid owning some animals as pets if you have an allergy to them, such as cats. Many allergies are brought on by animal dander (dead skin cells) and other shed animal particles. Animals with short hair or those that don't shed (like hamsters) may make better pets. Utilize mattress and pillow covers that are "mite-proof" Special covers for the bedding can be helpful for those who are allergic to dust mites. To kill mites, wash pillowcases, mattress covers, and sheets in hot (not warm) water. 1.12 Air Pollution Impacts There are three areas of study on the impact of air pollution: i. Human health effects of air pollution ii. Effect of air pollution on Materials iii. Effect of air pollution on some particular Materials

37 1.12.1 Effects on Human The health of both adults and children is significantly impacted by air pollution. Particles are a diverse group of pollutants, including nitrates, sulphates, carbon and acid aerosols. Depending on the time and place, airborne particles have different sizes and compositions. Adults who are exposed to low concentrations of the pollutant will have symptoms like coughing, chest pain, sore throats, and occasionally headaches. The impact of air pollution immediately affects the lung, an extraordinarily complex organ. More than 40 different types of cells can be found in the lung. Each of these cells is crucial to sustaining the body's health and fitness. By harming the lung cells that are most vulnerable to damage, air pollution can alter lung tissue. The lungs may not develop to their full potential if the cells necessary for the creation of new functioning regions of the lung suffer injury. Although the prevalence of other disorders like allergic responses, bronchitis, and respiratory infections has also been rising, asthma may be the most common condition with a growing frequency. Gaseous pollutants like ozone, sulphur dioxide, nitro-gen dioxide, and carbon monoxide are frequently present in the environment, which exacerbates the issue. Recent studies have shown that babies exposed to air pollution during the development of their organs may experience long-term alterations to those organs. Research on newborn rats demonstrated that exposure to carbon monoxide could alter the cardiac muscle tissue. The Table 1-2 below shows various health effects due to different air pollutants: Table 1-2: Human health effects of major air pollutants Pollutant Health effects Carbon monoxide Reduction in oxygen-carrying capacity of blood Sulfur dioxide Irritation of eyes, and respiratory system, increased mucus production, cough and shortness of breath Oxides of nitrogen Irritation of pulmonary tract affecting functioning of lungs Hydrogen sulphide Excessive inhalation leads to death Hydrocarbons Chlorine Lung cancer irritation of mucous membrane Suspended particulate matter Respiratory diseases Dust Silicosis Asbestos Asbestosis Acids and aldehydes Eyes, nose and throat irritation Ammonia Irritation of mucous membrane Pesticides Depression; leads to death if inhaled in excess Beryllium Fatal to heart and manufacture of house- lungs Lead Cumulative poison, impairment of central nervous system Arsenic Toxic Manganese Damages nerves and reproductive systems Benzene Leukemia, chromosomal damage

38 a. Domestic Pollution - The worst form of air pollution could be the wood smoke inhaled by women while cooking. b. Vehicle Pollution - There are three main categories of vehicles: passenger cars and jeeps with four-stroke engines, two- and three-wheelers with tiny two-stroke gasoline engines, and buses, lorries, and light commercial vehicles with four-stroke diesel engines. Carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NOx), and other chemicals like formaldehyde, acetaldehyde, acrolein, and benzaldehyde are the principal emissions from a gasoline-powered engine. The most hazardous substance among the particles is lead. Lead is present in high concentrations in Indian gasoline, and its emissions can cause cancer and lung illnesses. c. Thermal stations: Coal is the only fuel source for all thermal power plants. These plants mostly emit fly ash, soot, and sulphur dioxide as effluents. Less than 1% of the coal from India contains sulphur. Nonetheless, the coal has a significant ash percentage, ranging from 25% to 40%. Fly ash from power plants impairs visibility and may contain amounts of heavy metals like lead, manganese, cadmium, mercury, and chromium. Again, these have an impact on human health. d. Acid rain: Acid rain is the result of industrial emissions that release sulphur and nitrogen oxides. These oxides produce acids when they come into contact with water vapour, which has severe results. The soil is becoming more acidic, crops and forests are suffering, and fish in lakes and rivers are commonly observed to be dying. Heavy metals like cadmium and mercury are indirectly mobilised by acid rain, where they are then taken by plants and move up the food chain. e. Ozone layer: A layer of ozone located high in the stratosphere shields the planet from the sun's UV rays. The existence of life would not have been conceivable without this ozone layer. But once more, ozone layer disruption brought on by human activity is linked to several forms of skin cancer. Increased nitrogen oxide emissions into the atmosphere, an increase in supersonic aircraft (SSTs), and the presence of chlorofluorocarbons (CFCs), which are used as refrigerants, in fire extinguishers, and as propellants in aerosol spray cans, are some of the factors that cause the ozone layer to be disrupted. f. Greenhouse Effect - The "Greenhouse Effect" is the phrase used to describe how carbon dioxide affects the earth's temperature. The planet acts like greenhouse glass, allowing solar heat to pass through while keeping some of it from radiating back through the atmosphere. The more heat that carbon dioxide retains, the hotter the world becomes. Experts worry that polar ice caps would melt if temperatures rise merely a few degrees, submerging enormous tracts of land in the process.

39 1.12.2 Effects on Vegetation Air pollution has a high potential for harming crops, and this risk relies on the type, concentration, and timing of the pollution as well as the habitat's characteristics and current conditions. Ecosystems are considered to be most vulnerable if they are on substrates with a low capacity for buffering, occasionally experience high levels of pollution, or have sensitive important species. According to research, rather than leading to a species' extinction, air pollution has contributed to its decline and attenuation. Yet if the pattern holds, it's likely that vulnerable populations in temperate areas will continue to disappear until they are extinct. Since biodiversity and ecosystems are more fragile in the tropics than in temperate regions, pollution effects there, which are now growing more widespread, can also cause the extinction of species. There are several subheadings that can be used to discuss how pollution affects vegetation: Sulfur dioxide, HF, particle fluorides, smog, oxidants like ozone, ethylene (from automobiles), NO, chlorine, and pesticide and weedicide sprays are only a few of the air pollutants that have hazardous effects on plants. The damage typically appears as visual impairment, such as chlorotic marking, banding, silvering, or bronzing of the leaf's underside. In some circumstances, plant development can be slowed down. The kind and quantity of the pollutant, the length of exposure, the state of the soil and plant, the stage of growth, the relative humidity, and the amount of sunlight all affect how much harm a plant sustains. Plant Diseases - A number of plant diseases are also brought on by air pollutants that are released as a result of human activity. These conditions include (Raju, B.S.N., 1998): a. Necrosis: Also known as tissue death, leaf tissue destruction, or extreme drying, is one example. b. Chlorosis: This condition causes the green colour of the leaf to disappear by reducing the amount of chlorophyll in the leaf. c. Epinasty - Epinasty is the downward curling of the leaf's upper surface. d. Acute Damage - This type of damage is brought on when a plant is exposed to contaminants at a high concentration. Effects on Freshwater Systems - In places where the bedrock does not weather quickly, the surface waters are vulnerable to acid deposition. Many areas of the world have seen an increase in their acidity. With increasing acidity, consequences on freshwater life become more pronounced. In the beginning of acidification, some species and groups soon vanish, while others are impervious to harm and, in the absence of competition, may even thrive. According to estimates, between 15,000 and 25,000 European lakes where anthropogenic acid deposition has caused the pH to drop by more than 0.5 units have lost at least 20% of their plant and animal species. Impacts on Heath Lands - Acidic or base-poor heath lands can experience significant alterations as a result of air pollution. For example, excessive nitrogen inputs to unmanaged heath land have caused nitrophilus grasses to take the place of slower-growing heath plants.

40 Effects on Mountain Sites - Environments at high altitudes will be among the first to experience the effects of acidification. Although pollution often declines with elevation, deposition can still be considerable because of the rise in precipitation. In addition, harsh weather conditions prevent plants from absorbing extra atmospheric nitrogen, which instead seeps into steams. 1.12.3 Damage to farm animals The primary contaminants that harm livestock include arsenic, lead, and fluorides. When animals eat the polluted flora, which has accumulated with these airborne toxins, it poisons the animals. In many ores including coal, arsenic can be found as an impurity. Insecticides also make use of it. Arsenic poisoning affects livestock in the vicinity of smelting and other industrial processes, with symptoms including salivation, thirst, liver necrosis, inflammation, and central nervous system depression. Coke ovens and coal combustion in metallurgical smelters, lead arsenate sprays, and vehicle exhausts all produce lead. Horses and other animals can become lead poisoned and exhibit signs like sadness, lethargy, gastritis, paralysis, and breathing difficulties. Particularly vulnerable to flourine poisoning, which can result in fluorosis of the teeth and bones, are cattle and sheep. 1.12.4 Effects on Materials The ubiquitous process of atmospheric corrosion transcends all geopolitical boundaries. Several developing nations are situated in warm climates with high relative humidity and frequent precipitation, which raises the possibility of contaminants that might cause acidification. Buildings and historical sites are potentially under greater risk when SO2 and other pollutant emissions rise in emerging nations. Reducing SO2 may help emerging nations avoid expensive corrosion damage. Sandstone and limestone historical and cultural sites have also suffered extensive damage. Measurements of the impacts of sulphur dioxide (SO2), oxides of nitrogen (NO2), and ozone concentrations are used to describe atmospheric pollution. Throughout the last century, anthropogenic sulphur and nitrogen pollution have severely harmed technical constructions and cultural legacy in industrialised nations. Buildings, infrastructure, and cultural heritage are at risk due to the extremely high concentrations of SOx, which is the most harmful pollutant in this regard, as well as the rising car traffic in major Indian cities. The following are the Main Impacts that are related to how pollutants affect materials: 1 . A reduction in mechanical strength; 2 . Leaks; 3 . Deteriorating protective coatings 4 . Loss of carvings' fine detailing; 5 . Corrosion in pipes. Several Pollutants' Acidic Deposition Processes for Corrosion:

41 (a) Atmospheric corrosion - Direct effect frequently occurring close to the emission source. Climate factors including temperature, precipitation, and relative humidity influence it. Sulfur dioxide significantly speeds up the deterioration of several materials. The synergistic effect of many pollutants, such as sulfur-dioxide, SO_2, plus NO_2, or 02, is a growing source of worry. (b) Water and soil corrosion - Long-distance transboundary air pollution transport makes the indirect effects of soil and water acidity mostly a regional issue. Impacts of Particular Materials (a) Zinc and Copper - Increasing deterioration rates are caused by protective corrosion products dissolving. (b) Rock - The textures, structures, and compositions of rock-stone employed in construction vary. Due to the original calcium carbonate's transition into gypsum and calcium sulphate and subsequent deposition by sulphur dioxide, calcareous stone, such as limestone or marble, is extremely vulnerable to this process. (d) Cultural Heritage - The term "cultural heritage" refers to both prized indoor items housed in museums and archives as well as outdoor structures and sculptures. Cultural heritage has value that cannot always be quantified in monetary terms. (e) Sculptures - Sculptures are different from regular stone constructions in that architects choose the stones for their aesthetic appeal and practical value rather than only their physical and chemical characteristics. (c) Organic Material: Paints and rubber tyres. Ozone degradation is typically linked to temperature, solar radiation, and ozone. Moreover, indoor effects on specific paint pigments might harm priceless and significant pieces of architecture, sculpture, and art. (f) Stained Glass—Church windows made of mediaeval stained glass are susceptible to the damaging corrosion attack of air pollutants. Rock carvings, textiles, artwork, and archaeological monuments are some more objects. Corrosion rates are significantly higher than the worst values in Europe in South-Western China, test sites in towns where sulfur-containing coal is the main energy source. Thus, it is advised that developing countries reduce SO to prevent expensive corrosion damage. Darkening of sky and reduction in visibility Sky becoming darker and visibility becoming worse. Sky darkening may be brought on by dust storms, intense smoke and fog, or both. Smoke, fog, and industrial odours, which contain particles with a size range of 0.4 to 0.9 um and scatter light, may be the cause of the decreased visibility. Particle size, sun angle, aerosol density, air mass thickness, and meteorological elements like inversion height, wind speed, and humidity all determine how strong these effects are. 1.13 Prevention and Control of Air Pollution

42 Air pollution prevention is not an easy task. It is impossible to offer at a fair price. Modern life's expanding needs and conveniences are contributing to some air pollution. For instance, it can be challenging to operate a scooter or car powered by gasoline without contributing to some air pollution. Similar to this, it is challenging to operate an industry without contributing to air pollution. A thermal plant cannot be operated without polluting the atmosphere. The two fundamental methods for reducing air pollution are as follows: i. Limiting or controlling the pollution at its source. You can accomplish this by a. Changing the process such that pollutants do not form above allowed amounts at all. b. Using the appropriate tools to destroy, alter, or trap the pollutants created to lower the pollutant concentrations to acceptable levels before they are discharged into the environment. ii. Reducing air pollution levels to acceptable levels before it reaches the receptor. To prevent the build-up of hazardous ground level concentrations inside the defined zones, this can be accomplished by employing towering stacks, managing the process parameters, with due attention for the local meteorological circumstances, and effective community planning. 1.13.1 Methods and equipment used to control gaseous pollutants The following are various methods for reducing these pollutants: 1. Combustion: This method is employed when the contaminant has organic-based gases or vapours. These pollutants are converted into comparatively harmless compounds, like CO, and water vapour by catalytic or flame combustion. Fume incinerators, steam injection or venturi flares, and after-burners are examples of the machinery used for flame combustion. Catalytic combustion is used when lower operating temperatures are preferred, for as when burning waste cracking gases, paint or enamel baking oven fumes, or when roasting coffee. 2. Absorption: This method involves passing the gaseous effluents through scrubbers or absorbers with a suitable liquid absorbent to either remove or modify one or more contaminants from the gas stream. The degree of surface contact between the liquid and the gas, the duration of the contact, the concentration of the absorbing media, and the chemical reactivity of the gaseous pollutant in the liquid phase all affect how well gas is absorbed. The tools employed include liquid jet scrubber towers, plate towers, spray towers, packed towers, and bubble-cap plate towers. The removal of contaminants like NO_x, H_2S, SO_2, SO_3, and fluorides from gaseous effluents is commonly done using the gas absorption approach. Table 3 lists the various absorbing liquids that are frequently used.

43 Table 1-3: Absorbents for some gaseous pollutants. Pollutants Absorbents NOx H_2O, aq. HNO 3 SO 2 Alkaline water, water, suspension of Ca(OH),, sulphites of Ba or Ca or Na, ethanolamine, dimethyl aniline, 1:1 mixture of water and xylidine, aluminum sulphate, etc. H 2 S Ethanol amines, NaOH+ Phenol (in mole ratio of 3:2), sodium alamine, soda ash, tripotassium phosphate, ammonia liquor from coke ovens, sodium thioarsenate, etc. HF H2O, NaOH 3.Adsorption: This method involves passing gaseous effluents via porous solid adsorbents placed in the appropriate containers. Physical adsorption or chemisorption holds the organic and/or inorganic components of the effluent gases at the interface of the solid adsorbent. Adsorption efficiency is influenced by the adsorbent's surface area per unit weight, various physical and chemical properties, the kind and concentration of the gas being adsorbed, and other factors. Table 1-4: lists the typical adsorbents utilised for different gaseous contaminants. Pollutants Adsorbents NOx Silica gel, commercial zeolites SO 2 Pulverized lime stone or dolomite, alkalized alumina (Al 2 O 3 + Na 2 O) H 2 S Iron oxide HF Lump lime stone, porous pellets of NaF. Petroleum fractions Bauxite Organic solvent vapors Activated carbon Vapours associated with gases Alumina, Silica gel, Bauxite

44 Certain adsorbents are selective for particular uses due to their preferential adsorption properties. For instance, synthetic zeolite or silicate molecular sieves, activated alumina, and Silica gel-6 all favourably adsorb water vapour from a mixture of water vapour and organic contaminants. Increasing the temperature or decreasing the pressure is typically used to desorb the sorbed gases. Higher concentrations of the gases, such as NO 2 , SO 2 , etc., in waste gas streams allow for their economically viable recovery and use in the production of HNO, H 2 SO, etc. Pulverized limestone can be injected into the boiler furnace to remove SO from power plants. As the SOx and CaO combine, calcium sulphite and calcium sulphate are produced. Thus, there is no SO emission into the atmosphere. Masking, counter-action, sorption in a suitable solvent, or adsorption on activated carbon can all be used to regulate odorous gases. Methods and equipment used for controlling particulate emissions Both fixed and mobile sources can contribute to the ambient air's particle content. The size, shape, electrical characteristics, and hygroscopic characteristics of the particulates in question are used to determine the particulate collection devices. The numerous gadgets can be grouped under the following categories: 1) Mechanical gadgets: The following two mechanisms serve as the foundation for most of these devices' operations: (a) Gravity settling, in which the horizontal carrier gas's velocity is sufficiently lowered to cause the particles to settle through gravity force. (b) The particles separate out as a result of the gas flow's abrupt change in direction because they have more momentum. The most widely used mechanical devices for separating particles from gases include settling chambers, buffer chambers, and cyclone separators. Particulate matter is gathered in settling chambers either by centrifugal force or gravity. They are employed in enterprises producing rock products and power plants. Settling Chambers: These are sealed tanks with an inlet and output configuration. The dirty gas is permitted to enter chambers with reduced gas velocity that are closer to laminar flow conditions, which may allow the particles to separate from the gas stream via gravity. Baffle or mesh screens may be suspended in the chamber to guarantee uniform velocity. At the bottom of the settling zone, a hopper bottom with a 1:1 slope is supplied to collect the settled particles. Typically, the flow velocity falls between 0.5 and 3 m/sec. 10 microns is the smallest particle size that can be eliminated. For the removal of particles larger than or equal to 50 microns, efficiency is high.

45 Figure 1-2. Schematic diagram of Settling Chambers In cyclone collectors, the gas stream's velocity is reduced to create a small, constrained vortex, from which the centrifugal forces pull the suspended particles into the collection structure's sides. Cyclone collectors are used in the mining, metallurgical, iron and steel, and rock product industries to remove particle contaminants. Cyclone Separators: An enclosed, vertically positioned cylinder with an inverted cone at the base is a cyclone separator. The inlet is set up at the top of the cylinder with a tangential entrance and an outlet design. By the tangential intake, which provides a swirl option, the calate-containing gas enters the cylinder. The contaminated gas pushes against the cylinder's edge. The avy particles travel towards the cyclone's edge as a result of centrifugal force. The particles then descend into a conical collector at that location. The gas continues to descend until it reaches the conical section's base. A small inner spiral that is concentrically positioned with the first spiral is how the gas there rises. The clean gas exits the cylinder through an outlet pipe once it reaches the top.

46 Figure 1-3. Schematic diagram of Cyclone Separator 2) Filtration Systems: A porous material, such as woven or filled cloth, is used to force dust- laden gases through it. The particles are then caught and collected in the filters, and the dust- free gases are released. Filters made of fibre or deep beds and fabric bags are frequently utilised. The materials used to make fabric filter media include cotton, wool, nylon, dacron, asbestos, silicone-coated glass cloth, etc. Nylon and cloth filters are utilised up to 80-90°C, while glass cloth filters wrapped in asbestos and silicone may withstand temperatures of 250-350°C. For alkaline media, cloth, nylon, and asbestos filters are better than wool, Orlon, and Vinylon filters for acidic gases. Glass fibre filters are better at withstanding chemicals. Industries that deal with rock materials, pigments, etc. use fabric filters.

47 Bag Filters: Particles less than 10 microns in size are removed using bag filters. These particulate removal technologies are dependable and effective. They are set up in a structure known as the "Bag House". Each of the dangling bags has a diameter of 120 to 400 m and a length of 2 to 10 m. The bag's outlet ends open alternately and are joined to a manifold. The intake pipe is where the contaminated gas enters. Gravity will cause the big particles to fall into the hopper. Through the outlet pipe, the gas flows into the bags before exiting. The filter cake will become loose as the cake is cleaned using a shaking mechanism. This cake will fall into the hopper that is placed at the base of the bag house as it becomes looser. Figure 1-4. Schematic diagram of Bag Filters 3) Wet Scrubbers: Wet scrubbers are used when it is necessary to efficiently remove fine particles, remove particulates and gaseous contaminants, treat combustible gases, treat large variations in process flow rates, and treat gases that are 300 °C or higher in temperature. To capture SO 2 , NH 3 , metal vapours, etc., wet scrubbers are utilised in the chemical, mining, and metallurgical industries. It is crucially important to effectively remove particles and gaseous contaminants from anthropogenic gaseous effluents. If air pollutants are released into the atmosphere randomly, the dynamic balance already present in the atmosphere will be upset, having a negative impact on both man and his surroundings. The enclosed tanks known as wet collectors have separate inlet and output configurations for contaminated gas and a cleaning liquid. With a liquid, the particles are cleaned from the gas (scrubbing). Typically, water is utilised as the cleaning agent. When the particulates are made to strike a liquid surface inside the wet collector, the particulates are separated from the gas. These are pre-cleaners that can be used. Wet collectors are typically

48 divided into four basic categories based on the extent of contact made between the material and the liquid. ➢ Spray Tower ➢ Cyclone Scrubbers ➢ Venturi Scrubbers, and ➢ Packed Bed or floating Bed Tower. In addition to these, to reduce air pollution, a wide range of wet scrubbers are used, including ventilation scrubbers, gravity spray scrubbers, wet impinger scrubbers, wet centrifugal scrubbers, etc. Figure 1-5: Spray chambers (a) upward and (b) downward Figure 1-6: Cyclone scrubber Ventury scrubber

49 Figure 1-7: Schematic diagram of Packed Bed According on the mechanism of particle collection, wet scrubbers can be categorised as follows: (a) Liquid carrier type, in which the liquid carrying the trapped gas particles goes to a point outside the collection for final disposal after the gas stream containing the particles is allowed to impact a liquid surface inside the collector. (b) The particle conditioning type involves bringing the gas stream's dust particles into close contact with water, increasing the particles' effective size as a result of the creation of heavier water-particulate agglomerates. Any of the collection systems can more easily separate them from the gas stream. 4) Electrostatic precipitators: For the removal of very minute size pollutants (Aerosols, such as dust, fumes, or mist), electrostatic precipitators are particularly common. It is possible for the contaminated gas to travel between two electrodes. One is a high voltage, negatively

50 charged electrode, while the other is a plate or cylinder that is positively charged. They continue to have a potential difference. High potential difference causes a strong ionising field to emerge. This produces "CORONA," also known as an active glow zone, extremely close to the negative electrode. The passing particles pick up a charge as the negative ions go in the direction of the collecting electrode (low potential electrode). The particles are drawn to and deposited on the collecting electrode by the electric field. The following components make up an electrostatic precipitator: (a) A high-voltage source (b) A large surface area collecting electrode (often positive and at ground potential) and a high voltage discharge electrode (typically negative) with small cross-sectional area, such as a wire. (c) A means of discarding the material gathered; (d) a housing covering the electrode. Operation of an electrostatic precipitator involves the following four fundamental steps: (1) Ionizing the particles to electrically charge them (2) Moving the charged particles to the collecting surface by applying force to them in the electric field (3) Neutralizing the electrically charged particles that precipitated on the collecting surface (4) Removing the precipitated particles from the collecting surface by rapping or washing. Figure 1-8. Schematic diagram of Electrostatic Precipitator Ionization and collection are done in one step in one-stage electrostatic precipitators. In two-stage precipitators, collection comes after the pre-ionizing stage. The latter cannot be used in environments with high levels of dust. Usually, air-conditioning plants employ them. When handling (1) extremely large volumes of gases, (2) recovering valuable dry material, (3) needing a very high collection efficiency to remove fine particulates, and (4) needing very high gas temperatures, electrostatic precipitators are the preferred device. Power companies, paper and pulp businesses, chemical businesses like sulfuric acid plants, iron and steel businesses, mining and metallurgical businesses, rock product businesses, refineries, carbon black manufacturing businesses, etc. all employ electrostatic precipitators extensively.

51 1.14 Ambient Air Quality Standards in India Ambient air quality refers to the state or quality of air surrounding us in the outdoors. The Central Pollution Control Board (CPCB) has established ambient air quality guidelines known as National Ambient Air Quality Standards that are applicable across the country. The 1981 Air (Prevention and Control of Pollution) Act grants the CPCB this authority. Previous to the criteria in November 2009, India had established air quality guidelines on April 11, 1994, which were then updated on October 14, 1998. The 2009 standards uniformized the national standards and considerably reduced the maximum allowed values for contaminants. Industrial zones used to be subject to less strict regulations than residential areas. Also, a brand-new National Air Quality Index (AQI) (http://www.arthapedia.in/index.php?title=National_Air_Quality_Index) was introduced in October 2014 to provide the general public with information on air quality in a format that is simple to grasp. The National Ambient Air Quality Standards for short-term (up to 24-hourly averaging period) are based on
eight pollutants: PM10, PM2.5, NO2, SO2, CO, O3, NH3, and Pb.
The worst reading in these pollutants reflects the AQI for that city. NATIONAL AMBIENT AIR QUALITY STANDARDS CENTRAL POLLUTION CONTROL BOARD NOTIFICATION New Delhi, the 18th November, 2009 No.B-29016/20/90/PCI-L—In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No. 14 of 1981), and in super session of the Notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect, namely:- NATIONAL AMBIENT AIR QUALITY STANDARDS S. No. Pollutant Time Weighted average Concentration in Ambient Air Methods of Measurement Industrial, Residential, Rural and Other Area Ecologically sensitive area (Notified by Central Govt.) 1 Sulphur Dioxide (SO 2), µg/m 3 Annual* 50 20 • Improved West and Geake • Ultraviolet fluorescence 24 hours** 80 80 2 Nitrogen Dioxide Annual* 40 30 • Modified Jacob &
52 (NO 2), µg/m 3 24 hours** 80 80 Hochheiser (NaArsenite) • Chemiluminescence 3 Particulate Matter (size less than 10 µm) or PM 10 µg/m 3 Annual* 60 60 • Gravimetric • TOEM • Beta attenuation 24 hours** 100 100 4 Particulate Matter (size less than 2.5 microns) or PM 2.5 µg/m 3 Annual* 40 40 • Gravimetric • TOEM • Beta attenuation 24 hours** 60 60 5 Ozone (O3) µg/m 8 hours* 100 100 • UV photometric • Chemiluminescence • Chemical method 1 hour** 180 180 6 Lead (Pb) µg/m 3 Annual* 0.5 0.5 • ASS / ICP method after sampling on EPM 2000 or equivalent filter paper • ED – XRF using Teflon filter 24 hours** 1 1 7 Carbon Monoxide (CO) mg/m 3 8 hours* 2 2 Non Dispersive Infra RED (NDIR) Spectroscopy 1 hour** 4 4 8 Ammonia (NH3) µg/m 3 Annual* 100 100 • Chemiluminescence • Indophenol blue method 24 hours** 400 400 9 Benzene (C 6 H 6) µg/m 3 Annual* 5 5 • Gas chromatography based continuous analyser • Adsorption and desorption followed by GC analysis 10 Benzo (a) Pyrene (BaP) – particulate phase only ng/m 3 Annual* 1 1 Solvent extraction followed by HPLC / GC analysis 11 Arsenic (As) ng/m 3 Annual* 6 6 AAS / ICP method after sampling on EPM 2000 or equivalent filter paper
53 12 Nickel (Ni) ng/m 3 Annual* 20 20 AAS / ICP method after sampling on EPM 2000 or equivalent filter paper * Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals. ** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring. Note: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation. 1.15 Summary The existence of mankind in the planet is now directly impacted by air quality. The magnitude of the issue can indeed be managed unless the general public is aware of it. To achieve this, people must comprehend the meanings of the many terms used by environmentalists, such as the greenhouse effect, climate change, acid rain, and photochemical smog. The atmosphere resembles a bizarre, large kitchen where numerous recipes are being prepared continuously. Although while pollutants are produced naturally, if humans did not increase their levels through anthropogenic activity, nature would be able to handle them. Human civilization and the accumulated contaminants from pollution both pose a hazard today. With a focus on their production and clean-up, the principles of air pollution and different aspects of air pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit. Additionally, this unit describe air quality standards in Indian perspectives. 1.16 Questions/ Self-Assessment questions 1. How are air-pollutants classified? State five common air-pollutants, their sources and effects on the man and his environment. 2. What are the sources of NOx and SO, in the atmosphere? What are the undesirable effects manifested by them? How can they be controlled? 3. What is acid rain? How is it caused? What are its bad effects on the man and his environment? What steps are needed to control acid rain? 4. What is photochemical smog? How is it formed in the atmosphere? What are its consequences? 5. Discuss the sources and effects of particulates in the atmosphere.

54 6. Explain the terms "Lapse rate" and "temperature inversion". What are their consequences in the atmosphere? 7. Discuss with the help of diagram the plume characteristics under different lapse conditions. 8. Discuss the various techniques available for air-pollution control. 9. Discuss the sources of Pb in the particulate matter in the atmosphere. How can it be controlled? 10. State the characteristics and biochemical effects of the following air pollutants: (a) SOx (b) NOx 11. What is air-pollution? What are its different sources? 12. Distinguish between primary and secondary air-pollutants 13. What is acid-rain? What are its effects? 14. How does air-pollution affect human health? How does carbon monoxide affect the human body? 15. What is fumigation? What do you understand by mixing height? 1.17 Select Readings/ Suggested Readings 1 . R. K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi. 2 . H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 3 . S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001. 4 . M.N. Rao and H.V.N. Rao, “Air Pollution” McGraw Hill Education (India) Pvt. Ltd, New Delhi, 2013 5 . S.C. Bhatia, “Textbook of Air Pollution and its Control” Atlantic, New Delhi, 2007 6 . S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi. 7 . R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi. 55 UNIT 2: Water Pollution 2.1 Objectives 2.2 Introduction 2.3 Various Types of Water Pollution 2.4 Major Water Pollutants 2.5 Water Pollution Sources 2.6 Impacts of Water Pollution 2.7 Some Important Water Pollutants and Their Sources 2.8 Strategies for Water Pollution Control 2.9 Groundwater Pollution 2.10 Eutrophication 2.11
Summary 2.12 Questions/ Self-Assessment questions 2.13 Select Readings/
Suggested Readings 2.1 Objectives After successfully completing this unit, you will be able to: ➢
learn about the different water pollution sources, ➢ understand
different types of
water pollution and water pollutants, ➢ outline different inorganic, organic and biological pollutants ➢ know sources, effects and control measures of ground water pollution, ➢ learn about eutrophication phenomenon and its remedial measures, ➢ understand the different adverse effects of water pollution, ➢ comprehend the control mechanism of water pollution, ➢ understand the water legislation. 2.2 Introduction Every form of life requires water to survive. The average person drinks roughly 2 litres of water every day. account for water for roughly 70% of a person's overall weight. The earth's surface, which covers a total of 50,000 million hectares, is covered by water to an extent of about 80%. Just 33,400 m3 of the estimated 1,011 million km3 of total water on Earth are usable for drinking, farming, home use, and industrial use. The remaining water is trapped underground, in polar ice caps and glaciers, and in oceans as salt water. The need for water supply has been rising dramatically as a result of rising industrialization on the one hand and a population that is booming on the other. In addition, a sizeable portion of this scarce resource for water is contaminated by sewage, industrial waste, and a variety of synthetic chemicals.

56 The population's health is still under danger from water-borne diseases and epidemics, especially in developing and underdeveloped nations. As a result, both the quality and the availability of clean water are crucial to human welfare. India experiences annual rainfall of between 1400 and 1800 mm. 96% of this water is thought to be used for agricultural, 3% for domestic usage, and 1% for industry. According to a 1982 investigation, nearly 70% of the water that is available in our country is tainted. Many actions are being conducted to control water contamination in light of this circumstance. The phenomena of "water pollution" is defined as the decline in the quality of freshwater (rivers, lakes, marshes, and groundwater) or saltwater as a result of numerous human activities. When compared to now, human waste disposal did not cause issues in the past as long as human contamination was little and communication was dispersed throughout large expanses of land. Yet, as populations increased and towns and villages expanded, organized waste disposal began to take its place, though once more through the assistance of natural land and soil columns. Many communities that implemented the basket privy system resorted to collecting human waste and disposing of it in mud pits. Any physical or chemical alteration to the water that could harm organisms is referred to as water pollution. It is a global issue that affects both developed and developing countries. The streams of affluent countries are polluted by heat, harmful metals, acids, sediment, animal and human waste, and synthetic organic compounds. In the industrialized countries, human and animal wastes, silt, and harmful organisms are at the top of the list. Malnutrition and unclean water are the main causes of illness and mortality in these nations. Water pollution originates from a variety of anthropogenic and natural sources, just as air pollution. Similar to air pollution, water pollution from one country may spread to another, leading to complicated global control issues that could take decades to resolve. 2.3 Various Types of Water Pollution Four criteria can be used to classify water pollution. They include: i. Physical water pollution ii. Chemical Water Pollution iii. Biological Water Pollution iv. Water Physiological Pollution 2.3.1 Physical Water Pollution Water varies in terms of its colour, flavour, density, taste, turbidity, thermal properties, and other characteristics due to physical pollution.

57 a. Turbidity: Water turbidity is mostly caused by soil erosion, colloidal debris, and fine suspended particles. The concentrations of sewage and industrial effluent are often higher and the impacts are generally worse the higher the turbidity. The most serious turbidity is that caused by bacterial sewage contamination. b. Colour: Changes in colour are not hazardous unless they are brought on by a tonic substance, but they may modify the type of sunlight that reaches a certain depth and slow down plant and animal metabolism. c. Odour: Water odour pollution is brought on by both chemical (such as H2S, CI2, and NH3) and biological factors (such as algae, fungi, microorganisms etc.) The amount of HS produced will increase with a lower pH, as will the odour annoyance. d. Foam: Soaps, detergents, and untreated organic waste from the paper and pulp industries all produce foam. e. Thermal pollution of water: It is mostly caused by the release of heat that was produced inefficiently by different thermal power plants. Since there is less dissolved oxygen (DO) in the warmer waters, organic stuff breaks down more quickly. 2.3.2 Chemical Water Pollution Acids, alkalies, poisonous inorganic compounds, dissolved inorganic compounds, and dissolved organic compounds are only a few examples of the inorganic and organic chemicals that contribute to the chemical pollution of water. Acidity, alkalinity or pH, dissolved oxygen (DO), and other gases in water alter as a result of chemical contamination. Organic contaminants, inorganic pollutants, or a combination of both may be to blame. Both biodegradable and non-biodegradable organic contaminants are possible. Organic pollutants that don't degrade: These contaminants are those that linger for a long time in the aquatic system. Pesticides, fungicides, bactericides, etc. are a few examples. Inorganic pollutants include a number of gases, poisonous metals, and chemicals since they also significantly lower water quality. 2.3.3 Biological Water Pollution The presence of harmful bacteria, specific fungi, pathogenic protozoa, viruses, parasitic worms, etc. causes bacterial pollution of water. Domestic sewage and industrial waste are the main causes of bacterial pollution. The ideal environment for bacterial growth in water is solid human waste and sewage's decomposing organic content. The excretory by-products of warm- blooded mammals, such as humans, wild animals, and domestic animals, contribute to bacterial pollution of water. The coliform group, certain subgroups, streptococci, and other organisms are the primary contaminants.

58 2.3.4 Water Physiological Pollution Many chemical substances, including chlorine, sulphur dioxide, hydrogen sulphide, mercaptans, phenols, and hydroxy benzene, contribute to the physiological pollution of water. Depending on the origins and locations of the water, there are five different types of water pollution. i. Ground water pollution ii. Surface water pollution iii. Lake water pollution iv. River water pollution v. Sea water pollution Ground Water Pollution The amount of groundwater, including recharge from infiltration and seepage, is roughly 210 billion m3. Almost one-third of this is taken out for industrial, commercial, and don use, while the majority of the water is recycled into rivers. Sources of Ground Water Contamination: Drinking water supplies underneath are extremely polluted, particularly in smaller towns and cities' outskirts. The following is a list of the most common questions we get from our customers. 1 . Domestic wastes 2 . Industrial wastes 3 . Agricultural wastes 4 . Runoff from Urban Areas 5 . Soluble Effluents Surface Water Pollution The following factors affect the type and extent of surface water pollution: a. Diluting biocides' hydrological properties and their level of self-purification b. The amount of rock weathering, the kind of soil, and vegetation. c. The physical, chemical, and biological properties of wastewater that enters surface waters. d. Systems and methods for treating residential and sewage waste water disposal. Sources of contamination in surface waters: Lakes, streams, and surface chains all have direct contact with surface water and the atmosphere. As a result, while the waste is being introduced via water conveyances, dissolved and atmospheric gases are continuously exchanging.

59 Lake Water Pollution These enormously diverse water resources are seriously threatened by the speedy industrialization and urbanization processes. Polluting sources in lakes i. the release of hazardous effluents from cities and organic waste from hills. ii. factory waste sludges, as well as washings and tailings dumping. iii. Toxic organic materials in lake water are also a result of sewage treatment plants. iv. Industrial effluents that are toxic and dangerous seriously contaminate lake water. River Water Pollution Due to rising population, industrialization, urbanisation, and a wide range of human activities, pollution of water resources has been most exploited. The river water pollution leads to the following significant conclusions: i. Everywhere, the quality of the water is declining. ii. River pollution is worse during the monsoon season and least during the winter. iii. Depending on the distance and kind, effluents and discharge have different effects. Sea Water Pollution More than two thirds of the surface of the earth is covered by oceans, which are essential to maintaining the chemical and biological balance necessary for life. Marine pollution is the dumping of waste materials into the ocean that harms aquatic life, poses health risks to humans, hinders fisheries, and degrades seawater quality.

Changes in the physical, chemical, and biological properties of the saltwater are related to marine pollution. Because of its high salt concentration, this water is likewise unsuited for consumption by humans and for use in industry. Oil Pollution of Water: The most harm is done to water by petroleum and its by-products. The aquatic life in the surface layers as well as the flora and animals along the coast are put in risk by oil and its by-products. To keep the water from coming into touch with ambient oxygen, a single drop of petroleum covers a large area. 2.4 Major Water Pollutants The following five major categories can be used to categorize different forms of water pollutants:

60 Organic Pollutants: The organic pollutants may be further categorized as follows: (a) Oxygen-demanding wastes: They include sewage from people and animals, biodegradable organic compounds, industrial waste from meatpacking facilities, slaughterhouses, paper and pulp mills, tanneries, etc., as well as runoff from agricultural operations. All of these pollutants are neither degraded or decomposed by bacterial action when dissolved oxygen is present (D.O.) As a result, the amount of D.O. in the water quickly decreases, which is bad for aquatic life. For the sustaining of aquatic life, the ideal D.O. in natural waters is 4-6 ppm. Any drop in this D.O. value serves as a measure of pollution caused by the wastes that are oxygen-demanding stated above. At lower levels of D.O. in water, many aquatic creatures cannot thrive. (b) Disease-causing wastes: They include pathogenic microbes, which can seriously harm the public's health when they enter the water together with sewage and other contaminants. These severe water-borne diseases, which include cholera, typhoid, dysentery, polio, and infectious hepatitis in humans, can be brought on by these germs, which are primarily viruses and bacteria. As a result, the first step in reducing water contamination is disinfection. (c) Synthetic Organic Compounds: These include artificial substances including synthetic pesticides, synthetic detergents (syndets), food additives, medicines, insecticides, paints, synthetic fibres, elastomers, solvents, plasticizers, plastics, and other industrial chemicals. It's a good idea to have a backup plan in case something goes wrong. Most of these substances have the potential to be harmful to humans, animals, and plants. Even in tiny amounts, some bio-refractory (i.e., resistant to microbial degradation) organics, such as aromatic chlorinated hydrocarbons, can produce objectionable tastes, aromas, and colours in water, rendering the water (or fish living in it) unattractive. Persistent foams are frequently caused by non-biodegradable compounds such alkyl benzene sulphonates found in synthetic detergents. Alcohols, aldehydes, ethers, and gasoline are examples of volatile compounds that might explode in sewers. (d) Sewage and agricultural run-off: Plant nutrients are supplied by sewage and runoff from agricultural fields, which may encourage the growth of algae and other aquatic weeds in the receiving water body. The water body's worth is diminished as a result of this ungainly plant growth, which is intended for recreational and other uses. Furthermore, the water body eventually turns into a dead pool of water due to the natural biological process of eutrophication, which causes it to lose all of its D.O. (e) Oil: Oil spills from cargo oil tankers on the seas, losses during offshore oil exploration and production, unintentional fires in ships and oil tankers, accidental or deliberate oil slicks (as in the Gulf War between Iraq and U.S.-led allied forces in the year 1991), and leaks from oil pipe- lines, crossing waterways, and reservoirs are all potential causes of oil pollution. Reduced light penetration through surface waters as a result of oil pollution lowers the amount of photosynthesis by marine plants. Moreover, it lowers the D.O. in the water and puts waterfowl, animals, and plants around the coast in danger. As a result, oil contamination causes ugly and dangerous circumstances that are bad for marine life and seafood. Due to the rise in oil-based

61 technologies, huge oil shipments, accidental oil spills, and purposeful oil slicks during international confrontations, oil pollution in the oceans has been rising in recent years. Inorganic Pollutants Mineral acids, inorganic salts, finely divided metals or metal compounds, trace elements, cyanides, sulphates, and nitrates, as well as complexes of metals with organics found in natural waterways are examples of inorganic pollutants. Natural organic species like fulvic acids and manufactured organic species like EDTA are both involved in the metal-organic interactions. Redox equilibria, acid-base reactions, colloid formation, and reactions involving microorganisms in water all affect or are affected by these interactions. These interactions also have an impact on aquatic habitats' metal toxicity and algal growths. The amount of different metals and metallic compounds in water that are released due to human activity equals their background levels in nature. While some of these trace elements are vital to biological functions, others may be hazardous to biota at larger concentrations: The heavy metals, such as Hg, Cd, and Pb, and metalloids, such as As, Sb, and Se, are the most poisonous of the trace elements. The -SH bonds in enzymes are attacked by the heavy metals, which have a strong affinity for sulphur, immobilising the enzymes as a result. The heavy metal ions may also damage amino-groups (-NH) and carboxylic acid groups (-COOH) in proteins. The transport phenomena through the cell wall are hampered by the heavy metals that may be attached to the cell membranes. Moreover, heavy metals often precipitate phosphate bio-compounds or catalyse their breakdown. Most commonly, street dust, home sewage, and industrial effluents cause heavy metal water pollution. Suspended solids and sediments The main causes of sediments include soil erosion brought on by natural processes, agricultural expansion, strip mining, and construction activities. Silt, sand, and minerals that have eroded from the earth make up the majority of the suspended particles in water. For tropical nations like India, soil erosion caused by water, wind, and other natural factors is particularly important. 175 million hectares of the 328 million hectares of land that make up the entire planet are thought to be vulnerable to soil erosion. The continents are thought to lose 5.8 cm of surface soil every 1000 years. Every year, roughly 6000 metric tonnes of soil are washed into the ocean, which translates to approximately 5.37 million tonnes of NPK (nitrogen, phosphorous, and potassium) fertilisers. The soil in the land region degrades both qualitatively and quantitatively as a result of this erosion. As a result, soil from agricultural land may be relocated to places where it is not at all necessary, such water reservoirs. The process of sedimentation occurs when soil particles eroded by flowing water eventually end up in water reservoirs. Due to siltation, soil fragments and other solid materials are deposited inside reservoirs and dams. This shortens the lifespan of the dams and reservoirs by reducing their ability to store water. Similar issues are present with our reservoirs, including Ram Ganga, Hirakud, Nizamsagar, Bhakra, and Maithan, and the consequent decrease in live storage capacity of the reservoirs may result in a significant loss of our country's irrigation potential.

62 The suspended particles found in water bodies may also obscure the sunlight needed for photosynthesis by the bottom plants, in addition to filling up reservoirs and harbours. This might also suffocate corals, shellfish, and other bottom-dwelling organisms. The typical aquatic life in streams is harmed by the deposition of sediments in still sections. Moreover, organic solid-containing sludge blankets break down, creating anaerobic conditions and unpleasant gas production. By using effective soil and forest management techniques and good farming practises, the enormous problem of oil erosion can be reduced. In general, sediments have a larger organic matter content than do soils. To store trace metals like Cu, Co, Ni, Mn, Cr, and Mo, sediments and suspended particles exchange cations with the surrounding aquatic medium. Silt and coal are examples of suspended particles that can damage fish gills and result in asphyxiation. Radioactive Materials The following anthropogenic activities may be the source of the radioactive water pollutants: a. Ore extraction and processing, such as with uranium tailings. b. Growing usage of radioactive isotopes for research, industrial, agricultural, and medical (diagnostic and therapeutic) purposes, such as I 131 , P 32 , Co 60 , Ca 45 , S 35 , C 14 , Rb 86 , Ir 132 , and Cs 137 . c. Radioactive substances from nuclear reactors and power plants, such as Sr 90 , Cs 137 , Pu 248 , and Am 241 . d. Radioactive materials from nuclear weapon testing and usage, such as Sr 90 and Cs 137 Water contains the radioactive isotopes Sr 90 , I 131 , Cs 137 , Cs 141 , Co 60 , Mn 54 , Fe 55 , Pu 239 , Ba l40 , K 40 , and Ra 226 . These radioactive isotopes are poisonous to all living things. For instance, Sr 90 , which is produced during nuclear bomb testing and accumulates in bones and teeth, can lead to major health issues in people. Sr 90 can be present in water at a maximum concentration of 10 pico curies per litre (10 -12 curies = 1 pico curie). Heat In any process where heat is transformed into mechanical work, waste heat is produced. Hence, thermal power plants—especially those that produce electricity using nuclear fuel— significantly contribute to thermal pollution. Waste hot water from these industries, where water is utilised as a coolant, is returned to the original water bodies. As a result, the water body's temperature rises. Due to the drop in water's DO level brought on by this temperature increase, aquatic life is negatively impacted. Moreover, any increase in temperature may make aquatic life more vulnerable to the harmful effects of particular substances, including aromatic methyl mercury and several polycyclic hydrocarbons. The range of organisms that can adapt to live at that temperature and DO level may change if there is a reduction in DO in the water. In addition to producing unpleasant tastes and odours, suspended particles in water may also foster conditions that are conducive to the growth of harmful germs.

63 2.5 Water Pollution Sources All living things require water, the most plentiful and lovely natural resource, to survive. Yet, today's clean water is a valuable resource, and its quality is challenged by a variety of pollution sources, including: 1. Domestic waste and sewage, 2. Industrial waste products, 3. Agricultural effluent, 4. Plant Foods, 5. Detergents, 6. Harmful metals, 7. Siltation, 8. Thermal pollutants, 9. Radioactive substances Domestic Wastes and Sewage Sewage is often a mineral- and organic-rich diluted aqueous solution. Sewage, household trash, and food processing facilities account for around 75% of all water pollution. Moreover, it contains sewage sludge, soap, detergents, metals, glass, garbage, and human excrement. Household sewage and other wastes are frequently thrown into bodies of water like ponds, lakes, streams, and rivers either untreated or only partially treated. As the dumping is unregulated, particularly close to large cities, the water bodies are unable to recycle them and lose their ability to self-regulate. There is a danger that the water will become contaminated if domestic sewage is not correctly managed when it is produced or if the sewage collected at the end of the sewage treatment plant does not meet the required criteria. Domestic sewage handling without consideration may also contaminate wells and other subterranean water sources. The water of such rivers is tainted or polluted if sewage or poorly treated sewage is released directly into them. Industrial Effluents Industrial waste, hazardous chemicals, phenols, aldehydes, ketones, amines, cyanides, metallic waste, plasticizers, toxic acids, corrosive alkalies, oils, greases, dyes, biocides, suspended particles, and thermal pollutants are all found in industrial effluents that are discharged into water bodies. Some of the most significant causes of water pollution are effluents, or discharges from various industries, including those in the pharmaceutical, brewing, tannery, dyeing, textile, paper, plastic, chemical, metallurgical, fertiliser, etc. When these effluents are released into the sewage system, they contaminate the biological purification process used in sewage treatment and cause a number of pollution issues. Agricultural Discharges Water supplies are said to be heavily contaminated by plant nutrients, pesticides, fertilisers, farm wastes, manure slurry, sediments, drainage from silage, plant and animal detritus, and soil erosion, which is largely made up of inorganic components. In current agricultural pesticides, soil is amended using NPK fertilisers, which contain nitrates and phosphates. Some of these are irrigated and drained into water bodies by rainfall, where they seriously disrupt the aquatic ecology. When plant nutrients are used in excess, the nitrogen and phosphorus balance in the water is disturbed, which has an impact on plant growth. The BOD of receiving water rises as a result of organic waste.

64 Fertilizers Artificial fertilisers, such as various biocides, are widely used in modern agriculture. Despite the fact that these chemicals improve vegetation, they destroy the entire aquatic ecology. They seriously contaminate the water. Because some fertilisers get washed off the land into rivers and lakes by irrigation, rain, seepage, and drainage, excessive and indiscriminate use of fertilisers on land has also had a negative ecological impact on aquatic ecosystems. The main component of fertilisers that causes an algal bloom is phosphate salts. Detergents Surfactants (10–30%), builders (15%), and other components are used to make detergents, which are modern cleaning agents. Several contaminants included in household detergents have a negative impact on water bodies. They contain surface-active compounds that contribute to sodium (Na) phosphates, sodium silicates, sodium sulphates, and other salts. The environmental degradation brought on by industry waste being dumped into surrounding water sources is detergents' main drawback. Toxic Metals The mining sector is one of those with the highest heavy metal emission rates. industries like metallurgy, leather, distilleries, battery manufacturing, and thermal power plants. Industrial processes and home sewage disposal add toxic metals to the water system. It has been determined that traces of heavy metals like Hg, Cd, Pb, As, Co, Mn, Fe, and Cr are harmful to the aquatic ecology and human health. Trash containing dangerous metals in large concentrations, either singly or in combination, is exceedingly toxic to all living things. Siltation Silt is made up of dust and dirt that travel from the land to the river. The most pervasive and harmful contaminant, particularly in hill streams, is siltation. High turbidity levels in the water are caused by these soil particles, which may impede fish growth and productivity as well as the ability of aquatic organisms to move freely. Thermal Pollutants That leads to two significant issues: (a) Since biological life is more active at high temperatures, there is a greater need for dissolved oxygen as water temperature rises. (b) The amount of dissolved oxygen in water decreases as temperature increases. So, at higher temperatures, there will be less dissolved oxygen in the water. Thermal power plants are where the most unused heat is released, which is bad for the aquatic environment. Radioactive Materials in Water In water bodies where live species are acclimated to radioactive materials, man-made sources have started to introduce high doses of radio nucleoid with a variety of negative effects. Nuclear power facilities, reactors, fusion products, and other sources all release radioactive pollutants into the water streams.

65 2.6 Impacts of Water Pollution 2.6.1 Negative Impacts of Household Garbage and Sewage (a) Sewage is a great environment for pathogenic bacteria, viruses, and protozoa to develop. (b) Household sewage renders water absolutely unfit for drinking and domestic use. Domestic sewage is primarily constituted of spent water that contains wine, soapy water, and food particles. (c) Many pathogenic bacteria that are introduced into the water have negative effects on humans and animals and cause chronic illnesses. 2.6.2 Harmful Effects of Industrial Pollutants (a) It has harmful effects on living things and may result in death in sub-lethal kidney, liver, brain, and lung pathologies. (a) Disinfectants, which are added to water to reduce bacterial and algal growth, may linger in bodies of water and endanger fish. (c) Acidic and alkaline effluents render the water corrosive. 2.6.3 Effects of Fertilizers a) Impacts on People and Animals - When nitrogen fertilisers are applied excessively to the soil, nitrates typically build up in the water, where they are then transformed by gut bacteria into harmful nitrates when consumed by humans and animals. Methanoglobin is created when nitrates enter the bloodstream and interact with haemoglobin, which has a greater affinity for nitrates than for oxygen. This harms the vascular and respiratory systems, which increases the risk of suffocation and death. b) Effects on plant - Agricultural fertilisers drive out vital nutrients that are found in the upper soil layers, which has negative effects on plants. Humus that has been microbe-enriched promotes plant development. Nevertheless, soil that has been fertilised cannot sustain microbial life for very long. Fertilizers that are used to boost crop growth also boost algal growth in the surface water that crops are washed into. Eutrophication is the term used to describe the enhanced water fertility that accelerates the growth of water plants and algae. 2.6.4 Thermal pollution's effects on water The quality of the water and organisms are both significantly impacted by the increase in temperature in aquatic systems. Some negative impacts include the following: (a) Decreasing dissolved oxygen levels, b) Rise in BOD, c) Overuse of eutrophication, d) Lessening of gases' solubility in water; e) The aquatic food supply is impacted by the water's silt load setting up quickly.

66 2.6.5 Effects of Radioactive Pollutants in Water (a) Radiation sickness is a group of symptoms caused by contaminated water that contains radioisotopes and is characterised by nausea, vomiting, diarrhoea, epilation, and overall weakness. (b) It destroys the body's biological immune system, making it less resistant to certain illnesses. (c) It results in blood abnormalities, gene mutations, and somatic and genetic problems in higher animals, including man. (d) Water-borne radioactive elements build up in soil sediments, the atmosphere, and aquatic ecosystems. (e) Plant mutation rates may rise if radioactive traces are present. (f) According to a recent study, phosphatic fertilisers also include fluorine and trace amounts of uranium, which are harmful to plants' metabolism and reach the water supply through rainfall. 2.7 Some Important Water Pollutants and Their Sources Causative agents are as follows: 1 . BOD Content (Organic Matter): Brewery, sugar production, wool processing (wool washing), pulp and paper industry, leather industry, municipal sewage, and night soil treatment plant are some of the industries that deal with processing food (canned goods and dairy products processing, marine product processing, starch processing, etc.). 2 . Suspended Solids (SS): (Organic SS) Municipal sewage, coal washing, paper and leather industries, food processing. graveyard, mining industry, quarrying industry, and ceramic industry (inorganic SS). 3 . Fats and oils: industries involved in food processing, petrochemicals, the production of iron and steel, mild finishing, and wool processing (wool washing). 4 . Acids or alkalies: Mining, papermaking, pulp, electroplating, and metal all need acids or alkalies. chemical, textile, leather, and surgical industries. 5 . Ammonia: Gas and coke plants 6 . Phenols: Coke and gas production facilities, synthetic resin production, and other organic chemical businesses. 7 . Sulfides: Wastewater treatment facilities, the dyeing and leather industries, the pulp and gas sectors. 8 . Color: The production of dyes, dyeing, paint, leather, chemical industries, and nocturnal soil treatment facilities. 9 . Odour: Industries that produce odours include those that process chemicals, pulp, marine products, pork, sugar, or leather, as well as sewage and night soil treatment facilities. 10 . Detergents: (Active agents for laundry, textile industry, and municipal sewage surfaces).

67 2.8 Strategies for Water Pollution Control We are currently in a situation where water pollution has emerged as a major global issue, in part owing to the amazing growth of industrialization and in part due to the population boom. Man's activities have negatively impacted the neutral aquatic environment, either by overcrowding and insufficient or non-existent sanitation or through the uncontrolled huge discharge of trade waters into water systems. Using pollution control techniques is an investment that will yield long-term returns. It is a reality that the costs associated with implementing effective and long-lasting pollution control measures are far more than the harm caused by pollution. Pollution is a sign of an ineffective procedure. It signifies the waste of global resources, a financial burden on a country, and a loss of revenue for an organisation. Reducing inefficiencies will help to minimise and reduce pollution. The majority of industrialized or developed nations use energy with an overall efficiency of 40%. Almost 50% of the energy consumed is lost and manifests as waste heat, which affects both the climate and aquatic ecosystems. As a result, the civic society is increasingly opposing industries. Building wastewater treatment systems and plants wastes a lot of time and money. In many instances, altering the technique or the raw materials would guarantee that the issue is resolved for the least amount of money and without degrading the product's quality. Yet, the problem cannot be solved by the conventional pollution control method. Yet that might make it more difficult. For instance, whereas the combustion of chemical wastes produces harmful gases as well as particulate matter, the purification of wastewater produces sludge. Thus, an environmental dilemma result. It costs money to clean up pollution. Remaining after pollution has been removed. The removal of this residue requires additional resources, and doing so also results in an increase in pollution. Thus, the following measures need to be modified in order to control and avoid water pollution: a. In order to increase non-waste technology's structural dimensions, various industrial, agricultural, and urban activities should be linked together. In this way, one industry's trash can be used as the raw material for another. Such a technology would depend on the efficient use of resources as well as the internal transfer of wastes from one area to another where they would serve as the raw materials. The goals ought to be: a) Waste prevention, b) Reducing wastes that cannot be avoided; and c) making waste that is eventually released into the environment harmless. b. Cleaner manufacturing methods should be used to prevent pollution since they are safer because polluting waste is eliminated at the source. c. Stabilizing the aquatic ecosystem by regulating the intake and outflow of energy and nutrients is unquestionably the most effective strategy to prevent and control water pollution. Reducing waste inputs, managing hazardous industrial effluents and municipal sewage, harvesting biomass, storing nutrients, aerating the air, and managing fish populations to safeguard aquatic flora and fauna are all practical ways to promote ecological stability.

68 d. Wastes can be treated using affordable and effective techniques. For instance, oxidation or stabilisation ponds can also be employed where there is enough land, by utilising the abundant sunshine and hot heat that occurs in most places of India. Domestic or industrial waste is held in big, clearly defined shallow ponds for a few days in oxidation ponds. A healthy bloom of algae and bacterial colonies develop in the presence of enough sunlight and organic nutrients in waste. The bacteria quickly break down the organic waste and make it safe through this reciprocal process. There is no risk of pollution when using these effluents again for irrigation of land. If the procedure is run correctly, there is no offensive odour released. 2.9 Groundwater Pollution The earth's surface is covered by more than 98% of its fresh water supply. We observe the remaining 2% in lakes, rivers, streams, and reservoirs. Around 90% of the fresh water below the water table is ground water, which is water that exists in saturated materials below the water table. The unsaturated zone above the water table contains around 2% water as soil moisture, which is necessary for plant growth. Due to the large pore space in earth materials, ground water serves as a reservoir, a conduit for long-distance water transportation, and a mechanical filter that enhances water quality by eliminating bacteria and suspended particulates. The source of water for wells and springs is the important factor. The suggested source for rural home usage is the water that comes from springs and wells. It is new precipitation that falls as rain, snow, sleet, or hail. Industrial, household, and agricultural waste are now being continuously and alarmingly added to ground water reservoirs by human activities. Ground water contamination is typically irreversible, meaning that it is challenging to return the aquifer's original water quality once it has been poisoned. The water quality is reduced by excessive groundwater mineralization, which results in an unpleasant taste, odour, and excessive hardness. Although the soil mantle acting as an adsorbent and holding a significant amount of colloidal and soluble ions due to its capacity for cation exchange, ground water is not entirely immune from the threat of chronic pollution. India's key industries—metals, chemicals, pharmaceuticals, and petroleum—have adequate industrial infrastructure. But, other sectors—plastics, pesticides, fuels, solvents, paints, and food additives—release effluents and pollutants that harm the soil, water, and plant ecology. Heavy metal pollution of the soil and plant-animal ecosystems results from the discharge of solid and liquid wastes containing heavy metals as lead, mokel, chromium, molybdenum, and mercury in land or water bodies. 2.9.1 Factors Affecting Ground Water Pollution 1. Pattern of Rainfall 2. Water table depth 3. The separation from the contaminating source

69 4. The texture, structure, and titration of the soil 2.9.2 Ground Water Contamination Sources 1. Household waste 2. Wastes from industry 3. Animal manures 4. Runoff from cities. 5. Saturable wastes Household waste In metropolitan locations, household garbage and disposal techniques are of the utmost importance. Pathogenic organisms, oxygen demand, nutrients, and sediments from household wastes are some of the elements causing the water quality to deteriorate. Solid wastes represent a severe threat to the quality of the groundwater since they are partially burned and partially assimilated into the soil. Wastes from industry The majority of businesses often generate large amounts of organic and inorganic effluents, as well as wastes containing harmful heavy metals. These substances seriously harm the groundwater by contaminating it. In North Delhi, more than 500 companies are seriously contaminating the groundwater, which is used for domestic purposes. Heavy metal acids are being dumped into open cesspools and drains by steel re-rolling mills and pickling companies, and these pollutants then seep into the water. Those who live close to or work in these companies are most severely impacted since they frequently rely on hand pumps to provide them with drinkable water. Agricultural wastes The water is continually being supplemented with fertilisers, pesticides, insecticides, herbicides, processing wastes, and animal faeces. Nitrate, phosphate, and potash-containing leachates from agricultural land flow downward with percolating water and join the aquifers below, posing a threat to ground water. Hence, a seemingly benign activity like farming could result in undetectable nitrate contamination. Although in India phosphate is more to blame for this as it produces phyxiation of water bodies, nitrate also contributes to the eutrophication of rivers. Subsequent studies revealed that all pesticides were present in groundwater at higher levels than in surface water. The paper explains that the high pesticide residue concentration in ground water may be caused by the fact that ground water flows more steadily and experiences smaller dilutions than surface water, as well as by the concentration of organochlorine pesticide residues in ground water's higher stability. These pests accumulate in the soil, where they are gradually moved into the groundwater. Because people, especially in rural areas, rely more on groundwater than other sources because they think it is safer than surface water, this dangerous situation must be corrected. Runoff from Urban Areas 1. A lot of oils, greases, nutrients, metals, and detergents are concentrated in urban wastewater. Because they are soluble, detergents can penetrate the soil and reach groundwater.

70 2. Water pollution also results from raw sewage discharged in shallow soak pits and seepage from contaminated lakes, ponds, and streams. 3. Rainfall may carry significant impurities from air and dust into the aquifer below. Sand- filled soils and well waters may become polluted as a result of the intrusion of harmful liquid contaminants. 4. The problem has gotten worse as a result of forest clearing, which raises surface runoff and lowers groundwater levels. Soluble effluents 1. The ground water is severely polluted by several soluble effluents. In areas with sandy soils and in humid climates with high water tables, the extent of pollution is greater. 2. In dry tropics, agriculture frequently uses 90% of the water withdrawals. Crop kinds with high yields need a lot of water. Water bodies like rivers and lakes have become smaller as a result of the current high water withdrawal rates. 3. The levels of ground water have been directly impacted by this. Lowering groundwater levels are a result of increased groundwater consumption. 4. Saline wake has entered ground water as a result of rising ground water withdrawal prices. 5. Pollution is a significant role in the decline of water quality and, consequently, clean water availability. 6. Nature's capacity to degrade pollutants into less dangerous substances has been surpassed by the quantities and varieties of trash that are released. Other possible groundwater contamination sources 1. Lagunas for the treatment of sewage, 2. Mine Spills, 3. seep holes, 4. Municipal and rural waste, 5. Composting septic systems 6. Rubbish Dumping, 7. Pollutant Leaching and Downward Movement 2.9.3 Harmful Effects of Ground Water Pollution Ground water pollution causes irreparable damage to soil, plants and animals including 1. Harmful Effects on Man a. The main factor contributing to the spread of epidemics and chronic diseases in humans is contaminated ground water. It results in typhoid, hepatitis, jaundice, dysentery, diarrhoea, and tuberculosis. b. Lung cancer and asbestosis are lethal diseases brought on by water contaminated with asbestos fibres. ii. Groundwaters in locations with high rainfall levels have dangerous levels of iron as high as 20 ppm. In deep tube wells, iron is present as the ferrous ion, which when removed quickly undergoes oxidation and precipitation as ferric hydroxide, changing its hue to a bright yellow orange. Given that the acceptable limit for iron in drinking water is only 0.3 ppm, such waters are exceedingly dangerous.

71 iii. The woollen industries in Punjab-Ludhiana, Amritsar, Haryana-Sonepat, and Ambala contribute significant amounts of hazardous metals to groundwater, including Hg, Ni, Cu, Cr, Fe, and cyanides, which cause skin and stomach illnesses in humans. iv. High fluoride level (greater than 0.5–1.5 ppm) results in mottled teeth, bone deformation, and joint pain that renders people incapable of doing nearly all productive activities. v. Both people and animals are negatively impacted by rising nitrate levels in groundwater. "Methaemoglobinaemia" or "Blue baby disease" is brought on by nitrate's combination with haemoglobin, the blood's oxygen transporter, to create methaemoglobin, which reduces the tissue's ability to carry oxygen. 2. Harmful Effects on Soil i. When used to irrigate agricultural fields, dirty groundwater causes significant crop damage and lowers grain yields. ii. Dead bacteria and other soil microorganisms severely reduce soil fertility. I Contaminated groundwater makes soils more alkaline. iii. Groundwater pollution disrupts the entire ecosystem and has a negative impact on plant metabolism. 2.9.4 Control of Groundwater Pollution i. Carefully examine the sources of the contaminants ii. The location of municipal and industrial disposal sites should be chosen while taking the local groundwater levels and flow patterns into consideration. iii. The industry itself needs to take action to effectively remediate harmful industrial effluents. iv. Extreme caution should be exercised while choosing the location of wells for drinking water supply. v. The origins and directions of any nearby contaminants should be considered. vi. In the case of drinking water wells, it is not advisable to draw water from the topmost aquifer. 2.10 Eutrophication Introduction The word "eutrophos," which means well-nourished or enriched in Greek, is the source of the term "eutrophication," a natural process. Due to anthropogenic or natural factors, the lake water is enhanced in nutrients, nitrates, and sulphates during this process. This causes aquatic plants of all sizes, whether micro or macro, to grow excessively, which causes the phenomena of natural plant ageing. Nitrates and sulphates are the main nutrients, although other substances like phosphates and calcium levels can also contribute to eutrophication.

72 2.10.1 Nutrients' Sources When fertiliser nutrients are applied in unnaturally large concentrations, eutrophication quickly worsens. Urban drainage, detergents, animal waste, domestic and industrial waste, and sediments all enter water streams. 2.10.2 Eutrophication Types 1. Natural Eutrophication 2. Man-made eutrophication 1. Natural Eutrophication Natural eutrophication is the term used to describe the process of lake ageing marked by nutrient enrichment resulting from environmental factors. The micro-plants, such as algae, that helped the lake grow originally contribute additional nutrients to the lake waters when they are dying. The nutrients help in the formation of more and more aquatic planktons and plants, which causes the lakes to age. This promotes the growth of micro plants like water hyacinth, which further raise the concentration of the nutrients in their death phase. Consequently, oligotrophic (a lake without plants at first) lakes become eutrophic lakes throughout the process of natural eutrophication. In the beginning, it allows for the growth of phytoplankton, algal blooms, and aquatic vegetation like water hyacinth, aquatic weeds, water fern, and water lettuce, which in turn supplies plenty of food for fish and herbivorous zooplanktons, but in the later stages, it may cause aquatic animals to perish from DO depletion. 2. Man-made eutrophication Human activities, which provide 80% of the nitrogen and 75% of the phosphorus to lakes and streams, typically speed up this process. 2.10.3 Eutrophication's Impacts a. When there is eutrophication, harmful compounds are released by algal blooms, killing fish, birds, and other aquatic species and causing the water to sink. b. Algal bloom decomposition causes water to lose oxygen. Aquatic species start to perish as a result of the low oxygen levels and high CO levels, and the clean water degrades into a foul outflow. c. The same microorganisms produce oxygen by reducing nitrates when the oxygen level is zero (anaerobic zone). When nitrate is completely depleted, oxygen can only be recovered as a last option by reducing sulphate, which results in hydrogen sulphide and gives water a putrid flavour and odour. d. Sewage products support the growth of numerous harmful bacteria, viruses, protozoa, and other organisms under anaerobic conditions. It causes the spread of water-borne illnesses that can be lethal, including typhoid, polio, dysentery, diarrhoea, and viral hepatitis.

73 e. Overfertilization causes algae to become highly dominant. Algae and rooted weeds impair water quality and waterworks, block filters, and interfere with hydroelectric power generation. 2.10.4 Control of Eutrophication 1. To reduce the nutritional value, the wastewater must be treated before being released into water streams. 2. By eliminating nitrogen and phosphorus from the source, dividing nutrient-rich waters from the receiving bodies, and diluting these substances, eutrophication can be reduced. 3. Once an algae bloom has died and begun to decompose, it should be removed. 4. Dissolved nutrients can be removed using physicochemical techniques. For instance, nitrogen can be removed using nitrification, denim base, reverse osmosis, and ion exchange techniques. Phosphorus can be eliminated using precipitation. 5. Although the eutrophication process, which involves a natural series of events, is challenging to manipulate, it can be temporarily controlled by eliminating aquatic vegetation. To kill algae and rooted plants, respectively, CuSO4 and sodium arsenate are used. 2.11 Summary Protecting the environment and living things is one of the main goals of pursuing environmental science. For our quality-of-life water is a crucial resource. Therefore, the availability to safe water for consumption and hygienic reasons is a requirement for human health and well-being. Water bodies (such as lakes, oceans, rivers, aquifers, seas, and groundwater) can get contaminated through human activity. Any modification to

the physical, chemical, or biological characteristics of water that will have a negative impact on any living thing is referred to as water pollution. Chemical fertilisers and pesticides, sediment from soil degradation, discharge from sewer systems, effluent from cattle feedlots, toxic waste (some poisonous) from companies, plastics, and wastewater and other urban wastes from cities and towns are among the factors that contribute to water pollution. It has diverse range of adverse impacts on different components of the environment. Accordingly, the control of noise pollution is crucial. With a focus on their production and clean-up, the principles of water pollution and different aspects of air pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit. 2.12 Questions/ Self-Assessment questions 1. How are water pollutants classified? Give suitable examples. 2. Discuss the important characteristics of waste waters. 3. Define water pollution. Describe different types of water pollution. 4. Explain different Sources of water pollution. 5. What are biodegradable pollutants,

74 6. Explain the fallowing a) Industrial pollutants, b) Agricultural pollutants, c) Domestic pollutants 7. Describe briefly eutrophication causes and their control measures. 8. Describe briefly ground water contamination causes, effects and their control measures. 9. Briefly describe control strategies of water pollution. 10. Short note of water pollution effects. 2.13 Select Readings/ Suggested Readings 1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi. 2. P.K. Goel, "Water Pollution Effects and Control" New Age International (P) Limited; Publishers, New Delhi, 1997. 3. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 4. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001. 5. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi. 6. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

75 UNIT 3: Noise pollution 3.1 Objectives 3.2 Introduction 3.3 Characteristics of Sound and Its Measurement 3.4 Measurement of Noise 3.5

Sources of Noise Pollution 3.6 Effects of Noise Pollution 3.7 Control of Noise

Pollution 3.8

Noise Pollution - Legal Perspectives in India 3.9 Summary 3.10 Questions/ Self-Assessment questions 3.11 Select Readings/

Suggested Readings 3.1 Objectives After successfully completing this unit, you will be able to: ➢

learn about the

different noise pollution sources, ➢ understand sound wave characteristics, ➢ outline noise measurement units and different noise indices, ➢ understand the different adverse effects of noise pollution, ➢ comprehend the control mechanism of noise pollution, ➢ understand the noise legislation. 3.2 Introduction One of the many pollutants and polluting agents is noise, which has the ability to cause a wide range of illnesses, from a simple headache to heart attack and irreversible hearing loss. It is imperative that the authorities put a stop to the noise pollution sources since the amount of noise pollution is rising to frightening heights in every megacity. But, before dealing with noise pollution, we must be clear about the difference between noise and pollution in our minds. Although man has been plagued by the threat of loud noise and echophony since the dawn of time, Robert Alex Baron (1964) was the first to demonstrate that noise, which is an unavoidable component of daily life for many individuals, has negative physiological and psychological impacts. Too much loud noise, which is pervasive, especially in the nation's crowded cities where there is no moral or legal restriction on the use of blasting horns and high- pitched talk, has become a severe hazard to the environment for people. While, most people

76 are unlikely to experience excessive noise level, it may be annoying or disturbing to them. So, one definition of noise pollution is "unwanted sound that is released into the environment to annoy its recipients." Definition of Noise The latin word for nausea is where the word noise comes from. When all of the definitions of noise are taken into account, it becomes evident what noise actually is. Despite having a variety of deliberate interpretations, the subject is still up for debate. For example, at a political event, the attendees are ecstatic to hear their scary intrusion into their tranquilly. Similar to how young people may find beautiful music, the elderly and ill may find it to be hell. Hence, in essence, music is a sound that pleases the ear, whereas noise is a sound that irritates and annoys. These definitions will provide some insight. "Bad sound at any time," "Sound without value," "Sound that the recipient does not want" "Noise" as defined by the World Health Organization (WHO), is undesirable and unwanted sound." "Noise is generally defined as the sound that is disturbing to the normal level of human perception of sound". The degree of disturbance, however, varies widely with the sensitivity of the person vis-a-vis factors such as age, health of the hearing mechanism and the nature of the stress and strains undergone by the individual. Webster defines noise as "a sound that lacks agreeable musical quality or is noticeably loud, harsh or discordant". 3.3 Characteristics Of Sound and Its Measurement The motion of waves in an elastic material that result from molecular vibrations makes up sound. Periodic mechanical disruption of solids and fluids. Both vibrating surfaces and vibrating gases emit sound. Also, as exhaust gas speed increases, noise also increases quickly. The vibrations of solid objects or the separation of fluids as they move over or through holes in solid objects are what enable sound to be produced in the surroundings by alternating pressure changes in the air. These vibrations create compression, then rarefaction, and so forth in the surrounding air. Sound waves are created by the alternating compression and rarefaction of the surrounding air, and they travel in a sinusoidal pattern. Period: The interval between successive oscillation peaks or troughs is referred to as the period (P). The frequency is the number of times a peak appears within a second (D). Hence, = 1 Wave Length: Wave length (λ) is the separation between two succeeding peaks or troughs, when C is the sound wave's velocity.

77 λ = C × 1 Amplitude: The height of the peak sound pressure, measured above or below the zero- pressure line, is known as the amplitude (A) of the wave. Thus, a sine wave's equivalent pressure is denoted by the root mean square pressure (Prms), which is denoted as Prms = √ 2 × (t) = √ 1 ∫ 2 × ( ) × 0 Where P(t)= Pressure at any time t. Hence, to calculate the r.m.s. sound pressure, add the squares of the amplitude values at short time intervals, divide the sum by the averaging period, and then take the square root of the total. Sound Pressure = Total Atmospheric Pressure - Barometric Pressure Figure 3-1. Sound wave and their characteristics Power of sound (W): The pace at which a sound wave is producing work while travelling in its path of propagation is known as the power of sound (W). Hence, the power of a sound wave is defined as the amount of energy it transmits in the direction of propagation and is measured in watts in S.I. units. Sound Intensity: The sound intensity (I) is the sum of the sound power per unit area normal to the direction of the sound wave, averaged over time. The equation relates a sound wave's intensity and power. I = W/a

78 Where I = Intensity in watt/m^2 W = Power of sound wave in watts a = A unit area $\perp$ to the direction of wave motion I = P 2 r.m.s/ρ.C, where P 2 rms = r.m.s. sound pressure in pascal (P) ρ = density of air or medium in kg/m^3 C = velocity of sound in m/s (ρ,c) can be known if temperature of air is known c=20.05 √T, T= absolute temperature in Kelvin(k) c is in m/sec 3.4 Measurement of Noise 3.4.1 Decibels and Levels The decibel was developed to fulfil the scientific requirement of providing information about the physical amplitude of sound. It is the fundamental unit of sound. Although there are several sophisticated systems for measuring noise, the decibel is arguably the most often used one (dB). A sound's strength, or how loud it is to the ear, is measured in decibels. The decibel (dB) is a relative measurement of gradation; if a sound is 60 dB, it is 60 dB louder than a sound standard at, let's say, zero. The decibel scale is logarithmic, meaning that 60 dB is ten times as severe as 50 dB, one hundred times as intense as 40 dB, and one thousand times as intense as 30 dB. A jet taking off in close proximity produces noise levels of 140–150 dB, which are 10,000,000 times louder than the 50 dB of typical neighbourhood background noise. When compared to air pressure, the sound pressure variations that we are capable of hearing are extremely modest. As the pressure of typical speaking is on the order of one millionth that of atmospheric pressure. Yet, there is a very wide range of pressures between the quietest noises humans can hear and the loudest. The sound pressure that will induce pain is about 200 Pa, while the lowest audible pressure for a 1000 Hz pure tone is 2 × 10 -5 Pa. This is equivalent to a variation in pressure by a factor of 10 (ten million) or a variation in sound intensity by a factor of 10 14 . A quantity Q is related to a reference quantity Q o in decibels by the equation Decibel (Q) = 10 log (Q/Q o) d Bre.Q o The notation dB re Q o means that Q is expressed in terms of decibels relative (re) to the reference quantity Q o .

79 3.4.2 Other Units for Measuring Noise The "bels" unit, which bears Graham Bell's name, can also be used to quantify noise intensity. Tenth of a bel is a dB. Although it has been demonstrated in experimental settings, the threshold of hearing is a hypothetical phenomenon. What is referred to as silence, in general terms, it is normally around 25 dB. Noise inflicts pain at about 120 dB but severe pain and temporary loss of hearing are inflicted after only a few minutes at 140 or few seconds at 150 dB or more. Sons can also express how loud a sound is. A sone is defined as 40 dB of noise at 1000 hertz. For the ordinary person, the range of sound vibrations below 16 Hz and above 20,000 Hz are referred to as infrasonic and ultrasonic, respectively. Yet, some people are able to hear frequencies that others are unable to. Occasionally, the phon, a psychoacoustic language, is used to describe sound. Both frequency and intensity are considered. The loudness of 92 dB at 20 Hz is equal to 40 phons. Human Hearing Intensity The range of human hearing is between 0 and 120 dB in intensity. At 50 dB, we can hear normal conversation or speech, while 75 dB and 95 dB are regarded fairly loud and extremely loud, respectively. A jet's noise registers at 11 0 dB, which is regarded as being too loud. The noise is agonisingly loud at 140–150 dB. Hence, major cities like Delhi, Bombay, Kolkata, and Chennai are too noisy. A recent study done by the institute of Road Traffic Education, suggests that Delhi is the noisiest city in India with 83 dB during day and 77 dB at night, followed by Kolkata (82 and 75 dB), Bomaby (80 and 74 dB) and Chennai (77 and 73 dB). Sound Levels Sound Level: If the amplitude of pressure fluctuations has been P then the sound level in decibels has been given by L = 10 log 10 [P/P 0] 2 dB Where Po = 2x 10 -5 N/m^2 (a reference pressure) Sound Power Level: It is given by the equation L w = 10 log 10 W/W dB re Wo Where W = the sound power emitted by the source and W o = 10 -12 = reference sound power

80 Sound Intensity Level: L I = 10 log 10 [I/I o] dB re I o Where I = the sound intensity and the reference intensity is L o = 10 -12 W/m^2 Sound Pressure Level: The word "decibel" typically refers to sound pressure level, and the majority of sound measuring devices detect sound pressure. Decibel scales are frequently used to measure power-like ratios. As sound pressure squared is proportional to sound intensity, the sound pressure level is then stated in terms of sound pressure squared (power). The unit of sound pressure level is defined as Lp. Lp = 10 log (p^2/p o 2) dB re p o = 20 log (p/p o) dB re p o where the reference pressure is, P o = 2 x 10 -3 N/m^2 Both P and P o are expressed as rms values. Relationship Between Sound Power Level, Sound Intensity level, and Sound Pressure Level L I = 10 Log(I/I o) = 10 Log(p^2/p c I o) = 10 Log (p^2/P o 2) + 10 Log (p o 2 /p c I o) For standard atmospheric conditions in air, the quantity (P o ^{2} /P c I o) is almost equal to unity and, hence its logarithm is approximately zero. For most practical conditions, we may assume LI = LP 3.5 Sources of Noise Pollution Industrial and non-industrial sources are the two main types of noise pollution, and they are described here in more detail: 1. Noise pollution from industry Noise is a by-product of the conversion of energy from large machines employed in a variety of mills, foundries, and other enterprises. Hence, industrial complexes with heavy 81 machinery operating at high speeds make a lot of noise and have loud noise levels that cannot be tolerated without causing damage. Industrial workers are the ones that are most affected by noise in the workplace. Because of prior failures, industrial estates are built far from habitations. Yet, unauthorised cottage industries in residential areas might disturb nearby neighbours with loud noise. Actually, industry faces two challenges from noise. Diesel engines are used in open coal mines in the coal-bearing regions of Raniganj, Asansol, and Durgapur, which adds to the noise pollution. Similar circumstances exist in the Jammu and Kashmir regions of Handwara and Kalakote. 2. Non-industrial Noise Pollution Transportation noise from cars, trains, and planes is a major contributor to non- industrial noise pollution, as are noises from machinery and appliances like those found in cement plants, concrete mixers, crushers, and many others. Other non-industrial sources of noise pollution include the use of musical instruments, fireworks, radios, transistors, televisions, cables, and electric generators. Below is a discussion of each of these in turn: Transportation Noise: Vehicle noise is one type of transportation noise that has the biggest impact on urban residents. Broadly, it originated from three sources namely road traffic noise, rail traffic noise and air traffic noise. This consists of engine and exhaust noise, indiscriminate use of horns, usage of pressure horns, and vehicle repair workshop. According to a survey by the State Pollution Control Board, noise levels in major cities like Kolkata and Bombay can reach 95 decibels, with cars accounting for 70 to 85 decibels of that noise. In large cities, noise from aeroplanes and trains is a huge worry. The sound is louder and more intense close to train stations, becoming a physical irritant that, with prolonged exposure, has a variety of negative effects. In fact, the sound waves travel into the atmosphere and pollute the entire environment, and everyone feels uncomfortable in this environment. The train's noise intensity exceeds 150 dB. Table 3-1:Noise level from various sources Source Noise level (dB) Diesel truck (200 m) 85-110 Jet take off (100 m) 130-140 Jet take off (300 m) 100-110 Propeller Jet take off (300 m) 90-100 Rail traffic (30 m) 90-100 Medium road traffic (main stream) 70-80 Heavy road traffic (highway) 80-90 Light road traffic (side streets) 60-70 Bulldozer (10m) 90-105 Kitchen blender 90-95 Electric shaver 70-90

82 Normal conversion 60 Passenger car (25 m) 70-80 Large cooling tower (600 m) 120-130) Barking dog (250 m) high 65 Subway platform (as high) 110 Rock drill 120 Noise from Machinery and Gadgets: This includes the noise made by equipment used in construction, such as cement plants, concrete mixers, and crushers. Noise pollution always affects the urban man as a result of demolition and building for urban regeneration and expansions. In the newly constructed colonies in large cities, large, heavy machinery are used during the demolition of existing sites and construction of new structures, which makes a lot of noise. The obvious examples that have become familiar sights not only in cities and large towns but also in the villages where building is taking place include stone crushers, cement, and sand stone mixers. Pyrotechnics: During holidays like Diwali, Id, Baisakhi, etc. as well as other celebrations like weddings, marriages, religious gatherings, and social events, pyrotechnics like crackers and bombs are sources of intolerable noise generation. The use of blasting material in construction of roads, civil works and quarries also causes lot of noise. Use of Radios/Transistors and Loud Speakers: The clamour produced by tape recorders and stereos that are carelessly used in marketplaces, matadors, and buses while disregarding the needs of the public. The other sources of noise in the morning include bhajans played through loudspeakers from adjacent temples or shabad kirtans from Gurudwaras. Nothing is audible clearly since the sounds coming from both sources continuously crisscrossing one's ears. One simply has to put up with a loud noise that is uncomfortable in the morning. The difficulty is much the more serious for the pupils who get up in the morning to memorise their courses. Usage of Cable and TV: Due to their loud intensities, TVs contribute significantly to noise pollution. As major cities and megacities have become increasingly controlled by cable TV. The following TV sound intensity table from Doordarshan's network and cables may be useful to them. It is: i. 70 dB for TV sound at medium volume. ii. 80 dB for impulse noise of advertisements at the same. volume. iii. 86 dB for the film songs at same volume. iv. 82 dB for fighting scene sounds. v. 54 dB for minimum TV volume. vi. 94 dB for maximum TV volume.

83 Use of Electric Generators: Electric generators are now frequently used during social gatherings, weddings, and other ceremonies as a result of the patchy availability of electricity in towns and cities, as well as in shopping centres and other businesses. The business owners utilise electric generators as backups if the power goes out, which makes a terrible amount of noise and endangers the pedestrians. Use of Musical Instruments in Festivals: Many sound-producing instruments are employed throughout religious, cultural, and social events as well as festival celebrations throughout India. Drums are constantly beat during the Losar dance of Ladakh, the Kud dance of Bhaderwah (Jammu), and the Bhangra of Jammu during the Baisakhi fair. The traditional dances of Nagaland, Kulu and Chamba (Himachal Pradesh), and the Gidda dance of Punjab are not only performed to the beat of drums, but also to the blowing of conch shells and "brass surma" at these events. The amount of noise that is created in this way pollutes the entire environment. 3.6 Effects of Noise Pollution Recent research has revealed that between 90 and 110 million individuals in India experience daily annoyance from environmental noise pollution, with about 50 million suffering negative health effects. Noise pollution affects large cities far more than it does smaller ones. In contrast, the distant regions of the Himalayas are the ideal hubs of solitude and quiet. Compared to rural residents in the furthest reaches of the country, more than 20% of people in larger cities find it difficult to get a good night's sleep. Noise pollution has some odd and unpleasant impacts on both people and animals. These are a few of them: 3.6.1 Effects on Human Beings There are five ways that noise might hinder our activities: (i) At the audiological level by impairing the hearing mechanism's ability to work properly, (ii) On a biological level by obstructing the body's biological processes. (iii) On a psychological level by interfering with the body's ability to fall asleep and move, (iv) By influencing the respondents' social conduct on a behavioural level and (v) By affecting the personality on a personological level. Consequently, noise pollution affects how well humans perform in the areas of acoustics, biology, psychology, behaviour, and personology. Audiological Effects: According to studies, brief exposure to loud noise can cause temporary deafness that can last anywhere from a few seconds to a few hours. By the auditory reflex, a noise of 90 dB for more than 10 seconds contracts the tympanic membrane. Long-term exposure during the course of the workday can result in chronic, irreversible deafness. When the noise level exceeds 120 dB, permanent deafness results, while noise levels between 90- and 120-dB result in less damage. Yet, the following factors determine how severely hearing power is damaged: (a) The type of noise, (b) The level of intensity of the noise,

84 (c) The noisy area; (d) The type of the noise-generating device, and (e) Exposure time. Common sources of noise that might permanently harm the hearing mechanism include explosions, jet aircraft, and several industrial processes where the noise is amplified by the diaphragm. A 150 dB explosion can rupture the eardrum, permanently damaging the cochlea's nerve endings and other structures. Noise levels of 130 dB might produce ear ache or a tickling sensation. The auditory system is destroyed by noise exposure for 8 hours a day at a noise intensity of 79 to 90 dB. Also, this causes serious disruptions that even damage memory, retention, and expressive abilities. Additionally, it has been found that long-term exposure to noise levels exceeding 50 dB not only permanently impairs a person's ability to hear clearly, but also reduces their productivity at work. Another condition of its kind caused by loud noise is auditory fatigue. It may cause whistling and buzzing noises in the ear, which suggests that one can find it difficult to discern between different sounds while others are present. Biological Effects The harmful effects of noise pollution on people can also be shown biologically in a variety of ways. It interferes with metabolism, disrupts the nervous system, makes it difficult to concentrate, causes tension and weariness, and contributes to a number of other ailments. Unchecked exposure to noise can result in a variety of illnesses, including headaches, a loss of mental and physical equilibrium, insomnia, mental strain, and short-temperedness in men. Noise levels between 60 and 120 dB reduce productivity and induce mental stress. According to medical research, loud noise can cause heart attacks in people who have already suffered cardiac damage, and long-term exposure can result in chronic problems like hypertension or ulcers. In fact, prolonged exposure to loud noises causes blood arteries that carry and take in blood to constrict, blood pressure to rise, and faster heartbeats, all of which lead to heart conditions. Dr. D.P. Agarwal (All India Institute of Medical Sciences 2000) mentioned a Japanese experiment in which 300 workers were subjected to sound levels of 85 to 120 dB while at work to discuss the impact of noise on the cardiovascular system. Their heart rates were seen to decelerate down. Moreover, blood vessels tighten, pupils enlarge, and voluntary and involuntary muscles tense up at high noise levels. Table 3-2: Effect of different levels of noise on human ear Noise level Type of effects Zero dB Threshold of hearing 25 dB General Silence 85 30-55 dB Ordinary Conversation 60dB Normal conversation. 65 dB Does not pollute the environment 75 dB Moderately loud and not so uncomfortable. 85 dB Uncomfortable 85 dB (8 hours exposure) Impairs hearing ability of the worker. 95dB Very loud and more uncomfortable. 110 dB (constant exposure everyday) Develops hearing problems 120 dB Severe pain and temporary loss of hearing. 130 dB Tickling sensation or pain in car. 150 dB or more (Few seconds) Severe pain and temporary loss of hearing. 150 dB (constant exposure) Deafness 150 dB (Explosive sound) Rupture the ear drum The acceleration of the heartbeat and breathing rate by noise pollution might alter a person's physiological state. The effects of excessive noise on women, especially those who are pregnant, are addressed in the report. Noise pollution often prolongs and extends the duration of menstrual bleeding. The growing foetus is subject to noise pollution's harshest effects, which might result in preterm birth. Moreover, it is thought that noise pollution hinders sexual sensations. High intensity noise can cause psychological indisposition and pose a serious threat to young children in areas where it continues to be a problem. Very unpleasant noises seriously disrupt the female reproductive system, producing vomiting, pain, and restlessness in addition to heavy monthly bleeding. Loud noise causes urban girls' first periods to appear sooner than those of their rural sisters. It has been discovered in Japan that loud noises (between 85 and 120 dB) cause the stomach's gastric juice and salivary secretions to decrease, disturbing the digestive system. A sudden injection of adrenaline causes an increase in anxiety, agitation, irritability, and neuromuscular tension. Noise triggers convulsions in people with epilepsy. Psychological Effects Unwanted noise disrupts communication, causes annoyance and insomnia, as well as lack of cooperation and social disputes, all of which are psychologically and physiologically caused.

86 Paranoia, homicidal and suicidal impulses are some detrimental mental effects. When noise levels hit 90 dB, a man's visual response decreases by 25%. After impairing night vision and impairing colour perception, noise is also reported to produce a constriction of the pupils. Some of the symptoms of disruptive sound intensities include psychotic symptoms and terrified and furious inner and exterior dispositions. When the noise's origin is unknown, intolerable suffering could occur. Speech communication interruptions can hinder performance, increase error risk, and reduce production and efficiency. Muscle tightness, nervous irritation, and strain can all be brought on by noise. Behavioral Effects As a result of exposure to excessive levels of noise, numerous behavioural charts in people are reported. Certain symptoms are immediately observable. The unwanted sound could irritate others. Noise reduces a person's aural sensitivity, which has a negative impact on concentration and attention. It has been noted that students whose schools are located in crowded urban areas and subject to noise pollution do poorly in comprehension tests. Learning problems are the outcome of annoyance brought on by noise. A person can become uneasy and distracted by sudden noise. Housewives using various kitchen appliances cause headaches and giddiness owing to the noise and vibrations they produce. Some of the symptoms caused by specific anomalies in behaviour, which get built up slowly but surely during noise pollution, include the inability to think, analyse, and solve problems, amass stress, an inability to relax, and indifference to surroundings. Long-term exposure to sounds with very high intensities has an impact on how systems function, which can hinder growth, cause the thinking faculties to deteriorate, cause failure to respond to such things in the system that are necessary for integrating various functional processes, and interfere with coordination between various systems in the body. Personological Effects The damaging effects of noise can disrupt a person's entire personality when they last for a long time and generate consistent maladaptive reactions. The optimal personological development of children may be compromised by feelings of inadequacy, lack of confidence, and poor self-perception that may develop in children. When a youngster experiences these emotions in their formative years, it is difficult to get rid of them without leaving permanent scars. Other Effects The following is a list of other effects of noise pollution: i. Noise also has additional physical impacts. Medical researchers claim that loud noise can occasionally induce abrupt blindness, stuttering, and even epileptic fits—especially in young children.

87 ii. According to some evidence gathered by a British research team, noise from aircraft engines causes people who live close to airports to experience mental health problems. They experienced neurotic disease suffering. iii. Extreme noise levels adversely alter hormonal blood levels and cause miscarriage in females. Other effects of loudness include cyanosis and buzzing feelings. iv. Loudness and extreme unpleasantness can easily bother older individuals. Older folks seek more sleep, which is interfered with. Excessive amounts of environmental noise might impair the sleep of the babies also. v. The unwelcome sound may contribute to foetal nervous system malformations that may impact behaviour in later life. vi. Noise may be a factor in the development of gastrointestinal conditions such peptic ulcers. vii. The loudness disturbs the tranquilly of the mind and causes discomfort. viii. Loud noise has a long list of chronic health impacts, including emotional outbursts and various physical diseases. ix. The noise made by car horns close to hospitals or schools is a major annoyance. In hospitals, the blowing of horns disturbs the patients and makes them feel uneasy, while in classrooms, it interferes with students' ability to pursue their academic goals. x. A chain reaction can be started by an abrupt loud noise. The body tenses up. Several systems act unevenly, the veins constrict, the heart beats more quickly, and the blood rises. pressure xi. Industrial noise is substantially more harmful to workers than background city noise. The numbness around the ears that the mill workers experience is reported to be continuous. Child laborers suffer from permanent hearing losses due to their exposure of debilitating noise level at tender age. xii. Noise increases the likelihood of mistakes in manual and skilled work as well as in mental activity; as a result, there is a significant risk to both the operators' and others' safety. 3.6.2 Effects on Animals/Birds Noise pollution affects many animals and birds in addition to people. For the purpose of examining the impacts of noise, animals such as guinea pigs, rats, dogs, and cats are exposed to high levels of noise for relatively brief periods of time. Blood chemical changes, brain, heart, and liver damage, as well as hearing mechanism impairment, are some of these harms. The majority of agricultural animals exhibit decent adjustment. Animals suffering from noise pollution also experience mental fatigue. Noise pollution can also cause edoema, stiffness, and damage to the bones and joints. Although there is no proof that people are as sensitive to noise as animals are, abrupt loud noises can cause animals to convulse. Rats were shown to lose their reactions and behave erratically in trials where they were subjected to noise levels above 500 dB. High intensity sounds have been shown to cause a percentage of birds to cease producing eggs. Moreover, many birds relocate from noisy environments. When a location is exposed to noise pollution, migratory birds begin to leave that area in lower numbers.

88 The majority of poultry birds cannot become used to loud noises, especially sudden loud noise. In fact, a farmer who complained that flying aircraft were interfering with egg production in a letter to the Postmaster General in 1923 represents one of the earliest instances of an official complaint about aviation noise being made. 3.6.3 Buildings' Impacts High-intensity sounds have been said to have a serious negative impact on the building. Buildings and other structures acquire cracks and fissures when they are stressed by unpleasant and loud noises. Also, there are loud sounds of glass panels breaking. 3.7 Control of Noise Pollution The following actions can reduce noise levels to within tolerance levels or even completely eliminate them based on three fundamental concepts of noise control: control at noise sources, control at the transmission path, and control at the receiver end. 3.7.1 Noise Pollution Control at Source Limitations on the Usage of Old Vehicles and Horn Ban The Pollution Control Board must identify the sources of noise pollution and action should be done to reduce them. Old automobiles should not be permitted to ply as they produce maximum noise. Similar to this, traffic police should enforce strict measures to make motor vehicle users reduce the amount of noise coming from their vehicles. Because of this silencer, it should be in good shape. Ear piercing horns ought to be prohibited, as they are in western nations. Legislative restrictions can actually be used to limit noise pollution. Engineering Techniques Using engineering control techniques or regulating exposed employees are two ways to reduce noise exposure. Engineering control strategies include design modifications, adjustments to the way a noise source operates, and the building of soundproofing materials such soundproofing walls and sound absorbers. Air protecting devices must be provided or the exposure period must be reduced in order to regulate exposed personnel. Replacement with Quieter Equipment By using quieter equipment or quieter process activities, noise from equipment can be decreased. Examples are the use of centrifugal fan in place of axial flow fan, the use of welding to replace a nosier riveting process. Better Designs In case of machinery, automobiles, motor cycles and aircrafts, noise control can be achieved through superior design and effective silencing and sound proofing devices and procedures during the manufacturing stage.

89 Sealed Outlets The best way to stop noise from entering the building is to shut all of the outlets that lead outside. Double structures may be used in circumstances of high noise pollution. For high frequency sounds, they can lower the noise intensity by 5 to 10 dB. 3.7.2 Examining the Noise Source Checking various noise sources, such as radios, televisions, tape recorders, and stereos, can help minimise excessive noise. But, when turning these audio-visuals up, one must keep others in mind. Using Scrubbing Cloths The reflected sound can be dampened and absorbed by covering the walls, floors, and ceilings with a soft, pliable material. Availability of Gaskets Household door gaskets can also lessen noise transfer from one area to another. 3.7.3 Noise Pollution Control at the Transmission Path Zones of Vegetation Buffer Many evergreen trees and shrubs that make up vegetation buffer zones are great sources of sound absorption. So, these must be built in the heavily inhabited parts of cities and large towns, close to the workplaces, hospitals, and schools. It has been discovered that a dense evergreen hedge might minimise the noise by 10 dB during rubbish collection in the towns. Plantation Strip The house is successfully shielded from the noise pollution caused by traffic by a 6 m wide plantation of trees inside the compound wall. Rows of tall tree planting Tall trees planted in rows and densely covered bushes and shrubs placed on either side of busy roadways act as noise filters and noise absorbers. To reduce noise, it is helpful to plant trees, especially Polyalthia longifolia and Azadirachta indica, whose leaves work as noise absorbers. Srivastava (2001) recently identified a number of plant species that are effective in absorbing noise and maintaining a tolerably quiet environment. Table 3.3 has a list of them. Table 3-3 Noise Absorbent Plant Species Table 3-3:Noise Absorbent Plant Species Local name Scientific name

90 Neem Azadirachta indica Jangal Jalebi Inga duleis Semal Bombax ceiba Bargad/Borh Ficus bengalensis Peepal Ficus religiosa Katrer or Kachnar Bauhinia variegata Pink mohar Cassia nodosa Sal Shorea robusta Amaltas or Karangal Cassia fistula Pangara tree Erythrina variegata Var Orientalis Rumbal Ficus racemosa or Ficus glomerata Mahua Madhuca latifolia Ashoka Saraca indica Nili Gulmohar Jacaranda mimosaefolia Panjtara or Jerul Lagstromia flosregia Gulmohar Delonix regia Palah or Dhak Butea monosperma Not known Cassia racemosa Usage of Rugs and Drapery Spreading carpets or drapes and using acoustical materials inside of buildings can lower noise levels, but they have no impact on noise that enters from outside. 3.7.4 Noise Pollution Control at the Receiver End Technique for Lowering Noise Some of the newest aircrafts such as the 747 have included noise reducing technology developed in previous few years. Anything that can absorb and exchange sound can minimise noise, but of course at the cost of extra weight and space.

91 Use of Mufflers Due to turbulence created by the surrounding atmosphere, a stream of air and some moving fluids can generate high sound levels. The installation of a muffler is frequently the most practical way to reduce noise, especially for vehicles and motorcycles. A dissipative muffler installed in a gas flow pipe makes use of absorbing materials to reduce sound for horn or fibers may be used as sound absorbing material. Usage of Earplugs or Ear Muffs Workers in factories that produce loud noise should be given wool earplugs or muffs to block out dangerous sounds and protect their ears. In actuality, these ought to be given to passengers going by train and bus together with their tickets as well (upon request). Noise pollution can be reduced most effectively and affordably by wrapping cotton wool with vaseline. Public Awareness Using electronic media can significantly help to lessen noise pollution and improve the environment. The World Health Organization has also stated that noise pollution is the most easily remedied of all environmental issues, including air and water pollution. The dangers of noise pollution need to be brought to the attention of the general public. Strict standards The strictest noise control regulations must be applied to car horns. Its indiscriminate usage should be avoided and silence zones designated in cities near educational institutions, hospitals and offices. Setting up Noise Limits By carefully implementing the Air Pollution Act and establishing noise limitations in metropolitan areas, noise pollution can be reduced. Criminal sanctions should be applied to lawbreakers. Guidelines and Limitations At festivals, other festivities, rallies, and ceremonies, control over fireworks must be exercised. The agencies in charge of enforcing the legislation ought to be severe in their implementation of anti-pollution measures. It is true that permanent outside loud speakers should never be used in a place of worship or another sensitive environment. They should only be allowed to install them inside of buildings for the use of worshippers or followers. Robert Koch, a Nobel Laureate and bacteriologist, made the following forecast 90 years ago: "A Day will come when man will have to fight ruthless noise as the biggest enemy of health." If the government and the individual do nothing to reduce noise, Koch's prediction may soon come true.

92 3.8 Noise Pollution - Legal Perspectives in India In 1970, the Indian government created highly thorough and earnest plans and strategies to create a clean environment through environmental management. The National Fourth Five Year Plan (1969–1974), which highlighted the following environmental challenges, makes this very evident. i. Each generation has a responsibility to preserve the ability of the land, water, and animals to support life in a way that gives the next generation the option of maintaining a healthy environment. ii. The physical environment, which includes the land, the air, and the sea, is a dynamic, intricate system. Each of these components is impacted by actions in the others. The independence of living things (plants and animals) and their interactions with the ground, air, and water are also important. iii. Planting for harmonious development acknowledges the interdependence of man and nature. Only after a thorough analysis of environmental factors, particularly economic and ecological ones, is such planning conceivable. iv. There are situations where prompt, specialist advise on environmental issues might have aided in project design and prevented ensuing negative environmental effects that would have resulted in the loss of invested resources. Therefore, it is crucial to incorporate environmental considerations into our planning and development along with effective conservation and rational use of natural resources. These aspects, as well as their protection and improvement, are crucial for the well-being of the country. With the goal of preserving the environment and maintaining its management, the Sixth Five Year (1980–1985) Plan gave environmental issues a specific relevance. Environmental management has taken on a higher priority in the eyes of the government as a result of its awareness of environmental issues and their effects on the growth of the country. In order to address the ecological catastrophe and environmental issues, a separate Department of Environment (DOE) has now been established in every State of India as well. 3.8.1 Legal Control of Noise Because most people are still unaware of the dangers associated with various types of pollution, including air, water, noise, and soil pollution, they are attaining frightening proportions. They are eating the environmental qualities and harming the eco-system. So, in order to protect the environment from additional pollution and serve the interests of humanity, it is essential to regulate the various forms of pollution through specific laws. Many nations, like England and America, have passed special legislation to limit noise pollution. The Noise Abatement Act of 1960 in England states in Section 2 that loud speakers may not be used for any reason between the hours of 9:00 p.m. and 8:00 a.m., nor may they be used at any other time for the purposes of advertising, entertainment, trade, or business. Of

93 course, the Act specifies a few exceptions. But India does not have a similar Legislation that focuses solely on noise control issues. Because of this, vehicles continue to honk their horns whether they need to or not. What good does blowing horns loudly serve if their cars are stuck in a major traffic jam? A significant piece of legislation for regulating noise is the US Noise Pollution and Abatement Act, passed in 1970. To gather data on noise pollution, the Environmental Protection Agency, working through the office of Noise Abatement and Control, arranges public meetings in a few selected cities. Although there is no specific law governing noise pollution in India, Articles 39(e), 47, 48-A, and 51-A of the Indian Constitution do have provisions (6). The health and strength of employees, both men and women, and young children are not abused, according to article (e). The State is required under Article 47 to raise the standard of living, the level of nutrition, and public health. As of 1976, Article 48-A stipulates: "The State will endeavour to protect and improve the environment and to safeguard the forest and wild life of the country. In certain States viz. M.P., Rajasthan and Bihar, there are Acts which provide restrictions against the use and play of loud speakers". The Environmental Protection Act of 1986 was passed on November 19, 1986, to honour Mrs. Indira Gandhi, a passionate environmentalist who was well-known throughout the world. This law aims to instill environmental ethics in all citizens and to take the necessary actions to conserve and better the environment. According to Section 2 of the Act, "environment" includes "air, water, and land, as well as the interactions with living things (animals and plants)". The Noise Pollution (Regulation and Control) Rules, 2000 in India was implemented to control noise pollution. Table 3-4: Ambient noise
standards in India Area Code Category of Area / Zone Limits in dB(A) Leq*
Day Time
Night Time A Industrial area 75 70 B Commercial area 65 55 C Residential area 55 45 D Silence Zone 50 40
Note: 1. Day time shall mean from 6.00 a.m. to 10.00 p.m. 2. Night time shall mean from 10.00 p.m. to 6.00 a.m. 3. Silence zone is
an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority 4.
Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority. 94 *
dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.
A "decibel" is a unit in which noise is measured. "A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear. Leq: It is an energy mean of the noise level over a specified period. 3.8.2 Difference between Air/Water and Noise Pollution In contrast to other types of pollution, noise pollution is unique. It kills us mentally by causing a variety of mental disorders, including deafness and dumbness, restlessness, and abnormal behavior. The negative effects of noise pollution take time to manifest, much like those of breathing contaminated air or drinking polluted water. At the turn of the century, the majority of Indians will have substantially diminished hearing abilities if this threat is not stopped soon. According to current research, three out of five Indians (particularly those living in large cities and towns) have already lost some of their hearing ability and will never regain it. 3.9 Summary Today, noise pollution is a major issue. Noise is the name for the undesirable sound. The two qualities of noise—intensity and frequency—are typically used to describe it. Sound pressure level is another name for noise intensity (SPL). Its decibel value expresses it (dB). Noise is measured with a sound level metre or decibel metre, which expresses the frequency of the noise in cycles per second (cps) or hertz (Hz). In the environment, noise comes from a variety of sources. Industry, transportation, building sites and building services, domestic and recreational activities, etc. are the main noise sources. It has diverse range of adverse impacts on different ingredients. Accordingly, the control of noise pollution is crucial. Several noise mitigation strategies should then be implemented. The best option to reduce the noise pollution is to make an effort to quiet the source of the noise. Additionally, by altering the path between the source and the hearers, it can be decreased. The installation of noise barriers, Usage of personal protection gadgets might be successful to prevent noise impacts at the receiver end. Cities and industry should both be properly planned. For the purpose of reducing noise, legislation and the application of current law are crucial, all are described in this unit. Further, for noise pollution to be managed effectively, awareness and education are required. 3.10 Questions/ Self-Assessment questions 1. Define noise and noise pollution. How decibel is defined. 2. What are the different sources of noise pollution. 3. What are (a) Industrial noise (b) Transport noise (c) Neighbourhood noise.

95 4. What is the unit of noise pollution measurement. 5. What are the adverse effects of noise pollution. 6. What is the difference between noise pollution and air pollution. 7. What are the physiological and psychological effects of noise? 8. Discuss the different indices used for the measurement of noise levels? 9. Write informative notes on any two of the following: decibel scale, approaches for noise control 10. What are the various methods available for the protection of the personnel exposed to high noise levels? 11. Describe the various acoustical absorptive materials used for noise control. 3.11 Select Readings/ Suggested Readings 1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi. 2. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 3. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001. 4. S.C. Bhatia, “Textbook of Noise Pollution and its Control” Atlantic, New Delhi, 2007 5. S.C. Bhatia, “Textbook of Air Pollution and its Control” Atlantic, New Delhi, 2007 6. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi. 7. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.
96 UNIT 4: Soil Pollution 4.1 Objectives 4.2 Introduction 4.3 Causes
of Soil Pollution 4.4 Effects of Soil Pollution 4.5 Control Measures 4.6
Summary 4.7 Questions/ Self-Assessment questions 4.8 Select Readings/ Suggested Readings 4.1 Objectives After successfully completing this unit, you will be able to: ➢
learn about the different soil pollution sources, ➢ understand different types of
soil contaminants, ➢ outline different pesticides and heavy metals contaminating soil, ➢ know about the synthetic fertilizer contaminating soil, ➢ understand the different adverse effects of soil pollution, ➢ comprehend the control mechanism of soil pollution, 4.2 Introduction Many minerals as well as countless plants, animals, and bacteria are supported by soil. A geologist uses the soil to determine the age of the earth by analysing the several isotopes it contains, whereas chemists view the soil as a repository for plant nutrients. According to physicists, soil is made up of solid, liquid, and gaseous components. For limnologists, the soil is a reliable supply of food for the biota, and for agriculturists, it is the upper crust of the earth that can support plant life and other life forms. Above all, the soil is a living thing that has been the source of all significant ecological occurrences in the past. Yet, incorrect drainage and the unscientific, chemical utilization of organic wastes are the main causes of soil and land pollution. Due to the importance of these natural resources, erosion and pollution must be avoided in order to preserve them.
97 4.3 Causes of Soil Pollution Several factors contribute to soil pollution, including man-made chemicals, waste products from mining and quarrying operations, improper disposal of solid waste, etc. The following are the major sources: 4.3.1 Use of Chemical Fertilizers There is no question that the use of diverse fertilizers, such as nitrogenous, phosphatic, and potassic fertilizers, has enhanced the yield of numerous crops, particularly high yielding types of wheat, rice, and maize. However, its continued usage has contaminated the groundwater, making it unsafe for consumption by humans and all other species. Since almost all nitrogenous fertilizers are water soluble, nitrates are easily transported into the water. The applied fertilizers are washed away after heavy rains or irrigation, transporting nitrates into the streams or rivers as well as into drainage water. Due to their high percolation capability, sandy soils are far more dangerous for nitrate pollution. Methaemoglobinamia, often known as "blue blood baby illness," is brought on by a high nitrate concentration in drinking water and can be fatal to infants. Infants' high consumption has been linked to their vulnerability to nitrate. Nonetheless, adults are not seriously affected by this issue. Nitrate levels as low as 65 ppm in water are dangerous. The acceptable limit of this pollutant, 45 ppm, has not been detected in drinking water in any places where this disease has been recorded. When produced on soils with extensive applications of chemical fertilizers, fodders like oat and maize stalks may result in health difficulties such the deterioration of the vascular tissues in the lungs, heart, and liver in animals. According to reports, 100-150 ppm of nitrate is the essential level in this situation. Considering that phosphorus is an inert nutrient, little soil may be leached of it. But it becomes mobile and can be leached out into groundwater as soluble organic phosphorus in inorganic soils with lower levels of iron and aluminium. In addition, it is also transported by sediments into lakes and ponds. Increased eutrophication, which is damaging to fish and other aquatic life, will result from the addition of phosphorus together with excessive amounts of nitrate that have been applied to the soil. The soil pH is lowered and plants have less access to phosphorus when nitrogenous fertilizer is applied improperly. This may be seen in some of the Kandi belt soils in Jammu, where urea, a nitrogenous fertilizer, has been used continuously to cause soil acidity (pH 5.2– 6.5). Moreover, nitrogenous fertilizer is now being used alone, which is having detrimental impacts on many crops and is devastating in soils with low pH levels. Synthetic Fertilizers: To improve soil fertility and crop yield, synthetic fertilizers are used. The vital nutrients are concentrated in the top soil layer by these fertilizers. Synthetic fertilisers are produced in factories. Yet, when used improperly and in excess, as well as when they contain hazardous substances, fertilisers and manures will damage the soil and significantly alter its character and composition. Chemical fertilisers include urea, ammonium sulphate, ammonium phosphate,

98 ammonium nitrate, and ammonium chloride. Unfortunately, the microbial flora necessary to enrich the humus that supports plant growth cannot survive in soil that has been fertilized chemically. Soil pollution may occur if chemical fertilizers are used excessively and without consideration. More specifically, chemicals called fertilisers are administered to crops in order to increase production. They are regularly used by farmers to increase agricultural output. The fertilisers contain the minerals that plants require, such as nitrogen, potassium, and phosphorus. They increase the soil's fertility while simultaneously enhancing its ability to retain water. Inorganic fertilisers are generally made of chemicals and contain nutrients for crop growth that are produced by chemical processes. Examples of inorganic fertilisers include the following: Nitrogen Fertilizers • Nitrogen, which is necessary for crop development, is present in nitrogen fertilisers. • Nitrogen is a crucial part of chlorophyll that maintains the equilibrium of the photosynthesis process. • Furthermore, it is one of the amino acids that build up protein in plants. • Fertilizers containing nitrogen increase crop output and quality. Phosphorus Fertilizers • The most crucial nutrient in phosphorus fertilisers is phosphorus. • Effective phosphorus concentration, fertilisation techniques, soil characteristics, and crop strains all affect how successful a fertiliser is. • The protoplasm of the cell, which contains phosphorus, is essential for cell growth and proliferation. • The growth of plants roots benefits from the application of phosphorus-based fertilisers. Potassium Fertilizers • Another most crucial nutrient in potassium fertilisers is phosphorus. • Enhances drought resistance and root development, helps in photosynthesis and food production, enhances protein content of crops. • Keeps turgor up, cuts down on water losses and wilting, produces grains high in starch. • Helps delay the development of plant disease and worms. 4.3.2 Use of Pesticides Pesticides are a significant soil-based agricultural input. Weedicides, insecticides, nematicides, fungicides, antibiotics, and hormones are among the agricultural compounds classified as pesticides. Several pesticide chemicals have a mobility class rating of 1, which indicates a significant degree of immobility. A few examples of the substances in this group

99 are phorate, parathion, ethion, zineb, benomyl, paraquat, heptachlor, endrin, aldrin, chlordane, toxaphene, and DDT. For use in agriculture, several of these are already prohibited. Pesticides are compounds (or combinations of substances) used to eradicate or stop the spread of pests. Pesticides that are frequently applied in agriculture include • Herbicides are used to eradicate or manage weeds and other undesirable plants. • To kill insects, we employ insecticides. • Fungicides are substances that either kill or stop the growth of parasitic fungi. However, unintended pesticide diffusion into the environment, or "pesticide drift," raises a number of environmental issues such soil and water pollution. The following is a list of some significant soil pollutants discovered in pesticides.

Herbicides: Triazines, Carbamates, Amides, Phenoxyalkyl acids, Aliphatic acids Insecticides: Organophosphates, Chlorinated hydrocarbons, Arsenic-containing compounds, Pyrethrum Fungicides: Mercury-containing compounds, Thiocarbamates, Copper sulfate

In addition to this, pesticides like the ones listed below are frequently employed: i. Hydrocarbons with chlorine (e.g., DDT, Aldrin, Dieldrin, Lindane, BHC, etc.) ii. Compounds with carbamate (e.g., Carboryl or Sevin, Zectrion, etc.) iii. Compounds with organophosphorus (e.g., Methyl or ethyl parathion, melathion, guthion, etc.) iv. Organic substances (e.g., As 2 O 3 , PbO 2 , NiCl 2 , CuSO 4 , etc.) v. Other substances, such as organic mercurials (2,4D, 2,4,5T, etc.). vi. Herbicides containing sulfonylureas: Commercial sulfonylurea herbicides for controlling weeds include pyrithiobac-sodium, cyclosulfamuron, bispyribac-sodium, terbacil, and sulfometuron-methyl. vii. Biopesticides: Biopesticides are insecticides made from natural resources like plants, animals, microorganisms, and minerals. viii. Baking soda and canola oil are two examples of biopesticides. Atrazine, alachlor, propachlor, simazine, propanil, and diuron are common herbicides with moderate to high immobility, indicating greater persistence in soil. Using pesticides frequently throughout each crop season and applying them to soils with low levels of organic matter and microbial diversity will cause the chemicals to build up over time, creating significant soil and environmental contamination. Under temperate temperatures, some herbicides, such as atrazine, benulide, and chloroxuron, remain persistent in soil for intervals of 300 to 700 days. It is possible for 2,4-D, picloram, and dalapon to leak out into the water because of their increased mobility in soil. Much soil pollution will be caused by this. Following is a list of the relative soil mobility of pesticides: Decreasing trend

100 Dalapon Chloramben Picloram, 2, 4-D Propachlor, Atrazine, Simazine, Lapazine, Alachlor, Ametryne, Prapazine Propanil, Diuron, Azinphosmethyl, Diazinon Immobile Lindane, Phorate, Parathion, Disulfolton, Ethion, Zineb, Isodrin, Benomyl, Dieldrin Paraquat, Endrin, Aldrin, Chlordane, Toxaphene, DDT (Relative Mobility of pesticides in soils) 4.3.3 Unscientific Disposal of Organic Wastes The improper disposal of organic wastes of all kinds is one of the main causes of soil contamination in emerging nations like India. Animal organic waste is turned into manure and applied to fields in rural areas to boost their fertility. Nonetheless, these wastes are stored or deposited in open areas, and nature is left to finish the process of turning them into manures. In addition to polluting the land, this practice also significantly contributes to air pollution. Many gases, including ammonia and nitrogen oxides, escape from these wastes during bacterial degradation and enter the atmosphere. When it rains, there is a significant loss of nutrients. So, this practice, which is widespread in rural Jammu and Kashmir as well, has to be outright prohibited. Farmers should be encouraged to prepare manures out of their readily available organic wastes in pits that have had enough time to decay before being applied to the fields. Along with creating ammonia, nitrate, and methane, direct contact between waste and soil also serves as a breeding ground for soil pathogens, disease-carrying flies, ant and rodent attacks, and soil pathogens. Crows, vultures, and dogs are encouraged to distribute the trash at the dump sites. Soil pollution is caused by the improper usage of sewage sludges. In addition to dangerous bacteria, actinomycetes, fungi, and other species, they may have an adequate number of active viruses and viable worm eggs. These are harmful to human health and the environment when used to raise crops, including those that may be consumed fresh by both humans and animals. Comparable heavy metals like cadmium, chromium, nickel, and others build up to dangerous levels in soils over time. Due to agricultural goods produced on such soils, these components accumulated in people and animals, leading to a variety of complications. 1. Rate of Salts Similar to this, inorganic agriculture products contribute to ozone pollution. The practice of enhancing the stumbling at content in the animal fodder fields has been pushed in order to boost animal weight and milk production. When these dungs are employed as manures, they will have a greater salt concentration due to the lack of content in the animal's dungs. Due

101 to the soluble salts leaching from the soils, the long continual application of such manures to soils may eventually cause an increase in the soluble salt content in the soils and in the ground water. Salinity, sodicity, and acidity increases the degradation of the land is caused by the rise in sodium and soluble salt content (sodicity) brought on by water logging. The productivity of the soil and the condition of the land are both negatively impacted by an increase in the concentration of soluble sats. In intrigue water, dis salts build up on the soil's surface. Inadequate drainage, especially in food-prone locations and canal well-limited places, exacerbates this. Also, during summertime seas, the

salts from the lower levels migrate up by capillary action and are deposited as white crusts on the surface. 2.

Land Erosion Through water, wind, ocean, waves, and glaciers, soil is eroded. People's actions, such as tree-felling, overgrazing, over-cropping, and inappropriate tilling, hasten soil erosion. Whether a place is dry or wet, modern or traditional agriculture has little effect on erosion. Deforestation is a factor in flooding and soil erosion. The soil is kept intact by the roots of grasses, which are a good binding material. The soil is made more brittle and susceptible to being washed away by the force of heavy rains or high winds when the grass cover is disturbed by the flow. The pace of soil erosion is accelerated by

tilling or grazing on slopes or semi-arid soils. The biggest contributors to soil erosion

in India have been overgrazing and deforestation. In India, 80 million hectares of fertile land are thought to wash away more than 6,000 million tonnes of top soil each year. When the overall amount of arable and unarable land is taken into account, this number nearly doubles. The majority of this material is washed into the ocean, but some also accumulates behind dams, shortening their lifespan, or is dumped in river beds. This soil's 6,000 million tons of valuable plant nutrients (N, P, and K) are worth more than 700 crores of rupees. The degradation of land and loss of soil reduces the ability of the world to produce food, fuel, and fiber on an annual basis. The soil itself can become a destructive force by silting fertile fields below due to excessive crop production on hill slopes and denuded in forest region. Less sunlight penetration into water due to suspended soils in runoff can have an impact on the aquatic life forms that make up the food chain. 3. Land Degradation Besides pollution, there are additional issues that affect land and soil. They include soil erosion, overgrazing of pastures, frequent floods, water logging, and deforestation. By the end of this century, it is predicted that nearly one-third of all arable land would have been destroyed due to soil depletion and land degradation. 4. Acid Rains Acid showers are caused by an excess of sulfur dioxide and nitrogen oxides in the atmosphere as a result of industrialization, as was already explained in the chapter on "Air Pollution."

102 5. Agricultural Lands Increasing soil acidity can result in a variety of chemical alterations. Iron, aluminum, manganese, some heavy metals including cadmium and mercury, as well as other trace elements, can be released by acidic soils. These elements are transformed into more accessible forms in acidic soils, where they have a detrimental effect on plant growth. Moreover, plants suffer greatly because of the limited availability of phosphorus, calcium, magnesium, boron, and molybdenum to them. 6. Developmental Activities Numerous development activities, such as rapid urbanization and human settlements, mining and quarrying, building of factories, industries, dams, canals, roads, railways, airports, etc., are encroaching upon large areas of fertile and productive crop lands, forest areas, grasslands, and horticulture. Our government's careless approach is endangering the ability to produce food for future generations. 4.4 Effects of Soil Pollution 1 . Effects on Water Resources The impact of acid precipitation depends on the kind of soil. Acid deposition is neutralized by alkaline soils. In contrast, sandy soils and granite topography have a lower capability for neutralizing the effects of deposition and allow more acid to remain in the runoff into rivers and lakes. Large volumes of acidic water being abruptly released into rivers can be extremely harmful, especially for fish. All of the original aquatic life, including snails, crustaceans, and numerous insects, will be wiped out if the water is acidic. This will create a completely new environment. Acidic discharge will contaminate both the surface and subterranean waters with toxic substances. Aluminium, arsenic, mercury, and lead are extremely poisonous to fish. As soon as the fish hatches, aluminium poisoning could cause it to go extinct. Fish eggs can potentially be killed by acid in water. Fish species like salmon and trout are extremely susceptible to acidity. The majority of aquatic life requires a pH of 6.0 or higher. A number of algae, bug, insect larvae, and fish species suffer when the pH drops below this value. Snails and species of microscopic plants are less abundant below pH 5.5. Snails vanish at pH values below 5.2, and the acidification impacts the production and growth of aquatic plants, which in turn limits the availability of food for birds and other animals. 2 . Effects on Forest Resources There is ample evidence of the strong connection between acid pollution and tree die- back. Acid degradation alone or in conjunction with other pollutants has significantly impacted more than 5 million hectares of forests in West Germany, Poland, Yugoslavia, and Czechoslovakia. Acid rains also have an impact on the conifers that thrive in Germany. The 103 signs of severe acid damage include root damage, drying out of tree tops, soft rot, yellowing and loss of unnecessary growth, and stunted development. 3 . Damage to Animals and Wildlife A very steady and intricate food chain is necessary for the survival of both wild animals and tamed livestock. The base of their food chain, which takes the form of a herbaceous component, is formed by the forest floor and plants. The entire food chain is disrupted once the forest floor and its flora are harmed, which ultimately has an impact on the stability of the animal and wildlife population at different trophic levels of the ecosystem. 4 . Damage to Human Health Asthma, bronchitis, lung cancer, and harm to the central nervous system are among the diseases linked to acid rain. The excessive consumption of fluoride through water is the cause of fluorosis in livestock. When humans drink contaminated milk from sick animals, fluorosis also results. The high mercury concentration in water is to blame for thyroid issues, liver issues, paralysis, pulmonary edema, and corneal issues. 4.5 Control Measures Application of fertilizers, the use of pesticides, and the removal of solid waste are key components in the control of soil pollution. Among the controls to stop soil pollution are: i. The production and use of chemical fertilisers should be reduced, and their place should be taken by biofertilizers and thoroughly decomposed organic materials. ii. In order to lessen the usage of pesticides, biological and ecological techniques of pest management should be promoted. iii. It is important to reduce salinity/sodicity by providing the irrigated and flood-prone fields with adequate drainage. Barley and oats are examples of crops that can be grown in salt-affected soils, along with other tree species like Acacia nilotica and Acacia modesta, and by implementing better water management techniques. For the restoration of such soils, it has been discovered that the application of organic manures, particularly green manuring, is very beneficial. iv. Restoring grass and trees can help control erosion and floods while also slowing down land degradation. The simplest and most effective technique to stop soil erosion is by reforestation, which involves planting suitable tree species to provide adequate cover in the eroded regions. It is helpful to stop erosion by planting plants like Carissa spinarum, Adhatoda vasica, Desmodium spp., and Mimosa himalayana in eroded areas and public waste lands. These bushes fulfil the requirement for firewood in the community while also promoting soil and water conservation. Grasses such as Cenchrus and a legume Stylosanthes should be allowed due place to grow in the degraded areas for augmenting the feed and erosion management. v. Organic manures can be made from the solid and liquid excretions of livestock. Nonetheless, it is a flawed practise to store manure on a cultivator's field. Dung and

104 garbage are routinely collected each morning and deposited in heaps in open sections of the fields. As long as the dung heap is left exposed to rain and sunlight, there will be significant nutrient loss. The value of the manual is reduced by about 50 percent. Ammonia is lost during decomposition through volatilization. The scientific strategy outlined below is advised for creating high-quality farmyard management and preventing significant nutrient loss. a. Trenches measuring 6 to 7.5 metres long, 1.5 to 2 metres wide, and 1 metre deep should be used for the manure preparation. Keep all appropriate dry litter and agricultural waste close to the cattle shed, and place 2 kg (earth-mixed) beneath each animal's feet each evening to help absorb urine. The spots where pee often drips and soaks into the ground should be the only locations where litter is present. The dung and urine-soaked litter should be thoroughly mixed and carried to the manure trench every morning. A section of 1m length of the trench is taken up from one end for filling with daily collection of refuse. The next 1 m of the trench is filled after the section is filed 45–60 cm above ground level and the top surface is coated with cow dung earth slurry. b. A second trench is dug and entirely filled in the same way as the first one. The manure is prepared for use in three to four months. Usually, the first trench's manure would be ready for use by the time the second trench is full. Yet, the quantity of animals would determine how many ditches were required. Typically, two of these ditches are needed to 3 to 4 catle. vi. Recycling and material recovery is another practical way to lessen soil pollution. By doing so, the amount of waste would be reduced and natural resources would be preserved. Paper, grass, and various types of plastic, for instance, can all be recycled. Although though recycling glass and paper is expensive, it is beneficial for preserving resources. According to research, recovering one tonne of paper using this method would prevent the need to cut down at least 17 trees in order to obtain this quantity of paper. 4.6 Summary The existence of mankind in the planet is also directly related with land. The magnitude of the issue can indeed be managed unless the general public is aware of it. When waste, compost, and other poisons are deposited on the ground, they contaminate or pollute the environment. Soil pollution originates from a variety of sources. Human activities including littering and waste from ships, rigs, transportation, building sites and building services, domestic and recreational activities and sewage treatment facilities that wash ashore contribute to land contamination. With a focus on their production and clean-up, the principles of soil pollution and different aspects of soil pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit. Further, for soil pollution to be managed effectively, awareness and education are required.

105 4.7 Questions/ Self-Assessment questions 1. What are the sources of soil pollution? What are the detrimental effects of soil pollutants? 2. What are the major contributing factors of soil pollution? 3. Comment on the heavy-metal toxicity of soil. 4. What are the pesticide problems related to soil pollution. 5. What are the naturally occurring toxic elements in soil? 6. What are the naturally occurring pesticides in soil? 7. How acid rain can affect soil? 8. Comments on the remedial measures to soil pollution. 9. Discuss the role of urban waste and modern agro-technology in soil pollution. 10. How do industrial wastes contribute to soil pollution? What measures are to be taken to minimize soil pollution from this source? 4.8 Select Readings/ Suggested Readings 1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi. 2. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 3. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001. 4. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi. 5. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

106 UNIT 5: Thermal Pollution 5.1 Objectives 5.2 Introduction 5.3 Sources of Thermal Pollution 5.4 Effects of Thermal Pollution 5.5 Heat Islands 5.6 Thermal Pollution Control 5.7 Summary 5.8 Questions/ Self-Assessment questions 5.9 Select Readings/ Suggested Readings 5.1 Objectives After successfully completing this unit, you will be able to: ➢ learn about the different thermal pollution sources, ➢ understand different types of thermal pollution and thermal pollutants, ➢ learn about heat island concept and its characteristics, ➢ understand the different adverse effects of thermal pollution, ➢ comprehend the control mechanism of thermal pollution. 5.2 Introduction The harmful consequences of heated effluents discharged by various power stations have been referred to as thermal pollution. It refers to the degradation of the quality of the aquatic and terrestrial environments. Water is used as a cooling agent in many industrial operations, including mills and thermal, atomic, nuclear, and coal-fired plants. The temperature difference between the heated effluents and the intake waters is 8 to 10 °C, which lowers the content of D.O. (Dissolved Oxygen). Thermal pollution can be defined as: 1. An aquatic system being too warm to the point where desirable creatures are negatively impacted. 2. The addition of too much unwelcome heat to water, which renders it dangerous for people, animals, plants, and aquatic life, or poses other serious risks to the regular operations of aquatic organisms in water.

107 3. Heated effluents from both natural and artificial sources that are tainted with water supplies pose a risk to human health due to their toxicity, decreased levels of dissolved oxygen (D.O.), unattractive appearance, and potential for the spread of illnesses. 4. According to biological indices of community and variety, it depletes aquatic species and upsets the delicate balance of life in streams. 5. It is a by-product of unplanned, rapid industrial development and population growth. 5.3 Sources of Thermal Pollution The demand for thermal power plants has increased due to the fast industrialization, accelerated pace of growth, and dense population. Today, pollution from human activities is being continuously and alarmingly added to the air and water. Thermal pollution comes from the sources listed below: 1. Nuclear Power Plants Nuclear power plants release a significant amount of trapped radionuclides and wasted heat into neighbouring water streams, along with drainage from hospitals, research facilities, nuclear tests, and explosions. The temperature of aquatic bodies is also raised by emissions from processing equipment and nuclear reactors. Power plant discharges of heated effluents, which are released at temperatures 10 degrees higher than the coolant receptor, have a negative impact on aquatic life. 2. Industrial Effluents To remove heat, thermal energy-producing industries like coal-fired power plants need enormous quantities of cooling water. But to a far lower level, other industries including textiles, paper and pulp, as well as sugar, also release heat in water.

The heat from the turbo- generators placed in industrial settings raises the temperature of the effluent by 5 to 9 degrees Celsius above the standard stream temperature. In order to meet the rising demand for energy and the fast industrialization, more installations are being built, which leads to the discharge of more water and heated effluent that is hotter than the receptor water body temperature. 3. Coal-fired Power Plants A few thermal power plants discharge effluent that is 15 °C warmer than the water body it is released into. The primary source of thermal pollution is coal-fired power stations, which are used in thermal energy production. The temperature of the neighbouring water is raised when the heated coils are cooled with water from a nearby lake or river and then discharge the hot water back into the receptor water body. The amount of dissolved oxygen in the heated effluent is reduced. It causes the death of fish and other marine life. 4. Hydro-electric Power Occasionally, the process of producing hydroelectric power has a negative impact on water infrastructure. Many enterprises with cooling contribute to thermal loading besides the
108 electric power sector. According to reports, nuclear power plants provide cooling ponds with around 18% more heat than any other plant of comparable scale. 5. Household Sewage Whether or not it has been treated, domestic sewage is frequently dumped into rivers, lakes, and canals. The temperature of the municipal sewage is often higher than that of the receiving water. In addition to significantly increasing stream temperature, the released water has several negative consequences on aquatic life. The dissolved oxygen in the surface water is used by the organic materials in the sewage to oxidise it. The D.O. content falls and the need for oxygen increases as the water's temperature rises. As a result, the anaerobic environment will cause the emission of unpleasant and irritating gases. The marine species that depends on the D.O. will disappear, and the water's quality will also suffer. 5.4 Effects of Thermal Pollution The different effects of thermal pollution include: 1. Change in Water Properties As the temperature rises, water's chemical and physical characteristics change. Although water's viscosity is sharply decreasing, the vapour pressure is rapidly rising. The settling speed of suspended particles accelerates due to the decrease in gas density, viscosity, and solubility, which has a significant impact on aquatic species' ability to feed. 2. Decrease in Dissolved Oxygen Concentration As water temperature rises, dissolved oxygen concentration drops. For instance, the D.O. level in water is 14.6 ppm at 32 °F and 6.6 ppm at 64 °F. As a result, the high-water temperatures would be intolerable to cold-water fish, which need roughly 6 ppm to thrive. They would run out of oxygen if they stayed in the vicinity. A suitable amount of dissolved oxygen should be present in a healthy stream because aquatic biota are aerobic organisms. 3. Increased Toxicity The toxin found in water becomes more toxic as the temperature rises. A temperature increases of 10 °C doubles the toxicity of potassium cyanide, whereas an increase of 80 °C triples the toxicity of o-xylene, which causes high rates of fish mortality. 4. Interference with Reproduction Fishes depend on a certain ideal temperature for several functions, including nest construction, spawning, hatching, migration, and reproduction. For instance, lake trout may effectively spawn at a temperature of 8.9 °C. Warm water disrupts spawning and kills the eggs that have already been placed.

109 5. Changes in Reproduction Rate The female begins depositing eggs when the temperature rises. When the water temperature reaches a crucial level, estuarine fish spawn four hours later, which makes the triggering more spectacular. 6. Interference with biological processes It is thought that temperature has a crucial role in the physiology, metabolism, and biochemical processes that regulate respiration rates, digestion, excretion, and the overall growth of aquatic species. The ecosystem as a whole is completely disrupted by temperature variations. Temperature fluctuations are frequently damaging. due to the fact that aquatic organisms' lives include a number of chemical processes, the rates of which are affected by temperature fluctuations. 7. Increased Disease Vulnerability Higher temperatures speed up the activities of certain harmful bacteria. A bacterial infection brought on by hot water prevents some fish from developing eggs when the temperature is elevated. 8. Variations in Metabolic Rate Fishes' breathing rate, oxygen consumption, food consumption, and swimming speed all rise. Fish exhibit a noticeable increase in basal metabolic rate when temperature approaches the fatal level. 9. Invasion of harmful creatures Thermal pollution may allow the entry of organisms that are tolerant of warm waters and are extremely harmful, such as the invasion of ship worms into Oyster Creek in New Jersey. 10. Unwanted Changes in Algal Population Algal expansion has a significant impact on ecosystem life. The washout waters from thermal plants and farmlands contain too many nutrients, which promote excessive algal growth and speed up eutrophication and other unwanted effects. 11. Biochemical Oxygen Demand B.O.D. is achieved at a lower temperature when the temperature of a stream carrying biodegradable organic matter rises due to the enhanced action of aquatic organisms. Fish death may occur owing to synergistic action, which is caused by rapid chemical or biochemical action, when the temperature of a stream carrying biodegradable organic waste rises. 12. Destruction of Organisms in Cold Water It takes a tremendous amount of water to cool a stream. Unfortunately, the heat shock, increased pressure, and water viscosity kill a lot of the plankton, small fish, and insect larvae that are drawn into the condenser along with cooling water.

110 13. Impact on Marine Life The physiology, metabolism, growth, and development of marine species are all significantly influenced by temperature. Because they are poilkilothermic, marine species experience temperature changes in response to the water they are in. Certain aquatic organisms can't handle drastic temperature fluctuations; therefore, they perish at higher temperatures. 14. Impact on Bacteria The industrial facilities' and industries' hot emissions severely harm the bacteria. The result includes harmful action of metabolic products, melting of cell fats, coagulation of body protein, etc. 5.5 Heat Islands The heat from the sun is absorbed and emitted from structures more than it is from natural landscapes like woods and water bodies. These structures include buildings, roads, and other infrastructure. Urban areas become "islands" of greater temperatures compared to outlying areas because of the concentration of these structures there and the lack of greenery. "Heat islands" are the term used to describe these hot spots. Heat islands can develop in a variety of settings, including during the day or at night, in small or large cities, in suburbs, in climates in the north or south, and during any season. 5.5.1 Causes of Heat Islands Several things can cause heat islands to arise, including: Reduced Natural Landscapes in Urbanized Regions: By producing shade, transpiring water from plant leaves, and evaporating surface water, respectively, trees, vegetation, and water bodies tend to chill the air. Urban settings' hard, dry surfaces, such sidewalks, roads, buildings, and parking lots, offer less shade and moisture than the surrounding natural environment, which raises the temperature. City Size and Shape: The size and shape of cities differ significantly from rural areas in terms of aerodynamics. Tall structures serve as barriers and slow down winds. Urban canyons: The tall canyons created by city structures that absorb radiant energy. According to "canyon effect" comparisons between North American and European cities, heat islands will form more quickly in locations with taller and denser structures. Properties of urban materials: Compared to trees, vegetation, and other naturally occurring surfaces, conventional human-made materials used in urban contexts, such as pavements or roofing, tend to reflect less solar radiation and absorb and emit more of the sun's heat. The sluggish release of heat from urban materials is a common cause of heat islands, which frequently develop throughout the day and become more noticeable after nightfall. Urban haze: The air pollution haze that hovers over many cities can function as a tiny greenhouse layer, keeping heat from escaping from urban regions.

111 Effects of humidity: Although the amount of water that is retained in the atmosphere by cities and rural areas (absolute humidity) is similar, the greater urban temperatures actually cause the relative humidity to decrease (since warm air can hold more water than cold air). Anthropogenic heat: The heat that is released when fossil fuels are burned can also increase the temperature in cities. The amount of energy released by burning fossil fuels in Manhattan on an average winter day is four times greater than the energy that the Sun provides for the city. 5.5.2 Characteristics of Heat Islands The variance in temperatures between cities in relation to their surroundings is typically used to calculate heat islands. A city's internal temperature can also change. The uneven distribution of heat-absorbing pavements and buildings makes some locations hotter than others, while trees and other vegetation keep other areas cool. Intra-urban heat islands are created by these temperature disparities. Residential areas, urban ponds, and parks are cooler than downtown regions according to the heat island effect diagram. There are two different kinds of heat islands: surface heat islands and atmospheric heat islands. Surface Heat Islands: Roadways and rooftops, which absorb and emit heat more than most natural surfaces, are examples of urban surfaces that contribute to the formation of these heat islands. On a hot day with a 91°F temperature, typical roofing materials may get up to 60°F warmer than the surrounding air. The peak of surface heat islands usually occurs when the sun is shining during the day. Climatic heat islands: Warmer air in cities than in rural areas leads to the formation of these heat islands. Compared to surface heat islands, atmospheric heat islands have substantially smaller intensity variations. 5.5.3 Effects of Heat Islands Effects on animals Urban heat islands will lengthen the growing season in temperate regions, which will disrupt the breeding plans of the species that live there. The impact of urban heat islands on water temperature is the best example of this. As a result of precipitation warming up quickly and neighbouring buildings occasionally reaching temperatures of over 50 degrees and higher, there will be an excessive amount of thermal pollution from runoff into the streams, lakes, and rivers (or other bodies of water) in the area. The rise in thermal pollution has the potential to raise the temperature of the water by 20 to 30 degrees. Cities' urban heat islands have changed the course of natural selection. A new set of selected forces emerge as a result of the relaxation of selective pressures such as the temporal fluctuation in food and water. Further, see the air pollution effects on plants, animals, and people.

112 Weather and climate effects In addition to their impact on temperature, UHIs can change local wind patterns, cause clouds and fog to form, increase humidity, and vary precipitation rates, among other secondary effects on local meteorology. The additional heat from the UHI causes higher upward motion, which can increase the activity of showers and thunderstorms. Also, during the day, the UHI develops a small low-pressure area where relatively moist air from its rural surrounds converges, potentially resulting in more favorable conditions for cloud formation. Cities' downwind rainfall rates have increased by 48% to 116%. Monthly rainfall is roughly 28% higher between 20 and 40 miles (32 and 64 km) downwind of cities than it is upwind, in part due to this warming. Some cities experience a 51% increase in overall precipitation. 5.5.4 Control Measures of Heat Islands • Tree planting: Planting and efforts to increase the area covered by vegetation are the main requirements for reducing the amount of heat that metropolitan areas generate. • Passive Cooling: For both residential and commercial buildings, passive cooling technology, a popular method for creating naturally ventilated structures, can be a critical alternative to deal with the urban heat island. • Ancient Indian architectural designs that made use of this technology are mentioned in the IPCC report and could be applied to contemporary buildings in the context of global warming. • Using the right building materials is one of the other ways to reduce heat. • To reflect heat and lessen absorption, roofs and terraces should be painted in white or light hues. • Gardening in the kitchen and on terraces should be encouraged. 5.6 Thermal Pollution Control The condenser cooling waters must be cooled before being dumped into bodies of water. The following are the key tenets of the heat loss process: 1. Conduction 2. Convection 3. Radiation 4. Evaporation To reduce high temperatures brought on by thermal discharges, utilize the following techniques: 1. Cooling Ponds:

113 As may be seen in Fig. 1a, cooling towers are useful for dissipating heat. Figure 1a Figure 1b The earth dike ponds where the condenser water is held allow for natural evaporation to lower the temperature. Once more, the water is circulated. A different approach to installing cooling ponds is depicted in Fig. 1b. 2. Spray Ponds: In spray ponds, water is sprayed into cooling ponds using spray nozzles to create tiny droplets that have larger surface area and can transmit heat to the atmosphere more effectively. Figure 5-2 Schematic diagram of spray ponds 3. Cooling Towers

114 Wet Cooling Towers: In a wet cooling tower, warm water comes into touch with air that is constantly flowing. The temperature decreases as a result of evaporation. The water is broken down into droplets by the use of spray nozzles or by splashing it on the packing or baffles in the cooling towers, increasing the surface area of contact. Figure 5-3 Schematic diagram of wet and dry colling tower Atmospheric Cooling Towers: In atmospheric cooling tower, warm water falls and air enters sideways to comes into touch with falling water. Finally, the air come out by absorbing the heat from water.

115 Figure 5-4 Schematic diagram of atmospheric colling tower 5.7 Summary The release of warm water into water bodies is known as thermal pollution. Thermal or nuclear power plants, effluents from places like oil refining, paper mills, chemical industries, steel plants, and smelters, wastewater effluents, and biochemical activities are the main sources of thermal heat pollution. The enormous heat output to the environment has posed a significant impact. As a result, action must be taken in advance to use this thermal energy or treat it before discharging it to the environment. With a focus on remedial measure, the principles of thermal pollution and different aspects of thermal pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit. 5.8 Questions/ Self-Assessment questions 1. What is thermal pollution? What are the different types of thermal pollution? 2. Discuss in brief the different effects of thermal pollution. 3. Briefly stale different factors contributing to thermal pollution. 4. Discuss the steps taken towards solving the problem of thermal pollution. 5. Briefly describe heat island concepts.

116 5.9 Select Readings/ Suggested Readings 1. BHATIA, H.S. "Environmental Pollution and Control", 1998. Galgotia Publishers, New Delhi. 2. BHATIA, S.C. "Environmental Pollution and Control in Chemical Process Industries", 2001. Khanna Publishers, New Delhi. 3. CHATTERJEE, A.K. "Water Supply, Waste Disposal and Environmental Engineering", 1998. Khanna Publishers,

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117 UNIT 6: Marine Pollution 6.1 Objectives 6.2 Introduction 6.3 Types of Marine Pollution 6.4 Source of Marine Pollution 6.5 Effects of Marine Pollution 6.6 Monitoring and Control Measures of Marine Pollution 6.7 Coastal Zone Management 6.8

Summary 6.9 Questions/ Self-Assessment questions 6.10 Select Readings/

Suggested Readings 6.1 Objectives After successfully completing this unit, you will be able to: ➢

learn about the different marine pollution sources, ➢ understand different types of

marine pollution and marine pollutants, ➢ know the different adverse effects of marine pollution, ➢ comprehend the control mechanism of marine pollution and associated regulations, ➢ understand the coastal zone concept and its management perspective, ➢ know the coastal economic zone management rules. 6.2 Introduction Marine pollution is the term used to describe waste and pollutants that enter the ocean from land-based sources. Both the marine species and the economic systems that rely on marine infrastructure are severely harmed by this pollution. The phenomena of human-spread materials including industrial waste, agricultural waste, household rubbish, etc. being dispersed across sea bodies is referred to as marine pollution. All manmade items that wind up in the water, the majority of which are made of plastic, are considered marine garbage. This debris, which comes from sources on land in 80 percent of cases, accumulates as a result of littering, storm gusts, and poor waste management. Many plastic goods, such as shopping bags and beverage bottles, together with cigarette butts, bottle caps, food wrappers, and fishing equipment are examples of common maritime garbage. As such a persistent contaminant, plastic waste is particularly harmful. Decomposition of plastic products might take hundreds of years.

118 6.3 Types of Marine Pollution Ocean pollution, also known as marine pollution, is one of the major dangers today because of industrialisation and agricultural practises. It poses a threat not only to the aquatic ecosystem but also, perhaps unintentionally, to people. There are various forms of marine pollution, including: Toxin marine Pollution One of the most hazardous forms of marine pollution, poisons are brought on by several toxins that build up in the oceans. DDT, Furan, radioactive waste, pesticides, PCB, TBT, phenol, and other toxins don't dissolve or break down; hence they endanger marine life. Marine Plastic Pollution Plastic pollution in the world's oceans is a result of its continued expansion in use. At the same time that the human population is growing, more plastic is being dumped into the oceans. The marine ecology is in danger as a result of how profoundly the plastic dumps are impacting marine life. Eutrophication Marine Pollution It has an impact on how animals breed. Nutrient pollution, also known as eutrophication, is what happens when water contains excessive amounts of chemical nutrients, particularly nitrates and phosphates. It degrades water quality and lowers oxygen levels in the ocean, making the environment uninhabitable for marine life. Acidification Coastal Pollution By absorbing carbon dioxide from the atmosphere, oceans also benefit the ecosystem. Regrettably, the overabundance carbon dioxide in the atmosphere is causing the oceans' water to become acidic. Marine life is also being impacted by ocean acidification. 6.4 Source of Marine Pollution There are several causes of marine pollution, the most of which are produced by humans. Sometimes it results from dumping waste, and other times it results from ocean mining. Land-based sources account for 80% of the pollution that affects the marine ecosystem. Nonpoint source pollution, which results from runoff, is one of the main sources. Many minor sources, such septic tanks, automobiles, trucks, and boats, as well as larger ones, like farms, ranches, and forested regions, make up nonpoint source pollution. Every day, little volumes of oil are discharged into highways and parking lots by millions of motor vehicle engines. A large portion of this also ends up in the ocean. These are some of the sources of marine contamination that are discussed: 1. Sewage pollution contaminates ocean Sewage is one way that pollution gets into the ocean directly. Rivers carry sewage into the ocean, which contaminates the marine life. Because of the decreased oxygen content of the water, oceanic creatures and plants have a harder time surviving.

119 2. Oily-water discharge from ship Lubricating oil, fuel oil, grease, and water frequently leak into ship bilges as a result of the functioning of the power plants. When the oily-water separator is either not installed or is installed but is inoperable, the resulting emulsified water and oil constitute a source of maritime pollution from ships. Ballast water poured into oil cargo tanks is another form of oily water pollution. Before fresh crude oil is added, this water must typically be pumped overboard because it contains some oil residue and exotic species. Moreover, cleaning the crude oil tanks on these ships adds to marine pollution because the oily water used in cleaning contains detergent, solids, and rusty scales from corrosion that are dumped overboard. 3. Industrial waste As a result of industrial waste, the ocean is exposed to thousands of other pollutants. Every day, about 2.8 billion gallons of industrial wastewater are dumped directly into ocean seas, including wastewater from electric utilities and offshore oil and gas operations. Several marine species, including those that are eaten by humans, frequently include heavy metals generated by industry, such as mercury and lead. Longer-lived, larger fish, like king mackerel, tilefish, swordfish, and shark, usually have unhealthy levels of the pollutant mercury, which can disrupt children's developing brains and neurological systems and harm fetuses. Pesticides and pharmaceutical substances, together with biological contaminants like bacteria, viruses, and protozoa, made their way into the ocean. 4. Plastic Pollution Global plastic pollution is a serious issue. Many people are unaware of how toxic and dangerous plastic is to the environment and to marine life. The main drawback of plastics is that they cannot decompose. They are employed in the creation of containers, bottles, bags, and food product wrapping. When these things are eventually dumped into the ocean, they pollute it, endangering marine life and even humans who eat seafood that contains plastic debris. 5. Accidental Spillage during Terminal Loading During the loading and disposal of crude oil at offshore oil terminals, operational errors, pipe ruptures, and pump and valve malfunctions can result in oil spills. Ships may also spill while loading bunker oil or lubrication oil for their engines. Oil can spill if a hose ruptures. Tanks aboard a ship could overflow if someone is not keeping an eye on the amount of oil being pumped into them. 6. Industrial chemicals contribute to marine contamination Toxins and chemicals introduced into seawater through agricultural and industrial wastes are another factor in ocean pollution. These chemicals contribute to thermal pollution as heavy pollutants. Thermal pollution causes an increase in ocean temperature. In oceans, there are some creatures that cannot endure high temperatures and perish.

120 7. Tanker Accidents Oil spills are most frequently connected with ship pollution. Gas, chemical, and oil transports are vulnerable to common maritime risks such collision, grounding, explosion, and fire. Catastrophic accidents have been caused by the exploration, exploitation, and transportation of oil, gas, and their derivatives. Oil spills have disastrous effects, albeit being less common than the pollution that results from normal activities. When this leakage happens, effective efforts are typically taken to stop it. 8. Garbage and Other Solid waste When there is no enforcement, non-oil pollutants from ships, such as trash and other solid waste, are frequently dumped into the ocean or a river. Glass, paper, cardboard, aluminum and steel cans, plastic bottles, and solid debris from ships all fall under this category. It might have a dangerous or non-hazardous nature. Solid trash that enters the ocean has the potential to turn into marine debris, which then poses a risk to persons, coastal communities, and businesses that depend on marine waters. 9. Wastewater discharged from ships Black water and grey water are the two types of wastewaters produced on board ships. Sewage, often known as blackwater, is the waste water from bathrooms and hospitals that may include dangerous infections, viruses, parasites, and minerals. Grey water is used water from the laundry, kitchen, showers, and sinks. This includes water that has byproducts such as fat and oil, food scraps, household chemicals, soap and detergent that is high in phosphate, nitrate, and microbiological pathogens dissolved in it or that have not been declared (e.g., bacteria and viruses). Both types of wastewaters offer serious health concerns to humans when released into aquatic habitats because they can harm ecosystems, cause algal blooms, and harm human health. 10. Ballast-water discharged from ships at ports: Since about 120 years ago, when steel-hulled ships first appeared, water has been utilized as ballast to stabilize ships at sea. While ballast water is crucial for the safe and effective functioning of contemporary ships, the abundance of marine species that are transported in it raises severe ethical, financial, and health concerns. These consist of various species of bacteria, microbes, tiny invertebrates, eggs, cysts, and larvae. The transplanted species may endure to form a regenerative population in the host habitat, where it will become invasive, outcompete native species, and proliferate to pest levels. The consequences for direct and indirect health are getting worse, and environmental harm is frequently irreparable. 11. Marine Degradation via Land Runoff Land runoff also contaminates marine water. It happens when too much water from rain, flooding, etc. seeps into the sea water. This water pollutes the oceans when it enters them with toxins like pesticides, oil, fertilizers, and animal faeces. These contaminants have detrimental impacts on marine life and cause the demise of aquatic animals and vegetation.

121 12. Mining-related marine pollution Deep sea mining is a new method of resource recovery in which minerals are extracted from the ocean floor. Mining is done for precious metals like silver, gold, copper, cobalt, zinc, etc. Deep sea mining, like its land-based counterpart, immediately discharges large amounts of contaminants onto the ocean floor. Since it's a novel type of mining, its environmental implications haven't been properly investigated. Deep sea mining is undoubtedly damaging, just like its land-based equivalent. Corrosion, spills, and leaks will change the ecology of the mining region. In addition to contributing to marine pollution, ocean mining also makes noise. The ocean's bottom level is impacted by deep-sea mining. The marine ecology is impacted by the contaminants released into the ocean as a result of the mining of metals like silver, gold, copper, etc. 13. Atmospheric pollution Marine pollution also contributes to atmospheric pollution. In the vicinity of bodies of water, winds sweep dust and trash like plastic bags from landfills. For instance, during the warm season, when the ridge builds and advances northward through the subtropical Atlantic, dust from the Sahara passes over the subtropical ridge's southern periphery and moves into the Caribbean and Florida. As a result of increased carbon dioxide levels, altered marine ecosystems, and altered fish distributions, climate change is raising ocean temperatures over time. Fishing-dependent communities have been impacted as a result of this. 14. Underwater noise Sea life may be sensitive to noise or sound pollution from things like passing ships, seismic surveys for oil prospecting, and low-frequency active sonar used by the navy. In comparison to the atmosphere, sound travels faster and farther in the sea. Sea creatures, like cetaceans, frequently have poor eyesight and navigate their environment mostly by sound. This holds true for many fish living in the deeper waters, who dwell in a world of darkness. In one site in the Pacific Ocean, background noise increased by roughly ten decibels between 1950 and 1975. The Lombard vocal response, which occurs when there is noise, also causes species to communicate loudly. When submarine detectors are active, whale songs are longer. If species don't "talk" loud enough, human sounds may cover up their voice. These silent cries could be warnings, prey being found, or net-bubbling preparations. The entire ecosystem will eventually speak louder as a result of one species' voice masking the sounds of other species. The oceanographer Sylvia Earle has said that underwater noise pollution is similar to dying from a thousand cuts. Each sound may not be of immediate concern on its own, but when combined, the noise from seismic surveys, military activity, and shipping is transforming the environment in ways that were unimaginable even fifty years ago. Cnidarians and ctenophora, which are crucial components of the marine ecology, can be harmed by noise from ships and human activity. Because of their straightforward designs, they encourage a high degree of variation and serve as models for biology and ecology. The vibrations in the water caused by underwater noise harm the cilia hairs on the Coelenterates.

122 In a study, the creatures were subjected to sound waves for varying lengths of time, and the findings revealed that damaged hair cells had extruded or been absent, or had kinocilia and stereocilia that were twisted, flaccid, or missing altogether. Ships may be certified as meeting specific noise standards. Other sources of marine contamination - • Fossil fuel emissions that contribute to climate change are a major factor in marine pollution and water acidification. • Marine contamination is also influenced by atmospheric pollution. For instance, the acidity of ocean water is increased by atmospheric carbon dioxide. • The marine ecosystem is contaminated by nuclear waste from numerous sectors, which has an impact on the marine ecosystem's food chain. • Oceans are exposed to thermal pollution from industrial, power plants, and other sources, which raises the water's temperature. • Marine pollution is also a result of acid rain. • When acid showers, the sulphuric acid and nitric acid interact with marine water, increasing the acidity of the water. Simply, "marine pollution" is the word used to describe seawater contamination. Marine ecosystem is contaminated by a variety of factors, including soil erosion and mining. • One of the main components of marine pollution is plastic. Thrown into the sea are bottles, polythene, plastic bags, etc. • Sewage dumped into the ocean creates marine contamination. • The rivers and oceans are filled with industrial pollution. It has a terrible adverse effect on the water. • Many sources of toxins, including phenol, pesticides, and fertilisers. • Seawater is also contaminated by oil spills. • Another source of marine pollution is thermal pollution. The causes and effects of each type are all covered in full below. 6.5 Effects of Marine Pollution The impacts of marine contamination are as numerous and diverse as the impacts. Marine pollution has a significant impact on marine life. Some of the dangerous causes of marine pollution include poisons, chemicals, polluted wastes, etc. These contaminants have a variety of effects on the oceanic Eco-system, including: Particularly at risk are aquaculture installations, designated breeding grounds, fishponds, and cages. Garbage and toxins reduce the oxygen level in the ocean, making it impossible for many species to live, particularly larger ones like whales, dolphins, penguins, sharks, iguanas, and seals. A lack of oxygen and the development of a dead zone can result from an overabundance of oxygen-depleting compounds in the water. Also, precipitation that moves across paved surfaces is known as storm water runoff. It may gather deposits of

123 sediments, car fluids, and air pollutants, among other things. In actuality, ship storm water runoff from marine ports contributes to impairment in Nigeria's estuaries and coastal waters. Plastic trash, abandoned fishing nets, and other items of a similar nature that are present solely as a result of human irresponsibility act as serious marine pollution agents and have an effect that cannot be imagined unless observed. A significant number of animals die as a result of consuming plastic; one example is sea turtles, which mistake it for jellyfish and eat it. The main cause of (eutrophication), a rise in chemical nutrients in surface waters, usually compounds containing nitrogen or phosphorus, is excessive nutrient inputs into water bodies. Other repercussions include a shortage of oxygen and drastic reductions in water quality, fish numbers, and other animal populations, as well as an increase in the ecosystem's primary productivity (excessive plant growth and degradation). Nutrient surplus promotes the growth of algae. These marine poisons can spread to terrestrial animals because many animal feeds contain a lot of fish meal or fish hydrolysate, which eventually appears in meat and dairy products and poses a threat to human health when consumed. The most frequent ocean pollution is oil. Each year, the sea is contaminated by more than 3 million metric tonnes of oil. Oil contamination in the waters is primarily caused by land. Oil is carried into the ocean through runoff and garbage from towns, businesses, and rivers. Ships wash out their tanks or discharge their bilge water into the ocean, which contributes to nearly a third of the oil pollution in the ocean. Broadly the marine pollution effects are described below: Impact of pollution on marine bio-system Spilled oil poses major risks to freshwater and marine habitats, affecting surface resources as well as a wide range of subterranean creatures that are linked in a complicated food chain that includes human food resources. In addition to the physical harm that affects wildlife and their habitats (such as coating birds or mammals with an oily film), this can also poison exposed species due to the oil's toxicity. Oil that is drifting pollutes seals' fur and seabirds' feathers. In birds, it clogs and ruins the feathers' insulating and waterproofing abilities. The bird will deplete its fat reserves while attempting to maintain its body temperature, weakening it. It is almost impossible to rebuild these reserves since, in its debilitated condition, whenever it flies the bird has to carry as much as 20% extra body-weight in sodden feathers. Moreover, during incubation, oil is transferred to the surface of its eggs, which decreases the hatchability. Oil pollution also disrupts the life cycle of coral reefs, clogs fish gills and kills them, and hinders marine plants' ability to synthesize oxygen, which eventually kills them. Impact of pollution on Local industries Fishing Industry When an oil disaster happens, the fishing business suffers greatly. The fish are dangerous for several reasons, chief among them that they are frequently doused with oil or have ingested oil. Moreover, a great deal of fish perish, reducing the potential catch of fish. Since this pollution has an effect on the seafood population, it has significant economic

124 repercussions. Large-scale catastrophes, like an oil leak, have the potential to completely damage the local economies of coastal towns that depend on these businesses. Tourist Industry In seaside towns where the ocean is overrun with contaminants, tourism suffers. For instance, if oil is spilled and it gets close to the shore, it contaminates the beaches and the intertidal zone. As a result of the oil slick destroying the aesthetic splendor of the seashore, the local tourism business suffers. Operations must be suspended while the water is cleaned, which can have a negative impact on industries that depend on clean seawater for normal functions. The community's economy is then impacted by this. Impact of Marine Pollution on Public health Ocean pollutants find their way back to people. Larger predators, many of which are seafood that we eventually consume, eat little organisms that have ingested toxins. Toxins from contaminated animals can enter human tissue and cause cancer, birth abnormalities, and other long-term health problems. The most acute health issues when oil is spilled into a residential area, for instance, are those brought on by volatile compounds, which are airborne poisons that lead individuals to complain of symptoms like headaches and nausea while also worrying about long-term issues like cancer. However, a trace amount of heavy metals are also present in crude oil, though they rarely vaporise into the atmosphere. As the oil leaks onto the rivers, they remain with it instead. Several of these substances, like arsenic and lead, can harm the nervous system even at very low concentrations. These substances include mercury, manganese, nickel, chromium, and others that are poisonous at high quantities. Reduction in oxygen content The majority of the rubbish deposited in oceans throughout the world is unable to degrade for many years, dramatically lowering the oxygen content of the water. The amount of oxygen in the ocean is being alarmingly depleted by excessive trash. The health of marine plants and animals, including sharks, penguins, whales, dolphins, turtles, and seals, is directly impacted by the low oxygen levels. Impact on oceanic food chain Industrial and agricultural garbage are dumped into the sea via the river that eventually empties into the ocean. Pesticides, chemicals, radioactive waste, and other industrial and agricultural waste settle to the ocean's bottom and remain there for a long time. The ocean's surface and bottom are both affected by this accumulated garbage. Little marine creatures that consume these substances are later consumed by larger marine creatures. The entire food chain is impacted in this way.

125 Disruption of the coral reef cycle Oceanic plants cannot grow when sunlight cannot penetrate an oil spill that covers the seawater's surface. Hence, it has an impact on photosynthesis. As a result, the coral reef cycle adversely affected. Impact on aquatic species' reproductive systems Chemicals that are detrimental to marine life make up the trash from industries and agriculture. Some substances are sufficiently harmful that they can harm aquatic creatures' internal organs, including their reproductive systems. The inability of the reproductive system to function has an impact on how water animal species reproduce. Toxins' detrimental consequences on marine life As the chemicals in the oceans continue to build up, they are beginning to have serious effects on aquatic life, including cancer, tissue and cell damage, organ failure, behavioural disorders, and reproductive system failure. These creatures are directly or indirectly exposed to hazardous chemicals, pesticides, and oil spills, which can cause a variety of health problems and even death. Common victims of ocean pollution include sea life. For instance, oil spills can trap and drown marine life by seeping through their gills. Seabirds that have oil in their feathers may be unable to fly or feed their young. Animals not killed by crude oil may get cancer, have behavioural abnormalities, or lose the ability to reproduce. As well as becoming entangled in or strangled by plastic bags and abandoned fishing nets, marine creatures also mistake small pieces of plastic garbage for food. Dolphins, fish, sharks, turtles, seagulls, and crabs are among the animals most at risk from marine plastic trash impact. Other implications of marine contamination include: • Unconditional death of helpless aquatic life results from a disruption in the natural water equations caused by an increase in oceanic temperature brought on by pollution. • Sea pollution also affects human health indirectly. • The pollutants from the harmed ocean animal are passed into people' bodies when they consume affected species. • The ocean's acidity is increased by the dissolved poisons, putting marine life at serious risk. • The sun and the ocean floor are separated by pollutants like oil spills. The photosynthetic mechanism of plants is hampered by these pollutants because they prevent sunlight from reaching the bottom.

126 6.6 Monitoring and Control Measures of Marine Pollution It is necessary to take action to stop waste chemicals and oil from being dumped into the ocean. For the management and prevention of maritime environmental contamination, there are national and international legislation, recommendations, and codes. Everyone has a responsibility to protect marine life because it is an essential component of our eco-system. Working together to stop marine pollution will have an impact. The following is a summary of some of the crucial preventative methods for marine pollution: We must all work together to prevent marine pollution since, as we are all aware, prevention is always preferable to treatment. Everyone has a responsibility to protect marine life because it is an essential component of our eco-system. Working together to stop marine pollution will have an impact. The following is a summary of some of the crucial preventative methods for marine pollution: • Use less chemical fertilizer: Eventually, extra chemical fertilizer finds its way into the oceans. Choose organic fertilizers, which typically contain less nutrients, and apply them half as often or at half the recommended dosage. • Choose reusable containers and cutlery: Straws and other disposable plastic utensils contribute significantly to ocean pollution. Use reusable containers and utensils to avoid adding to the threat to marine life. • Create a cleanup strategy: Plan a cleanup event to promote social distance at the beach or a neighboring park. Less garbage enters our waters as a result of more trash being picked up and properly disposed of. • Dispose of trash and plastics properly: One of the main causes of marine pollution is now plastic bottles, bags, and other products. To avoid plastics and other recyclable items from ending up in the ocean, properly dispose of them is one of the simplest strategies to decrease ocean pollution. Take your rubbish home with you while you're in an outside area, such as a park or the beach. To protect marine life and the ecosystem, we must cease consuming products manufactured of plastic. • Studies show that trash from land-based sources is responsible for about 80% of marine contamination. By reducing the waste produced, we can lower this. • Cleaning up the seashores requires effort from all of us. Cleaning up beaches will help minimize marine pollution to some extent. • In place of employing chemical pesticides and fertilizers, the farmers should practice organic agricultural methods. The plants and animals of the sea suffer a variety of health problems when these fertilizers and pesticides are introduced into ocean water. • Since the majority of drain water ends up in the oceans, we must all take care that only rainwater enters the drainage system. The marine life will eventually suffer if sewage and other waste are allowed to enter the drainage system.

127 • The majority of rivers empty into the sea, where waste also mixes with the water. As a result, we also need to maintain the rivers' purity to prevent marine life from becoming contaminated. • To safeguard the marine ecosystem, we ought to stop using single-use plastic. • Say "NO" to disposable items like straws, mugs, and plastic shopping bags. These things only contribute to an increase in the amount of trash that ends up in the oceans. • Ocean environment is greatly protected through recycling. • To lower the ocean's temperature, we should make an effort to utilize as little energy as possible. • Buy eco-friendly goods and materials whenever possible. • Raise people's awareness of the need to protect and value the maritime environment. • You can become a member of any group that strives to protect marine life from pollution. 6.6.1 Laws and Regulations Since there are numerous ways for the ocean to become polluted, numerous laws, rules, and treaties have been established throughout history. Policies have been created globally to protect the ocean from marine pollution. • The Federal Water Pollution Control Act which Harry Truman signed into law in 1948, gave the federal government authority to manage marine pollution in the United States of America. • The US Congress passed the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) in 1972, which governs the ocean dumping of waste into US waterways. • Due to flag states' disregard for the law, both the 1973 International Convention for the Prevention of Pollution by Ships and the 1954 Convention for the Prevention of Pollution of the Sea by Oil were only loosely implemented. • MARPOL 73/78 was a convention created in 1973 and 1978 to limit pollution from ships, particularly with reference to oil. The MARPOL 73/78 pact was internationally enforced in 1983 by the International Convention for the Prevention of Pollution from Ships. • By requiring states to limit their ocean pollution, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) was developed to safeguard the marine ecosystem. It set limits on the quantity of poisons and pollutants that are released from all ships that travel abroad. • The Marine Debris Research, Prevention and Reduction Advisory Council (MDRPRAC). • The National Oceanic and Atmospheric Administration (NOAA) created it to aid in the identification, attribution of origin, mitigation, and prevention of marine debris. • The Ad Hoc Open-Ended Expert Group on Marine Litter and Microplastics was established by the UN Environmental Agency (UNEA) in December 2017 with the aim of researching marine plastic pollution and determining solutions.

128 6.7 Coastal Zone Management The area where land and sea meet are known as a coastal zone. The territorial waters up to the high-water mark serve as the boundary for the coastal zones. These are long, narrow characteristics of the continent, islands, and seas that typically define the outer limit of the coastal domain. These areas are crucial since they are home to the vast majority of the world's inhabitants. The Coastal Zone Management (CZM) process of governance comprises of the institutional and legislative structure required to guarantee that management and development plans for coastal zones are integrated with environmental and social goals and are established with the participation of people impacted. 6.7.1 Coastal Zone Management's Objectives The objectives of CRZ are to "preserve, protect, develop, enhance, and restore the coastal resources where practicable." These are the goals of coastal zone management: 1. The main goal of CZM is to strike a balance between the need for development and the protection of natural resources, so if coastal ecosystems are managed according to the principles of sustainability, millions of people's livelihoods will be safeguarded, and their survival will be ensured. 2. To make the most of the advantages offered by the coastal zone 3. To reduce disputes and negative repercussions of actions on one another, resources, and the environment 4. Encourage connections between various sectoral operations 5. To direct the ecologically appropriate development of coastal areas 6. To maintain and safeguard the coastal zone from actions that can result in quality degradation or loss of coastal land. 6.7.2 Necessity of Regulating Coastal Zones • Preservation of ecologically sensitive areas, such as mangrove swamps and coral reefs that serve as a barrier against cyclones and tsunamis • enhancing coastal populations' quality of life, particularly fishing communities • Resilient strategies for reducing the effects of climate change and strong cyclones • To strike a balance between growth and coastal environment preservation 6.7.3 Difficulties of Management of Coastal Zone The definition of problems and their remedies in the coastal zone are handled through the interdisciplinary and cross-sectoral practise of coastal zone management. It faces a variety of difficulties, some of which are listed below: 1. Failing to recognise how connected coastal systems are

129 2. Insufficient regulation and non-enforcement 3. Insufficient knowledge of and expertise with ICZM 4. Inadequate comprehension of marine and coastal processes 5. A lack of knowledgeable staff, appropriate technologies, and apparatus 6.7.4 Coastal Zone Management Strategies The Rio Declaration on Environment and Development, which outlines accepted worldwide principles, serves as the foundation for the Coastal Zone Management (CZM), which is also based on the bio-physical characteristics of the coastal zone. The changes brought about by the Coastal Regulation Zone (CRZ) Notification make it relevant to Government Policies/Indian Polity. To safeguard and preserve the ecology and ecosystem along the nation's coastline, the Government of India issued a notification in 1991 under the Environment Protection Act, 1986, which is overseen by the Ministry of Environment and Forests (MoEF). The Coastal Regulatory Zone is defined by the notification as the coastal area up to 500 metres from the High Tide Line (HTL) and a stage of 100 metres along the banks of creeks, estuaries, backwaters, and rivers vulnerable to tidal fluctuations (CRZ). 6.7.5 Tide Lines and Tides In order to understand the Coastal Regulatory Zone, it is crucial to comprehend Tide Lines. Spring Tide: This extraordinarily high tide is caused by the complimentary role that the Sun and Moon play. It should be noted that a Syzygy occurs when the Sun, Moon, and Earth are all in the same line. These take place twice a month, once during the full moon and once during the new moon. High Tide Lines (HTL): It is the area of land that the highest water line during the spring tides extends to. Low Tide Lines (LTL): It is the area of land up to which the lowest water line during spring tides extends. 6.7.6 Coastal Regulation Zone Classification The Ministry of Environment and Forest and Climate Change published the Coastal Regulation Zone Notification in 1991 with the intention of conserving and protecting the coastal environment. According to the CRZ Notification from 1991 through 2003, there are four different classifications for the coastal regulation zones across the nation. For regulation of developing activities, the coastal sections within 500 m of HTL on the landward side are categorised into four groups, viz.

130 Category I (CRZ-I) Areas that are ecologically sensitive and significant, such as national parks, marine parks, sanctuaries, reserve forests, wild habitats, mangroves, corals/coral reefs, areas near fish breeding and spawning grounds, historical and heritage areas, areas rich in genetic biodiversity, areas likely to be inundated due to sea level rise brought on by global warming, and such areas as may be declared by the authorities. The region including the Low Tide Line and high tide line Regulations: Rules prohibit new development within 500 metres of the HTL. Category II (CRZ-II) The region that has previously been developed up to or around the shoreline is classified as Category II (CRZ-II). For this purpose, "Developed Area" refers to any area that is considerably developed, inside municipal borders or in other legally recognised urban regions, and that has access to drainage and approach roads as well as other infrastructure like water supply and sewage mains. Regulations: a) Structures are not authorised on the seaward side of either the current road (or any roads proposed in the area's approved Coastal Zone Plan) or the projected road. Existing approved structures must adhere to current Town and Country Planning laws, including FIS/FAR standards. b) The authorised building may be rebuilt as long as it complies with current FSI/FAR standards and its intended purpose is not altered. c) Building designs and construction must complement the architecture and natural surroundings. Category III (CRZ-III) Places that are neither in Category I nor II but are nonetheless relatively undeveloped are classified as Category III (CRZ-III). Coastal zones in both developed and undeveloped areas, as well as places inside municipal boundaries or in other officially recognised urban areas that are not extensively built up, will be included in this. Regulations: a) A "No Development Zone" is designated for the region up to 200 metres from the HTL. Except for repairs to already-authorized structures that don't go above existing FSI, existing plinth area, and existing density limits, no construction is allowed in this zone. Nonetheless, the following uses—agriculture, horticulture, gardens, pastures, parks,
131 play fields, forestry, and the production of salt from sea water—might be allowed in this zone. b) Construction of hotels or beach resorts for short-term occupancy by tourists or visitors is permitted on unoccupied lots between 200 and 500 metres of the High Tide Line in designated CRZ-III zones with the previous clearance of the Ministry of Environment and Forests. c) Building or reconstructing residential structures within 200 to 500 metres of the High Tidal Line is permissible as long as it respects traditional rights and customary usage, such as those of existing fishing villages and gothans. Construction approval for such Construction and reconstruction will be subject to the limitations that the number of housing units combined cannot reach twice the number of existing units, that the total area covered on all floors cannot exceed 9 metres, and that the number of floors of building cannot exceed two (ground floor plus one floor). d) Reconstruction or alteration of an authorised existing building is allowed under the conditions of (1) to (3) above. Category IV (CRZ-IV) Coastal lengths of the Andaman and Nicobar Islands, Lakhadweep, and small islands that are not part of the CRZ I, CRZ II, or CRZ III are classified as Category IV (CRZ-IV). Regulations a) On the Andaman and Nicobar Islands, no new building construction is allowed within 200 metres of the HTL. b) Buildings between 200 and 500 metres from the HTL must have no more than two floors, a total area on all floors no larger than 50% of the plot's size, and a maximum height of 9 metres. c) Buildings must be built in a manner that complements the local architectural style and surrounding surroundings. d) Sand and coral from beaches and coastal waters are not to be exploited for building or other purposes. e) Underwater blasting and dredging are not allowed near or within coral formations. f) However, with the prior consent of the MoEF and in such designated structures, coastline portions in some of the islands may also be categorised into categories of CRZ-I, II, or III. 6.7.7 Things That Are Prohibited Inside the CRZ Inside the CRZ, the following activities have been declared illegal. 1. Establishing new industries and growing existing ones, with the exception of those with a direct connection to the waterfront or that genuinely require seafront infrastructure. 2. The production, handling, or disposal of hazardous materials.

132 3. Establishing and growing fish processing facilities, including warehousing (excluding hatchery and natural fish drying in permitted areas) 4. Installing and expanding equipment for dumping garbage and effluents into waterways. 5. Discharging of untreated wastewater and city waters from businesses, towns, and other populated areas. 6. The practise, if any, of dumping municipal garbage for land filling or other purposes shall be phased out within a reasonable period of time not to exceed three years from the date of notification. 7. Ash or other trash disposal after the notice date. 8. Land reclamation, construction, or other activities that alter the normal flow of seawater with similar observations, excluding those necessary for maintaining or controlling coastal erosion, sandbar construction, or storm water recharge. 9. Mining of non-existent substrata resources outside CRZ regions, such as sand, rocks, and other minerals. 10. Groundwater harvesting or drawing is allowed within 200 metres of the HTL, but within 500 metres of the HTL, it must only be done manually through regular wells for drinking, horticulture, agriculture, and fishing. 11. Building projects in ecologically delicate locations 12. Any construction between LTL and HTL, with the exception of facilities for treating effluents and waste discharges, pipelines for oil, gas, and similar substances, and dressing or altering of sand dunes, hills, and other natural features, including landscape changes for aesthetic, recreational, and other similar purposes. Table 6-1: CEZ at a glance Category Description CRZ1 Regions that are environmentally sensitive and necessary for preserving the ecology along the shore are known as high tide lines (HTL) and low tide lines (LTL). Permissions: • Natural gas exploration • Salt extraction CRZ2 Areas that have been developed right up to the coast's edge. Permissions: • Some construction that only complies with the rules. • Rebuilding the permitted structure while maintaining the current use. CRZ3 Locations in both urban and rural settings that are not included in CRZ-1 and CRZ-2 fall under CRZ-3. Although they have been given to the municipality, they are not heavily developed. Permission: • Only specific activities associated with forests, salt production from seawater, horticulture, gardens, pastures, parks, and play areas.

133 • In this area, only repairs to already-authorized structures are allowed for construction. • Only public facilities to be built. CRZ4 Lakshadweep, small islands, and coastal sections in the Andaman and Nicobar Islands, excluding those designated as CRZ I, CRZ II, and CRZ III. In this area, solid garbage should be disposed of. Permissions: • Sand and coral from beaches and coastal waterways are not permitted to be used for building or other purposes. • In and near coral formations, dredging and underwater blasting are prohibited. Coastal Regulation Zones Announcement 2011 The 2011 Coastal Regulation Zone Notification took into account the problems of the 1991 notification and made appropriate adjustment recommendations. The 2011 Coastal Regulation Zone Notice made the following changes: Category Description CRZ1 Exemption for brand-new buildings • Building highways and trans-harbour sea links between HTL and LTL, etc., without affecting the tidal flow. • Initiatives involving the Department of Atomic Energy. Additional authorizations given for interactions between HTL and LTL include: • Exploration and extraction of natural gas Salt production Desalination facilities • Facilities for non-hazardous cargo storage in the notified ports. CRZ2 • Permits for construction of buildings on the dangerous line's landward portion. • Among other things, are among the licences given for activities between HTL and LTL. o Desalination plans o Only in accordance with the notification's rules are certain types of building allowed. CRZ3 • New construction exceptions. o Building highways and trans-harbour sea links between HTL and LTL, etc., without affecting the tidal flow. o Projects for public facilities, petroleum products, salt production, and the Department of Atomic Energy. • Building homes for nearby communities in some places. CRZ4 • The traditional fishing practiced by nearby communities is unrestricted.

134 • These places may not be used for the discharge or dumping of solid waste or untreated sewage. Under the leadership of Dr. Shailesh Nayak, the Ministry of Environment, Forest, and Climate Change established a Committee in June 2014 to investigate the different challenges and worries of Coastal States/UTs and other stakeholders in order to recommend necessary adjustments to the CRZ Notification, 2011. In 2015, the Shailesh Nayak Committee delivered its recommendations following extensive talks with state governments and other stakeholders. The Union Cabinet gave its approval to that draught notification in December 2018. New CRZ requirements were then announced by the MoEFCC in January 2019. Coastal Regulation Zone Notification 2018 and 2019 In accordance with Section 3 of the Environment Protection Act of 1986, the revised CRZ Notice aims to: • "to advance sustainable development based on scientific principles, taking into account the risks associated with natural calamities, sea-level rise as a result of global warming," and • "to conserve and safeguard the unique ecosystem of coastal stretches and marine areas, besides livelihood security to the fisher people and other local groups in the coastal area". The following new changes are included in the Coastal Regulation Zone Notice for 2018 and 2019: • Development projects o Reduction of No Development Zones (NDZ) • New Categories in CRZ Two distinct classifications have now been established for CRZ-III(Rural) areas, and they are as follows: CRZ-III A CRZ-III B Highly inhabited rural areas with a 2161/km2 population density. They will have a 50-meter NDZ from the horizontal. Highly inhabited rural areas with a 2161/km2 population density. NDZ will be 200 metres from HTL for them.

135 According to the 2011 CRZ Notice, it was previously 200 metres from the HTL. • Tourism Infrastructure • FSI Norms for Relaxed o According to the CRZ, 2011 Announcement, the Floor Space Index (FSI) or Floor Area Ratio (FAR) for CRZ-II (Urban) regions had been frozen at 1991 Development Control Regulation (DCR) levels. o It has been agreed to de-freeze the same and allow FSI for construction projects, as they were on the date of the new Notification, in the CRZ, 2019 Notification. • Pollution Abatement • Critically Vulnerable Coastal Areas (CVCA) o Sundarban region of West Bengal and other ecologically vulnerable places recognised as such under the Environment (Protection) Act, 1986. o Coastal communities, notably fishermen who rely on coastal resources for a sustainable living, are involved in their management. 6.8 Summary Aquatic environments with elevated amounts of dissolved salt make up marine ecosystems. They encompass the open ocean, the deep-sea ocean, and coastal maritime ecosystems, each of which has diverse physical and biological properties. An international issue is ocean pollution. It crosses international borders and has many sources. It results from irresponsible, opportunistic, and untenable resource extraction. It puts marine ecosystems in danger. Marine air pollution is a mixture of chemicals and debris, which mostly comes from terrestrial sources and is washed or blown into the ocean. This contamination leads in environmental damage, to the welfare of all species, and to economic systems globally. With a focus on remedial measure, the principles of marine pollution and different aspects of marine pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed thoroughly in this unit. 6.9 Questions/ Self-Assessment questions 1. What is marine pollution? What are the different types of marine pollution? 2. Discuss in brief the different effects of marine pollution. 3. Briefly stale different factors contributing to marine pollution. 4. Discuss the steps taken towards solving the problem of marine pollution. 5. What do you mean by coastal zone? Write down different types of coastal regulation zone with characteristics. 6. Differentiate between low and high tide. 7. Briefly describe coastal zone regulation notification.

136 6.10 Select Readings/ Suggested Readings 1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi. 2. P.K. Goel, "Water Pollution Effects and Control" New Age International (P) Limited; Publishers, New Delhi, 1997. 3. H.S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 4. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001. 5. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi. 6. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

137 UNIT 7: Radioactive Pollution 7.1 Objectives 7.2 Introduction 7.3 Fundamental Radiation Types 7.4 Radioactive Decay 7.5 Sources of Radio Active

Pollution 7.6 Radioactive Pollution's Effects 7.7 Control of Radioactive

Pollution 7.8 Summary 7.9 Questions/ Self-Assessment questions 7.10 Select Readings/ Suggested Readings 7.1 Objectives After successfully completing this unit, you will be able to: ➢

learn about the different radiation pollution sources, ➢ understand different types of

radiation and their characteristics, ➢ understand the different adverse effects of radiation pollution, ➢ comprehend the control approaches of radiation pollution. 7.2 Introduction A physical kind of environmental contamination is radioactive pollution. It differs from other forms of pollution in that it not only has a negative impact on the individual but also causes physiological alterations in future generations. Radionuclides damage man's essential life support system by contaminating the air, water, and soil. Any radioisotope that is introduced to the environment and has a long enough half-life is said to enter a person's body. There are dangers associated with even the slightest increase in radiation over the background radiation from the environment. Radiation contamination is now being brought to unprecedented levels by the expansion of nuclear testing, X-ray fluoroscopy, radars, and light materials like colour televisions. Radiation is the energy that is emitted from a source. Ionizing radiation is any electromagnetic or particle radiation that can produce ions by interacting with matter, either directly or indirectly. Many medicinal, nuclear, and industrial uses produce ionizing radiation. On the basis of wavelength, different types of radiation are categorized. A radiation type's

138 associated energy is determined by its wavelength. The frequency and energy increase with decreasing wavelength. The three main systems that support life—air, water, and soil—are all affected by radioactive pollution, which is a unique type of physical pollution. Because radioactive contamination has a very different nature from other types of contamination, it must be explained separately. Also, its impacts are unique in sort. Radioactivity is a phenomenon that results from the spontaneous breakdown of the atomic nuclei of specific elements, which causes the emission of protons (alpha particles), electrons (beta particles), and gamma rays (short wavelength electromagnetic waves). Wavelength = Velocity/ Frequency The medium that radiation passes through affects its speed. 7.3 Fundamental Radiation Types 7.3.1 Alpha Particles i. Only marginally penetrating, and halted by 80 mm of air or by thin materials. ii. Repelled by magnetic and electric fields. iii. Moves fairly slowly iv. Very high ionisation v. Have two helium ions in their nucleus. 7.3.2 Beta Particles i. Has the ability to pierce aluminium sheeting. The energy of the particles affects the penetration strength. ii. In magnetic and electric fields, strongly deflected. iii. Are electrons with great velocities. 7.3.3 γ-rays i. Depending on the radiation's energy, it can penetrate several centimetres of lead. ii. In magnetic fields, undeflected iii. Are protons with a very high frequency. 7.4 Radioactive Decay This is a natural process that resulted from some kind of nuclear instability. It is a random process, meaning that the likelihood that a given nucleus would decay over a unit of time depends on both the timing of the time interval and any chemical or physical variables. Equation for decay N = N o e -λt

139 Where N = number of nuclei present at time, t N o = Original number of nuclei λ = decay constant Activity, A = n/t where n is the number of transformations in time, t. The AN, decaying per unit time, is subject to statistical fluctuations that follow a Poisson distribution. Half Life (T/2): It is the amount of time needed for half of the nuclei to decay. 7.5 Sources of Radio Active Pollution Natural and man-made processes are the two main sources of radioactive pollution. 7.5.1 Natural Sources The primary natural sources of radioactivity are thought to include cosmic radiation from space, naturally occurring radioisotopes found in the environment, and those found inside the bodies of living things. The solar system's cosmic radiations are alien in origin and likely come from beyond the sun. They are made up largely of protons and a few heavy nuclei, which are incredibly energetic particles. When these cosmic particles strike the upper atmosphere's gas molecules, they intensely ionise the gases and create secondary cosmic rays, which are mostly made up of neutrons, mesons, and gamma rays. The earth eventually receives cosmic rays, which are a complicated collection of particles. Moreover, significant amounts of 3H and 14C are produced by these particles in the air. The existence of radionuclides in the lithosphere, hydrosphere, and atmosphere is another source of natural radiation. Every element with an atomic number higher than 82 (Lead) is radioactive by nature and emits varying amounts of radiation. Uranium, Thorium, and potassium-40 are the three radionuclides that are found in nature in the greatest abundance. Little amounts of 40K, as well as uranium and its daughters, are present in soils, minerals, and even building materials. 7.5.2 Artificial Sources Nuclear weapon testing, the construction of nuclear power plants, the mining and processing of plutonium and thorium, and the production of radioactive isotopes are all examples of human activity that results in radioactive contamination. 1. Nuclear weapons

140 Testing nuclear weapons includes: a. Fissioning of uranium 235 and plutonium 239. b. Lithium or hydrogen as fusion fuel. Chain reactions beyond our control cause atomic explosions. These result in situations with very big neutrons that make other materials in the immediate area radioactive. Enormous clouds of tiny radioactive gases and particles are released into the atmosphere and carried by the wind to far-off locations. They gradually descend to the ground as they fall or are carried there by rain. 2. Atomic Reactors and Nuclear Fuel Uranium, thorium, and plutonium are the most frequently employed fuel types for fission in nuclear power reactors. Before entering reactors, as well as during the mining process, uranium travels through a number of steps. When the energy has been used, the spent reactor materials are reprocessed to recover unburned uranium, plutonium, and some other significant isotopes that can be employed in medicine or for other beneficial reasons. The term "nuclear fuel cycle" refers to the entire process, including the mining of the fuel and its ultimate disposal. Since liquid, gaseous, and solid radioactive wastes are emitted at practically every stage of the nuclear fuel cycle and have a high potential to contaminate the environment, extreme care must be taken to ensure environmental safety at the time of nuclear operations. 3. Radioactive Isotopes Different levels of radioactive materials are present in radioactive isotopes including 125I, 14C, and 32P as well as their compounds, which are widely used in scientific research organisations. This effluent causes water pollution when it enters various water sources like rivers, streams, lakes, etc. through sewers. Radioactive phosphorus and iodine also enter the food chain through water, where they may eventually make their way to man through fish, etc. 4. Radioactive Fallout Radioactive fallout is the term for the radioactive dust that results from atomic explosions. Depending on the type of bomb that detonated, different radioactive fallout exists. Iodine 131 and phosphorous 32 are two radioactive elements with extremely limited half-life. As a result, they decompose quickly and are blocked from entering plant metabolic pathways. However, some radioactive elements have extraordinarily long half-lives, or very slow rates of disintegration. Strontium-90 and cesium-137, for instance, have even longer half-life than calcium-45, which has a half-life of 160 days. Likewise, the most harmful isotopes for humans and other vertebrates are those with longer half-lives. 5. Other Sources Many medical procedures involve the introduction of differing levels of radiation into the body. For example, X-rays are frequently used to diagnose skeletal problems, and radiation therapy for cancer patients frequently involves radium and other isotope radiations.
141 Dental X-rays, which can run at a voltage of roughly 10 KV, emit more penetrating radiation and may be more dangerous if not adequately insulated. X-rays are a common type of ionising radiation and are produced by radiography equipment, X-ray therapy equipment, and other devices. Over 240 million dental and medical X-rays are taken each year, and 15 million tests employing radioactive materials as tracers in the human body are also conducted, according to reports. 7.5.3 Man's Exposure to Radiations Ionizing radiation exposure to humans comes from the following sources: Industrial Applications: Some examples of this source include the luminous dials found on watches and other instruments, the sterilisation of food and medications, radiography of metallic objects, X-ray fluoroscopy, X-ray crystallography, and spectroscopic examinations. Medical Applications: This source of radiation consists of tracers, internal therapeutic agents, and external therapeutic techniques that are used in the body to study the behaviour of particular elements, determine the selective absorption of particular elements by specific tissues, and find the location of tumours and other diseases, respectively. Civil Exposure: Man is slightly exposed to radiation through cosmic rays, nuclear reactor accidents, X-rays produced by televisions, and fallout from nuclear weapon testing, all of which have been previously covered. Mode of Action of Radiations The primary result of radiations entering the body is the formation of ions, which is followed by changes to the chemical makeup of enzyme systems. Damage is more noticeable in cells that are going through mitosis. Moreover, chromosome damage can lead to genetic disorders and cancer. Radiation can seriously harm the developing foetus. As previously indicated, the risk is larger for radioactive elements with lengthy half-life, and it is lower for those with short half-life that are removed more quickly. 7.6 Radioactive Pollution's Effects The impacts of radioactive pollutants depend on i) the ability to release energy, (ii) the radioactive elements' half-lives, (iii) the rate of diffusion, and (iv) the rate of contamination deposition. Atmospheric and climatic conditions, such as temperature, rainfall, and wind, also have an impact on their impacts.

142 7.6.1 Damages to a Biological System The majority of the harm done by radioactive contaminants is due to their ability to emit extremely destructive high-energy radiations to living systems. A biological system may be endangered by radioactive pollution in one of two ways. i. Radiation damage from an external source. ii. Radiation damage brought on by internal body sources. Damages brought on by radiation at various levels 1. Molecular level damage: Ionization cross-linkages within and between two impacted molecules cause harm to macromolecules like enzymes, DNA, RNA, and other types of molecules. 2. Damages at the subcellular level: mitochondrial dysfunction, chromosomal fragmentation, cell membrane damage, etc. 3. Damages at the cellular level: It include the prevention of cell division, as well as cell death, ageing, and malignancy. 4. Tissue and Organ Injury: disruption of various systems, including the central nervous system, blindness, inactivation of bone marrow function leading to blood cancer and intestinal ulcers. 5. Damages to the individual and population as a whole: Radiation-induced death or life- shortening mutations might alter a person's features. Radiation exposure in humans initially has little consequences that are observable. However, damage symptoms only become apparent after 12 to 24 hours. This includes skin reddening, anaemia, anorexia, vomiting, and diarrhoea, as well as blister formation, skin pigmentation, burning sensations throughout the body, loss of vision, etc. with excessive doses. It should be mentioned that there is no known remedy for any of these. A person must deal with the effects of radiation exposure once it has occurred. Ineffective medical assistance. Moreover, delayed effects have been noted. Some results don't manifest for many months or even years. Which are: (i) Leukemia and malignant tumours. (ii) Skin infections, dermatitis, ulcers, and burns, (iii) Gangrene sickness, (iv) Leucopaenia in the lymphatic system, (v) Depressed bone marrow, causing granulocytosis, aplastic anaemia, and thromocytopaenia. (vi) Blood vessels: Oedema of the vessel wall and surrounding tissues, increased permeability, and haemorrhages, (vii) cataract in the eyes, (viii) Gonads-Sterility in both sexes, (ix) Osteosarcoma and bone necrosis, (x) Genetic effects: Inability to conceive, stillbirths, congenital malformations, epilepsy, mental problems, neuromuscular, haematological, and endocrine system disorders. Though innocuous, therapeutic radiation exposure to humans can occasionally cause radiation sickness, which is characterised by nausea, loss of appetite, a moderate temperature, and a general feeling of malaise. There is practically any safe dose, and even a small increase in background radiation can lead to leukaemia and cancer. Moreover, it causes mutations. The harmful genes can survive in humans, animals, and plants and eventually impact their

143 offspring. The protoplasm is damaged by ionising radiations including alpha, beta, neutron, and gamma rays, which also replace some elements like calcium, carbon, and zinc when their quantity in the protoplasm rises. 7.6.2 Radiation effects and their key characteristics As ionising radiation penetrates living tissues, wreak havoc on the atoms and molecules in its route, making man

the final victim of radiation attempts and the end of all reactions and interactions. (1)

Man's exposure to ionising radiation, (ii) Microwave radiation effects, iii) Consequences of radioactive fallout, (iv) X-ray effects, (v) Non-ionizing radiation effects, (vi) Radiofrequency radiation effects, (vii) Radiation's biological effects, (viii) Plant effects of radiation, ix) Effects of plutonium as a carcinogen, item, x) Nuclear radiation's effects on polymers, (xi) Nuclear threat, power plant danger, and reactor danger 7.7 Control of Radioactive Pollution It might not be able to control natural radioactive pollution. Only artificial radioactivity- out of all the sources—is subject to intervention, whenever controls are imaginable. The following safety precautions can be strictly enforced to reduce radioactive pollution. All wastes, whether they are low level or high level, have a great potential to harm the ecosystem. Low level wastes cannot be contained since they are frequently created in significant amounts. They go through a visual process to remove the radioactive, and then they are released normally in water or on land. High level wastes, on the other hand, must be concentrated, contained, and kept away from the area where people live. They cannot be dumped into the environment at will. Typically, the radioactive wastes that cause water pollution are in a liquid or solid state. These varied waste types provide a variety of issues since disposal methods safe for one type of waste may be harmful for another. All methods, however, are aimed at preventing radioactive waste components from harming living things, particularly humans. Treatment of Solid Radioactive Wastes Reducing their volume is the goal of the treatment of radioactive solid waste. Incineration, compacting, and fragmentation are the three basic techniques for treating radioactive solid waste. Before burning, materials should be properly sorted to remove anything that could produce explosive or hazardous fumes, as well as non-combustible things. A press can be used to compress some types of solid waste. The garbage is placed into single-use containers for disposal after compaction.

144 Radioactive waste disposal alternatives The disposal of this garbage in space, ice sheets, a very deep hole of three to five kilometres where the rock is still heated, and a deep ocean floor beneath the sediments are the significant choices. Some technologies are, however, no longer used or put on hold for potential future use, either because they are very expensive, provide a larger risk to the environment, or need more technical expertise than is currently available. In summary, following measure can be adopted to stop radioactive pollution, including: i. Atomic reactor leakages need to be monitored and regulated on a regular basis. ii. Radioactive fuels, fission products, and radioactive isotopes shall never again be handled, transported, or used in any way without proper safety precautions. iii. The safety precautions must to be strictly and completely implemented. For instance, no safety measures are required if the radiation level is less than 5 millicuries. Therefore, in order to prevent contamination, doctors must wear strong rubber gloves, plastic aprons, plastic shoe covers, and spectacles if the body contains radioactive material between 5 and 30 millicuries. iv. Before sending contaminated clothing to the laundromat, it should be carefully cleaned with soap and water and stored for proper radioactive material decay. v. The radioactive waste must be disposed of in a secure manner. In dangerous situations, regular monitoring must be provided through frequent sample and quantity analysis. vi. Preventative measures must be used to ensure that background radiation levels do not exceed allowable levels. vii. Safety precautions should be put in place and reinforced to prevent accidents. Moreover, measures against occupational exposure must be adopted that are appropriate. viii. Very low radiation radioactive wastes should be disposed of in sewage systems. 7.8 Summary The introduction or build-up of radioactive materials into an area when its presence is unintentional or the quantities of radiation are unwanted is known as radioactive contamination. Radionuclides are the principal sources of pollution; they release beta particles and gamma rays, radioactive compounds. Radioactive pollution of water, water supplies, and air space is the outcome of radioactive fallout from the clouds of a nuclear explosion. Due to the ionising radiation, it emits, this kind of pollution is dangerous to human health. Accordingly, with a focus on remedial measure, the principles of radioactive pollution and different aspects of radiation pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed thoroughly in this unit. 7.9 Questions/ Self-Assessment questions 1. What is Radiation Pollution? What are its effects on biological system?
145 2. What are the types of radiation? 3. Write a note on sources of radiation pollution. 3. Describe the control measures of radiation pollution. 7.10 Select Readings/ Suggested Readings 1. G. N. Pandey, "Environmental Management" Vikas Publishing House, Pvt, Ltd, 1997, New Delhi. 2. P.K. Goel, "Water Pollution Effects and Control" New Age International (P) Limited; Publishers, New Delhi, 1997. 3. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 4. Suresh K. Dhameja, "Environmental Engineering and Management" S. K. Kataria & Sons - Publishers, New Delhi 2002. 5. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi. 6. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998 7. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001. 8. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi. 9. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

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Course: Environmental Geosciences and Climate Change Content Netaji Subhas Open University P.G. Environmental Science PGES-CC-202

1 Unit 1: Fundamental of Earth Processes 1.1 Objectives 1.2 Introduction 1.3 Origin of Earth 1.4 Geological Time Scale 1.5 Internal Structure of the Earth 1.6 Continental Drift 1.7 Mountain Building 1.8 Landform Development due to Water action 1.9 Landform Development due to Wind action 1.10 Landforms Development Due to Glacier 1.11 Summary 1.12 Questions for self-assessment 1.13 Suggested Readings 1.1 Objectives By successfully completing this unit, you will be able to: • know the theories behind the origin of the earth. • visualize the geological time scale • demonstrate the structure of the earth • learn how the mountains are build • understand different structure developed by water • understand different landform development due to wind action • understand different landform development due to glacier movements 1.2 Introduction Earth processes shape the earth's surface and the sedimentary deposits that record those processes link human timescales to geologic history. The dynamic environments at earth's surface reflect connections between biological, physical and chemical systems. The study of earth processes is based on number of fundamental principles, some of which are unique. The earths topographic features are mixtures of landforms being formed at the present time and others that have been shaped in the past by processes no longer active, it embraces the investigation of both mechanics of modern processes and the historic influence of geologic time. The surface processes responsible for most of the earth's topographic features are: • Weathering • Mass wasting

2 • Running water • Ground water • Glaciers • Waves • Wind • Tectonism • Volcanism Earth's surface is a dynamic interface across which the atmosphere, water, biota, and tectonics Interact to transform rock into landscapes with distinctive features crucial to the function and existence water resources natural hazards, climate, biochemical cycles, and life 1.3 Origin of Earth In the ancient times, the earth occupied a central place in the universe. Even Aristotle, the famous Greek Philosopher proclaimed that the earth was the centre of the universe. Ptolemy declared that the sun, the moon and the stars revolved round the earth. Pythagoras and Philolaus stated that the Earth was not stationary in the universe but rotates around its axis and makes one rotation in 24 hours. The famous thinker Aristarchus is reported to have believed that the Earth revolves around the sun. Galileo & Copernicus had to keep their mouths shut inspite of their intense desire to say the truth. It was an important turning point in the history of thought when on January 17, 1610 Galileo, a prominent mathematician of Padua University invented a telescope and proved in a practical way that the Earth like any other plane was an ordinary one and revolved around the sun. 1.3.1 Solar System: We know that the earth is a member of the solar system. Sun, the principal member of the system is located in the centre and revolving round the sun are the nine planets of which our earth is one. 98.7 % of the matter of the solar system is concentrated in the sun. From the point of view of mass, its weight is 2 X 10 (27) tonnes and is 3,30,000 times that of the earth. Its diameter is 109 times that of the earth. Basic information of the planets is given below – Table 1.1: Basic information of the planets Planets Distance from the Sun in Million km Average Density (gm/cc) Period of Revolution Around the Sun Period of Rotatio n No. of Sub- planets Mercury 58.0 5.10 88 Days 58.64 Days 00

3 Venus 108.0 5.30 225 Days 243 Days 00 Earth 149.6 5.52 365.256 Days 23 Hours 56 Min. 01 Mars 227.9 3.94 687 Days 24 Hrs. 37 Min. 02 Jupiter 777.9 1.34 12 Years 9 Hrs. 50 Min. 16 Saturn 1427 0.70 29.46 Days 10 Hrs. 14 Min. 23 Uranus 2867 1.55 84.01 Days 17 Hrs. 5 Min. 12 Neptune 4504 2.27 164.8 Days 16 Hrs. 6 Min. 2 Pluto 5936 1.50 247.69 Days 6.38 Days 1 These planets can be divided into two groups – Terrestrial or the Inner Planets or Pygmy Planets and the Outer Planets or Jovian Planet or Giant Planet. Subject Terrestrial Planet Jovian Planet Avg. Relative Density 5 1.5 Size Small as compared to Jovian Larger as compared to terrestrial planets Composition Rocks, solid material with All gaseous, mostly hydrogen, helium minor amount of gases with varying amounts of ice like ...etc 1.3.2 Origin of the Earth: Man has been curious about the origin of the earth and the solar system from ancient times and various hypothesis have been put forward time to time on the basis of imagination, speculation as well as observation. None of these, however, can be considered to be wholly satisfactory acceptable. There appears to be, however, unanimity on one point regarding the origin of the solar system and that is that all the planets of the solar system appear to have originated broadly at the same time and in a similar way, as the direction of both their rotation and revolution round the sun are the same. But there are several other questions for which no satisfactory answers are available. Based on the scientific studies and evidences, some conclusions have been arrived at in respect

of the origin of the earth and the solar system

about which there is not much difference of opinion. For instance, it is now generally believed that the stars of our and other galaxies came into existence about 7,000 million years ago and possibly the earth came into existence about

4 4500 to 5000 million years ago. We may divide the scientific views regarding the origin of the earth broadly into two classes: A) Monistic Hypothesis: This hypothesis believed that, solar system and earth originated from a single star or nebula. The chief protagonists of this school of thought are Kant, Laplace, Hoyle, Kuiper etc. B) Dualistic Hypothesis: Solar system and earth have originated as a result of the coming together of two stars. In this school of thought we may include the Planetesimal hypothesis of Chamberlin & Multon, tidal hypothesis of Jeffreys etc. 1.3.2.1 Monistic Hypothesis/ Parental Hypothesis: 1.3.2.1.1 The Gaseous Hypothesis of Kant: Immanuel Kant, the Prussian philosopher, presented his gaseous hypothesis in these treaties entitled "The General Natural History and Theory of the Heavens or the Essay on the Working and Mechanical Origin of the Entire Universe on the Basis of Newtonian Laws" in 17. Obviously, Kant hypothesis was primarily based on Newton's law of gravitation and rotatory motion. Ge assumed that, primordial matter was scatter in the universe. This matter consisted of small, hard and cold particles. These particles were attracted towards one another under the influence of gravitational pull. In due course of time, they began to collide against one another. The friction between these particles

generated heat and the temperature of the primordial matter started rising. The collision also generated

random motion in the primordial matter and angular velocity was produced. Thus, original cold and motionless cloud of primordial matter became a vast hot nebula. It was so vast that it extended from the sun in the centre to as far away as the orbit of the outer most planet. The rise in temperature changed the state of primordial matter from solid to gaseous. The repeated collision of the particles increased random motion and angular velocity to such an extent that the nebula started rotating at a terrific speed and large amount of centrifugal force was generated. When centrifugal force became larger than the gravitational force, a ring was thrown away from the equator of the nebula. This process was repeated nine times and nine rings were formed. The irregularity of the rings caused the development of cores which led to the formation of corresponding planets. Our earth is a planet formed one of the nine rings which got separated from the nebula. By small scale repetition of the same process, the gaseous mass of some of the planets throw away rings which became their satellite. The remaining part of the original gaseous mass is our present sun. Thus, the entire solar system comprising the sun, nine planets and their satellites came into being. Merits:
5 • It was the first theory which is based on fundamental scientific facts such as Newton's law of gravitation and motion. • Kant's hypothesis appears to be simple and sounds more logical. • This theory
provided ground for developing future ideas about the origin of earth.
Demerits: • The basic assumption on which Kant based his hypothesis was
that there was primordial matter in the universe. He has not explained the source of origin of the primordial matter. • According to Kant's view, the collision between the particles of the primordial matter was due to gravitational pull. Scientists have asked whether this force did not exist before the collision and if it existed, what prevented it to act and collision take place. • Kant did not explain how angular momentum was generated in the primordial matter after collision of its particles. 1.3.2.1.2 The Nebular Hypothesis of Laplace: Laplace was a French scientist. He explained the origin of the earth and the solar system in the last year of the eighteenth century. He started that primordial matter in the beginning existed in the form of intensely hot and rotation gaseous mass called Nebula. As the gaseous mass cooled, its volume decreased. Due to decreasing volume, its rotation increased. The mass of the nebula began to shift around the Equator. Due to the increased rotation, centrifugal forces also increased. The matter of the nebula was attracted to the centre of the nebula on account of the force of gravitation. Thus, the two forces (centrifugal and gravitational) were opposed to each other. When the centrifugal force became equal to the force of gravitation, the excess matter around the equator separated from the equator in the shape of a ring and became weightless. With time, as the nebula cooled further, its rotation increased which increased its centrifugal force. When the centrifugal force exceeded the gravitational force, the ring moved away from the nebula and broke into many smaller rings. These rings, on cooling, took the forms of planets and sub-planets. The central part of the nebula which remained the sun. Merits: • It explains the rotation and the revolution of the planets and sub-planets because it assumes a hot and rotating nebula. • The ring separating from the rotating nebula must be rotating and could took the form of a planet.

6 • All the planets of the sun revolve around the sun in almost the same plane. Laplace explained that the planets formed from one ring, must of necessity, revolve in one plane. Demerits: • Laplace paid little attention to the quantitative aspect of the hypothesis. The present mass, the distance and the speed of the members of the solar system are such that it can be proved that the angular momentum of the nebula was so low that a ring could not separate out of the nebula. • Laplace did not explain how the parts of the ring took the form of solid masses. In fact, the ring should disappear by disintegration into tiny particles. • Some of the sub-planets of the Uranus and Saturn revolved in direction to those of other planets. This fact cannot be explained on the basis of the hypothesis. 1.3.2.1.3 The Nova Hypothesis of Hoyle & Lyttleton: F. Holey and Lyttleton have jointly formulated this hypothesis, this is based on bright star called nova as its name indicate. There are several stars in the universe which suddenly increase their brightness by 100 times. The brightness of such star may be several thousand times that of the sun. Such bright stars are called nova. Some of the stars are reported to have brightness one billion times that of our sun, although for a short period Stars with such a high degree of brightness are called supernova. It has been found that the planets of our solar system are made of heavy elements like oxygen, silica, aluminium, iron, calcium etc. These elements account for 98 percent of the planets. Like elements like hydrogen and helium comprise only one percent of the planets. In sharp contrast the stars are formed of lighter mineral like hydrogen and helium. Thus, a major question arises that how planets of heavy material could be formed from stars of light material. To solve this riddle, Hoyle conceived the nova hypothesis. According to this hypothesis, there were two stars i.e., binary stars. One of them was our sun and the other was a much bigger and powerful companion star which became supernova at a later stage. It has been scientifically observed that the energy which is emitted by a star in the form of heat, light, etc. is generated by nuclear fusion. The star generally contains large quantities of hydrogen, the nuclei of which combine with each other to form heavier matter i.e., helium. Consequently, vast amount of energy is released by the stars. A star whose helium is consumed in the process of nuclear reaction and release of energy is called supernova. According to Hoyle 15 to 20 nova are seen every year but a supernova is seen only once in two or three centuries. Because of high temperature, the lighter hydrogen in the star is continuously change into heavier helium; thus, producing tremendous amount of energy. Both the companion star produced far greater amount of energy than the sun. When large amount of energy was emitted by the companion star, i.e., nova, it contracted at a very fast rate which suddenly increased its rotational

7 speed. In due course of time of the contraction and rotational speed of the nova increased tremendously and its hydrogen was almost completely consumed. Thus, it came close to a split and then violently exploded. Due to this violent explosion in the companion star (now supernova), huge mass of dust came out of it. Hoyle believed that the mass of dust thus coming out of the supernova was ejected unevenly, i.e., more towards the sun and less on the opposite side. This matter was attracted by the sun due to its gravitational pull. Consequently, it started revolving around the sun and in due course of time condensed into planet. However, Lyttleton expressed a slightly different view. He believed that after the explosion, the matter of the supernova was thrown equally in all the directions. Under such circumstances, the recoil of the gigantic stellar explosion might drive the nucleus of the companion out of the gravitational reach of the sun, while leaving a residual mass of gas capable of forming a rotating circular disc around the sun from which planetary condensation might form. In this way, the hot and gaseous matter of the disc provided material for the future planets. With the passage of time, part of the matter of the disc was conver4ted into planets. It is worth mentioning here that the intense heat generated at the time of explosion of the supernova resulted in the formation o9f heavy elements like helium, carbon, oxygen, silicon etc. Thus, it is clear that the planets were not made from the light material of the sun but from the heavy material thrown out of the supernova dure to nuclear reaction and violent explosion. Lyttleton further pleaded that some of the planets grew much bigger in size by attracting more material from the disc and their rotation also increased. With the passage of time, those bigger planets divided themselves into two parts. A chain of smaller bodies was created between the two parts due to their gravitational pull. The smaller parts were near the planets and became their satellites. The middle part of the chain was occupied by larger body which became independent planets. Lyttleton believed that Jupiter and Saturn of the present solar system are two broken parts of a bigger planet and Mercury, Venus, Earth and Mars are smaller bodies which were created by division of the bigger planet. Merits: • This hypothesis does explain the material variety of planets. • This hypothesis justifies the angular momentum of the planets of the solar system. • This hypothesis does not deal with imaginary celestial bodies. A large number of supernova can be seen in the universe. One such supernova can be seen in the Carb Nebula. It is about twice as larger as the earth but is thirty thousand times brighter than the sun. Its surface temperature is about five lakh degree Celsius. Demerits: • It fails to explain the peculiar arrangement of planets on the basis of their size. • Formation of planets and satellites is not very clear.

8 • It does not explain the rotation of planets in the same direction and their revolution in the same plane. 1.3.2.2 Dualistic Hypothesis 1.3.2.2.1 Tidal Hypothesis of James & Jeffrey: Sir James Jeans and Prof. Harold Jeffreys, the British scientists put forward a tidal hypothesis in 1919 to meet the objections against Laplacian hypothesis and the shortcomings of tidal theory of Chamberlin and Multon. Jeans and Jeffreys suggested the approach of a passing star which produced the tidal effect. It may be pointed out that Prof. Harold Jeffreys modified this theory in 192 9 in his own way. His modified theory was also full of many shortcomings. It may be pointed out that the passing star was much larger than the sun in size and mass. Under the gravitational pull of the passing star the sun would be deformed into a lobate body in the direction of the former. The passing star raised enormous tides and pulled outward gaseous filament of solar matter as the star approaches nearer and nearer. By the time the star reached the farthest position, the filament had so much enlarged itself that ultimately it was detached from the sun. Figure 1.1: Tidal Hypothesis of James & Jeffery The filament being so massive, it is able to maintain itself without dispersal. Gravity would cause the formation of knots. The passing star gives a rotary motion to the filament It is noteworthy that the filament was considered to be the building material of planets of the solar

9 system. The filament was given a rotary motion by the passing star. As the star passed into space the filament was left behind in the gravitational range of the sun. So, the filament revolves round the sun. As the star recedes, the filament breaks up and the planets condensed out of it. When the star was nearest the sun, its pull was greatest, so the filament would naturally be thickest in the middle. The planets, therefore, would be larger than those at the outer ends of the filament. In this way the solar system came into existence. The planets thus formed retain the angular momentum imparted by the passing star. The planets revolve round the sun in the same plane which contained the sun and the passing star. As regards the origin of satellites, the tidal theory of James Jeans suggests that the planets which were bigger in size would remain in gaseous state for longer time and they took longer time to cool. On the contrary, the planets that were smaller in size took less time to cool and condense. The gravitational pull of the sun was more effective in raising small filaments from the outer surface of the bigger planets due to their gaseous form. Whereas the larger number of satellites were formed from the bigger planets, the smaller planets could produce lesser number of satellites. No satellites were formed from small planets located at the extreme end of the planetary system because they took very little time to come into solid form. By the time the satellites were formed, their parent-planets were cooled to a liquid state. Therefore, it is possible that satellites were formed as liquid masses. According to this theory, the original orbits of the planets were eccentric, not circular, but the intruding star by its tidal effect might have catered solar matter round the sun in addition to raising the filament. The resistance offered by the scattered matter would have reduced eccentricity of the planetary orbits and made them circular. Merits: • This hypothesis does explain arrangement of planets. • According to this theory the bigger planets had more mass and remained in gaseous state for a longer period than their small counterparts. Thus, larger number of satellites were formed from bigger planets while the smaller planets had to content with lesser number of satellites. • This theory presumes that planets were formed from the filament which starting revolving around the sun after getting detached from it by the gravitational force of the approaching star. Consequently, the planets should also revolve around the sun. All the present planets are revolving around the sun in the direction of motion of the ejected filament. Also, the orbital plane of majority of the planets is the same. Leaving a few exceptions, majority of the planets are rotating in the same direction. Demerits: • Because of the vastness of the distances among stars in the universe, the fact of encounter of a star with the sun is a remote possibility

10 • Raising a filament of matter by a passing star may be possible, but the imparting of revolutionary motion to the filament or its constituents is improbable. • The question of angular momentum, i.e., the great distance of the outer planets from the sun is difficult to explain. 1.3.2.2.2 Planetesimal Hypothesis of Chamberlin and Multon: Chamberlin & Multon

considered that a wandering star approached the sun, and a cigar- shaped extension of material was separated from the solar surface.

As the passing star moved away, the material separated from the solar surface continued to revolve around the sun and slowly condensed into planets.

Obviously, according to this hypothesis the origin of planets is supposed to be due to severe tidal eruption and disruption of some of the sun's mass. An approaching star caused the tidal eruption by its gravitational power. The disrupted solar matter was thrown to long distance from the sun. The larger nuclei of the tidal ejection gathered together. These larger bodies gathered smaller scattered bodies or planetesimal and eventually grew into the mature planets of the solar system. Planetesimal are the tiny planets which coalesced owing to gravitational attraction of collision. According to this hypothesis "the total mass of the planets is only a smaller fraction (1/700) of the mass of the whole solar system, but they carry nearly 98 % of its energy revolution" (Wooldridge & Morgan). Merits: The main merits of the hypothesis when it was presented were as follows – • The earth grew bit by bit by accretion of planetesimal matter. • When the mass of the earth became condensed and compacted, it developed internal heat. This created pocket of melting. Subsequently, there was differentiation of a metallic core and a stony outer crust. • The constituents of the atmosphere and ocean also originated from the planetesimal. Demerits: • This hypothesis does not explain the number of planets in the solar system. • Due to the collision of planetesimals, the orbit of the planets should not be near-circular as it is at Present. • The hypothesis has been built on a catastrophic and extraordinary event. It is unreasonable to base any concrete scientific hypothesis on such a event.
11 1.3.2.2.3 The Binary Star Hypothesis by H. N. Russell: The principal weakness of the hypothesis that we have considered so far, is that they are unable to provide a satisfactory explanation for the great distance of the planets from the sun and their circular orbits round the sun. This difficulty can be removed if it is assumed that the materials which formed the planets were far removed from the sun from the very beginning or in other words, if it is assumed that the planets have not been from the sun. Accordingly, H.N.Russell suggested that there was another companion star of the sun and the two together formed a binary star or a twin-star system. A third star happened to pass close to the companion star of the sun and this resulted in the ejection of gaseous matter from the latter in t5he form of a filament which ultimately separated from it. The planets were formed from this gaseous filament of matter in course of time. In the beginning the planets were closer together and the satellites owe their birth to the mutual gravitational attraction between them. This third star was too far away from the sun to have any impact on the latter. Merits: • The suggestion that the primitive sun was a binary star can not be dismissed as mere imagination, because at least 10 % of the stars in the universe are binary stars. In fact, in the opinion of some scholars the number of binary stars is probably 30 % of the total. • This hypothesis helps us to explain the great distance of the planets from the sun as well as their high angular momentum. Demerits: • The greatest weakness of the hypothesis is its inability to account for the removal of the sun's companion from its control and for the retention of the tidal filament which is later supposed to condense into planets and revolve round the sun. R.A. Lyttlenton (1936) has supported this hypothesis and has tried to show by mathematical calculations that is the possible under certain circumstances. If it is assumed that (a) the mass of the sun, the companion star as well as the third star was roughly equal (b) the distance of the companion star from the sun was 1700 million miles (c) the speed of revolution of the companion star round the sun was 6 miles per second and the speed of the third was at least 20 miles per second, and (d) the third star had come within a distance of approximately 3 to 4 million miles of the companion star. Under the above stated conditions, it is possible that tidal filaments will be ejected both from the companion star and the third star, the elliptic orbit of thew companion star will change into hyperbole orbit and it will escape from the gravitational control of the sun. • Another objection raised against this hypothesis, is its failure to account for the present position of the planets, that is, their distance from the sun and their orbit, if it is assumed

12 that the planets were formed at roughly equal distance from the sun as the hypothesis apparently seems to suggest.
1.4 Geological Time Scale A critical analysis of the methods of finding out the age of the earth clearly shows that there is general disagreement among scientists on this subject. However. majority of the modern scientists are of the opinion that the age of the earth may vary from 3 to 5 billion years. Besides the scientific community believes that the earth has passed through certain geological processes marking a well- established geological time scale. The earth was a hot gaseous mass and remained so in the first billion years of its history. Since then, it has been cooling. In the process, it acquired liquid state and later on its outer surface solidified. Conditions suitable for earliest life forms to survive on the earth were created about 3,100 million years ago. However, man appeared on the earth at a much later stage. So, he knows very small part of the earth's geological history from direct observation. The rest is derived from the study of fossils. The main purpose of studying the geological history of the earth is to establish the succession of geological events and to work out a 'geological time scale'. •The geological time scale refers to the chronological programming of various geological forms and forms of life in the past according to their time and place of origin, evolution and extinct. In other words, this deals with the distribution of rock formations and animals since the beginning of life on the earth." The first geological time scale was developed by Giovanni Arduina, an Italian scientist. in 1760 During the second half of the 19th century, steps were taken to unify the geochronological and stratigraphic subdivisions. For that purpose, the Geological Time Scale common for the whole world was adopted in 1881 at the second session of the International Geological Congress in Bologna. The scale has been modified and improved several times since then. On the geological scale, the longest time span is called an era which is divided into periods. The period in its turn is divided into epochs. This division is like years. months and days in a calendar. The earth's crust consists of five major rock strata, each subdivided into minor strata, one lying on the top of the other. These sheets of rock were formed by the accumulation of mud or sand at the bottom of oceans. seas and lakes, and each contains certain characteristic fossils that serve to be identified as deposits made at the same time in different parts of the world. Based on the evidences of geological conditions and life in the past, the total span of geological time is generally divided into five eras. The geological time scale is customarily presented in the form of a table.
13 Table 1.2: Geological Time Scale Era Period Epoch Time from beginning to recent (Millions of years) Geological Conditions Variety of biota (life) Cenozoic (Age of mammals) Quater nary Holocene (Recent) 0.025 End of last ice age. Climate became warmer with distinct climatic zones Modern man appeared in the beginning of this period. Herbs dominant. Modern genera and species of animals and plants. Pleistocen e 1.0 Four ice ages of the great ice age. Periodic continental glaciers. Cold and mild climate Development of modern vegetal and animal world. Expansion of herbs and decline of woody plants. Age of man, prehistoric man. Flourishing of mammals birds, fishes and insects but extinction of many large mammals. Cenozoic (Age of mammals) Tertiary Pliocene 12 Dry and cool climate, volcanic activity, rise of mountains in North America Expansion of herbs and grasslands, decline of forests. Mammal abundant. Emergence of man. Elephants, horses and camels almost similar to modern forms. Miocene 28 Moderate climate. Plains and grasslands developed Forests declined but grasslands spread. Evolution of mammals at its climax. Development of anthropoid apes (First man like apes).
14 Oligocene 39 Warmer climate. low lying lands and mountain building Abundance of tropical forests. Flowering plants and monocotyledons common. Extensive flourishing of primitive mammals but extinction of archaic mammals. First apes and monkeys appeared. Eocene 58 Climatic belts well established Angiosperms and placental mammals diversified. Establishment of hoofed and carnivorous mammals. Paleocene 75 Formation of climatic belts. Mountain building activity Modernization of angiosperms. Archaic mammals dominant. Rise of modern birds, placental mammals and first primates. Mesozoic (Age of reptiles, era of medieval life) Cretaceo us Late Cretaceou s Early Cretaceou s 189 Diverse climate. Formation of mountains and swamps Rise of monocotyledons and decline of gymnosperms. Deciduous trees abundant. Extinction of dinosaurs and toothed birds. First teleost fishes and modern birds. Archaic mammals common.
15 Jurassic Late Middle } Jurassic Early 195 Warm climate Continents fairly high. Shallow seas Extensive development of ammonites and belemnites. First angiosperms appeared. Cycads and conifers common. Flourishing of reptiles on land, in air and water. Dinosaurs dominant. Rise of first toothed birds. Insects abundant. Triassic Late Middle } Triassic Early 230 Global tropical and subtropical climate. Continents elevated. Wide spread deserts Extinction of seed forms and primitive amphibians. Decline of gymnosperms. Rise of first dinosaurs and egg laying mammals. Paleozoic (Era of Ancient Life) Permian Late Permian Early Pem1ian 280 Rise of continents. Arid climate, Glaciation in southern hemisphere Decline of primitive plants. Trilobites extinct. Reptiles abundant. Decline of amphibians. Therapsids appeared. Carboni- ferous Upper Carbonife rous Lower Carbonife rous 320 345 Uniform climate- first humid and later cooler. Expansion of tropical seas Luxuriant forest growth. First reptiles. Appearance of winged insects. Foramini ferous spiny brachiopods and cronoid abundant. Ancient sharks and amphibians present. Few corals and trilobites.

16 Devonia n Late Middle } Devonian Early 405 Warm and semi- arid climate. Rise in temperature of inland seas. Mountains appeared First forests grew. First amphibians. Flourishing of armed fishes. Crinoids, corals, brachiopods abundant. First ammonites. Decline of trilobites. Silurian Late } Silurian Early 425 Mild cool climate. Rise of lands. Flat continents. Extensive continental seas First land plants (cratimosses) algae dominant. Origin of insects. Origin of jawed fishes. Abundance of coraly, brachiopods and crinoid millipeds present. Decline of trilobites. Ordovici an Late Middle } Ordovicia n Early 500 Climate warmer. Expansion of Oceans Algae, fungi, bacteria present. First plant fossils available. Origin of jawless armoured fishes (first, vertebrates) crinoids, nautiloid cephalopods, ostracods, grapolites, brachiopods, molluscs and trilobites abundant. Cambria n Late Middle} Cambrian Early 600 Warm mild climate. Low lands submerged Dominance of trilob1tei among established invertebrate groups. Also, brachiopods. calcareous sponges corals, diversified mollusks present. Marine algae abundant.

17 Proterozoic (Era of early life) 2000 Great volcanic eruptions. Extensive erosion. Repeated glaciations, cool climate Primitive aquatic plants (algae, fungi, bacteria), calcareous deposits by algae. Graphite deposits. Origin of simple marine invertebrates (worm burrows). Archeozoic (Dawn of life) 3600 Great volcanic activity. Some sedimentary deposition, extensive erosion Indirect evidence of beginning of life. No recognizable fossils. Calcareous deposits by algae some 2600 million years old. Graphite deposits. [Source: Physical Geography, D. R. Khullar] 1.5 Internal Structure of the Earth Though the study of constitution of the interior of the earth is outside the domain of geography but its elementary knowledge is necessary for the geographers because the nature and configuration of the reliefs of the earth's surface largely depend on the nature, mechanism and magnitude of the endogenetic forces which originate from within the earth. It is decidedly true that it is very difficult task to have accurate knowledge of the constitution of the earth's interior because it is beyond the range of direct observation by man but recently seismology has helped to have some authenticated knowledge about the mystery of the earth's interior. The sources which provide knowledge about the interior of the earth may be classified into 3 groups. 1 . Artificial source 2 . Evidences from the theories of the origin of the earth 3 . Natural sources 1.5.1 Artificial Sources: 1.5.1.1 Density: Numerous incurrences can be drawn about the constitution of the interior of the earth on the basis of density of rocks, pressure of super incumbent load (weight of overlying rocks) and increasing trend of temperature with increasing depth inside the earth. It is commonly believed that the outer thinner part of the earth is composed of sedimentary rocks the thickness of which ranges between half a mile to one mile (0.8 km to 1.6 km). Just below this sedimentary layer there is the second layer of crystalline rocks, the density of which ranges between 3.0 and 3.5 at different places. The average density of the whole earth is about 5.5. Thus, it appears

18 that the density of the core of the earth will be, without doubt, more than 5.5. Generally, the density of the core of the earth is around 11.0. Cavendish attempted to calculate the average density of the earth in 1798 on the basis of the Newton's gravitational law. According to him the average density of the earth is 5.48. Poynting calculated the average density of the earth as 5.49 g cm -3 in the year 1878. Since 1950 several attempts are being made to calculate the density of the earth on the basis of satellites. The satellite studies have revealed the following results about the density of the various parts of the earth-average density of the earth =5.517 g cm -3 , average density of the earth's surface = 2.6 to 3.3 g cm -3 and average density of the core = 11 g cm -3 . Thus, it is proved that (l) the density of the core of the earth is highest of all parts of the earth. 1.5.1.2 Pressure: Now question arises, what is the reason for very high density of the core? previously it was believed that very high density of the core was because of heavy pressure of overlaying rocks. It is common principle that pressure increases the density of rocks. Since the weight and pressure of rocks increase with increasing depth and hence the density of rocks also increases with increasing depth. Thus, it is proved that (2) very high density of the core of the earth is due to very high pressure prevailing there because of super incumbent load. This inference is proved wrong on the ground that there is a critical limit in each rock beyond which the density of that rock cannot be increased in spite of increasing pressure therein. It may be, thus, forwarded that (3) very high density of the core of the earth is not because of very high pressure prevailing there. If the high density of the core of the earth is not because of high pressure of overlying rocks then (4) the core must be composed of intrinsically heavy metallic materials of high density. The experiments have revealed that the core of the earth is made of the mixture of iron and nickel. This inference is also validated on the basis of geocentric magnetic field. The metallic core is surrounded by a zone of such rock materials, the upper part of which is composed of crystalline rocks. 1.5.1.3 Temperature: It is evident on the basis of information available from the findings of bore holes and deep mining that temperature increases from the surface of the earth downward at the rate of 2 0 to 3 0 C for 100 metres. It may be pointed out that it becomes very difficult to find out the rate of increase of temperature beyond the depth of 8 km. The rate of increase of temperature in the continental crust has been calculated based on geothermal graphs and the following generalization has been made. In the tectonically active areas (like the Basin and Range Province of the USA) temperature remains 1000 0 C at the depth of 43 km from the surface of the earth while the temperature remains only 500 0 C at the depth of 40 km from the surface in tectonically stable areas. This information provides significant knowledge about the nature and behaviour of the continental crust. It is evident that high temperature of 1000 0 C at the depth of 43 km in the tectonically active areas is nearer to the initial melting point of the rocks of lower crust and mantle mainly basalt and peridotite.

19 The temperature of the upper part of the magma slab representing the upper portion of the Oceanic crust has been estimated to be 0 0 C whereas the temperature of the lower part of the magma slab which comes in contact with the asthenosphere remains 1200 0 C which is quite nearer to the melting point. If we believe the rate of general increase of temperature with increasing depth the temperature should be around 25,000 0 C at the depth of 2,900 km but under such circumstances most part of the earth would have melted but this has not so happened. It is evident from this discussion that most parts of the radioactive minerals are concentrated in the uppermost layer of the earth. This fact explains the situation of high temperature in the continental crust as described above because disintegration and decay of radioactive minerals generate more heat in the crustal areas. It, thus, appears that the rate of increase of temperature downwards decreases with increasing depth. The following facts may be presented about the thermal condition of the interior of the earth. i. The asthenosphere is partially molten. The temperature is around 1100 0 C at the depth of 100 km which is nearer to initial melting point. ii. The temperature at the depths of 400 km and 700 km (from the earth's surface) has been estimated to be 1,500 0 C and 1,900 0 C respectively. iii. The temperature at the junction of mantle and outer molten core standing at the depth of 2,900 km is about 3700 0 C. iv. The temperature at the junction of outer molten core and inner solid core standing at the depth of 5,100 km is 4,300 0 C. 1.5.2 Evidences from the Theories of the Origin of the Earth Various exponents of different hypotheses and theories of the origin of the earth have assumed the original form of the earth to be solid or liquid or gaseous. According to the 'planetesimal hypothesis' the earth was originated due to accretion and aggregation of solid dust particles known as planetesimals'. Based on this corollary the core of the earth should be in solid state. According to the 'tidal hypothesis' the core of the earth should be in liquid state because the earth has been taken to have been formed, according to this hypothesis, from the tidal materials ejected from the primitive sun. According to the 'nebular hypothesis' of Laplace the core of the earth should be in gaseous state. Zoeppritz and Ritter have opined that the core of the earth is made of gases but this concept may not be accepted because if we assume the core of the earth in gaseous state many more problems will emerge. There may be only two possibilities viz. either the core may be in solid state or liquid state. This problem would be dealt with while dealing with the evidences of seismology.

20 1.5.3 Natural Sources: 1.5.3.1 Vulcanicity: Some scientists believe on the basis of upwelling and spread of hot and liquid lava on the earth's surface during volcanic eruption that there is at least such a layer below the earth's surface which is in liquid state. Such molten layer has been termed as 'magma chamber' which supplies magma and lava during volcanic eruptions. It may be, thus, surmised, on the basis of above connotation, that some part of the earth should be in liquid state but this inference is refuted if one considers the increasing pressure with increasing depth inside the earth. It is known to all that increasing pressure increases the melting point of the rocks. Thus, the inner part of the earth may not be in molten state in spite of very high temperature prevailing therein because the enormous weight and pressure of the overlying materials (super incumbent load) increases the melting point of the rocks. It, thus, appears that the core of the earth should be in solid state. Now question arises, where hot and liquid lavas come from during volcanic eruption? It may be pointed out that when the pressure of super incumbent load is released due to fracturing and faulting in the crustal surface, the melting point of underlying rocks is reduced (lowered) and thus the rocks are instantaneously melted because required degree of high temperature is already present there. It, thus, appears that no authenticated knowledge about the composition of the earth's interior is obtained from the evidences of volcanic activities. 1.5.3.2 Evidence of Seismology:

Seismology is the science which studies various aspects of seismic waves generated during the occurrence of earthquakes. Seismic waves are recorded with the help of an instrument known as seismograph.

It may be pointed out that seismology is the only source which provides us authenticated information about the composition of the earth's interior.

The place of the occurrence of an earthquake is called 'focus' and the place which experiences the seismic event first is called 'epicentre', which is located on the earth's surface and is always perpendicular to the 'focus'. On the other hand, the focus or the place of the origin of an earthquake is always inside the earth. The
deepest focus has been measured at the depth of 700 km from the earth's surface.

The different types of tremors and waves generated during the occurrence of an earthquake are called 'seismic waves' which are generally divided in 3 broad categories e.g., primary waves, secondary waves and surface waves. (i) Primary waves—also called as longitudinal or compressional waves or simply 'P' waves, are analogous to sound waves wherein particles move both to and fro from the line of the propagation of the ray. P waves travel with fastest speed through solid materials. Though
these
also pass-through liquid materials but their speed is slowed down. (
ii) Secondary waves—are also called as transverse or distortional
or simply S waves. These are analogous to water ripples or light waves wherein the particles move at right angles to the rays. S waves cannot pass through liquid materials.

21 (

iii) Surface waves—are also called as long period waves or simply L waves. These waves generally affect only the surface of the earth and die out at smaller depth. These waves cover longest distances of all the seismic waves. Though their speed is slower than P and S waves but these are most violent and destructive.

When an earthquake occurs the seismic waves are recorded at the epicentre with the help of seismograph. In the beginning a few small and weak swings are recorded. Such tremors are called 'preliminary tremors'. After a brief interval the 'second preliminary tremors' are recorded and finally the 'main tremors' or strong waves are recorded. Figure 1.2: Seismic waves 1.5.3.3 Recent Views: The aforesaid views about the composition and structure of the earth 's interior have now become obsolete. The scientific study and analysis of various aspects of seismic waves (mainly velocity and travel paths) of natural and man-induced earthquakes have enabled the scientists to unravel the mystery of the earth's interior based on authentic information. Three zones of varying properties have been identified in the earth on the basis or changes in the velocity of seismic waves while passing through the the earth (fig 5.4) e.g. crust, mantle and core. It may be pointed out that there is still difference of pinions about the thickness of these zones, mainly about the thickness of the crust. Various sources put the thickness of the crust between 30 km and 100 km. On the basis of the change in the velocity of seismic waves crust is further divided into (i) upper crust and (ii) lower crust because the velocity of P waves suddenly increases in the lower crust. For example, the average velocity of P waves in the upper crust is 6.1 km per second while it becomes 6.9 km per second in the lower crust. Fig. 5.4 depicts the different velocity of P and S waves in different parts of the earth and the relationship between velocities of seismic waves and different zones of the earth.

22 Figure 1.3: Presentation of velocities of seismic waves from the crust of the earth to its interior and rela1ionsihps between the velocities of seismic waves and different zones of the earth (after K. E. Bullen). (1) CRUST The average density of the outer and lower crust is 2.8 and 3.0 respectively. It may be pointed out that in the beginning vast difference between structure and composition of the upper and lower crust was reported by the scientists but now the evidences of seismology have revealed almost identical structure and composition of these two subzones of the crust. The difference of density between the upper (2.8) and lower crust (3.0) is because of the pressure of supper incumbent load. The formation of the minerals of the upper crust was accomplished at relatively lower pressure than the minerals of the lower crust.

23 Figure 1.4: Internal structure of the earth (2) MANTLE

24 There is sudden increase in the velocity of seismic waves at the base of lower crust as the velocity of seismic waves is about 6.9 km per second at the base of lower crust but it suddenly becomes 7.9 to 8.1 km per second. This trend of seismic waves denotes discontinuity between the boundaries of lower crust and upper mantle. This discontinuity was discovered by A. Mohorovicic in the year 1909 and thus it is called as 'Mohorovicic discontinuity' or simply 'Moho discontinuity'. The mantle having mean density of 4.6 g cm- 3 extends for a depth of 2900 km inside the earth. It may be mentioned that the thickness of the mantle is less than half of the radius of the earth (6371 km) but it contains 83 per cent of the total volume and 68 per cent of the total mass of the earth. Previously the mantle was divided into two zones on the basis of changes in the velocities of seismic waves and density e.g. (i) upper mantle from Moho discontinuity to the depth of 1000 km and (ii) lower mantle from 1000 km to 2900 km depth but now the mantle is divided on the basis of the information received from the discovery of the International Union of Geodesy and Geophysics into 3 sub- zones e.g. (i) first zone extending from Moho discontinuity to 200 km depth, (ii) second zone extending from 200 km to 700 km depth and (iii) third zone extending from 700 km to 2900 km depth. The velocity of seismic waves relatively slows down in the uppermost zone of the upper mantle for a depth of 100 to 200 km (7.8 km per second). This zone is called the zone of low velocity. Mantle is believed to have been formed largely of silicate minerals rich in iron and magnesium. e.g. (i) first zone extending from Moho discontinuity to 200 km depth, (ii) second zone extending from 200 km to 700 km depth and (iii) third zone extending from 700 km to 2900 km depth. The velocity of seismic waves relatively slows down in the uppermost zone of the upper mantle for a depth of 100 to 200 km (7.8 km per second). This zone is called the zone of low velocity. Mantle is believed to have been formed largely of silicate minerals rich in iron and magnesium. (3) CORE The core, the deepest and most inaccessible zone of the earth, extends from the lower boundary of the mantle at the depth of 2900 km to the centre of the earth (up to 6371 km). The mantle-core boundary is determined by the 'Weichert-Gutenberg Discontinuity' at the depth of 2900 km. It is significant to note that there is pronounced change of density form 5.5 g cm- 3 to 10.0 g cm- 3 along the Gutenberg Discontinuity. This sudden change in density is indicated by sudden increase in the velocity of P waves (13.6 km per second) along the mantle-core boundary or Gutenberg Discontinuity. The density further increases from 12.3 to 13.3 and 13.6 with increasing depth of the core. It, thus, appears that the density of the core is more than twice the density of the mantle but the volume and mass of the core are 16 per cent and 32 per cent of the total volume and mass of the earth respectively.

25 The core is further divided into two sub-zones e.g., outer core and inner core, the dividing line being at the depth of 5150 km. S waves disappear in this outer core. This means that the outer core should be in molten state. The inner core extends from the depth of 5150 km to the centre of the earth (6371 km). This lowermost zone of the interior or the earth is in solid state, the density of which is 13.3 to P waves travel through this zone with the speed of 11.23 km per second. It is generally believed that the core is composed of iron and nickel but according to the second view point the core may be formed of silicates. It is also believed that after disintegration on high pressure the electronic structures have changed into heavy metallic materials, thus the density of the core has increased. According to the third view point initially the core was composed of hydrogen but later on hydrogen was transformed into metallic materials due to excessive pressure (over 3 million atmosphere). This possibility is questioned on the ground that though the transformation of silicate or hydrogen due to very high pressure in the core may be believed tentatively but this process cannot increase the density of the core as high as it is at present. For example, the planet Mercury is smallest of all the planets of our solar system but its density is highest of all the planets. It may be argued that least compression and pressure cannot generate highest density in the core of Mercury. Most of the present-day geophysicists and geochemists believe that the core is made of metallic materials mainly iron and nickel. 1.6 Continental Drift Continental Drift is the gradual movement of the continents across the Earth's surface through geological time. This concept is based on a premise that all the continents were once joined together as a single huge continental landmass which has rifted and drifted apart over the Earth's surface. The movement was considered as the primary factor in explanation of climatic changes, formation of landforms such as mountains, islands, volcanoes etc. The concept of continents 'drift' was first proposed by Abraham Ortelivs in 1596. Then FB Taylor postulated his concept of "Horizontal displacement of Continents" in the year 1908. But the Continental Drift Theory was mainly developed by Alfred Wegner in 1912, it was based on the works of a host of scientists such as geologists, geophysicists and others. 1.6.1 Continental Drift Theory of Alfred Wegner:
Alfred Wegner, a German climatologist, propounded the Continental Drift Theory in 1912. It came into light in 1922 in a book titled, "Die Entstehung der Kontinnente and Ozeane"
which was translated to English in 1924 named as "The Origin of Continents and Oceans". Wegner, being a climatologist, needed to explain the climatic changes that occurred throughout the past history of Earth. He explained the climatic changes, occurring on the surface of the Earth, in two ways-
26 • Continents remained stationary and
climatic zones shifted from one region to another. • Climatic zones remained stationery
and continents displaced. Assumptions • Continents mass was made up of SiAl and Oceanic crust was made up of SiMa. • Continents mass floated over oceanic crust with minimum resistance between them. • There was a huge united landmass named Pangea in Carboniferous period and it was surrounding by a water body called Panthalassa. Forces and Processes • According to Wegner, the main forces responsible for the movement of continental landmasses were Buoyancy force, Differential gravitational force and Tidal force. • The continental landmasses, floating over the oceanic crust moved in two directions towards the Equator and Westwards. • Equator ward movement was under Buoyancy and Differential gravitational force. The westward movement was under Tidal force. • Pangea landmass was broken attitudinally into two parts namely northern part was Angaraland and southern part was Gondowanaland respectively. The intervening space between two landmasses came to be known as 'Tethys Sea'. • Gondowanaland, during Cretaceous period, split into Indian Peninsula, Madagascar, Australia, Antarctica, Africa and South America. • Angaraland split into two continents. Namely North America and Eurasia. • The 'S'-shape of Atlantic is due to differential movement of North and South America. Indian Ocean was formed due to Northward movement of Indian peninsula. Remaining portion of Tethys became Mediterranean Sea. Arctic was formed due to movement of continental blocks towards North Pole.
27 Figure 1.5: Different stages of landmass and water distribution of the world 1.6.2 Evidence in Support of the Continental Drift Theory: Wegner cited various evidences to show that the continents could have been close together in the past as Pangea. The evidences are- i. Juxta fix
of Continents: The shorelines of Africa and South America facing each other have a remarkable and unmistakable match. Thus, there is a geographical similarity between the two continents. They could fit like pieces of a puzzle. ii. Structural and Stratigraphic Evidences:
The radiometric dating methods developed in the recent period have facilitated correlating the rock formation from different continents across the vast ocean.
In north-western Africa and Eastern Brazil both 550 million years old rocks lie adjacent to rocks dated more than 2 billion years. iii. Fossil Evidences:
Mesosaurus was an aquatic
reptile adapted to shallow brackish water. The skeletons of these are found only in
localities- the southern cape province of South Africa and Iraver formation of Brazil.
iv. The

fossil fern, glossopteris, is widely distributed in Africa, Australia, India, South America etc. country. v. Paleoclimatic Evidences: layers of glacial deposits i.e., tillites, striations and grooved marks are found in tropical regions of South America, South Africa Australia and India. vi.
Tillite: It is the sedimentary rock formed out of deposits of glaciers.
Counterparts of this succession are found Africa, Falkland Island, Madagascar, Antarctica.
It proves paleoclimates
and
drifting of continents. vii. Placer Deposits: Occurrences of rich placer deposits of gold in Ghana coast and the absolute absence of source rock in the region.
Also, presence of
gold bearing veins in
28 Brazil show that obviously gold deposits of Ghana are derived from Brazilian plateau when
they were together. viii.
Geological Similarity: The Appalachians of North America are similar to mountain systems of Ireland, Wales and North-Western Europe. 1.6.3
Limitations of Continental Drift Theory of Wegner Although Alfred Wegner spoke of the first the continental drift in 1912, which was translated in English in 1924 and since, then there has been a storm of controversy in the expert communities. Contemporary geologist such as Washington, Willis, Jeffreys have not accepted this theory. They criticized this theory in many ways. i. The forces, Differential gravitational force, Buoyancy force and Tidal force were not sufficient enough to drift the continents to thousands of km. If these forces were so enormous in their magnitude and all the continents would be concentrated near Equator. ii. Wegner's theory has several contradictions. In the earliar part he states that SiAl is floating over SiMa with very less resistance. But later, distributing the formation of mountains, he describes the friction between SiAl and SiMa as the cause of formation of mountains. iii. Wegner did not describe the situation in pre-carboniferous times. Many questions still remain unanswered such as – Why the Pangea was intact in pre-carboniferous period? Why did the continental drift not start earlier? Etc iv. Wegner did not describe the correct sequence and chronology of displacement of continents. It may be concluded that even if all the matter of his theory is wrong, geologists and others can but remember that it is largely to him that we owe our more recent views on world tectonics.
Though most point
of Wegner's theory was rejected but its central theme of horizontal displacement
was retained. In fact, the postulation of Plate Tectonic Theory after 1960 is the result of this Continental Drift Theory of Wegner. Wegner is thus, given to credit to have started thinking in this precarious field. 1.7 Mountain Building Orogeny is the geological term for Mountain Building.
The term was coined by the American geologist GK Gilbert in 1890, to describe the process of Mountain Building. Gilbert originally coined the term for the fold mountain belts of Rockies and Alps. The term cannot be applied to
29 ocean ridges and rises which are submerged under seas. i.e., submerged mountains, which originate through processes quite distinct from those rich produced mountain chains such as the Rockies and the Alps. 1.7.1 Types of Mountains: • Fold Mountains: They form as a result of compressive action on thickly bedded sedimentary layer. All the great mountains on the Earth such as Himalayas, Alps, Rockies and Andes are of this type. • Volcanic Mountains: They are formed as a result of constant accumulation of volcanic material, lava and pyroclasts around a volcanic vent until a height is reached. Mountain Vesuvius, Mountain Etna, Mountain Fujiyama etc are of this type of Mountain. • Block Mountains: They are tabular shaped mountains with flat tops that result from vertical upliftment of blocks along faults or are left elevated by the sinking of the surrounding areas. The various examples are Vosges, Black Forest etc. • Relict or Residual Mountains: they are the remnants of former old mountains and plateaus which have been subjected to severe denudation, thus exposing the base of mountains. The Aravallis form a very good example of such types of mountains. 1.7.2 Mountain Building with reference to Plate Tectonics The rigid lithospheric slabs or rigid and solid land masses having a thickness of about 100 km composed of Earth's crust and some portions of upper mantle are technically called 'Plates'.
The term 'plate' was first used by Canadian geologist J. T. Wilson in 1965.
The
whole mechanism of the
evolution, nature and motion and resultant reactions of plates is called "Plate Tectonics".

According to plate tectonic theory mountains are found due to collision of two convergent plates. Mountains are always formed along destructive plate boundaries. It is obvious that the process of mountain building is associated with destructive plate boundaries of two convergent plates. The convergence and consequent collision of plate boundaries occurs different mountains. These collisions are 1.7.2.1 Continent- Ocean Collision: The collision of continental and oceanic convergent plates results in the formation of Cordillera type of folded mountain. The major events in the evolution of mountain belt by continent-ocean collision are— 1 . A considerable thickness of sandstone, shale and lime stone accumulates in the miogeocline along the continental margins. At the same time, deep marine sediments accumulate in the deep ocean basin.

30 2 . As the plate converge, the buoyant granitic mass of the continental crust being of lower density, overrides the adjacent oceanic plate 3 . As the convergence proceeds, the deep marine sediments on the oceanic plate are crumpled and deformed 4 . Then, the thick sequence of geoclinal sediments along the continental margins are compressed and deformed. Explanation with Example: The Rockies and Andes mountains were formed due to subduction of the Pacific Ocean plate under the American continental plate. The pacific oceanic plate heavier due to denser materials is subducted below the light denser American continental plate. The sediment deposited on the American continental margins are squeezed and folded due to compressive forces and formed Rockies and Andes Mountains. Continent-Ocean collision and mountain Formation The Appalachian Mountain of the Eastern United States was deformed during late Paleozoic is this type of mountain building. 1.7.2.2 Continent-Continent Collision: The continent-continent occurs, when two continental plates collide. The major events in the generation of mountain belts by continent-continent collision are i. Geoclinal sediments occur along the margins of each continent. ii. The wedge of sediments along the margins of the continent are deformed above the subduction zone as the ocean basin decreases in size. iii. As the continents approach each other before colliding, segments of remaining ocean crust are deformed by over thrusting and are finally squeezed between the converging plates. iv. The oceanic slab descending into the mantle, becomes detached and sinks independently. When the slab has been consumed, the volcanic activities and earthquakes generated by it. v. As resisting forces build up, convergence stops, the mountain belt erodes and adjusts isostatically. vi. The welding together of two large continents produces a single large continental mass with internal mountain range.

31 Figure 1.6: Continent- Continent collision and formation of Mountains Explanation with Example: The geosynclines sediments of Tethys Sea were squeezed and folded into Alpine-Himalayan Mountain chains due to lateral compressive forces caused by the convergence and collision of Eurasia and African-Indian continental plates during Cenozoic era. It may be pointed out that the formation of Alpine-Himalayan Mountain chains could be possible due to continued collision of continental plates and consequent orogenesis along several subduction zones for long period of time. The other examples of this type of mountain buildings are the Alps, the Urals, the Atlas Mountain etc. 1.8 Landform Development due to Water The running of water is involved in continuous erosion transportation and deposition of materials on the surface of the Earth. The landforms formed by progressive removal of rock mass are known as erosional landforms while landforms formed by deposition of different eroded materials are known as depositional landforms. 1.8.1 River

Erosion The erosional works of rivers depend upon the channel gradient, volume of water, velocity

of flow, kinetic energy of river. The erosion also dependent upon the size of erosional tools known as river load. River is mainly involved in three types of erosion- i) Vertical erosion, ii) Lateral erosion and iii) Headward erosion. Erosional landforms: These are the erosional landforms of rivers---

32 i. V-Shaped Valley:

Valleys start as small and narrow rills, the rills will gradually develop into long and wide gullies, the gullies will further deepen, widen and lengthen to give rise to valleys. Depending upon dimensions and shape, many types of valleys like V-shaped, gorge, canyon etc can be recognized.

ii. Gorge:

It has a steep precipitous wall within which a narrow river is confined. It can occur due to channel deepening as a result of recession of fall that has happened with Niagara gorge. Each continent has example of gorges. The Indus, Sutlej, Brahmaputra and Arun form gorges in the Himalayan region where they are antecedent streams. iii. Canyon: The narrowness of the valley is determined by both vertical erosion and humidity of the area. The Grant Canyon, Colorado is very deep but its wall is not vertical because it passed through an arid zone where frost weathering and other forms have tended to form the V shape. iv. Waterfall: When especially small rivers tumble down almost vertically from a height along its course, these form the waterfalls. A bar of resistant rock lying across a river valley leads to the formation of a waterfall, as in the case of Niagara Falls on Zambezi rivers in South Africa or a plunge down the edge of a plateau like Zaire of Africa. v. Hanging valley: In glaciated areas at points where tributary stream joins the main stream, the over- deepening of the main valley leaves the side valley hanging high above the valley of the master stream. vi. Potholes: Over the rocky beds of hill streams, more of

less

circular depressions called

potholes form because of stream erosion aided by the abrasion of rock fragments.

vii. Rapids: The occurrence of the band of a hard rock along the path of a river makes it jump over or rail downwards. This leads to the formation of rapids at place where the valley bottom offers greater resistance to the erosion than the strips above and below it. viii. Plunge pools:

At the foot of waterfalls, large potholes, quite deep and wide, forms because of the sheer impact of water and rotation of boulders. Such large and deep holes at the base of waterfalls are called plunge pools.

Figure 1.7: V-Shaped Valley Figure 1.8: Waterfall Figure 1.9: Rapids

33 River Deposition The factors such as deceasing channel gradient, decease in velocity, spreading of stream over a large area, obstruction in channel flow, decrease is discharge for creating river deposition and its landforms. Depositional Landform i. Meanders: Meanders are described as serpentine flow of rivers. Meanders are formed due to lateral erosion. The outer bank of a river is eroded due to lateral erosion and steep cliff is formed. The inner bank has depositional features. ii. Alluvial Fans: It is formed where a heavily laden stream reaches the plain, its velocity is checked, it widens and much of its load is deposited the deposited sediments spreads out as an Alluvial Fan. iii. Alluvial Cones: An alluvial cone is a type of alluvial fan, but one in which the slope angles are steeper and the deposited materials is generally coarser and thicker having been transported by ephemeral rivers. iv. Flood plain: A flood plain often is an area of marsh and numerous lakes, usually crescent shaped known as Ox- Bow lakes. These are the remnants of meanders that have been cut off. When the river is in flood, it spills over its channel and often covers the whole of the flood plain which it deposits sediment. v. Natural levees:

Natural levees are found along the bank of large rivers. It is

low, linear and parallel ridges of coarse deposits along the banks of rivers.

The levee deposits are coarser than the deposits spread by flood waters away from the river.

vi.

Point Bars:

Point bars are also known as member bars. They are found on the convex side of meanders of large rivers and are sediments deposited in a linear fashion by flowing waters along the bank.

vii. Braided stream: The stream which thus, gets divided into a network of a channels forming bars of sand and islands is known as a Braided Stream. viii. Ox-Bow Lake: An ox-bow lake is a horse-shoe shaped lake at the side of a river. A long time ago, an ox-bow lake would have been a meander on Figure 1.10: Flood Plain Figure 1.11: Ox-Bow Lake

34 the river. Over time the river eroded the land at the start of the meander. The meander curved almost to a circle. Then the river took the more direct path and went straight through. The meander was left as a curved lake beside the river. ix. Delta: The sediment deposited in the estuary builds up in layers to form a gently sloping platform. In time, the platform may extend up to the surface and above, when it is called Delta, delta is a low-lying swampy plain which gradually becomes colonized by various types of plants. There are three basic types of deltas –a) Bird's foot, b) Arcuate c) Estuarine. Figure 1.12: Different types of Deltas 1.9 Landform Development due to Wind action Wind is the most active agent in arid and semi-arid regions. It is involved in erosion, transportation and deposition of sediments which mainly includes sand. The work of Wind is greatly helped by the process of mechanical weathering active in such areas. The wind has a great scope of work with it by blowing over large areas free of any obstacles. 1.9.1 Wind

Erosion Wind Erosion is largely controlled and determined by—(i) wind velocity (ii) nature and amount of sand dust (iii) composition of rocks (iv) nature of vegetation (v) humidity, rainfall and temperature

amount. Wind erosion occurs as –

35 a) Deflation: The process of removal and blowing away of dry and loose particles is known as Deflation. b) Abrasion: Sand blast action of sand grains against the rock surface known as Abrasion. c) Attrition: mechanical weak and tear of rock particles against each other is known as Attrition. Landforms produced by Wind Erosion These are the erosional landform of Wind--- i. Deflation Hollows: In those regions, where unconsolidated rocks are exposed, wind deflation over a prolonged period results in excavation of wide shallow basins or depressions called deflation hollows or blow acts. These develop where calcium carbonate is dissolved by ground water leaving loose sand grains, which are picked up and transported by wind. ii. Mushroom Rocks: The rocks have broad upper portion in contrast to their narrow base and thus resembles an umbrella or mushroom. Mushroom rocks are also called pedestal rocks or pilzfelsen. iii. Pediments: Landscape evolution in desert is primarily concerned with the formation and extension of Pediments.

Gently inclined rocky floors close to the mountains at their foot with or without a thin cover debris,

are called Pediments.

iv. Zeugens: Frost action and other agents break the hard rock capping and expose the points of weaknesses in the rock. It then becomes exposed to the abrasive action of the wind. When this process goes on, a tabular mass of resistant capping rocks lying upon softer rocks below it are formed straight side ridges called Zeugen. v. Yardangs: When the wind is blowing steadily over the hard and soft strata the softer materials are eroded forming passage ways between deeply undercut overhanging ridges. These rocks cuts ridges are called Yardangs. Yardangs commonly occur in clusters and are aligned to the direction of prevailing winds. vi. Demoiselles: These are rock pillars which Figure 1.13: ??? Figure 1.14: Mushroom rocks Figure 1.15: Zeugens Figure 1.16: Trough and Yardangs

36 stand as resistant rocks above soft rocks as a result of differential erosion of hard and soft rocks. vii. Inselbergs: The term was first used by Passarge in 1904, to delineate relict hills of South Africa. There has been a debate regarding the origin of these inselbergs as bornhardts. 1.9.2 Wind Deposition Wind transports loosened sand and dust from one place to another for their deposition. Deposition of and obstructions caused by bushes, forests, marshes and swamps etc. sand and dust is deposited on both windward as well as leeward sides of obstructions. Depositional Landforms Produced by Wind These are depositional landform of Wind--- i. Burchan: It is crescent shaped and lying at right angles to the prevailing wind with the horns pointing downward. A Barchan moves forward as grains of sand are carried up the windward face, which then slip down the leeward side. A Barchan ranges in height from a few meters to 30m and may be wide as 400 m they occur singly and groups. ii. Loess: It is loose, unstratified, non-indurated, buff-coloured fire sediments, which are deposited at places far from their source of origin. Loess is of mainly two types i.e., Desert Loess and Glacial Loess. Loess is known as 'liman' in France and 'Adobe' in America. iii. Seifs: They are Ridge-shaped with steep sides and lying parallel to the prevailing wind and parallel to each other. The crest of seif is sharp and over 100 m high and 150km long and 25 m to 400 m wide. Some example s of seif dunes occur in the Great sand sea of Egypt and Libya, in the Namib Desert between Walvis Bay and Luderitz. iv. Sand Dunes: Sand dunes are heaps of sand found in deserts. Generally, their heights vary from a few meters to 20 m, but in some cases, dunes are several hundred meters high and 5 to 8 km long. The formation of sand dunes requires – Figure 1.17:Inselbergs Figure 1.18: Burchan

37 • Wind of high velocity • Abundant sand • Obstacles such as trees, bushes, rock outcrops, walls against, which dunes may settle • Ideal place i.e., dune complex, dune colony or dune chain. 1.10 Landforms Development Due to Glacier Masses of the ice moving as sheets over the land flowing

down the slopes of mountains are called 'Glacier'. The movement of glacier is slow unlike water flow. The movement could be a few centimetres to a few meters a day. Glacier moves basically because of the force of gravity. 1.10.1 Glacier Erosion: Glacier erosion is caused by huge mass of ice sliding over the rocks and eroding them by its overweight, under the influence of gravity. Two principal processes are important Abrasion and plucking. i. Abrasion: The grinding and cursing of rocks, is not accomplished by the ice itself as it is too soft, but by the rock debris frozen into the lower layers of the ice. ii. Plucking: Plucking occurs in response to the drag exerted by the moving ice on the bed rock. As the tensile strength of ice is not very great, plucking is most effective where the rock has been already weakened. Erosional Landforms of Glacial Processes: These are the erosional landforms of glacial regions— i. Cirques: These

are the most common of landforms in glacial mountains.

The cirques quite often are found at head of glacial valleys.

They

are deep, long and wide troughs or basins with very steep concave to vertically dropping high walls at its heads as well as sides. A lake of water can be seen quite often within the cirques after glacier disappears, are called 'Cirque Lakes'. Figure 1.20:Abrasion & Plucking Figure 1.19: Sand Dunes

38 ii. Sheep Rocks: A glacier does not avoid hard outcrops like cliffs falling along its path. It rides or flows over them so that the slope of the obstacle from the side the ice moved becomes gentler, while the other side where the ice flowed down is left rougher and steeper. These knolls having a Crag and the Tail and look like Sheep from a distance. iii. Rock Steps: There is very uneven excavation of the glacier floor depending on the nature and structure of bedrocks, thickness of the glacier and the rate of glacier flow. When the glacier come across a rock sequence, which is varying in resistance, the floor is excavated into a series of successive steps called Rock Steps. iv. U-Shaped Valley: Mountain glaciers cannot dig a new valley but deepen, straighten as well as widen the pre- exiting valley by eliminating irregularities and projecting spurs during its passage. The original V-shaped valley becoming narrower towards its head is turned into a U-shaped trough in this way. v. Glaciated Lakes: Long ribbon of finger shaped lakes gets excavated into the flow of glacial troughs as a result of ice erosion. The great lakes of North America have been formed by a similar deepening and damning. vi. Horns: Horns are

through head ward

erosion of the cirque walls. If three or more radiating glaciers cut

head ward

until their cirques meet,

high sharp pointed and steep sided peaks called Horns

are formed. vii. Glaciated
valleys Troughs: Glaciated valleys are trough like and U-shaped
valleys
with broad floors and relatively smooth and steep sides. The valleys may contain littered debris or debris shaped as moraines with swampy appearance.
viii. Hanging Valley: Tributary glaciers also carve 'U' shaped troughs. But they are smaller in cross section, with floors lying high above the floor level of the main trough i.e., main glacial valley. Figure 1.22: U-shaped Valley Figure 1.23: Hanging Valley Figure 1.21: Cirques
39 ix. Trans: The bed rock is not always evenly excavated under a glacier, so that floors of troughs and cirques may contain rock basin and rock steps. Cirques and upper parts of troughs thus, are occupied by small lakes called Trans. Figure 1.24: Erosional landform by glacier movement 1.10.2 Glacial Deposition The rock debris carried by the glaciers down the slope is known as Glacial Drift. The rock debris is deposited at the base of the glacier trough the movement of slowly moving cinemas down the slope. Landforms generally include moraines and drumlins. Depositional Landforms of Glacial processes These are the depositional landforms of glacial regions- 1 . Glacial till:
The unasserted coarse and fine debris dropped by the melting glaciers is called Glacial Till. Most of the rock fragments in till are angular to sub-angular in form. 2 .
Moraines: It consists of the heterogeneous rock materials of unsorted nature, it is a mixture of many sediments called glacier flour, angular stones and boulders of different sizes and shapes. These materials dropped at the end of a valley glacier is in the form of ridge called the 'Terminal Moraine'. The materials deposited at either of its sides Figure
1.25:Moraines
40 is known as 'Lateral
Moraine'. When two glaciers join, their lateral moraines also join near their confluence and are called 'Medial
Moraine'. 3 . Eskers:
Very coarse materials like boulders and blocks along with some minor fractions of rock debris carried into this stream settle in the valley of ice
beneath the glacier and after the ice melts it can be found as a sinuous ridge called Esker. 4 . Outwash
Plain: It is also known as over wash plain. Glacial streams carry a huge quantity of rock debris and then form fan like plains beyond the terminus of glaciers. These are stratified. When, they occur on valley floors, such outwash plains are called valley trains. 5 . Erratics: These are stray boulders of rocks which have undergone a prolonged glacial transport and have subsequently been deposited in an area, where the country rocks are of distinctly different types. At times they are delicately balanced upon glaciated bedrock and are called poking or logging-stone. 6 . Drumlins:
The drumlins form due to dumping of rock debris beneath heavily loaded ice through fissures in the glacier. The sots get blunted due to pushing by moving ice.
They
are smooth oval shaped ridge like features composed mainly of glacial till with some masses of gravel and sand.
They may measure up to 1 km in length and 30 m or so in
Figure 1.26:Outwash Plain Figure 1.27:Drumlins
41 height. Figure 1.28:Glacial Landforms – Depositional 1.11 Summary There are many hypotheses on origin of earth. However. Majority of the modern scientists are of the opinion that the age of the earth may vary from 3 to 5 billion years. Through many evolutionary steps human raise appears, this has been evident in geological time scale. The internal structure is consisting of inner core, outer core, lower mantle and upper mental and finally the outer layer named as crust. The elements of earth whose have the momentum namely wind, water and glacier, are responsible for various type of land forms. These landforms are created in erosional and depositional activity of those elements. 1.12 Questions for self-assessment 1 . Discuss the internal structure of the earth with suitable diagram.

42 2 . What is seismology? Critically examine the seismological evidence in understanding the internal structure of the earth. 3 . Briefly outline the essence of plate tectonic theory and mention the origin of mountain in the light of the above-mentioned theory. 4 . Describe the geological time scale. Mention its importance in geoscience. 5 . Discuss the continental drift theory as proposed by A. wagner. Differentiate between plate tectonic theory and continental drift theory. 6 . Give an account of three principal hypothesis put forward to explain the origin of the solar system and the earth. 7 . "Since about 1943, there has been a swig back to theories of Laplacian type" Discuss this statement with reference to the theories that have been put forward regarding the origin of the solar system and earth. 8 . Give a concise account of the standard geological time scale. 9 . Discuss the principal characteristics of the crust, mantle and core of the earth. 10 .How does seismology help in understanding the internal structure of the earth and what are its main findings? 11 .Write an account of the work which a river does in the different parts of its course. 12 .Give an account of either erosional or the depositional landforms produced by river action. 13 .How are deltas formed? Classify deltas according to their shape. 14 .Describe the processes of wind erosion under arid conditions and discuss the chief topographical features produced by them. 15 .Discuss the landforms resulting from either glacial erosion or glacial deposition. 16 .How does the theory of plate tectonic explain the present lay-out of the young fold mountain chains of the earth? 17 .Describe the landforms produced by erosional activities of valley glacier. 18 .Write a critical account of theory of continental drift as proposed by Weagner. 19 .Give an account of the evolution of landform by the erosional activities of the wind. 20 .

Give an account of the landforms developed by the depositional action of wind in hot

desert. 21 .Describe and explain with sketches the geomorphic features resulting from erosion by valley glacier. 1.13 Suggested Readings 1 . Harland, W. B. (1983). Geotectonics in the USSR. Geological Magazine. 2 .

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44 Unit 2: Rocks and Minerals 2.1 Objectives 2.2 Introduction 2.3 Physical properties of rock 2.4 Formation of rocks 2.5 Types of rocks 2.6 Igneous rocks (primary or massive rocks) 2.7 Sedimentary rocks 2.8 Metamorphic rocks 2.9 Minerals 2.10 Summary 2.11 Questions/ Self-Assessment questions 2.12 Select Readings/ Suggested Readings 2.1 Objectives After successfully completing this unit, you will be able to: • know the properties and characteristics of rocks. • visualize the formation of rocks • demonstrate different types of igneous, sedimentary and metamorphic rocks • understand different types of minerals • understand different properties of minerals 2.2 Introduction Rocks and the minerals are known to be the building blocks of our active planet. They are the reason how the landscapes are formed and these provide all the necessary valuable resources needed within our environment. Knowing about these structures, we will be able to know about the events that have shaped our earth and those which will continue to shape our planet. You would have learnt about the phrase 'rocks and minerals' at some stage of science in schooling. The reason for which we say 'Rocks and minerals' is because that they both are two different words. Rocks are composed of minerals, but minerals are not said to be composed of rocks. The Main rocks on the earth contain minerals such as magnetite, feldspar, quartz, mica, epidote etc. Minerals have a commercial value which is of very immense, whereas the rocks are mined in order to extract these minerals. These mined rocks are called as ores, and the residue of these rocks after mineral has been extracted from it is called as tailing. What is Rock?

45 Rocks are the materials that form the essential part of the Earth’s solid crust. “Rocks are hard mass of mineral matter comprising one or more rock forming minerals”. Rocks are formed from the molten material known as magma. The study of rocks is called Petrology (in Greek, petra means rock, logos means science). Petrology deals with the description of rocks; petrogenesis is the study of the origin of rocks. 2.3 Physical properties of rock Physical properties of rocks are of interest and utility in many fields of work, including geology, petrophysics, geophysics, materials science, geochemistry, and geotechnical engineering. The scale of investigation ranges from the molecular and crystalline up to terrestrial studies of the Earth and other planetary bodies. Geologists are interested in the radioactive age dating of rocks to reconstruct the origin of mineral deposits; seismologists formulate prospective earthquake predictions using premonitory physical or chemical changes; crystallographers study the synthesis of minerals with special optical or physical properties; exploration geophysicists investigate the variation of physical properties of subsurface rocks to make possible detection of natural resources such as oil and gas, geothermal energy, and ores of metals; geotechnical engineers examine the nature and behaviour of the materials on, in, or of which such structures as buildings, dams, tunnels, bridges, and underground storage vaults are to be constructed; solid- state physicists study the magnetic, electrical, and mechanical properties of materials for electronic devices, computer components, or high-performance ceramics; and petroleum reservoir engineers analyze the response measured on well logs or in the processes of deep drilling at elevated temperature and pressure. Since rocks are aggregates of mineral grains or crystals, their properties are determined in large part by the properties of their various constituent minerals. In a rock these general properties are determined by averaging the relative properties and sometimes orientations of the various grains or crystals. As a result, some properties that are anisotropic (i.e., differ with direction) on a submicroscopic or crystalline scale are fairly isotropic for a large bulk volume of the rock. Many properties are also dependent on grain or crystal size, shape, and packing arrangement, the amount and distribution of void space, the presence of natural cements in sedimentary rocks, the temperature and pressure, and the type and amount of contained fluids (e.g., water, petroleum, gases). Because many rocks exhibit a considerable range in these factors, the assignment of representative values for a particular property is often done using a statistical variation. Some properties can vary considerably, depending on whether measured in situ (in place in the subsurface) or in the laboratory under simulated conditions. Electrical resistivity, for example, is highly dependent on the fluid content of the rock in situ and the temperature condition at the particular depth.

46 2.3.1 Characteristics of Rocks 1 . Colour 2 . Streak 3 . Hardness: Moh's scale of hardness 4 . Cleavage 5 . Fracture 6 . Luster a) Color: • Some minerals have characteristics color due to composition of the minerals and the arrangement of the constituent atoms: for example, black color of magnetite, green of chlorite and brassy yellow of pyrite • Minerals like quartz and calcite have variable color • Color can’t be sole identification property b) Streak: • Color of mineral in powder form is called streak • Powder is obtained by crushing the mineral. • Color of the streak differs from color of mineral: for example, the color of pyrite is brass yellow and its streak is dark green. c) Cleavage: • The cleavage of the minerals is its capacity to split more readily in certain directions than in others, due to the arrangement of the atoms. • Minerals break with ease producing smooth surfaces is called perfect cleavage. It can be either good, distinct, indistinct and imperfect. • Some minerals such as mica have perfect cleavage in one direction. The feldspars, which is the most abundant of all minerals, have two cleavages. d) Luster: • Appearance of mineral in ordinary light (that is the appearance due to reflected light). Luster may be metallic, glassy, earthy, pearly or silky • If the minerals look metal as do galena and pyrite, its luster is said to be metallic. If the minerals look glassy, like quartz, its luster is glassy.

47 e) Hardness: • The hardness of a mineral, as commonly determined on fresh material, is measured by its ability to resist scratching. If a mineral is scratched by a knife, it is softer than the knife. If it cannot be scratched by a knife, the two are equal hardness or the mineral is the harder. • In order to have a standard method of expressing hardness of minerals, a simple scale, known as the Mohs scale, has been universally adopted. • In sequence of increasing hardness from 1 to 10, the following minerals are used as standard of comparison: • Talc, Gypsum, Calcite, Fluorite, Apatite, Orthoclase (feldspar), Quartz, Topaz, Corundum and Diamond f) Other Characteristics of Rocks: • Crystal Form: Internal atomic arrangement in definite geometric patterns is sometimes outwardly expressed in crystal form. •

Specific Gravity is meant

the weight of a substance compared with the weight of an equal volume of water.

The specific gravity of quartz is 2.65. Some minerals are heavy than the others. The specific gravity of majority minerals range from 2.55 to 3.2. • Magnetism: A few minerals are attracted by a magnet. Of these minerals, magnetite, and pyrrhotite are the most common examples. 2.4 Formation of rocks 1 . Cooling and consolidation of molten magma within or on the surface of earth = Igneous or Primary rocks 2 . Transportation and cementation of primary rocks = Sedimentary or Secondary rocks 3 . Alteration of the existing primary and secondary rocks = Metamorphic rocks

48 Figure 2.1: Rock formation 2.5 Types of rocks Rocks are classified in to three types according to their formation. Which are 1. Igneous rock 2. Sedimentary rock 3. Metamorphic rock

49 2.6 Igneous rocks (primary or massive rocks) Igneous rocks are formed as m agma (molten rock) cools and solidifies. Magma is produced far below the Earth's surface by heat generated mainly from radioactive disintegration of uranium, thorium and potassium. The two main types of igneous rock are extrusive and intrusive. Extrusive rocks or volcanic rocks These rocks are formed due to the consolidation of magma on the surface of the earth. The magma, when it flows on the Earth surface is called LAVA. E.g., Basalt. Intrusive rocks or plutonic rocks These rocks are produced due to solidification of magma below the surface of the earth. Plutonic – intrusive rocks solidify at greater depth and Hypabassal rocks solidifies at shallow depth from the surface. e.g., Granite, syenite, diorite, Gabbro etc. Rocks formed in vertical cracks are called dykes and in horizontal cracks are called sills. Vesicular rocks: Rocks Igneous Intrusive Gabbro Garnite Extrusive Basalt Rhyolite Sedimentary Clastic Sandstone Shale Chemical Limestone Metamorphic Foliated Slate Schist Nonfoliated Quartzite Marble Figure 2.2: Igneous rock

50 Molten magma cools on the surface. Steam of water is entrapped into rocks and forms vesicles. Based on the silica content, rocks are also classified as 1. Acid rocks: <65% SiO 2 (Granite, Rhyolite) 2. Intermediate: 56 to 65% SiO 2 (Sub acid rocks 60 to 65% SiO 2 (Syenite and Trachyte)) (Sub basic rocks 56 to 60 % SiO 2 (Diorite and Andesite)) 3. Basic rocks: 40 to 55% (Gabbro, basalt) The table below shows the relationship between different igneous rocks and how they form. Table 2.1: Details of some igneous rocks S. No. Rocks Origin Essential minerals Common minerals Average specific gravity Remarks 1. Granite Plutonic holocrystalline Quartz (20- 30%) Hornblende, magnetite, mica 2.64 Light coloured white or reddish

51 2. Syenite Plutonic holocrystalline Quartz, orthoclase Hornblende, magnetite, biotite 2.80 Light coloured white or reddish 3. Diorite Plutonic holocrystalline Quartz Hornblende, magnetite, biotite 2.85 Darker 4. Gabbro Plutonic holocrystalline Labradorite, augite, olivine Hornblende, ilmenite 3.0 Blackish 5. Dolerite Hypabasal Labradorite, augite, olivine Hornblende, ilmenite 3.0 Blackish 6. Basalt Volcanic crystalline with glassy mass Labradorite, augite, olivine Hornblende, ilmenite 3.0 2.7 Sedimentary rocks These rocks are formed from the consolidation of sediments accumulated through wind or water action at the surface of the earth. Many are deposited in layer or formed through chemical reactions as precipitates from aqueous solutions. Sediments may contain various size particles cemented together by substances like SiO 2 , Fe 2 O 3 or lime. These rocks are also called as clastic rocks. Sedimentary rocks may have a coarse- grained, gravel-like appearance or be extremely fine grained, and may be hard or soft. The principal varieties are sandstone, limestone and shale. Many sedimentary rocks contain fossils and some, such as coral reefs, are composed entirely of such organic remains. The figure below illustrates how sedimentary rocks form Figure 2.3: Sedimentary rock

52 2.7.1 Types of sedimentary rocks Based on the origin, the sedimentary rocks are classified as 1 . Residual : Laterite 2 . Transported a. Deposited as solids in suspension : Sandstone, shale b. Deposited by chemical precipitation : Limestone, ironstone c. Deposited through agency of organic matter : Peat, Phosphatic deposits Based on the grain size, sedimentary rocks are classified as 1 . Rocks with boulder pebbles sized minerals (Rudaceous) : Conglomerate 2 . Rocks with sand size particles (Arenaceous) : Sandstone 3 . Rocks with silt size particles (silt rocks) : Siltstone 4 . Rocks with clay size particles (Argillaceous) : Shale Table 2.2: Details of some sedimentary rocks S. No. Rock Mineral composition Colour and structure 1. Sandstone Mainly quartz with some CaCO 3 , iron oxides and clay Light to red, granular 2. Shale Clay minerals, quartz and some organic matter Light to dark thinly laminated 3. Limestone Mainly calcite with some dolomite, iron oxides, clay, phosphate and organic matter Light grey to yellow, fine grained and compact

53 2.7.2 Sedimentary rocks divided into six groups as follows 1 . Arenaceous: Formed of the deposits of coarse-grained particles. They are composed of siliceous material derived from the disintegration of older rocks. The fragmental material so derived is deposited in beds of varying thickness through the agency of water. Depending upon the nature of cementing material present, some arenaceous rocks are hard and refractory, but most are loose and fall away very easily. e.g., Sandstone, grit, conglomerate and breccia. 2 . Argillaceous rocks: Consist of small sized particles known as clay. They are composed of hydrated silica of alumina in admixture with sand, various other silicates and calcareous matter. When clay is deposited mainly of silicate of alumina, it is known as kaolin or China clay. e.g., clay, mudstone, shale and fuller's earth. 3 . Calcareous rocks: Consists of carbonate of lime or lime and magnesia. They may be of sedimentary origin or formed by chemical precipitation or by organic agency. When, they are of organic agency, they are composed mainly of debris from plant and animal life. They are formed either by growth and decay of organisms in situ or by the transport and subsequent accumulation of their remains. The rocks so formed are found in layers, which vary considerably in depth of thickness. When formed by chemical precipitation, the calcareous material is deposited in the form of layers/sheets from waters containing calcium carbonate in solution. The precipitate when first formed is usually soft and chalky, but soon acquires a hard, compact structure and crystalline texture. The important calcareous rocks of aqueous origin are limestone, chalk, magnesian, ferruginous limestones, dolomite, marks of various varieties and coral. 4 . Carbonaceous rocks: Formed from decomposing vegetation under anaerobic conditions. When plants undergo decomposition under restricted air supply, is greater portion of the carbonaceous matter is retained and the material is slowly converted into coal. e.g., peat, lignite, coal, anthracite. 5 . Siliceous rocks: Siliceous rocks of organic origin formed from parts of minute plants and animals like diatoms, radiolaria etc, some are soft and friable and crumble to powder very easily. Others like flint and chert are hard and compact. 6 . Precipitated salts: Consist mainly of deposits formed as rock masses either by cooling, evaporation or by chemical precipitation. Water charged with acid or alkaline material, acting under pressure as it does under subterranean regions, dissolves various mineral substances from rocks with which it comes in contact. The salts thus formed deposit as rocks and such rocks vary in composition. They are i. Oxides: e.g., hematite, limonite, bauxite and quartz. ii. Carbonates: e.g., stalactite, stalagmite, magnetite and limestone. iii. Sulphates: e.g., gypsum and anhydrite iv. Phosphates: e.g., phosphorite

54 v. Chlorides: e.g., rock salt. 2.8 Metamorphic rocks Metamorphic rocks are formed when rocks of any class are subjected to heat and pressure at depth. This causes new minerals to form and other minerals to recrystallize. During the process, material from the rock may be added or lost. Marked changes in temperature (T) and pressure (P) occur, which may produce completely new types of rocks. In addition to the formation of new minerals, existing minerals may be realigned into parallel bands and new textures may be formed. At sufficiently high temperatures, the rock may undergo partial melting to form m agma, which may then become the source of an igneous rock. Metamorphic rocks include, gneiss, schist, slate, quartzite and marble, and the below figure shows how they form. Figure 2.4: Metamorphic rock [Gneiss]

55 Table 2.3: Details of some metamorphic rocks S. No. Rock Mineral composition Colour and structure 1. Gneiss Formed from granite Alternating light and dark colours, banded and foliated 2. Schist Formed from basalt or shale As original rock, foliated 3. Quartzite Formed from sandstone Light or brown, compact and uniform texture, foliated structure 4. Slate Formed from shale Grey to black, compact and uniform texture, foliated structure 5. Marble Formed from lime stone Light red, green, black, compact fine to coarse texture, foliated structure 2.9 Minerals Minerals are naturally occurring solids with a definite chemical composition and crystal structure. "Solid substances composed of atoms having an orderly and regular arrangement". When molten magma solidifies, different elements present in them freely arrange in accordance with the attractive forces and geometric form. Silica tetrahedron is the fundamental building blocks for the formation of different minerals. (SiO 2). Different silicate minerals are ortho silicates, ino-silicates, phyllosilicates and tectosilicates. There are nonsilicate minerals also. These are different oxides, carbonates, sulphates, phosphates etc. Minerals that are original components of rocks are called primary minerals. (feldspar, mica, etc.). Minerals that are formed from changes in primary minerals and rocks are called secondary minerals (clay minerals). Those minerals that are chief constituents of rocks are called as essential minerals (Feldspars, pyroxenes micas etc) and those which are present in small quantities, whose presence or absence will not alter the properties of rocks are called accessory minerals (tourmaline, magnetite etc).

56 2.9.1 Types of minerals 2.9.1.1 Ferro magnesium minerals a. Pyroxenes and amphiboles: The pyroxenes and amphiboles are two groups of ferromagnesian minerals (heavy group) the structure of which consists of long chains of linked silica tetrahedral. The pyroxenes consist of a single chain (2 oxygen shared in each tetrahedron) whereas amphiboles consist of a double chain (alternately 2 and 3 oxygen atoms shared successive tetrahedral). These chain silicates are sometimes referred to inosilicates. The pyroxene group of minerals comprised of different minerals namely enstatite, hypersthene, diopside and augite, of which augite is the most important minerals in soils and it is found in basic rocks. The amphibole group of minerals are common in acidic rocks and it can be represented by the isomorphous series between tremolite actinolite olivine and hornblende. Hornblende weathers fairly rapidly. Olivine (olive-green) minerals from an isomorphous series between foresterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4). Pyroxenes are more basic in character and therefore it weathers more rapidly than amphiboles. b. Micas: Micas occur extensively in soils. They are primarily originated from the parent rock from which the soil is derived. Generally, soils are inherited from well-ordered and imperfectly ordered micas. Well-ordered micas are derived from sedimentary rocks. The most common well-ordered micas are muscovite, paragonite, biotite and phlogopite (trioctahedral). The imperfectly ordered micas contain less potassium and more water as compared to well-ordered micas and this type of micas are most abundant in the clay fraction of soils. Among the ordered micas, biotite weathers more rapidly than muscovite. In imperfectly ordered micas, many of the illite-type specimens as well as the disordered micas of soils exhibits some mixed-layering with phases of vermiculite, smectite group of minerals, chlorite and intergrades of several of these species.

57 2.9.1.2 Non-ferromagnesium minerals i. Feldspars: Feldspars are anhydrous aluminosilicates of K, Na and Ca and occasionally of other large cations such as Ba. The feldspar structure consists of tetrahedral which are attracted by sharing each oxygen atom between neighbouring tetrahedran. The tetrahedral contain mainly Silicons with sufficient Al substitution. It belongs to the group of minerals that are light in weight. There are two groups of feldspars: i. potassium feldspars ($KA1Si_3O_8$) include orthoclase, microcline, adularia and sanidine. Orthoclase and microcline are more common in the plutonic and metamorphic rocks. The potassium feldspars occur commonly in the silts and sands of soils and also abundant in clay-size, ii. plagioclase feldspars- a series consisting of a solid solution of albite ($NaA1Si_3O_8$) high in sodium and anorthite ($CaA1_2Si_2O_8$) high in calcium. Plagioclase weathers more rapidly than orthoclase. ii. Quartz: It is very densely packed and occurs in a high degree of purity. It is strongly resistant to weathering as the structure is densely packed, electrically neutral and free from any substitution. It is the most abundant mineral next to feldspars. Serpentine, a hydrous magnesium silicate occurs more commonly as a secondary product. Garnets are characteristic of metamorphic rocks and are very hard and most resistant to weathering. 2.9.1.3 Silicate minerals a. Ortho/ Neosilicates The minerals in this group are composed of single tetrahedral linked together by Mg or Fe. To effect a break down, it is considered sufficient to sever the weaker Mg-O or Fe-O bonds. Non- withstanding the bond energy considerations susceptibility of the minerals in this group to breakdown by weathering appears to vary considerably from one mineral to another, e.g., zircon makes the mineral comparatively hard. On the other hand, the looser packing of oxygens in olivine makes the mineral weather faster. b. Inosilicates The inosilicate group has in its structure single-chain (pyroxenes) and double chain (amphiboles) silica tetrahedral linked together by Ca, Mg, or Fe. Because of the presence of many weak spots provided by the Ca-O, Mg-O, or Fe-O bonds, these minerals tend to weather rapidly c. Phyllosilicates Linkages of silica tetrahedral and Alumina octahedral sheets by mutually shared oxygen atoms from the basis for the structure of this group. Some of the minerals, e.g., biotite and muscovite, are relatively susceptible to weathering, whereas others, like clay minerals, are resistant weathering products and further breakdown of clays is difficult. Disruption of interlayer ions, or through cleavage of A1-O bonds in tetrahedral and octahedral positions.

58 d. Tectosilicates The minerals are considered solid solution minerals with a framework of silica tetrahedral, in which the cavities are occupied by Na, Ca, and so on. The minerals in this group may also vary considerably in their resistance to weathering, e.g., leucite and plagioclase versus potash fertilizers. The relative degree of close packing of atoms in their structural frame work may be the reason for such variability in weathering. Increased substitution of A1 and Si in tetrahedral of plagioclase mineral is also considered a factor that makes these minerals weaker than potash feldspars. 2.9.1.4 Non-silicate minerals Oxides: Hematite (Fe_2O_3) Limonite ($Fe_2O_3, 3H_2O$) Goethite ($FeO(OH)H_2O$) Gibbsite ($Al_2O_3H_2O$) The red, yellow or brown colours in soils are due to the presence of goethite and hematite, which occur as coatings on the surface of soil particles. Carbonates: Calcite ($CaCO_3$) Dolomite ($CaMgCO_3$) Sulphates: Gypsum ($CaSO_4.2H_2O$) Phosphates: Apatite (Rock phosphate $Ca_3(PO_4)_2$ - primary source of phosphorus 2.9.2 Physical properties of minerals 1 . Color 2 . Streak 3 . Fracture/ cleavage 4 . Hardness 5 . Luster 6 . Crystal form 7 . Taste 8 . Specific gravity 9 . Magnetism 10 .Effervescence (fizz) 11 .Birefringence

59 12 .Fluorescence a. Color • Denotes the natural colour of the mineral • The most obvious, but least reliable. • Calcite has more colours • Sulfur and Pyrite have same colour b. Streak • Refers to the colour of the powder form of the mineral When an unknown mineral is rubbed against a piece of unglazed porcelain (streak plate) it produces a colored line. ➢ Hematite - red ➢ Magnetite - Black ➢ Talc - white c. Fracture and Cleavage These terms describe the way a mineral breaks Fracture is the nature of the surface produced as a result of its breakage Conchoidal - curved surface Uneven - Uneven surface Hackly - Jagged surface Earthy - Like chalk Even - Smooth

60 d. Cleavage Some minerals break along certain well-defined planes called cleavage planes. Gypsum - 1 set Calcite - 2 sets Flourite - 3 sets e. Hardness This is how resistant a mineral is to being scratched. We use the Mohs scale to classify a given minerals hardness. Try to scratch the unknown mineral with various items, such as a fingernail (hardness of about 2.5), a coin (3), a steel nail (5.5) and a steel file (7) Table 2.4: Mohs Scale of Hardness Mineral Hardness Mineral Hardness Talc 1 Feldspar 6 Gypsum 2 Quartz 7 Calcite 3 Topaz 8 Fluorite 4 Corundum 9 Apatite 5 Diamond 10 f. Luster The way a mineral reflects light Metallic (Magnetite); sub-metallic, Vitreous (Opal), Resinous (Pyrite), Pearly, Adamentine (Diamond), silky (Asbestos) and greasy. g. Crystal form Crystal structure is the result of regular grouping of atoms that are homogeneous. A crystal is a polyhedral form, which means it is a geometric solid. It has a specific set of faces, corners and edges, which is consistent with the geometric packing of the atoms There are 6 basic crystal forms 1 . Isometric 2 . Tetragonal 3 . Hexagonal 4 . Orthorhombic 5 . Monoclinic

61 6 . Triclinic h. Taste This property is used to identify the mineral halite (salt) i. Specific Gravity This characteristic relates to the mineral's density. If the mineral is heavy for its size, then it has a high specific gravity j. Magnetism Is the mineral magnetic (try using a compass), or is it attracted by a magnet? This property is characteristic of Magnetite. k. Effervescence When some minerals are exposed to acids, they begin to fizz (calcite). l. Birefringence This is also known as double refraction. Birefringent minerals split the light into two different rays which gives the illusion of double vision in this Iceland Spar Calcite m. Fluorescence Some minerals display the phenomenon of photoluminescence. Table 2.5: Relative abundance of important rock forming minerals Minerals (arranged in the order of their crystallization) Important constituents Percent distribution Primary minerals Ferro magnesium minerals Ortho-ino silicates 16.8 Olivine Fe, Mg Pyroxenes Ca, Na, Fe, Mg Amphiboles Ca, Na, Fe, Mg, Al, OH Phyllo Silicates 3.6 Biotite K, Fe, Mg, Al, OH Muscovite K, Al, OH

62 Non-Ferro Magnesium minerals Tecto Silicates Feldspars 61.0 Anorthite Ca, Al Albite Na, Al Orthoclase K, Al Quartz Secondary minerals Clay minerals Na, K, Ca 11.6 Others Mg, Fe, Al, OH 6.0 2.10 Summary Rock is the hard mass of mineral matter that form the essential part of the earth's solid crust. Rocks can be distinguished through their characteristics (colour, streak, hardness, cleavage, fracture and luster). According to the formation rocks are three types i. Igneous, ii. Sedimentary and iii. Metamorphic rocks. Minerals have some distinct characteristics through which the minerals can be identified and classified. The Moh's depending on hardness in 1-10 scale minerals also can identified. 2.11 Questions/ Self-Assessment questions 1 . What are the major characteristics of rocks? 2 . Briefly describe different types of rocks? 3 . How does sedimentary rock forms? 4 . Describe types of minerals. 5 . What is Moh's scale? 6 . What are the Physical properties of minerals? 7 . Describe the Relative abundancy of important rock forming minerals. 2.12 Select Readings/ Suggested Readings 1 . Pellant, C. (2002). Rocks and minerals. 2nd American ed. New York, Dorling Kindersley. 2 . Merritts, D. J., Menking, K., & De Wet, A. (2014). Environmental geology: an earth systems science approach. Second edition. New York, W.H. Freeman and Company. 3 . Erickson, J. (2002). Environmental geology: facing the challenges of our changing earth. New York, Facts on File. 4 . Carla W. Montgomery (2011). Environmental geology. McGraw-Hill, Dubuque, IA,

63 5 . https://www.bgs.ac.uk/discovering-geology/rocks-and-minerals/ 6 . https://www.nps.gov/subjects/geology/rocks-and-minerals.htm 7 . https://www.nps.gov/subjects/geology/rocks-and-minerals.htm

64 Unit 3: Soil 3.1 Objectives 3.2 Introduction 3.3 Major component of soil 3.4 Soil Forming Processes 3.5 Weathering 3.6 Erosion 3.7 Sedimentation 3.8 Identification and characterization of clay minerals 3.9 Cation Exchange Capacity 3.10 Soil testing and analysis 3.11 Soil Contamination 3.12 Soil conservation and management 3.13 Summary 3.14 Questions/ Self-Assessment questions 3.15 Select Readings/ Suggested Readings 3.1 Objectives By successfully completing this unit, you will be able to: • know the components of the soil and how does it form. • visualize the weathering process and it types • demonstrate the erosion process of soil • understand the sedimentation process • understand different structure and chemical composition of clay minerals • know about the cation exchange capacity • understand the soil contamination and its management from degradation 3.2 Introduction As early as 5000BC, the Vedas and Upanishad as well as other Indian literature mentioned soil as synonymous with land "the Mother" supporting and nourishing all life on earth. For a layman it is the dirt and dust on the surface of the earth. But for the farmer, soil is that portion of the earth's surface which he can plough and grow crops to provide him with food and fiber for his own needs and that of animals, to the poor man. For a mining engineer soil is debris covering the rocks. Engineers think that soil is any unconsolidated material removed in excavations and used for filling or provide foundation structure Definitions:

65 Whitney (1892): Soil is a nutrient bin which provides all the nutrients required for plant growth. Hilgard (1892): Soil is more or less loose and friable material in which plants, by means of their roots , find a foothold for nourishment as well as for other conditions of growth. Simonson (1957): The soil is three-dimensional body having length, breadth and depth which form a continuum over the land surface and differ gradually from place to place. Soil Science Society of America (1970): i. The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of plants ii. Soil is the unconsolidated mineral matter on the surface of the earth that has been subjected to and

influenced by genetic and environmental factors viz. parent material, climate, macro and microorganisms and topography, all affecting over a period of time

and producing a product, that is "SOIL" that differs from the material from which it is derived in physical, chemical, biological and morphological properties and characteristics. 3.3 Major component of soil: • Soil is composed of partly weathered, unweather, transformed products of rocks, rock minerals and organic matter. • The mineral soil consists of four major components/phases: mineral material and organic matter (solid), water (liquid) and air (gases). In an ideal surface soil these components are observed in amounts (by volume, Fig.2) as follows, Soild Phase (Mineral matter) The solid phase is broadly composed of inorganic and organic constituents. The inorganic constituents which forms bulk of solid phase of soil includes silicates, carbonates, soluble salts and free oxides of Fe, Al and Si in addition to some amorphous silicates. Only a small fraction of the solid phase is of organic origin. The sources of organic constitutes are plant and animals. Of total volume, about half is solid space, 45 per cent mineral matter and 5 % organic matter. Liquid phase (Soil water) Forty to fifty per cent of the bulk volume of the soil body is occupied by soil pores, which may be completely and partially filled with water. The soil acts as a reservoir for supplying water to plants for their growth. The soil water keeps salts in solution which act as plant nutrients. Thus, liquid phase is an aqueous solution of salts. Gaseous Phase (Soil air)

66 The air-filled pores constitute the gaseous phase of the soil system. The volume of the gaseous phase is thus dependent on that of liquid phase. The nitrogen and oxygen contents of soil air are almost same as that of atmospheric air but concentration of carbon dioxide is much higher. The four major components of a typical soil exist mainly in an intimately mixed condition. The proportion of these components may vary from time to time and from place to place. The volume composition of sub- soil is different from the surface soil. Compared to top soils they are lower in organic matter content, lower in total pore space and contain a higher percentage of small pores. This means they have a higher percentage of mineral and water and considerable lower content of organic matter and air. Figure 3.1: Composition of surface soil 3.4 Soil Forming Processes A. Fundamental Soil Forming Processes Humification: • It is the process of transformation or decomposition of raw organic matter in to humus. • In this process the soluble organic substances regroup themselves in to large molecules by polymerization and become poorly soluble. • The characteristics are influenced by the nature of vegetation residue and the way it becomes decomposed and synthesized in to new organic compounds. Eluviation (Latin, ex or e,out and lavere, to wash):

67 • Eluviation means washing out. It is the process of removal of constituents in suspension or solution (Clay, Fe2O3, Al2O3, SiO2, humus, CaCO3, other salts etc) by the percolating water from the upper to lower layers. The Eluviation process involves mobilization and translocation of mobile soil constituents resulting in textural differences. Translocation depends upon relative mobility of elements and depth of percolation. • The horizon formed by the process of eluviation is termed as eluvial horizon (A2 or E horizon). Illuviation (Latin- il, in, and lavere, to wash): • The process of deposition of soil materials (removed from the eluvial horizon) in the lower layer is termed as Illuviation. • This is the region of maximum accumlation of materials such as iron and aluminium oxides and silicate clays. • The horizon formed by this process is termed as illuvial horizon (B-horizon, especially Bt). • The process leads to horizon of gains and textural contrast between E and Bt horizons. B. Specific Soil Forming Processes The fundamental processes provide a framework for more specific processes like- Podzolization (Russian, pod means under and zola means ash) • It is the process of eluviation of oxide of iron and aluminium (sesqui oxides) and also humus under acidic condition (pH 4-5), removal of carbonates by organic acids formed by organic matter and illuviation of the silicon in surface horizon. • Abudant organic matter, commonly found under forest, cold and humid climate are favourable for the formation of such soils. • The eluiviated horizon assumes a bleached grey colour and is left in highly acid, siliceous condition and, the term podzol has been used for such soils. Laterization (Latin, later-a brick) • The term laterite is derived from the word later meaning brick or tile and was originally applied to a group of high clay Indian soils found in Malabar hills of Kerala, Tamil Nadu, Karnataka, Madya Pradesh and Maharashtra. • Laterization is inverse process to that of podzolization i.e., the process that removes silica, instead of sesquioxides from the upper layers and thereby leaving sesquioxides to concentrate in the solum.

68 • The process operates under rain forests of tropical areas, warm and humid (tropical) climate and basic parent materials are favourable for such soils. • It refers specifically to a particular cemented horizon in certain soils which when dried, become very hard, like a brick. • Such soils (in tropics) when massively mixed with sesquioxides (iron and aluminium oxides) to an extent of 70 to 80 per cent of the total mass, are called laterites or latosols (Oxisols). Salinization • It is the process of accumulation of salts, such as sulphates and chlorides of calcium, magnesium, sodium and potassium in soils in the form of a salty (salic) horizon. • The intensity and depth of accumulation vary with the amount of water available for leaching. • It is quite common in arid and semi arid regions. • It may also take place through capillary rise of saline ground water and by inundation with seawater in marine and coastal soils. • Salt accumulation may also result from irrigation or seepage in areas of impeded drainage. Desalinization • It is the process of removal of excess soluble salts from horizons that contained enough soluble salts to impair the plant growth. • Drainage is essential for desalinization. Alkalization (Solonization) • The process by which soils with high exchangeable sodium and pH < 8.5 are formed; often sodium carbonate and sodium bicabonate are formed in extreme cases. • The soil colloids become dispersed and tend to move downward. The dispersion results in poor physical condition of the soil. Dealkalization (Solodization) • The process refers to the removal of Na + from the exchange sites. This process involves dispersion of clay. Dispersion occurs when Na + ions become hydrated. • The process is effected by intensive leaching and degradation which takes place in older soils. Calcification

69 • The process operates in arid and semi-arid regions and refers to precipitation and accumulation of calcium carbonate (CaCO3) in some part of the profile. The accumulation of CaCO 3 may result in the development of a calcic horizon. • Calcium is readily soluble in acidic soil water and/or when CO2 concentration is high in root zone as: CO 2 + H 2 O = H 2 CO 3 H 2 CO 3 + Ca = Ca (HCO 3) 2 (soluble) Ca (HCO 3) 2 = CaCO 3 + H 2 O + CO 2 (precipitates) Decalcification • In regions where some water percolates through the soil profile, decalcification takes place leading to the formation of calcic horizon down below. • In humid regions, calcium cabonate reacts with water containing dissolved carbon dioxide to form soluble bicarbonate which may be completely leached out of the soil profile. CaCO 3 + CO 2 + H 2 O (insoluble) = Ca(HCO 3) 2 (soluble) Carbonation • It occurs when carbon dioxide interacts chemically with minerals. When carbon dioxide is dissolved in water, it forms weak carbonic acid. • When carbonic acid comes in contact with the surface of the earth it dissolves large masses of limestone, creating caves and caverns. Gleization: • The term glei is of Russian origin means blue, grey or green clay. • The gleization is a process of reduction, due to anaerobic condition, of iron in waterlogged soils with the formation of mottles and concretions. Such soils are called as hydromorphic soils. • The process is not dependent on climate (high rainfall as in humid regions) but often on drainage conditions. Pedoturbation: • It is the process of mixing of the soil. 1 . Faunal pedoturbation: It is the mixing of soil by animals such as ants, earthworms, moles, rodents, and man himself 2 . Floral pedoturbation: It is the mixing of soil by plants as in tree tipping that forms pits and mounds 3 . Argillic pedoturbation: It is the mixing of materials in the solum by the churning process caused by swell-shrink clays as observed in deep Black cotton soils.

70 3.5 Weathering Weathering is the combination of processes that breaking down of rocks, soil and minerals, eventually transforming into sediment. On the other hand, disintegration or alteration of the rock surface in its natural or original position through physical, chemical and biological processes induced or modified by wind, water and climate. Weathering involves physical, chemical, and biological processes that act separately or more often together to cause fragmentation and decay of rock material. Physical decomposition causes mechanical disintegration of the rock and therefore depends on the application of force. Weathering involves breaking up the rock into the forming minerals or particles without disturbing the forming minerals. The main sources of physical Weathering are the expansion and contraction of heat, the erosion of overlapping materials, the release of pressure on the rock, alternatively the freezing and thawing of water, the dissolution of water between the cracks and cracks in the rock, the growth of plants and organisms in the rock. Organisms in the rock. Rock exchange usually involves chemical deterioration in which the mineral composition in the rock is altered, rearranged or redistributed. Rock minerals are subjected to solution, carbonation, hydration and oxidation with circulating water. These effects on the Weathering of minerals are added to the effects of living organisms and plants as nutrient extraction to rocks. After the rock breaks, the remaining materials cause soil with organic materials. The mineral content of the soil is determined by the parent material; therefore, a soil derived from a single rock type may often be lacking in one or more minerals required for good fertility, whereas a ventilated soil from a mixture of rock types (such as glacial, aeolian or alluvial deposits) generally makes more fertile soils. In addition, most of the Earth's landforms and landscapes are the result of decomposition processes associated with erosion and re-accumulation. Explain the disintegration or dissolution of rocks and minerals on the Earth's surface. Water, ice, acids, salts, plants, animals and changes in temperature are all weather conditions. After a rock is shredded, a process called erosion removes rock and mineral fragments. No rock on earth can resist erosion. Weathering and erosion constantly changes the rocky landscape of the Earth. Wear abrades exposed surfaces over time. Exposure time generally contributes to how vulnerable a rock is to weather conditions. Rocks buried under other rocks, such as lava, are less susceptible to wear and erosion than rocks exposed to wind and water. It is the first step in soil production in weather conditions as it smooths hard, sharp rock surfaces. Small pieces of worn minerals mix with plants, animal remains, fungi, bacteria and other organisms. A single type of weathered rock generally produces infertile soil, the weathered materials from the rock collection are richer in mineral diversity and contribute to more fertile

71 soil. Soil types associated with the weathered rock mixture include untouched and alluvial deposits until icing. 3.5.1 Types of weathering Weathering is the breaking apart of rocks that are exposed at Earth's surface. Rocks cannot be weathered unless they are at Earth's surface and exposed to the hydrosphere, biosphere, and atmosphere. Weathering can break down rocks into fragments of varying sizes. Weathering is also responsible for the formation of sedimentary rocks. The process of weathering creates the sediments needed to form these rocks. Weathering can take place in a variety of ways, which are classified into two main groups: a. Physical weathering or Mechanical weathering b. Chemical weathering c. Biological weathering A. Physical weathering or Mechanical weathering Physical weathering, also called mechanical weathering or disaggregation, is a class of processes that cause rocks to break up without chemical change. The primary process in physical weathering is abrasion (the process by which clips and other particles are reduced in size). Temperature, pressure, freezing and so on. Physical weathering may occur for reasons. For example, cracks resulting from physical weathering will increase the surface area exposed to the chemical effect, thereby increasing the rate of disintegration. i. Frost wedging Freezing water blows pipes and breaks bottles; because water expands when the walls of the container freeze and push. The same phenomenon occurs on the rock. When stuck water in a joint freeze, it forces the joint to open and may cause the joint to grow. These freezing wedges allow the blocks to be freed from solid bedrock. ii. Salt wedging Figure 3.2: Frost wedging Figure 3.3: Salt wedging

72 In arid climates, dissolved salt in groundwater precipitates and grows as crystals in open pore spaces in rocks. This process, called salt wedging, pushes apart the surrounding grains and weakens the rock so that when exposed to wind and rain, the rock disintegrates into separate grains. The same phenomenon happens along the coast, where salt spray percolates into rock and then dries. iii. Root wedging Have you ever noticed how the roots of an old tree can break up a sidewalk? As roots grow, they apply pressure to their surroundings, and can push joints open in a process known as root wedging iv. Thermal expansion When the heat of an intense forest fire bakes a rock, the outer layer of the rock expands. On cooling, the layer contracts. This change creates forces in the rock sufficient to make the outer part of the rock break off in sheet-like pieces. Recent research suggests that the intense heat of the Sun's rays sweeping across dark rocks in a desert may cause the rocks to fracture into thin slices. v. Animal attack Animal life also contributes to physical weathering: burrowing creatures, from earthworms to gophers, push open cracks and move rock fragments. And in the past century, humans have become perhaps the most energetic agent of physical weathering on the planet. When we excavate quarries, foundations, mines, or roadbeds by digging and blasting, we shatter and displace rock that might otherwise have remained Figure 3.4: Root wedging Figure 3.5: Thermal expansion

73 intact for millions of years more. Figure 3.6: Weathering caused by Animal attack B. Chemical

weathering Chemical weathering changes the composition of rocks, often transforming them when water interacts with minerals to create various chemical reactions. Chemical weathering is a gradual and ongoing process as the mineralogy of the rock adjusts to the near surface environment.

New or secondary minerals develop from the original minerals of the rock. In this the processes of oxidation and hydrolysis are most important. Chemical weathering is enhanced by such geological agents as the presence of water and oxygen, as well as by such biological agents as the acids produced by microbial and plant-root metabolism. The process of mountain block uplift is important in exposing new rock strata to the atmosphere and moisture, enabling important chemical weathering to occur; significant release occurs of Ca 2+ and other ions into surface waters. i. Dissolution Chemical weathering during which minerals dissolve into water is called dissolution. Dissolution primarily affects salts and carbonate minerals (Fig. B.6a, b), but even quartz dissolves slightly.

74 Figure 3.7: Weathering caused by Dissolution ii. Hydrolysis During hydrolysis, water chemically reacts with minerals and breaks them down (lysis means loosen in Greek) to form other minerals. For example, hydrolysis reactions in feldspar produce clay. iii. Oxidation Oxidation reactions in rocks transform ironbearing minerals (such as biotite and pyrite) into a rustybrown mixture of various iron-oxide and iron-hydroxide minerals. In effect, iron-bearing rocks can "rust." Figure 3.8: Hydrolysis

75 Figure 3.9: Weathering caused by oxidation iv. Hydration the absorption of water into the crystal structure of minerals, causes some minerals, such as certain types of clay, to expand. Such expansion weakens rock. C. Organic or Biological Weathering A number of plants and animals may create chemical weathering through release of acidic compounds, i.e., the effect of moss growing on roofs is classed as weathering. Mineral weathering can also be initiated or accelerated by soil microorganisms. Lichens on rocks are thought to increase chemical weathering rates. Some plants and animals can cause chemical weathering through the release of acidic compounds, ie, classification of algae grown on the roof as degradation. Mineral weathering can also be initiated or accelerated by soil microorganisms. It is thought that lichens on the rocks increase the chemical weathering rates. Figure 3.10: Weathering caused by Hydration

76 The most common forms of biological weathering are the release of chelating compounds (i.e., organic acids, siderophores) and acidifying molecules (i.e., protons, organic acids) to break down aluminum and iron-containing compounds in soils beneath plants. The decomposition of the remains of dead plants in the soil can form organic acids which, when dissolved in water, cause chemical weather conditions. Excessive release of chelating compounds can easily affect the surrounding rocks and soils and lead to soils podsolization. 3.6

Erosion What Is Erosion? Erosion is a geological process in which earthen materials (i.e., soil, rocks, sediments) are worn away and transported over time by natural forces such as water or wind; sometimes this is sped up by poor management or other human impacts on land. The natural process of river erosion, in fact, created the Grand Canyon, as the Colorado River cut deep and wide through the rock over millions of years, and glacial erosion carved Yosemite National Park's iconic landscape. (The difference between weathering and erosion is that in the process of weathering, materials are worn away but not transported. And erosion is the opposite of deposition, when natural forces leave earthen materials behind.) Soil erosion refers to the erosion of the top layer of dirt known as topsoil, the fertile material vital to life. The rate of soil erosion depends on many factors, including the soil's makeup, vegetation, and the intensity of wind and rain. Because our own activities can also influence the speed of soil erosion, we have the power (and the responsibility) to solve one of the planet's greatest environmental challenges. 3.6.1 Causes

of Erosion

Soil erosion occurs primarily when dirt is left exposed to strong winds, hard rains, and flowing water. In some cases, human activities, especially farming and land clearing, leave soil vulnerable to erosion. For example, when farmers till (plow) the soil before or after growing a

77 season of crops, they may leave it exposed to the elements for weeks or months. The overgrazing of farm animals like cattle and sheep can also leave large areas of land devoid of ground- covering plants that would otherwise hold the soil in place. Another practice that has devastating consequences for soil health is deforestation, particularly clearcutting, a widespread practice of the industrial logging industry. When trees are cleared away, the land is left exposed to wind and rain without the security of roots to prevent the soil from being swept away. Climate is also a major driver of erosion. Changes in rainfall and water levels can shift soil, extreme fluctuations in temperature can make topsoil more vulnerable to erosion, and prolonged droughts can prevent plants from growing, leaving soil further exposed. 3.6.2 Water Erosion Water erosion

occurs when rain or snowmelt displaces the soil on the ground. The more water flowing over the land, the more soil particles are moved or transported away. Land that has no vegetation—including farm fields that are left barren after crop harvest—are especially vulnerable to water erosion. Since there's no vegetation to absorb the water, hold dirt in place, or break up the energy of falling raindrops, a rainstorm leads to increased runoff and erosion. Intense weather events (heavy rains, flash floods, and rapid snowmelt) can lead to more rapid soil

erosion.

For water to cause erosion and harm to farm fields, several factors come into play. Damage is more likely to occur if a great deal of rainfall and water runoff flows over the land during storms. Soil type, quality, and texture—the combination of soil particle size and how loosely or densely the particles are compacted—also influence the erodibility of a field's soil. Other factors are the length and slope of a piece of land, which can affect the speed and strength of water runoff. (That's one reason farms built on steep hillsides—often as a result of limited arable land—can be susceptible to devastating soil erosion and washouts.) Vegetation—typical cropping as well as the strategic use of cover crops—can buffer the impact water has on a farm field. Land managers may also mitigate soil erosion through selective tillage practices. Typically, farmers till their soils to prepare fields for seed planting, control weeds, and retain moisture. But decades of agricultural research have revealed that a less-is-more approach may be the best way to minimize soil erosion. In other words, reducing mechanical disturbance to farm fields may help preserve soil. 3.6.2.1 Common Forms of Water Erosion Water, though vital for life and agriculture, can be incredibly corrosive. Every raindrop splash has the potential to impact the structure of soil. Below are four common types of water erosion. i. Sheet erosion

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The removal of soil in thin, uniform layers (sheets) by raindrop impact and shallow surface water flow. Sheet erosion can sometimes be difficult to detect unless the soil is deposited nearby or if the damage is already severe. This erosion process removes the fine soil particles that contain most of the important nutrients and organic matter. ii. Rill erosion

It is

a type of erosion that results in small yet well-defined channels—typically smaller than gully erosion channels. After some time, rill erosion may fade away or, in more serious cases, be smoothed over with tilling. iii. Gully erosion

Gully erosion is

the washing away of soil through deep grooves or channels across unprotected land. Gully erosion can refer to soil being washed away through human-made drainage lines or describe the process of soil traveling through grooves created by hard rains. Farmers will typically fill these grooves back in with fresh soil as a temporary solution. As seen across the Midwest in 2019, gully erosion can hinder the ability to plow fields and grow crops. iv. Bank erosion

Bank erosion is

the progressive undercutting, scouring, and slumping of natural rivers and streams as well as man-made drainage channels by the intense movement of water. When land managers remove vegetation or ranchers allow their livestock to overgraze the land near streams and riverbanks, it can exacerbate the problem. Bank erosion represents a serious threat to lands around the globe. For example, the claylike soil of southwestern Bangladesh is particularly vulnerable to erosion during the rainy season. Every year, riverbank erosion displaces tens of thousands of people and has a devastating impact on regional farming.

Figure 3.11: Sheet erosion Figure 3.12: Rill erosion Figure 3.13: Gully erosion

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Wind Erosion Wind erosion is a natural process that moves loose soil from one location to another. Very strong winds, in fact, can form large, destructive dust storms.

Soils types that are loose, dry, and finely granulated are less desirable for farmland, as these qualities create smooth surfaces and increase erodibility. On the other hand, soil structure—roughness, clumps, and ridges—can help absorb wind energy and reduce erosion. Fields that are covered with vegetation or bordered by shrubs and trees (also known as shelterbelts) are also much less vulnerable, as the plants can help block wind. Last but not least, climate plays a big role in wind erosion: Studies suggest that a warmer climate would bring a greater risk of wind erosion on arid and semiarid lands. 3.6.3.1 Effects of Wind Erosion

Crop damage: When wind causes soil to become airborne, the blowing soil can sandblast delicate leaves and stems or even bury plants and seeds, resulting in decreased crop yields.

Dust

storms: When dry, loose soil particles are suspended in the air, large dust storms can form and last for several hours. These storms can damage crops, harm livestock, and cause a variety of serious human health problems, including asthma attacks and dust pneumonia.

Adverse operating conditions: Dust storms can damage or impede the use of farm equipment and make it unsafe for agricultural workers to be in the fields.

Chemical drift: Wind can cause pesticides, herbicides, fertilizers, and various other agriculture chemicals to become airborne and move far beyond the intended area of application. This can be especially problematic for farmers trying to decrease chemical overuse on their fields, and for communities that live near farmland where many agrochemicals are applied. 3.6.4

Erosion Control Methods and Practices Below are some common strategies for effective erosion control, many of which are part of the philosophy of regenerative agriculture. It’s worth noting that finding appropriate erosion-control treatments relies on understanding which specific erosion processes are at play. Build soil organic matter: To be healthy, soil needs just the right mixture of water, air, minerals, and organic matter. Soil organic matter, made up of decomposing plant and animal material, is the glue that helps bind soil together and keeps it anchored in place. Research suggests that
Figure 3.14: Bank erosion
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increasing organic matter from 1 to 3 percent can reduce erosion by 20 to 33 percent because it increases the water-holding capacity of soil. Plant vegetation: Trees, shrubs, hedgerows, and ground plants can block corrosive wind. Ensuring uninterrupted ground cover, such as through planting cover crops, also helps bind soil to roots. Use erosion control matting: Also known as an erosion control blanket, this ground covering is often made of open-weave, biodegradable materials that shield the soil and provide support for growing vegetation on bare ground. This erosion control method is often effective for solar farms and construction sites where large areas are left barren and vulnerable to wind and water erosion. Practice no-till/minimal tillage: Farmers have been plowing farm fields for centuries, but in recent decades agriculture scientists have helped prove that a no-tillage approach may offer more benefits. By not disturbing soil, farmers have been able to reduce erosion and runoff, which benefits crop productivity and water quality. No-till practices can also help reduce the loss of nitrogen and other vital soil nutrients. Use grazing practices that reduce erosion: Rotational grazing is a method that moves livestock from one pasture paddock to the next. Each paddock gets a rest period and is allowed to regrow undisturbed, which minimizes soil compaction and erosion. Other beneficial practices include installing fencing and stream crossings to keep pastures safe from degradation. 3.7
Sedimentation
Sedimentation is the deposition of rock fragments, soil, organic matter, or dissolved material that has been eroded, that is, has been transported by water, wind, ice, or gravity. A variety of human activities and environmental processes affect: rates of sedimentation, where sediment is deposited, and the nature of the deposited sediment, including: • Rates of weathering and erosion, which are affected by climatic conditions, such as precipitation rates, snow and ice cover. • Human land and water use, including deforestation and agricultural activities. For example, the damming of rivers changes where and how much sedimentation occurs, which affects soil quality and causes changes in habitats. • The size and depth of the bodies of water, such as lakes, rivers, or the ocean, where the sediment is deposited. Slower rates of water flow lead to the deposition of finer grained sediments and to slower rates of deposition. • Plants and other organisms, such as those that build coral reefs, can trap sediment that otherwise might be deposited elsewhere.
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Figure 3.15: Depositional environments where sediments accumulate. [Source: Wikimedia] 3.8 Identification and characterization of clay minerals Clay minerals are one of the most common minerals in the earth. They are found in many different parts of the world, and they are used in a wide variety of applications. In this article, we will discuss how to identify and characterize clay minerals. 3.8.1 Clay Clay is a soft, freely bound, fine grained natural rock or earthy material having diameter less than 0.005 mm and composed essentially of clay particles. Based on the standard definition of mineral, clays are mainly inorganic materials except peat, muck, some soils, etc. that contain huge amount of organic/natural materials. The clay particles are formed due to the weathering and erosion of rocks containing soil, ceramic clays, clay shales, glacial clays (including great volume of detrital and transported clays) the mineral group feldspar (known as the ‘mother of clay’) over vast spans of time. During weathering, the content of feldspar is distorted by hydrolysis process results in formation of clay minerals such as kaolinites (the primary minerals in kaolin clays) and smectite (the primary minerals in bentonite clays). Clay can incorporate with one or more clay minerals even in presence of minute quantities of quartz (SiO 2), metal oxides (Al 2 O 3 , MgO etc.) and organic matter. The plasticity of clays are due to their particle size, geometry as well as content of water and become hard, stiff, coherent and non: plastic upon drying or firing. Plasticity and hardness are greatly affected by the chemical composition of the

82 material present in the clay. Clays can be molded in any form when they retain water. For example, some species of chlorite and mica are found to be non-plastic while grinding macroscopic flakes even where more than 70% of the material is >2 μm esd (equivalent spherical diameter). Whereas some species of chlorites and micas become plastic on grinding the macroscopic flakes where 3% of the materials is >2 μm esd. Clays are easily molded into a form that they retain when dry, and they become hard and lose their plasticity when subjected to heat. Mostly, geologic clay deposits composed of phyllosilicate minerals having variable amounts of water present in the mineral structure. The clay can appear in different form of colors from white to dull gray or brown to deep orange-red depending on the soil's content [4]. The colloidal suspensions are formed when clays are immersed in water and flocculation occurs when they immersed in saline water. Clays are divided into two classes: Residual clay: Residual clays are found in the place of origin and formed by surface weathering which give rise to clay in three ways: • Chemical decomposition of rocks, such as granite, containing silica and aluminia • Solution of rocks, such as limestone, containing clayey impurities, which, being insoluble, are deposited as clay • Disintegration and solution of shale Transported clay, also known as sedimentary clay, removed from the place of origin by erosion and deposited in a new and possibly distant position. 3.8.2 Structure and chemical composition of clay minerals The properties that define the composition of clay minerals are derived from chemical compounds present in clay minerals, symmetrical arrangement of atoms and ions and the forces that bind them together. The clay minerals are mainly known as the complex silicates of various ions such as aluminum, magnesium and iron. On the basis of the arrangement of these ions, basic crystalline units of the clay minerals are of two types: silicon – oxygen tetrahedron consists of silicon surrounding by four oxygen atoms and unite to form the silica sheet. aluminum or magnesium octahedron consists of aluminum surrounding by six hydroxyl units and combine to form gibbsite sheet (If aluminum is main dominating atom) or brucite sheet (If magnesium is main dominating atom) (Figure 3.16) .

83 Figure 3.16: Structure of tetrahedral and octahedral unit. Tetrahedral sheet The main dominating atom in the tetrahedral sheet is found in form of Si^{4+} cation. The basic building block of tetrahedral sheet is a unit of Si atom surrounded by four oxygen atom known as silica tetrahedra. The tetrahedral sheet is formed by sharing of three oxygen of each tetrahedra with three nearest tetrahedra as shown in Figure 3.17. These oxygen atoms are known as basal oxygen which connect pairs of all tetrahedra together (more or less) in one plane whereas the fourth oxygen atom remain free and form the bond with other polyhedral elements known as apical oxygen. Apical oxygens are all in a separate plane and provide a link between both tetrahedral and the octahedral sheet. As only one apical O is present per tetrahedron therefore, each tetrahedron shares a corner with an octahedron in the octahedral sheet. Figure 3.17: Arrangement of tetrahedral unit to form the tetrahedral sheet. Octahedral sheet

84 The main dominating atoms in octahedral sheets are Al^{3+} or Mg^{2+} surrounded by six oxygen atoms or hydroxyl group give rise to eight-sided building block known as octahedron. Since, octahedral sheet is present in two forms: dioctahedral or trioctahedral sheet. When aluminum having three positive valences present in the octahedral sheet, only two-thirds of the sites are filled so that the charges will be balanced which results in formation of dioctahedral sheet. When magnesium having two positive charge valences is present, all three positions are filled to balance the charge which results in formation of trioctahedral sheet. Therefore, for di – octahedral sheet, Al^{3+} is the main dominating atom with $Al_2(OH)_6$

a unit cell formula and often abbreviated as the stoichiometric equivalent $Al(OH)_3$

where two Al^{3+} atoms coordinated with six oxygen/or hydroxyl ions Arrangement of octahedral unit to form the octahedral sheet 3.9

Cation Exchange Capacity Soil clay minerals and organic matter tend to be negatively charged, thus attracting positively charged ions (cations) on their surfaces by electrostatic forces. As a result, the cations remain within the soil root zone and are not easily lost through leaching. The adsorbed cations may easily exchange with other cations in the soil solution, hence the term "cation exchange." The adsorbed cations replenish the ions in the soil solution when concentrations decrease due to uptake by plant roots. Cation exchange capacity (CEC) is a measure of the total negative charges

Figure 3.18: Schematic diagram showing exchange of cations between the soil surfaces and the soil solution, and the movement of these cations from soil solution to roots (rhizosphere) for uptake

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within the soil that adsorb plant nutrient cations such as calcium (Ca 2+), magnesium (Mg 2+) and potassium (K +). As such, the CEC is a property of a soil that describes its capacity to supply nutrient cations to the soil solution for plant uptake. Figure 3.18 illustrates cations retained on soil clay minerals that can exchange with those in the soil solution. Plant roots can remove nutrients from the soil solution, which results in nutrients moving away from the clay particles. Addition of fertilizer to soil causes an initial increase in nutrient concentration in the soil solution, which results in nutrients moving toward clay particles. The nutrient cations plants use in the largest amounts are potassium (K +), calcium (Ca 2+) and magnesium (Mg 2+). Other cations adsorbed on exchange sites are ammonium (NH 4 +), sodium (Na +), hydrogen (H +), aluminum (Al 3+), iron (Fe 2+ or Fe 3+), manganese (Mn 2+), copper (Cu 2+) and zinc (Zn 2+). Micronutrient cations such as zinc, copper, iron and manganese are typically present at very low concentrations in soils. Ammonium concentrations are also typically very low because microorganisms convert ammonium to nitrate in a process called nitrification. 3.9.1 How CEC changes with Soil pH The CEC of soil organic matter and some clay minerals varies with pH. Generally, the CEC is lowest at soil pHs of 3.5 to 4.0 and increases as the pH is increased by liming an acid soil, as shown in Figure 3.19. Because CEC may vary considerably with soil pH, it is a common practice to measure a soil's CEC at a pH of 7.0. Also note that some positive charges may occur on specific soil mineral surfaces at low pH. These positive charges retain anions (negatively charged ions) such as chloride (Cl -) and sulfate (SO 4 2-). Figure 3.19: Influence of pH on the surface charge of soil and its components.

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Calculating the Cation Exchange Capacity from a Routine Soil Test The CEC value included on typical soil testing laboratory reports is calculated by adding together the concentrations (expressed as milliequivalents of charge per 100 grams of soil) of potassium, magnesium, calcium, sodium and hydrogen, which are extracted from soils using an appropriate extraction method. The University of Georgia Soil Testing Laboratory uses the Mehlich I procedure, based on a double acid (0.05 N HCl + 0.025 N H 2 SO 4) extracting solution. This method is appropriate for acidic, low CEC soils, which are commonly found in Georgia. The CEC of soils containing large amounts of clay or organic matter, or that are alkaline, cannot be satisfactorily analyzed using the Mehlich I extract. Other soil extraction methods should be used on these types of soils.

Table 3.1: Cation exchange capacity and specific surface area of different clay minerals. Cation-exchange capacities and specific surface areas of clay minerals mineral cation-exchange capacity at pH 7 (milliequivalents per 100 grams) specific surface area (square metres per gram) kaolinite 3–15 5–40 halloysite (hydrated) 40–50 1,100* illite 10–40 10–100 chlorite 10–40 10–55 vermiculite 100–150 760* smectite 80–120 40–800 palygorskite- sepiolite 3–20 40–180 allophane 30–135 2,200 imogolite 20–30 1,540 3.10 Soil testing and analysis 3.10.1 Soil Sampling The first and most critical step in soil testing is collecting a soil sample. A soil analysis can only be as good as the sample sent to the laboratory. It is important to recognize what a tiny portion of a field is actually analyzed in the laboratory. For example, a 1 kg soil sample collected from a 5 acre field represents just 1/10,000,000 of the field! Therefore, it is vital that the soil sample be representative of the entire field. The most common and economical method for sampling an

87 area is composite sampling, where sub-samples are collected from randomly selected locations in a field, and the subsamples are composited for analysis. The analytical results from composite sampling provide average values for the sampled area. The actual number of sub-samples depends on field size and uniformity. Generally, a larger field or a less uniform field should be more intensively sampled than one that is small and uniform. No less than 5 sub-samples should be taken from a sampled area, and 15 to 25 are preferable. Alternatively, areas can be grid-sampled in a regular pattern. Each sample is analyzed separately, so that variability in soil properties can be determined. With data provided by grid sampling, maps of soil test values can be constructed. This information can be entered into a geographical information system (GIS) and combined with additional geospatial data, such as soil texture, crop yields, leaf analyses, etc. and used in precision agriculture systems for variable application of fertilizers and other crop inputs. This is a much more expensive method of soil analysis because of the large number of analyses required, although it provides valuable information about geospatial uniformity which can be used in precision agriculture. Ideally, samples should be collected with a soil probe or auger (a small shovel or trowel can also be used), to the depth of tillage (usually 6 to 8 inches) or to the effective rooting depth of plants. Deeper samples may be collected for evaluation of subsoil properties, such as salt or nitrate accumulation. It is helpful to sample to the same depth each time a soil is sampled, so that year to year samples can be directly compared to monitor changes over time. Each sub-sample should be approximately equal in size. The sub-samples should be placed in a clean plastic bucket and mixed thoroughly. The desired sample amount is then removed from the bucket and the remainder discarded. Check with your testing laboratory to find out how large a sample they require. The area or size of the field sampled is dependent upon management practices. Sample the smallest unit that will be managed separately. For example, if a field has two distinctly different sections, perhaps one half level and the other sloped, then sample the two areas separately, and fertilize each half separately to obtain optimum results. However, if each half of the area will not be fertilized or managed individually, there is no need for separate sampling. A single, representative sample will be less expensive and just as useful. Sample the smallest management unit. Soil samples should be air-dried or taken to a test laboratory as soon as possible. To dry a soil sample, spread the soil out in a clean, warm, dry area, and let it dry for two to three days. It is best not to heat or dry soil samples in an oven because soil chemical properties may be altered. Bag the sample and send itto a laboratory for analysis. Soil samples can be refrigerated for several days if they cannot be dried immediately. When is the best time of year to collect soil samples? Soil test values change slightly during the year, but the primary consideration for timing for most soil sample collection is convenience

88 (nitrogen tests are an exception, see below). Collect samples early enough in the cropping cycle to allow results to be used to adjust management practices. How frequently should soil samples be collected? The frequency with which soil samples should be collected depends on the specific soil test, environmental conditions, and value of the crop. Status of some soil nutrients can change quickly, whereas others do not. For example, phosphorus levels in soil are unlikely to change rapidly and annual testing may be unnecessary. Nitrogen levels, on the other hand, change very quickly and frequent tests are required to obtain accurate determinations of plant-available levels. A new soil analysis might be necessary after heavy rains or after a prolonged period of water-logging if one needs an accurate measure of soil nitrogen. When making substantial changes to soil fertility levels, it is a good idea to make the change over a period of two to three years, retesting the soil annually. If a crop does not have a high economic value, then occasional soil testing (once every 3 to 4 years) may be adequate in the absence of any noticeable nutritional problems. In contrast, commercial production of high value crops may warrant annual testing to ensure maximum yields. Figure 3.20: On the left: dividing and sampling scheme for a sloped field with distinct upper, middle, and lower areas. Circles represent sub-sample locations which are composited for each of the three areas. On the right: grid-sampling a field. Each sample is analyzed separately to evaluate field variability. 3.10.2 Soil Analysis Soil testing followed by accurate and reliable soil analysis data gives the knowledge of the chemical, physical and biological status of a soil that is fundamental to many of the management decisions made on the farm.

89 Soil testing enables the planning of cultivation and soil management actions as well as providing the basis for a sustainable crop nutrition programme that is accurate, timely and -- increasingly importantly -- environmentally responsible. In short, soil testing provides the critical information required to ensure all crop nutrition decisions are accurate, efficient, cost-effective and responsible. What to analyse? Most of the work, and cost, of soil testing, is in the sampling and transportation of the samples to be analysed to the laboratory. Once the sample has arrived it makes sense to get as much information as possible from the sample. 1. Nutrient analysis Soil testing provides an inventory of crop available nutrients and the background to build a nutrient management plan. Basic soil analysis (P, K, Mg and pH) is a legal requirement in England, but this analysis only provides a part of the picture as other nutrients and factors can be limiting to crop growth. In order to get the most from a soil sample, it is important to analyse for all nutrients using Yara's Broad Spectrum analysis group which includes the analysis for secondary nutrients, such as sulphur, and micronutrients 2. Chemical and physical analysis The physical and chemical characteristics of the soil need to be considered before making any soil management decisions or planning a nutrient application strategy. Soil pH, Cation Exchange Capacity, organic matter and soil texture all have an impact on how we manage our soils and crops. 3. Biological analysis An active population of soil organisms is essential to a healthy soil; they contribute to crop nutrition, recycling nutrients from the humus, organic matter and soil particles, as well as influencing soil structure. Together with the analysis of organic matter, a biological analysis provides a rounded picture of a soil's overall health, it's response to soil management practices and its potential for producing high yielding, quality crops. 3.11 Soil Contamination

Soil contamination is the occurrence of contaminants in soil above a certain level causing deterioration or loss of one or more soil functions.1 It occurs in 2 forms:

90 • 'Point pollution', caused by a specific event or series of events to a particular place, such as a former factory site. This is relatively well mapped and understood. • 'Diffuse pollution', this involves low levels of contaminants spread over very wide areas that become lodged in the soil as it acts as a sink. This is difficult to analyze and track. Examples of such contaminants would be heavy metals or herbicides or pesticides used in agriculture. Soil pollutants can consist of various forms, such as organic and inorganic or particulate pollutants. 3.11.1

What causes it? Human activities The most important sources of contamination in soils are those connected with human activities. Examples of point pollution include metal mining and smelting, industrial production, waste disposal and diffuse pollution examples include industrial activities, car emissions, application of agrochemicals, manure containing veterinary drugs, etc. Municipal and industrial wastes contribute most to soil contamination (37%), followed by the industrial/commercial sector (33%). Mineral oil and heavy metals are the main contaminants contributing around 60% to soil contamination. In terms of budget, the management of contaminated sites is estimated to cost around 6 billion Euros (€) annually. 3.11.2 How can it be measured or assessed? Table 3.2: The table below shows the list of indicators for soil pollution Topic Problem Indicator Diffuse pollution by Inorganic pollutants Which areas show critical heavy metal contents in excess of national thresholds? Heavy metal contents in soils

91 Topic Problem Indicator Diffuse pollution by Inorganic pollutants Are we protecting the environment effectively against heavy metal pollution? Critical load exceedance by heavy metals Diffuse pollution by nutrients and biocides What are the environmentally relevant key trends in agricultural production systems? Area under organic farming Diffuse pollution by nutrients and biocides Is the environmental impact of agriculture developing? Gross nutrient balance Diffuse pollution by persistent organic pollutants Which areas show critical concentration of organic pollutants? Concentration of persistent organic pollutants Diffuse pollution by soil acidifying substances How is the environmental impact of soil acidification developing? Topsoil pH Diffuse pollution by soil acidifying substances Are we protecting the environment effectively against acidification and eutrophication? Critical load exceedance by sulphur and nitrogen Local soil pollution by point sources How is the management of contaminated sites progressing? Progress in management of contaminated sites

92 Topic Problem Indicator Local soil pollution by point sources Is developed land efficiently used? New settlements established on previously developed land Local soil pollution by point sources How many sites exist which might be contaminated? Status of site identification Filtering function of soil What is the impact on soil function? Cation exchange capacity Filtering function of soil Is there a loss of organic matter? Organic matter content Filtering function of soil What is the actual availability of pollutants for plants and animals? Bioavailability of pollutants 3.12

Soil conservation and management Some of the less developed parts of the world employ slash-and-burn agriculture as well as other unsustainable subsistence farming techniques. Massive erosion, depletion of soil nutrients, and occasionally complete desertification are common effects of deforestation. Crop rotation, cover crops, conservation tillage, and installed windbreaks are methods for better soil conservation that have an impact on both erosions as well as fertility. Plants that die decompose and mix with the soil. For thousands of years, farmers have conserved their soil. In order to adequately address soil conservation in Europe, programmes like the Common Agricultural Policy focus on the adoption of best management practices including reduced tillage, winter cover crops, plant residues, as well as grass margins. To address the erosion issue, additional political and economic action is necessary. The way we value the land is a straightforward governance obstacle that can be overcome by cultural adaptation. As a carbon sink, soil carbon helps to slow down global warming.

93 3.12.1 Various Soil Conservation Methods i. Contour Ploughing With contour ploughing, furrows are oriented to follow the contour lines of the farmland. Runoff is decreased because furrows shift to the left and right to keep a steady altitude. For slopes from two to ten per cent, the ancient Phoenicians used contour ploughing. Crop yields can rise by 10% to 50% with contour ploughing, in part due to better soil retention. ii. Terrace Farming Creating almost level spaces on a hillside is a procedure known as terracing. The terraces are like a succession of steps, each one taller than the one before it. Other soil barriers shield terraces from erosion. Small farms tend to use terraced farming more frequently. iii. Keyline Design The improvement of contour farming known as keyline design involves creating contour lines while taking into account all of the characteristics of the watershed. iv. Perimeter Runoff Control By obstructing surface flows, ground cover, trees, and shrubs are efficient perimeter treatments for preventing soil erosion. The usage of a "grass path," which both channels and scatters runoff via surface friction, delaying surface runoff and enabling penetration of the sluggish surface water, is a unique kind of this perimeter or inter-row remedy. v. Windbreaks On the windward side of a field of agriculture vulnerable to wind erosion, windbreaks are adequately thick rows of trees. Although, as long as leaves are present throughout the months of bare ground surfaces, the impact of deciduous trees may also be sufficient. Evergreen species offer shelter all year round. vi. Soil Conservation Farming No-till farming, "green manures," and other soil-improving techniques are used in soil conservation agriculture, making it difficult to balance the soils. These farming techniques aim to replicate the biology of arid environments. They can restore depleted soil, reduce erosion, promote plant growth, do away with the need for nitrogen fertiliser and fungicides, yield yields that are above normal, and safeguard crops from drought and flooding. Less labour is required as a result, which lowers expenses and boosts farmers' earnings. Cover crops and no-till farming serve as nutrient sinks for nitrogen and other elements. Soil organic matter is increased as a

94 result. Repeated tilling and ploughs destroy the soil's beneficial fungus and earthworms. Even under ideal conditions, it may take several seasons for soil to make a full recovery once it has been harmed. vii. Salinity Management Irrigating using salty water contributes to the salinity of the soil. The salt is then left behind as the water is evaporated from the soil. Infertility and stunted growth result from salt's destruction of the soil's structure. Below is the list of ions that cause the salinisation of soil: Sodium (Na^+) Potassium (K^+) Calcium (Ca^{2+}) Magnesium (Mg^{2+}) and Chlorine (Cl) One-third of the world's arable land is said to be affected by salinity. Crop metabolism is negatively impacted by salinity in the soil, and erosion frequently follows. Drylands become salinized as a result of excessive irrigation and in locations with low saline water levels. Over- irrigation accelerates the pace at which salts are deposited in the upper soil layers as a consequence of soil infiltration. Given the extensive irrigation, the use of humic acids might avoid oversalination. Both anions and cations can be fixed by humic acids, which then remove them from root zones. Lowering water tables can be utilised to slow the capillary and evaporative accumulation of surface salts by planting species that can withstand salty environments. Saltbush is a plant that can withstand salt and is widespread in Europe's Mediterranean regions as well as much of North America. After the Aswan Dam was built in 1970, Egypt experienced the most well-known instance of shallow saline water table capillary activity. High salt contents in the water table were caused by the change in the groundwater level. Salinization of the soil was caused by the water table's persistently high level. viii. Soil Organisms A healthy variety of minerals and plant nutrients are transformed into forms that roots can absorb when worms excrete their waste as casts. In comparison to the surrounding top 150 millimetres (5.9 in) of soil, earthworm excretes are 5 times higher in available nitrogen, 7 times higher in available phosphates, and 11 times higher in available potash. More than 4.5 kg of castings per worm could be produced annually. The earthworm increases soil porosity by burrowing, forming

95 channels that help the aeration as well as drainage processes. To achieve high yields on degraded soil, synthetic fertiliser is needed. Lack of structure accelerates erosion and causes the pollution of rivers and streams with nitrogen. Every 1% increase in organic matter increases the capacity of the soil to hold 20,000. Nematodes, mycorrhiza, and bacteria are further significant soil creatures. Of all animal species, approximately 25 per cent live underground. There are significant information gaps regarding soil biodiversity, as per the 2020 Food and Agriculture Organization's report, "State of knowledge of soil biodiversity – Status, challenges and potentialities". ix. Mineralisation Active soil mineralisation is occasionally done in order to assist plants to reach their maximum phytonutrient ability. Broken rock or chemical soil additives may be added in this situation. Combating mineral depletion is the goal in both scenarios. A wide variety of minerals, from more familiar ones like zinc and selenium to less common ones like phosphorus, can be employed. The stage transformations of minerals within soil under aqueous contact have been extensively studied. An alluvial plain may get large sedimentation from flooding. While adding to a floodplain is a natural process that can revitalise soil chemistry with mineralisation, this impact may not be desired if floods endanger lives or if the silt comes from productive land. 3.13 Summary Soil is the upper most layer of the earth crust and a nutrient bin which provides all the nutrients required for plant growth. Soil forms through humification, eluviation and illuviation process. Weathering is the combination of process that breaking down of rocks, soil and minerals. It took place in variety of way, which are classified in to physical weathering that involves physical process, chemical weathering that involves chemical process and biological weathering that in involves biota. Clay material are divided into two class residual clay and transported clay. 3.14 Questions/ Self-Assessment questions 1 . Why is soil conservation important? 2 . What are effects of soil conservation? 3 . What is pH level of soil? 4 . How does the soil forms? 5 . What do you know about eluviation and illuviation process? 6 . describe physical weathering process. 7 . what do you mean by sedimentation? 8 . describe different structure prevails in clay minerals.

96 9 . What is cation exchange capacity of soil? 3.15 Select Readings/ Suggested Readings 1 . Benjamin K. The Clay Mineral – Structure. 2004. Available from http://www.groundwaterresearch.com.au/reference_files/hydrology_and_the_clay_miner als/structure.htm (Accessed on 2020-07-23) 2 . https://byjus.com/free-ias-prep/soil-conservation/ 3 . Glossary of Soil Science Terms. https://www.soils.org/publications/soils-glossary/# 4 . Guggenheim S. Introduction to the properties of clay mineral. Available from http://www.minsocam.org/msa/Monographs/Mngrph_03/MG003_371-388.pdf 5 . https://secure.caes.uga.edu/extension/publications/files/pdf/C%201040_3.PDF 6 . https://ugc.berkeley.edu/background-content/sedimentation/ 7 . https://www.nrdc.org/stories/soil-erosion-101 8 . https://www.recare-hub.eu/soil-threats/contamination 9 . Kerr, P. F. (1952). Formation and occurrence of clay minerals. Clays and Clay Minerals, 1, 19-32. 10 .Kumari, N., & Mohan, C. (2021). Basics of clay minerals and their characteristic properties. Clay Clay Miner, 24, 1-29. 11 .Layer silicate clays – Genesis and classification. Available from http://ecoursesonline.iasri.res.in/Courses/Introduction%20to%20Soil%20Science/SSAC1 21/Data%20Files/lec15.pdf, (Accessed on 2020-07-30) 12 .Marshak, S., & Repcheck, J. (2009). Essentials of geology. WW Norton. 13 .Ombaka, O. (2016). Characterization and classification of clay minerals for potential applications in Rugi Ward, Kenya. African Journal of environmental science and Technology, 10(11), 415-431. 14 . Soil Test Handbook for Georgia. Kissel, D.E. and L. Sonon (Eds). 2008. http://aesl.ces.uga.edu/publications/ soil/STHandbook.pdf

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Unit 4: Fundamentals of climatology 4.1 Objectives 4.2 Introduction 4.3 Scale of meteorology 4.4 The Elements of Weather and Climate 4.5 Coriolis force 4.6 Pressure gradient force 4.7 Frictional force 4.8 Indian Monsoon 4.9 Koppen's Classification of Climatic Regions of India 4.10 Summary 4.11 Questions/ Self-Assessment questions 4.12 Select Readings/ Suggested Readings 4.1 Objectives By successfully completing this unit, you will be able to: • know about different scale of meteorology. • Understand the elements of climate • Understand the Coriolis force and pressure gradient force • visualize the Indian monsoon • demonstrate koppen's classification of climatic regions of India 4.2 Introduction

Weather is the condition of the atmosphere over a brief period of time. For example, we speak of today's weather or the weather this week. Climate represents the composite of day-to-day weather over a longer period of time. A climatologist attempts to discover and explain the impacts of climate so that society can plan its activities, design its buildings and infrastructure, and anticipate the effects of adverse conditions. Although climate is not weather, it is defined by the same terms, such as temperature, precipitation, wind, and solar radiation.

Atmospheric scientists often subdivide study of complexity of gaseous envelope that surrounds the earth into specific areas of interest. One such division identifies the fields of meteorology and climatology. Meteorology is a science that deals with motion and the phenomena of the atmosphere with a view to both forecasting weather and explaining the processes involved. It deals largely with status of atmosphere over a short period of time and utilizes physical

98 principles to attain its goal. Climatology is the study of atmospheric conditions over a longer period of time. It includes the study of different kinds of weather that occur at a place. Dynamic change in the atmosphere brings about variation and occasionally great extremes that must be treated on the long term as well as the short term basis. As a result, climatology may be defined as the aggregate of weather at a place over a given time period. There is diversity of approaches available in climate studies. Figure 4.1. Illustrates the major subgroups of climatology, the approaches that can be used in their implementation, and the scales at which the work can be completed. Figure 4.1: Subgroups, Analytical methods and scales of climatic study. [Source: J. E. Olive 1981, P4 used by permission of V. H. Winston and Sons.] Climatography consists of the basic presentation of data and its verbal or cartographic description. Physical Climatology deals largely with the energy exchanges and physical components.

99 Dynamic Climatology is more concerned with atmospheric motion and exchanges that lead to and result from that motion. Applied Climatology is the scientific application of climatic data to specific problems within such areas of forestry, agriculture, and industry. It can involve the application of climatic data and theory of other disciplines, such as geomorphology and soil science. The analytical approaches suggested in the above figure 1. are self-explanatory, with the possible exception of the synoptic approach, an analytic method that combines each of the others. The object of synoptic climatology is to relate local or regional climates to atmospheric circulation. 4.3

Scale of

meteorology The scale of meteorology is the spatial, but also the temporal scale of individual weather phenomena and their combination. In other words, when studying weather, meteorologists, as well as geographers and other scientists, use maps of different scales in order to better search, study, understand and predict these or those phenomena, focusing on a certain area whether it is a local phenomenon or the whole world. And this is very logical: to study a small weather event, it is important to immediately draw its boundaries, which cannot be exceeded; a bigger one wider boundary, and so on all the way around the world. Hence, there are four main scientific scales, including meteorology: microscale, mesoscale, macroscale, or synoptic, and megascale. Important: we are talking about both horizontal weather scales from a few centimeters to the whole world, and vertical scales within the troposphere and the beginning of the stratosphere, that is, the first two layers of the atmosphere from the earth, which are actually where all weather phenomena are contained. So, in this article, we will deal with all four types of meteorological scales. Let us say at once that these divisions are somewhat conditional, their boundaries may be blurred, and they also may not coincide in exact values with similar scales in other sciences. 4.3.1 Microscale meteorology — small or local Microscale meteorology or micrometeorology (as well as small or local meteorology) studies the smallest weather phenomena on a scale of a few centimetres to a kilometer or a bit more, which lasts no more than a day (24 hours). For example, soil temperature in some small areas, certain features of clouds of particular types, short-lived thunderstorms, local turbulence, and others, but more importantly, their relationships with each other or how one passes into the other.

100 This also includes, for example, the study of individual air pollutants, which are taken into account in calculating the Air Quality Index (AQI). Specifically, there are top five air pollutants in the US are ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide. So, this is the kind of weather phenomenon that cannot be depicted on a normal weather map. (Although there are air quality maps.) Figure 4.2: Types of clouds. [

Source:

Valeriya Milovanova / Windy.app] 4.3.2 Mesoscale meteorology — medium or regional Mesoscale meteorology or mesometeorology (as well as medium or regional meteorology) studies medium-scale weather phenomena from a few kilometers to several hundred and a thousand or two, but usually not more, that last from one day to several days to a week. For example, these are weather fronts or collision boundaries of air masses of different temperatures, which refer to convection processes (circulation) in the atmosphere. They are of two main types — cold and warm. Fronts bring with them certain weather, but above all speak of its variability. Weather fronts can be as large as a medium-sized U.S. state such as Ohio. This also includes weather phenomena such as large thunderstorms, squall lines, sea and land breezes, vortexes, and others.

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Figure 4.3: Cold fronts and warm weather fronts. [Source:

Valeriya Milovanova / Windy.app] 4.3.3 Synoptic scale meteorology — large or national and continental Macroscale meteorology more commonly called synoptic scale meteorology or large-scale meteorology (as well as national or continental) studies large-scale weather events of several hundred to several thousand kilometers that last up to several weeks. The word "synoptic", different from the other names, comes from the Greek word συνοπτικός (synoptikos), which means "seen together." For example, it is atmospheric pressure or the force with which a column of air presses against the surface at a particular place on the earth. Hence it can be low or high, and cover vast areas. Like the circulation of air masses, pressure is the essence of large-scale weather events or systems such as tropical cyclones (hurricanes in North America and typhoons in Asia), heat and cold waves, and others. Cyclones can be the size of several states in the southeast U.S. or several countries in East Asia, which they basically go through every year. This also includes another, rarer variety of cyclones — extratropical cyclones or mid-latitude cyclones, with a more self-speaking name. They also carry severe gales, thunderstorms, blizzards, tornadoes, and other extreme weather events.

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Figure 4.4:

Cyclones formation in North Atlantic Ocean. [Source: Valeriya Milovanova / Windy.app] 4.3.4 Megascale meteorology — largest or global Megascale meteorology or megameteorology (as well as largest or global meteorology), as the name suggests, studies weather phenomena on a worldwide scale that last up to a month or more and occur continuously or with a certain periodicity, that is, they go from weather to climate (average weather over months, years, decades, and further down to millions of years). For example, these are the global winds that blow around the globe. The two main types of global winds are trade winds, which blow all the time from the tropics to the equator, and monsoons, which change direction according to the seasons. It carries air masses of varying temperature and humidity, causing drought and rain. We emphasize again that global winds and other large-scale weather phenomena travel vast distances as they circle the earth (equatorial length is 40.075 km), and time intervals. This also includes, say, El Niño in South America, which occurs once every five years and disrupts the usual atmospheric and oceanic processes.

103 Figure 4.5: Wind direction on the planet: global winds and west winds. [Source: Valeriya Milovanova / Windy.app] 4.3.5 Four meteorological scales: comparison table

104 4.4

The Elements of Weather and Climate Weather is nothing more than the different elements it is composed of, as well as the way they interact with each to create different atmospheric conditions or weather events. We first need to identify what the elements are that make up the weather. Eight primary elements/factors drive all weather: 1 . Temperature 2 . Air (Atmospheric) Pressure 3 . Wind (Speed & Direction) 4 . Humidity 5 . Precipitation 6 . Visibility 7 . Clouds (Type & Cover) 8 . Sunshine Duration 1 . Temperature We all know what temperature is. When discussing the weather, this will probably be one of the first topics that come up. It is because we are so sensitive to temperature and quickly become aware of feeling cold or hot. We know what it feels like, but what exactly is temperature? What Is Temperature? Temperature is a measurement of the amount of kinetic energy present in the air, which manifests itself physically through the experience of heat or cold. The scales typically used to measure temperature, is Celsius, Fahrenheit, and Kelvin. The instrument used to measure temperature is called a thermometer. In more practical terms, it means that the particles in the air move or vibrate at a certain speed, which creates kinetic energy. When the particles start to move/rotate around faster, temperature increases. When the particles begin to slow down, the temperature also starts to decrease. Instrument for Measuring Temperature The thermometer is the instrument used to measure temperature. They come in all shapes and sizes and dates all the way back to 1714. The mercury, bimetal, and digital thermometer are the 3 most commonly used instruments for measuring ambient temperature. 2 . Air Pressure

105 Air pressure is another essential element of weather, especially when it comes to creating or changing atmospheric conditions. It is also one of the critical variables used to make accurate weather forecasts. What Is Air (Atmospheric) Pressure? Air Pressure is the result of the pressure created by the weight of the air in the Earth's atmosphere. It is also called a barometric pressure, named after the instrument used to measure air pressure. Although it may not be visible, air has weight since it is not empty. It is filled with small particles of nitrogen, oxygen, argon, carbon dioxide and a few other gases. The weight of the particles in the air creates pressure due to the gravitational force of the Earth. Since more air is present above the air close to the ground, air pressure is the highest on the planet's surface and decreases as altitude increase. Instrument for Measuring Air Pressure The barometer is the instrument used to measure air pressure. Evangelista Torricelli developed the first device in 1643. Like the thermometer, the barometer also comes in different forms. Some examples include mercury, water, aneroid, and digital barometers. 3 . Wind (Speed & Direction) The movement of air (wind) is one of the main driving forces of weather. The majority of major and even extreme weather events like cold & warm fronts, clouds, thunderstorms, and hurricanes are all driven by wind. What Is Wind? Wind is the large-scale movement of

air from an area of high to an area of low pressure in the atmosphere. The speed and strength of wind are determined by the distance between the lowpressure and high-pressure areas, as well as the difference in air pressure. Instruments for Measuring Wind Speed and Direction The anemometer is the instrument used to measure wind speed. Consisting of 3-4 half-cups on arms rotating around a central axis, you can typically find it on top of a weather station or at an elevated position. A wind vane (or weather vane) is the instrument used to measure wind direction. It is a flat-shaped object that spins freely on an axis. Very often in the shape of an arrow or cockerel, you can also find it on top of a weather station or highly elevated objects. It is common to see them on top of roof chimneys, church towers, and even communication towers.

106 4 . Humidity Humidity is another weather element that cannot be seen but can be felt. It not only plays a big part in weather formation but also directly influence our physical comfort levels. What Is Humidity? Humidity is the amount of water vapor that is present in the atmosphere at any specific time. Water vapor is nothing more than water in a state of gas (after the liquid has evaporated). Although humidity and its effects can usually be felt, it is normally invisible to the naked eye. Humidity can be challenging to understand and interpret correctly. Then you also have to be able to make a clear distinction between absolute and relative humidity. Instrument for Measuring Humidity The hygrometer is the instrument used to measure wind speed. You also find more than one type of this device, like the psychomotor and the resistance hygrometer. 5 . Precipitation There is no argument that water in any of its forms is an absolute necessity for life on Earth to exist. Humans, animals, and plants need water to grow or stay alive, and precipitation is the only way to replenish the dams, rivers, reservoirs, and groundwater on which we rely. What Is Precipitation? Precipitation is water in all its different states, which formed after condensation turned water vapor into its solid form, which falls to the ground after it becomes too heavy to stay suspended in the air. Precipitation can take the form of rain, snow, hail, or graupel. Precipitation is primarily the result of evaporation and condensation. Instrument for Measuring Rainfall A rain gauge is the instrument used to measure rainfall. It is essentially a measured container that captures rain and measures the amount that falls over a set period of time. 6 . Visibility Visibility may seem like a very unlikely element of weather, but is especially important when discussing and measuring weather conditions like fog, mist, freezing drizzle, and smog. What Is Visibility? Visibility is the measurement of the degree through which an object can be observed over a certain distance. This measurement is crucial when conditions like mist, haze, fog, and freezing drizzle are present, which can severely impede visibility. The importance to be able to measure

107 this element is often underestimated. It is especially applicable in areas where visibility plays a crucial role, like airports and harbors where it can literally be a matter of life or death. Instrument for Measuring Visibility Visibility sensors like "forward scatter sensor" are the instruments used to measure visibility. In the past, using your own vision (eyes) to measure the degree to which you can observe an object, was the standard. 7 . Clouds (Type & Cover) It is no secret that clouds are one of the quickest ways to determine current and future weather conditions. Studying them in more detail with scientific equipment is very valuable to make very accurate assessments of present and feature atmospheric conditions. What Are Clouds? Clouds are water droplets or water in different states (like ice and snow crystals), which formed after water vapor reached condensation level and could no longer remain in gaseous form. Knowing how to identify a certain type of cloud and the weather associated with it, can prove valuable when assessing weather conditions with only visual references. Instrument for Measuring Clouds The advanced instruments meteorologists use to study clouds in detail are weather satellites and radars. Satellite and radar images are able to accurately measure cloud density, the amount of moisture, the temperature, and movement of the clouds. 8 . Sunshine Duration The amount of sunshine the Earth receives (which is a characteristic of solar radiation) greatly influence other elements of the weather like ambient temperature, and more indirectly humidity and air pressure. What Is Sunshine Duration? Sunshine duration is the length of time the Earth's surface is directly exposed to solar radiation. It is also referred to as sunlight hours and measure the amount of exposure over a set period of time (generally in hours per day or year.) As already stated, sunshine duration influences other weather elements, which can change the whole makeup of the weather conditions. This ability makes it a more powerful and influential factor than you might think. Instrument for Measuring Sunshine

108 Sunshine recorders, more specifically Campbell–Stokes recorders, are the instruments used to record sunshine duration. Campbell–Stokes recorders basically consist of a spherical lens that focuses sunlight on a specific type of tape to make its measurement. 4.5

Coriolis force What is the Coriolis Force? In any rotating reference frame, such as the Earth, a merry-go-round or a spinning ice skater, an observer sees a new influence on the motion of objects. A ball thrown between two friends on a merry-go-round will appear to them to take a curved path. They are spinning with the merry-go- round, while the ball moves freely through the air. The force that causes this curvature of motion in the rotating reference frame is the Coriolis force. It always points perpendicular to the object's velocity. This famous force is most widely associated with large-scale phenomena, especially in meteorology. However, the Coriolis force is named after a French mathematician who worked in a very different field. Gaspard Gustave Coriolis' (1792-1843) most famous paper was entitled "On the equations of relative motion of a system of bodies," and an earlier paper was called "On the principle of kinetic energy in the relative motion in machines." Coriolis is credited with extending the concepts of work and energy to the rotating reference frame and applied his research to machines such as waterwheels.

Once air has been set in motion by the pressure gradient force, it undergoes an apparent deflection from its path, as seen by an observer on the earth. This apparent deflection is called the "Coriolis force" and is a result of the earth's rotation.

109 As air moves from high to low pressure in the northern hemisphere, it is deflected to the right by the Coriolis force. In the southern hemisphere, air moving from high to low pressure is deflected to the left by the Coriolis force. The amount of deflection the air makes is directly related to both the speed at which the air is moving and its latitude. Therefore, slowly blowing winds will be deflected only a small amount, while stronger winds will be deflected more. Likewise, winds blowing closer to the poles will be deflected more than winds at the same speed closer to the equator. The Coriolis force is zero right at the equator. 4.5.1

Deflection of Moving Objects One simple example of the Coriolis force has been observed at least as early as 1651. Italian military officers wrote that in artillery practice their cannon balls always landed to the right of where their calculations predicted. Their observations were correct. The cannon ball was shot over such a long distance that while it was in the air, the Earth rotated underneath it. Since these officers were in Italy, they saw the cannon balls curve to the right (Earth rotates counter clockwise in the northern hemisphere). Earth is a rotating reference frame. This is why the Coriolis force can be observed acting on a cannon ball (as long as it is shot over a sufficiently large distance). There are countless other examples of the Coriolis force acting on Earth. In fact, it is crucial to creating the conditions on Earth that we take for granted. Some of the major instances of the Coriolis force on Earth are discussed under the "Rotating Earth" section of this website. 4.5.2 Quantifying the Coriolis Force From a rotating reference frame, any object in motion will be influenced by the Coriolis force. Its strength depends on only a few variables, and the relative direction of their vectors. First of all, the object's linear (tangential) velocity must be considered. Only the component of velocity that is perpendicular to the rotating frame's axis of rotation contributes to the Coriolis force. Angular

110 velocity, then, is also a factor in the equation for the Coriolis force. In particular, one must determine the cross product of linear velocity and angular velocity. The final factor in the Coriolis force is the mass of the object.

F Coriolis = $-2m(\Omega \times v)$

The vector equation for the Coriolis force is shown above. The underlined and bolded characters are vectoring whose magnitudes and directions must be considered. As mentioned, the cross product between rotational velocity (omega) and linear velocity (v) multiplies only the vector components that are orthogonal. The result of the cross product is orthogonal to both v and Ω. Its direction can be determined by the right-hand rule. Take your right hand and orient your index finger, middle finger and thumb as shown below.

111 4.6

Pressure gradient force The variation of heating (and consequently the variations of pressure) from one locality to another is the initial factor that produces movement of air or wind. The most direct path from high to low pressure is the path along which the pressure is changing most rapidly. The rate of change is called the pressure gradient. Pressure gradient force is the force that moves

air from an area of high pressure to an area of low pressure. The

velocity of the wind depends upon the pressure gradient. If the pressure gradient is strong, the windspeed is high. If the pressure gradient is weak, the windspeed is light. Figure 4.6 shows that the flow of air is from the area of high pressure to the area of low pressure, but it does not flow straight across the isobars. Instead, the flow is circular around the pressure systems. Pressure gradient force (PGF) causes the air to begin moving from the high-pressure to the low-pressure system. Coriolis (deflective) force and centrifugal force then begin acting on the flow in varying degrees. In this example, frictional force is not a factor. Figure 4.6: Pressure gradient

force 4.7

Frictional force Friction is the force that resists motion when the surface of one object comes in contact with the surface of another. The mechanical advantage of a machine is reduced by friction, or in other

112 words, the ratio of output to input is reduced because of friction. An automobile uses one-quarter of its energy on limiting friction. Yet, it is also friction in the tires that allows the car to stay on the road and friction in the clutch that makes it possible to drive. From matches to machines to molecular structures, friction is one of the most significant phenomena in the physical world. In this article, let us discuss frictional force and its different types. What is frictional force? The force generated by two surfaces of two objects when they come in contact and slide against each other is called the force of friction. The factors affecting frictional force include: • The frictional force is significantly affected by the texture of the surface and the quantity of force that propels them together. • The force of friction is affected by the position and angle of the object. • If we place an object flat against another object, then the force of friction is equal to the object's mass. • If we push an object against the surface of another object, then the amount of the frictional force is increased, which becomes higher than the object's weight. Calculating Frictional Force The friction
force formula is given by: F = μN Suppose we consider a wood block weighing 2 kg lying on a table to be moved from rest. We consider the static friction coefficient in this case, which is 00.5 in the case of wood. The normal force can be calculated with the given details, N = 2 kg × 9.8 N/kg = 19.6 N As we now have the values of static friction coefficient and normal force, the frictional force can be calculated as follows: F = 0.5 × 19.6 N = 9.8 N
113 4.8
Indian Monsoon • The climate in India is hot monsoonal, as is the climate in South and Southeast Asia. • Out of four seasons prevailing in the Indian subcontinent, monsoon seasons acquire two. They are • The Southwest Monsoon Season • The North-East Monsoon Season 4.8.1
Onset of the Monsoon • When the sun shines vertically over the Tropic of Cancer in April and May, the large landmass to the north of the Indian Ocean becomes extremely hot. • In the
north western
part of the subcontinent, this results in the formation of an intense low-pressure system. • The low-pressure cell attracts southeast trades across the Equator because the pressure in the Indian Ocean to the south of the landmass is high due to the slow heating of water. • These conditions aid in the ITCZ northward shift in position. •
After crossing the Equator, the southwest monsoon can be seen as a continuation of the southeast trades deflected towards the Indian subcontinent. • Between 40°E and 60°E longitudes, these winds cross the Equator. • The southwest monsoon arrives on the Kerala coast on June 1st and moves quickly through Mumbai and Kolkata between June 10th and 13th. • The southwest monsoon engulfs the entire subcontinent by mid-July.
Intertropical
Convergence Zone (ITCZ)
114 The ITCZ is a low-pressure belt that determines precipitation in the tropics by its northward and southward movements along the equator. 4.8.2
The Southwest Monsoon Season • The Rainy Season is from June to September. • As a result of the rapid rise in temperature over the north western plains in May, the low- pressure conditions there have become even more intense. • They are powerful enough to attract the Southern Hemisphere trade winds coming from the Indian Ocean by early June. • These southeast trade winds cross the equator and enter the Bay of Bengal and the Arabian Sea, only to become entangled in the air circulation over India. • They bring a lot of moisture with them as they pass over the equatorial warm currents. • They travel in a
south-westerly
direction after crossing the equator. Southwest monsoons are named after this.
115 Figure 4.7: The direction of Southwest Monsoon in India 4.8.3 Southwest Monsoon Bursts • The rain begins abruptly during the southwest monsoon season. • The first rain has the effect of significantly lowering the temperature. • The "break" or "burst" of the monsoons refers to the sudden onset of moisture-laden winds accompanied by violent thunder and lightning. • In the coastal areas of Kerala, Karnataka, Goa, and Maharashtra, the monsoon may arrive in the first week of June, while in the interior, it may arrive in the first week of July. • Between mid-June and mid-July, the daytime temperature drops by 5°C to 8°C. • The relief and thermal low pressure over northwest India modify the south westerly direction of these winds as they approach the land.
116 • The monsoon is divided into two branches as it approaches the landmass: • The Arabian Sea branches • The Bay of Bengal branch 4.8.4
North-
East Monsoon • The northeast monsoon enters India from the northeast. • The wind blows from the sea to the land in this type of monsoon. • The moisture from the Indian Ocean is carried by the monsoon winds. • The northeast monsoon is limited to south India, bringing rain to Tamil Nadu, Puducherry, Karaikal, Yanam, Andhra Pradesh, Kerala, Mahe, and south interior Karnataka from October to December. • Low-pressure systems, depressions, and cyclones cause the associated rainfall, also known as the winter monsoon. • This is Tamil Nadu's main rainy season, with the state receiving 48% (447.4mm) of its annual rainfall during these three months.

117 Figure 4.8: The direction of North-East Monsoon in India 4.8.5

Monsoon winds of the Arabian Sea The three branches of the monsoon winds that originate over the Arabian Sea are as follows: • The first stream hits India's west coast, dumping over 250 cm of rain on the country. • It strikes the Western Ghats perpendicularly, resulting in abundant Orographic Rainfall [400 to 500 cm annual rainfall on the windward side]. • On the leeward side of the crest, rainfall is reduced to about 30-50 cm. • On the immediate leeward side of the Western Ghats, there is a narrow belt of severe aridity. • However, once it has passed, the air begins to rise again, and rainfall amounts increase further east.

118 • The second stream flows through the Narmada—Tapi troughs (narrow rift valley) before reaching central India. • Due to the lack of a major orographic obstacle across the rift, it does not produce much rain near the coast. • This stream brings rain to some parts of central India (Ex: Nagpur). • The third stream runs parallel to the Aravali Range and does not produce much rain. As a result, Rajasthan is primarily a desert state. • On the south-eastern edge of the Aravali Range, however, there is some orographic effect. • Mt. Abu receives about 170 cm of rain, whereas the surrounding plains receive only 60

to 80 cm. 4.9

Koppen's Classification of Climatic Regions of India • Koppen's Classification of Climatic Regions of India

is an empirical classification

based on mean annual and mean monthly temperature and precipitation data. •

Koppen

identified a close relationship between the distribution of vegetation and climate. •

He selected certain values of temperature and precipitation and related them to the distribution of vegetation and used these values for classifying the climates. •

Koppen recognized

five major climatic groups, four of them are based on temperature and one on precipitation.

The capital letters: 1 . A, C, D and E delineate humid climates and 2 . B dry climates.

The climatic groups are subdivided into types, designated by small letters, based on seasonality of precipitation and temperature characteristics. The seasons of dryness are indicated by the small letters: f, m, w and s, were 1 . f – no dry season, 2 .

m – monsoon climate, 3 . w – winter dry season and 4 . s – summer dry season. • The

above mentioned major climatic types are further subdivided depending upon the seasonal distribution of rainfall or degree of dryness or cold. a: hot summer, average temperature of the warmest month over 22°C

119 c: cool summer, average temperature of the warmest month under 22°C f: no dry season w: dry season in winter s: dry season in summer g: Ganges type of annual march of temperature; hottest month comes before the solstice and the summer rainy season. h: average annual temperature under 18°C m (monsoon): short dry season. • The capital letters S and W are employed to designate the two subdivisions of dry climate: 1 . semi-arid or Steppe (S) and 2 . arid or desert (W). • Capital letters T and F are similarly used to designate the two subdivisions of polar climate 1 . tundra (T) and 2 . icecap (F).

Table 4.1: Climatic Groups According to Koeppen

120 Table 4.2: Climatic Types According to Koeppen

121 Figure 4.9: Koeppen's classification of Indian Climate

122 Table 4.3:

Koeppen's Scheme – Climatic Regions of India Climate type Region Annual rainfall Amw (Monsoon type with short dry winter season) Western coastal region, south of Mumbai over 300 cm As (Monsoon type with dry season in high sun period) Coromandel coast = Coastal Tamil Nadu and adjoining areas of Andhra Pradesh 75 – 100 cm [wet winters, dry summers] Aw (Tropical Savanah type) Most parts of the peninsular plateau barring Coromandel and Malabar coastal strips 75 cm BShw (Semi-arid Steppe type) Some rain shadow areas of Western Ghats, large part of Rajasthan and contiguous areas of Haryana and Gujarat 12 to 25 cm BWhw (Hot desert type) Most of western Rajasthan less than 12 cm Cwg (Monsoon type with dry winters) Most parts of the Ganga Plain, eastern Rajasthan, Assam and in Malwa Plateau 100 – 200 cm Dfc (Cold, Humid winters type with shorter summer) Sikkim, Arunachal Pradesh and parts of Assam ~200 cm 123 Et (Tundra Type) Mountain areas of Uttarakhand The average temperature varies from 0 to 10°C Rainfall varies from year to year. E (Polar Type) Higher areas of Jammu & Kashmir and Himachal Pradesh in which the temperature of the warmest month varies from 0° to 10°C Precipitation occurs in the form of snow 4.9.1

Advantages • It has precise definitions that can be applied easily to standardize data that are available for • locations throughout the world. • reasonable correlation globally with major vegetation regions • It requires a minimum amount of calculation. • It is widely used in educational circles throughout the world. 4.9.2 Limitations • It utilizes, for example, only the data or mean monthly temperature and precipitation. • There is not provision for variations in the strength or constancy of winds, temperature extremes, • precipitation intensity and range, amount of cloud cover, or the net radiation balance. • more precise and varied factors are not included. 4.10

Summary 4.11 Questions/ Self-Assessment questions 1 . Make a comparison on different scale of meteorology. 2 . What is Coriolis force? How does it works? 3 . What is pressure gradient force 4 . Describe the north-east monsoon and southern burst of Indian monsoon. 5 . Demonstrate koppen's classification of climatic regions of India

124 6 . What are the advantages of koppen's classification? 7 . What is ITCZ? 4.12 Select Readings/ Suggested Readings 1 . Global climate change. Ipswich, Mass., H.W. Wilson, a division of EBSCO Information Services 2 . https://phys420.phas.ubc.ca/p420_12/tony/Coriolis_Force/Home.html 3 . http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/fw/crls.rxml 4 . Balasubramanian, A.. (2017). ELEMENTS OF CLIMATE AND WEATHER. 10.13140/RG.2.2.30133.58085. 5 . http://www.jiwaji.edu/pdf/ecourse/tourism/elements%20of%20weather%20and%20clima te.pdf 6 . https://windy.app/blog/scales-of-meteorology.html 7 . https://www.imdpune.gov.in/training/training%20notes/Climatology-IMTC.pdf 8 . https://drought.unl.edu/Education/DroughtIn-depth/WhatisClimatology.aspx 9 . https://www.pmfias.com/climatic-regions-of-india-stamps-koeppens-classification/ 10 .https://old.amu.ac.in/emp/studym/99993675.pdf 11 .https://prepp.in/news/e-492-indian-monsoon-geography-notes 12 .https://meteorologytraining.tpub.com/14312/css/14312_65.htm 13 .https://www.turito.com/blog/physics/frictional-force 14 .https://pcsstudies.com/climatic-regions-of-india/ 15 .Climatology, Lal. D.S. Sharda Pustak Bhawan (1 January 2011)

125 Unit 5: Climate Change 5.1 Objectives 5.2 Introduction 5.3 Climate Change 5.4 National Action Plan on Climate Change (NAPCC) 5.5 Green Building 5.6 GRIHA Rating Norms 5.7 COPs 5.8 Summary 5.9 Questions/ Self-Assessment questions 5.10 Select Readings/ Suggested Readings 5.1 Objectives By successfully completing this unit, you will be able to: • know about climate change and its feedback and response's • know about the National Action Plan on Climate Change (NAPCC) • Understand the green building why it called • Understand GRIHA rating procedures • visualize the time frame of COPs 5.2 Introduction Recognition of climate change as a significant global environmental change has a recent origin. International effort to address climate change formally began two decades ago with the adaptation of the United Nation Framework Convention on Climate Change (UNFCCC)

in 1992. Notwithstanding the ultimate objectives of the convention to stabilize the green houses gases concentration in the atmosphere, scientific assessment has continued to warn about plausible futures with varying degrees of climate change (IPCC,2001). Multilateral negotiation till date have paid greater attention to the control of greenhouse gas emission that cause the climate change. The prominence of emission mitigation in global negotiation obscured the importance of the vulnerability of natural and human system to climate changes and their adaption to such changes. And of the need for strategies to adopt to the chaining climate (IPCC,2001). The complexity of the climate change regime arises from multiple asymmetries. An important asymmetry is the separation between the historical sources of emissions and those who are vulnerable to its effects, while most of the anthropogenic greenhouse gas emission are contributed by economic activities in affluent nations, the burden of climate change impacts on poorer nations is disproportionately high. The risk of the poorer nations are greater due to dual

126 effects; first is the uneven natural distribution of impacts that causes greater damage in tropical regions, second is the higher vulnerability of poorer nations due to their lower capacity and means to adopt. The fact that the impacts are inadequately understood adds further to the existing risk. Realization that climate is far from being constant came only during the 1840s, when indisputable evidence of former Ice Ages was obtained. Studies of past climate began with a few individuals in the 1920s and gained momentum in the 1950s. Instrumental records for most parts of the world span only the past 100 to 150 years, and are typically assembled at monthly, seasonal or annual time resolution. However, proxy indicators from tree rings, pollen in bog and lake sediments, ice core records of physical and chemical parameters, and ocean foraminifera in sediments provide a wealth of paleoclimatic data. Tree rings and ice cores can give seasonal or annual records. Peat bog and ocean sediments may provide records with 100 to 1000-year time resolution. In any study of climate variability and change, one must pay careful attention to possible artifacts in the records. For instrumental records, these include changes in instrumentation (e.g., rain gauge types), observational practices, station location, or the surroundings of the instrumental site, or even errors in transcribed data. Proxy records may suffer from errors in dating or interpretation. Even when climate signals are real, it may be difficult to ascribe them to unique causes owing to the complexity of the climate system, a system which is characterized by myriad interactions between its various components on a suite of spatial and temporal scales. 5.3 Climate Change The United Nations Framework Convention on Climate Change (UNFCCC) offers a different definition that can help to resolve some of these problems. They define climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the atmosphere and which is in addition to natural climate variability observed over comparable timescales'. This definition is useful in that it makes a clear distinction between natural processes and anthropogenic influences. The remainder of this chapter will view climate change in this context. Variability, in turn, will be viewed as associated with natural processes. 5.3.1 General Considerations In this final chapter we examine climate variability and change, climate forcing factors, feedbacks and projected future states of the climate system. In many parts of the world, the climate has varied sufficiently within the past few thousand years to affect patterns of agriculture and settlement. As will become clear, the evidence is now overwhelming that human activities have begun to influence climate.

127 Realization that climate is far from being constant came only during the 1840s, when indisputable evidence of former Ice Ages was obtained. Studies of past climate began with a few individuals in the 1920s and gained momentum in the 1950s (see Box 13.1). Instrumental records for most parts of the world span only the past 100 to 150 years, and are typically assembled at monthly, seasonal or annual time resolution. However, proxy indicators from tree rings, pollen in bog and lake sediments, ice core records of physical and chemical parameters, and ocean foraminifera in sediments provide a wealth of paleoclimatic data. Tree rings and ice cores can give seasonal or annual records. Peat bog and ocean sediments may provide records with 100 to 1000-year time resolution. In any study of climate variability and change, one must pay careful attention to possible artifacts in the records. For instrumental records, these include changes in instrumentation (e.g., rain gauge types), observational practices, station location, or the surroundings of the instrumental site, or even errors in transcribed data. Proxy records may suffer from errors in dating or interpretation. Even when climate signals are real, it may be difficult to ascribe them to unique causes owing to the complexity of the climate system, a system which is characterized by myriad interactions between its various components on a suite of spatial and temporal scales. What is the distinction between climate variability and change? Climate variability, as defined by the Intergovernmental Panel on Climate Change (IPCC), refers to fluctuations in the mean state and other statistics (such as the standard deviation, extremes, or shape of frequency distribution, see Note 1) of climate elements on all spatial and temporal scales beyond those of individual weather events. Variability can be associated with either natural internal processes within the climate system, or with variations in natural or anthropogenic climate forcing. Climate change, by contrast, is viewed by the IPCC as a statistically significant variation in the mean state of the climate or in its variability persisting over an extended period, typically decades or longer. Climate change may be due to natural internal processes, natural external forcings, or persistent anthropogenic-induced changes in atmospheric composition or land use. The student may be excused if the distinction seems fuzzy. A given climate record, whether from instrumental or from proxy sources, may exhibit a suite of behaviors. It may document a rapid shift from one mean state to another (B), a gradual trend, followed by a new mean state (C) or a change in the variance with no change in the mean over the period of record (D). Even within a fairly stable mean state, there can be fluctuations about that state that are quasiperiodic (B) or non-periodic (C). In turn, a record might be characterized only by long periodic oscillation (A). Given that climate variability as viewed by the IPCC includes fluctuations on all spatial and temporal scales beyond synoptic weather events, one could legitimately view all of the behaviors in the figure as expressions of variability. On the other hand, while one can correctly say (for example) that the major glacial and interglacial cycles of the Pleistocene are expressions of climate variability within the past two million years, it is also appropriate to consider the evolution from full glacial to interglacial conditions as an expression of climate change. Similarly, while we usually view the global temperature rise over the past 100 years as climate

128 change, reserving the term variability for embedded shorter timescale features, the century long warming could also be viewed as an aspect of climate variability over the past 1000 years. The distinction between variability and change is hence dependent on the time frame over which one considers the climate statistics. The United Nations Framework Convention on Climate Change (UNFCCC) offers a different definition that can help to resolve some of these problems. They define climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the atmosphere and which is in addition to natural climate variability observed over comparable timescales'. This definition is useful in that it makes a clear distinction between natural processes and anthropogenic influences. The remainder of this chapter will view climate change in this context. Variability, in turn, will be viewed as associated with natural processes. 5.3.2 Climate Forcing, Feedback and Response The most fundamental measure of the earth's climate state is the global mean, annually averaged surface air temperature. Year-to-year and even decadal-scale variations in this value can occur due to processes purely internal to the climate system. The warm phase of ENSO, for example, may be viewed as an internal process in which heat in the ocean reservoir (i.e., heat already within the climate system) is transferred to the atmosphere, expressed as a rise in global mean surface temperature. When considering timescales of decades or longer, thinking must turn to climate forcings and attendant feedbacks. Forcing factors represent imposed perturbations to the global system, and are defined as positive when they induce an increase in global mean surface temperature, and negative when they induce a decrease. Forcing factors may in turn be of natural or anthropogenic origin. The magnitude of the global temperature response to forcing depends on the feedbacks. Positive feedbacks amplify the temperature change while negative feedbacks dampen the change. 1. Climate forcing Many different types of climate forcing can be identified. Key forcings are associated with the following processes: Plate Tectonics: On geological timescales, plate tectonics have resulted in great changes in continental positions and sizes, the configuration of ocean basins and (through associated phases in volcanic activity) atmospheric composition. While there is little doubt that such changes altered the globally averaged surface albedo and greenhouse gas concentrations, plate movements have also altered the size and location of mountain ranges and plateaus. As a result, the global circulation of the atmosphere and the pattern of ocean circulation were modified. In 1912, Alfred Wegener proposed continental drift as a major determinant of climates and biota, but this idea remained controversial until the motion of crustal plates was identified in the 1960s. Alterations in continental location have contributed substantially to major Ice Ages of the distant past (such as the Permo-Carboniferous glaciation of Gondwanaland) as well as to intervals with
129 extensive arid (Permo-Triassic) or humid (coal deposits) environments during other geological periods. Over the past few million years, the uplift of the Tibetan Plateau and the Himalayan ranges has caused the onset, or intensification, of desert conditions in western China and Central Asia. Astronomical periodicities: As noted in Chapter 3A.2, the earth's orbit around the sun is subject to long-term variations, leading to changes in the seasonal and spatial distribution of solar radiation incident to the surface. These are known as Milankovich forcings after the astronomer Milutan Milankovich, whose careful calculations of their effects built upon the work of nineteenth-century astronomers and geologists. There are three principal effects: the eccentricity (or stretch) of the orbit influencing the strength of the contrast in solar radiation received at perihelion (closest to sun) and aphelion (furthest from sun), with periods of approximately 95,000 years and 410,000 years; the tilt of the earth's axis (approximately 41,000 years) influencing the strength of the seasons; and a wobble in the earth's axis of rotation, which causes seasonal changes in the timing of perihelion and aphelion (Figure 13.3). This precession effect, with a period of about 21,000 years, is further illustrated in Figure 3.3. The range of variation of these three components and their consequences are summarized in Table 13.1. Astronomical periodicities are associated with global temperature fluctuations of +2-5 O C per 10,000 years. The timing of orbital forcing is clearly represented in glacial-interglacial fluctuations with the last four major glacial cycles spanning roughly 100,000 years (or 100ka). The astronomical theory of glacial cycles became widely accepted in the 1970s after Hays, Imbrie and Shackleton provided convincing evidence from ocean core records. Solar variability: The sun is a variable star. The approximately 11-year solar (sunspot) cycle (and 22-year magnetic field cycle) are well known. As discussed in Chapter 2, the 11-year sunspot cycle is associated with +1W m -2 fluctuations in solar irradiance (i.e., a departure from the solar constant; in terms of radiation receipts globally averaged over the top of the atmosphere, the effective value is only 0.25W m -2). Effects on ultraviolet radiation are proportionally larger in terms of percent change. There is also evidence for longer-term variations. Intervals when sunspot and solar flare activity were much reduced (especially the Maunder Minimum of AD 1645-1715) may have been associated with global temperature decreases of about 0.5 O C. Solar variability also seems to have played a role in decadal-scale variations of global temperature until the latter part of the twentieth century, when anthropogenic effects became dominant. Turning to the distant past, it is known that solar irradiance three billion years ago (during the Archean) was about 80 percent of the modern value. Interestingly, the effect of this faint early sun was offset, most likely, by a concentration of carbon dioxide that was perhaps 100 times higher than now, and perhaps also by the effects of a largely water- covered earth (meaning lots of water vapor in the atmosphere). Volcanic eruptions. Major individual explosive eruptions inject dust and sulfur gases (especially sulfur dioxide) into the stratosphere, the latter forming sulfuric acid droplets.

130 Equatorial eruption plumes spread into both hemispheres, whereas plumes from eruptions in mid-to high latitudes are confined to that hemisphere. Observational evidence from the past 100 years demonstrates that major eruptions can be associated with global averaged cooling of several tenths of a degree C in the year following the event and much larger changes on a regional to hemispheric basis. The cooling is primarily from the sulfuric acid droplets which reflect solar radiation. Dust also causes surface cooling by absorbing solar radiation in the stratosphere, but compared to the sulfuric acid these effects are short-lived (weeks to months) Stratospheric aerosols may also cause brilliant sunsets (see Figure 2.12). The most recent major volcanic eruption with significant climate impacts was Mt. Pinatubo in 1991. Human-induced changes in atmospheric composition and land cover: The effect of greenhouse gases such as carbon dioxide and methane on the radiation budget has already been introduced (see also Chapter 2). The observed buildup of these gases since the dawn of the industrial age represents a positive forcing. Human activities have also led to a buildup of tropospheric aerosols, which induce a partly compensating cooling. Changes in land use and land cover have also led to a small increase in surface albedo that promotes cooling. While the common feature of all of these forcings is that they influence aspects of the earth's radiation budget, they are obviously distinguished in large part by the timescales at which they operate. In terms of inducing global temperature change over the past 100 years, as well as changes projected through the twenty-first century, the effects of plate tectonics (operating on timescales of millions of years) and Milankovich forcings (operating on timescales of tens of thousands of years) are irrelevant. Note also that while Milankovich forcings are associated with very significant impacts on the seasonal and spatial distribution of solar radiation incident on the surface, impacts on incident radiation when globally averaged through the annual cycle are quite small. For example, while a decrease in obliquity means less summer radiation in the Northern Hemisphere summer, it means more in the Southern Hemisphere winter, with these seasonal effects largely canceling out. Milankovich forcings hence contrast fundamentally with the effects of changing solar irradiance, volcanic eruptions, or human-induced changes in atmospheric greenhouse gas concentrations and surface albedo, all of which, considered in terms of their immediate effect, have a globally and annually averaged impact on the radiation balance at the top of the atmosphere. Because of this property, they are termed radiative forcings. For example, an increase in solar output will lead to more radiation incident to the top of the earth's atmosphere, irrespective of latitude or season. The immediate effect will be a globally averaged radiation imbalance at the top of the atmosphere (more energy coming in than going out), leading to a rise in temperature that would eventually bring the earth/atmosphere system into a new radiative equilibrium. Similarly, the immediate response to increasing the concentration of greenhouse gases will be a globally averaged decrease in longwave emission to space, a radiation imbalance promoting warming, also eventually leading to a new radiative balance (provided that the forcing remains constant).

131 Global climate change (change due to human influences by our adopted conventions) is best viewed in the context of global radiative forcing. In the IPCC framework adopted here, radiative forcing specifically refers to the amount by which a factor alters the globally and annually averaged radiation balance at the top of the atmosphere, expressed in units of W m -2 , evaluated as forcing relative to the year 1750, the start of the Industrial Revolution. In 2005, there was an estimated radiative forcing from human activities of 1.6W m -2 . 2.Climate feedbacks Building on the framework of radiative forcing, consider further the change in global average surface temperature resulting from increasing the atmospheric concentration of carbon dioxide. As just discussed, because of the imposed perturbation, more of the longwave radiation emitted upward from the surface is absorbed by the atmosphere, and directed back towards the surface. The result is a radiation imbalance at the top of the atmosphere - net solar radiation entering the top of the atmosphere exceeds the longwave loss to space. The climate forcing from adding carbon dioxide is hence positive. Now consider the feedbacks. The most important of these is the water vapor feedback. Warming results in more evaporation, and a warmer atmosphere can carry more water vapor. However, water vapor is also a greenhouse gas, so it causes further warming. Some of the earth's snow cover and sea ice will melt, reducing the earth's surface albedo, also causing further warming. These are examples of positive feedbacks, as they amplify the global surface temperature change induced by the climate forcing. If the carbon dioxide concentration in the atmosphere were lowered, thereby imposing a negative climate forcing, the positive feedbacks would foster further cooling. A fascinating aspect of the global climate system is that positive feedbacks dominate. For example, one of the responses to increasing greenhouse gases could be an increase in cloud cover, which through increasing the planetary albedo would represent a negative feedback. However, this and other potential negative feedbacks would only appear to be capable of slowing the rate of warming, not reversing it. While climate feedbacks can be either positive or negative, they can also be broadly differentiated regarding how quickly they operate. In the framework of global radiative forcing appropriate to understanding human-induced global climate change, it is the fast feedbacks which are relevant. The most important are changes in water vapor and albedo (mentioned above). Both can operate over timescales of days and even less. Cloud cover can also change very quickly (hours). Examples of slow feedbacks are changes in the extent of continental ice sheets (influencing planetary albedo) and greenhouse gases during the Pleistocene in response to Milankovich periodicities. Records from ice cores show that these glacial-interglacial cycles were nearly coincident with fluctuations in both atmospheric carbon dioxide (+50ppm) and methane (+150ppb). The nature of these trace gas feedbacks remains incompletely resolved. Potential mechanisms include changes in ocean chemistry, increased plankton growth acting to sequester carbon dioxide, suppression of air-sea gas exchange by sea ice, changes in ocean

132 temperature that affect the solubility of carbon dioxide, and altered ocean circulation. Most likely a suite of processes worked in concert. Negative (positive) excursions in greenhouse gas concentrations are associated with cold (warm) intervals, as illustrated in Figure 2.6. 3.Climate Response How much does the global mean surface temperature change in response to a radiative forcing of a given magnitude? How long does it take for the change to occur? These are among the most important, pressing questions in climate change science. The first question deals with the issue of equilibrium climate sensitivity. In the IPCC framework, equilibrium climate sensitivity is the equilibrium change in annual mean global averaged surface air temperature following a doubling of the atmospheric equivalent carbon dioxide. Doubling the carbon dioxide concentration equates to a radiative forcing (top of atmosphere radiation imbalance) of about 4W m -2 . In response to this doubling the surface and atmosphere would warm up. Eventually, radiative balance would be restored again with a new and higher surface temperature. Estimates of equilibrium climate sensitivity obtained from the current generation of global climate models range from 2-4.5 o C, with a best estimate of 3.0 o C. The uncertainly lies largely in the spread of model estimates of the climate feedbacks, particularly in the cloud feedbacks. Cloud feedbacks are complex and hard to model. Negative feedbacks may operate when increased global heating leads to greater evaporation and greater amounts of high-altitude cloud cover, which reflect more incoming solar radiation. However, other types of clouds, and clouds in the polar regions, can induce surface warming Expressed in a more convenient fashion, the best estimate of 3 o C for carbon dioxide doubling equates to 0.75 o C global mean surface temperature increase per W m -2 of forcing. It is stressed that the climate simulations used to obtain these sensitivity numbers only deal with the fast feedbacks. If there were no feedbacks present in the climate system, the climate sensitivity would be only about 0.30 o C per W m -2 . While equilibrium climate sensitivity in the IPCC framework is based on a doubling of atmospheric equivalent carbon dioxide, it appears that the equilibrium temperature response to any radiative forcing is roughly the same. This is an important concept, since it means that to a first approximation, one can linearly add different forcings to obtain a net value from which an equilibrium temperature change can be estimated. It also appears that most of the equilibrium temperature response to a radiative forcing with the fast feedbacks at work occurs over a time span of 30 to 50 years. Most of the time lag is due to the large thermal inertia of the oceans. The basic issue is that the oceans can absorb and store a great deal of heat without a large rise in the surface (radiating) temperature. Consider what is happening in response to the current radiative forcing from human activities of 1.6Wm -2 . Using the equilibrium climate sensitivity of 0.75 implies that this radiative forcing, if maintained, will eventually yield about 1.2 o C of warming. Over the instrumental record, the global mean temperature has risen by about 0.7 o C, implying another 0.5 o C remaining after the ocean

133 sufficiently heatsup. How much has the heat content of the ocean already increased? Based on available hydrographic data from 1955-1998, the world ocean between the surface and 3000m depth gained ~ 1.6 x 10 22 J. Compared with atmospheric kinetic energy (p. 70), this is a very large number. An obvious shortcoming of the concept of equilibrium climate sensitivity is that radiative forcing is always changing. Consider explosive volcanic eruptions. While the global radiative forcing from a single eruption can be very significant (2-3W m -2 at peak), the forcing is short- lived (several years) such that the system can never come into equilibrium with it (while the global surface temperature can be temporarily reduced by several tenths of a degree, this is much smaller than the calculated temperature change in equilibrium with the peak forcing). Similarly, the system could never be in equilibrium with solar variability associated with the 11-year sunspot cycle. If we were to somehow freeze the current radiative forcing from human activities at its present value, the climate system would eventually approach a new temperature in equilibrium with it (assuming no complications like multiple volcanic eruptions). However, radiative forcing from human activities has grown over the past century and will continue to grow in the future, meaning that the equilibrium temperature value has changed and will continue to change. Put differently, the picture over the past 100 years and into the future is a climate system constantly trying to catch up with a growing radiative forcing but always lagging behind it. 4. The importance of framework While the distinction between climate forcing and feedback is fairly straightforward when considering changes in globally averaged temperature, it must be stressed that this distinction may change if adopting a different framework, such as the evaluation of regional climate variability and change. For example, due to loss of its sea ice cover, rises in surface air temperature are expected to be especially pronounced over the Arctic Ocean. In the framework of human-induced global climate change, this may be viewed as part of the feedback process that amplifies the global average temperature response to increased greenhouse gas concentrations. However, if one were to conduct a regional study of the Arctic, one could legitimately view the sea ice loss as a forcing on Arctic temperature change. Similarly, global climate change may be attended by shifts in patterns of atmospheric circulation, precipitation and cloud cover. While on the global scale these would be viewed as feedbacks, investigations of regional impacts could view them as forcings. Another framework issue regards how one views transitions between glacial and interglacial conditions. While changes in ice sheet area and greenhouse gas concentrations during these transitions are appropriately viewed as slow feedbacks, if one considers full glacial and interglacial conditions as two equilibrium states, these slow feedbacks may instead be thought of as climate forcings. With estimates of the global temperature change between the equilibrium states and the forcings, one then has another way to estimate equilibrium climate
134 sensitivity. Numbers obtained from this approach turn out to agree fairly well with those coming from global climate models. Hence, in summary, depending on the chosen framework, one person's feedback may be another person's forcing. 5.3.3 The Climatic Record 1.The geological Record Understanding the significance of climatic trends over the past 100 years requires that they be viewed against the backdrop of earlier conditions. On geological timescales, global climate has undergone major shifts between generally warm, ice-free states and Ice Ages with continental ice sheets. There have been at least seven major Ice Ages through geological time. The first occurred 2500 million years ago (Ma) in the Archean period, followed by three more between 900 and 600Ma, in the Proterozoic. There were two Ice Ages in the Paleozoic era (the Ordovician, 500- 430Ma; and the Permo-Carboniferous, 345-225Ma). The most recent Ice Age began about 34Ma in Antarctica at the Eocene/Oligocene boundary and about three million years ago in northern high latitudes. At present, we are considered to be still within this most recent Ice Age, albeit in the warm part of it known as the Holocene, which began about 11.5ka. While the total volume of land ice today (mostly comprising the Antarctic and Greenland ice sheets) is certainly much smaller than it was at 20ka, it is still substantial compared to other times of the earth's past. Major Ice Ages and ice-free periods can be linked to a combination of external and internal climate forcing (plate tectonics, greenhouse gas concentrations, solar irradiance). The ice sheets of the Ordovician and Permo-Carboniferous periods formed in high southern latitudes on the former mega-continent of Gondwanaland. Uplift of the western cordilleras of North America and the Tibetan Plateau by plate movements during the Tertiary period (50-2Ma) caused regional aridity to develop in the respective continental interiors. However, geographical factors are only part of the explanation of climate variations. For example, warm high-latitude conditions during the mid-Cretaceous period, about 100Ma, may be attributable to atmospheric concentrations of carbon dioxide three to seven times higher than at present, augmented by the effects of alterations in land-sea distribution and ocean heat transport. Much more is known about ice conditions and climate forcings through the Quaternary, which began about 2.6 million years ago, comprising the Pleistocene (2.6Ma-11.5 ka) and the Holocene (11.5ka-present) epochs. It is abundantly clear that this most recent Ice Age we live in was far from being uniformly cold. Instead it was characterized by oscillations between glacial and interglacial conditions . Eight cycles of global ice volume are recorded in land and ocean sediments during the last 0.8-0.9Ma, each averaging roughly 100ka, with only 10 percent of each cycle as warm as the twentieth century (Figure 13.4D and E). Each glacial period was in turn characterized by abrupt terminations. Because of reworking of sediments, only four or five of these glaciations are identified from terrestrial records. Nevertheless, it is likely that all were characterized by large ice sheets covering northern North America and northern Europe. Sea-

135 levels were also lowered by about 130m due to the large volume of water locked up in the ice. Records from tropical lake basins show that these regions were generally arid at those times. Prior to 0.9Ma the timing of glaciations is more complex. Ice volume records show a dominant 41ka periodicity, while ocean records of calcium carbonate indicate fluctuations of 400ka. These periodicities are linked to the Milankovich forcings discussed earlier. The precession signature (19 and 23ka) is most apparent in low-latitude records, whereas that of obliquity (41ka) is represented in high latitudes. However, the 100ka orbital eccentricity signal is generally dominant overall. The basic idea is that onset of glacial conditions is initiated by Milankovich forcings that yield summer cooling over the northern land masses. This favors survival of snow cover through summer, feedback promoting further cooling and ice sheet growth, leading to even further cooling through slow feedbacks in the carbon cycle discussed earlier. Onset of an interglacial works the other way, with Milankovich forcings promoting initial warming over the northern land masses, setting feedbacks into motion to give further warming and ice melt. 2.The last glacial cycle and postglacial conditions The last interglacial, known as the Eemian, peaked about 125ka. The last glacial cycle following the Eemian was itself characterized by periods of extensive ice (known as stades) and less extensive ice (known as interstades), Maximum global ice volume (the Last Glacial Maximum, or LGM) occurred around 25-18ka. The LGM ended with abrupt warming between about 15 and 13ka, depending on latitude and area, interrupted by a cold regression called the Younger Dryas (13-11.7ka). This was then followed by a renewed sharp warming trend. The Holocene (our present interglacial) is considered to begin at 11.5ka, after the close of the Younger Dryas event. Based on assessments of Milankovich forcings, the present interglacial should last for at least another 30,000 years. A particularly striking feature of the last glacial cycle is rapid millennialscale changes between warm and cold conditions, known as Dansgaard-Oeschger (D- O) cycles. The Younger Dryas event is considered to be the last of these D-O cycles. As is evident in a number of proxy records, the onset and termination of the Younger Dryas cold event, with a switch from near glacial to interglacial climate conditions and back again, apparently occurred within a five-year time interval for both transitions! The processes driving D-O events like the Younger Dryas are still incompletely understood, but likely in some way involve massive discharges of fresh water from melting ice sheets to the North Atlantic that disrupted the Atlantic thermohaline circulation. Early Holocene warmth around 10ka is attributed to July solar radiation being 30-40W m -2 greater than now in northern mid-latitudes, again due to Milankovich effects. Following the final retreat of the continental ice sheets from Europe and North America between 10,000 and 7000 years ago, the climate rapidly ameliorated in middle and higher latitudes. In the subtropics this interval was also generally wetter, with high lake levels in Africa and the Middle East. A Holocene Thermal Maximum (HTM) was reached in the mid-latitudes about 5000 years ago,

136 when summer temperatures were 1-2 O C higher than today and the Arctic tree line was several hundred kilometers further north in Eurasia and North America. By this time, subtropical desert regions were again very dry and were largely abandoned by primitive peoples. A temperature decline set in around 2000 years ago with colder, wetter conditions in Europe and North America. Although temperatures have not since equaled those of the HTM (we are getting close), a relatively warmer interval (or intervals) occurred between the ninth and mid-fifteenth centuries AD. Summer temperatures in Scandinavia, China, the Sierra Nevada (California), Canadian Rocky Mountains and Tasmania exceeded those that prevailed until the late twentieth century. 3.The past 1000 years Temperature reconstructions for the Northern Hemisphere over the past millennium are based on several types of proxy data, but especially dendrochronology, ice cores and historical records. Figure 13.6 shows a reconstruction based on such proxies for the past millennium. Until about AD 1600 there is still considerable disparity in different estimates of decadal mean values and their range of variation. Conditions appear to have been slightly warmer between AD 1050 and 1330 than between 1400 and 1900. There is evidence in Western and Central Europe for a warm phase around AD 1300. Icelandic records indicate mild conditions up until the late twelfth century, and this phase was marked by the Viking colonization of Greenland and the occupation of Ellesmere Island in the Canadian Arctic by the Inuit. Deteriorating conditions followed. This cool period, known as the 'Little Ice Age', was associated with extensive Arctic sea ice and glacier advances in some areas to maximum positions since the end of the last glacial cycle. These advances occurred at dates ranging from the mid-seventeenth to the late nineteenth century in Europe, as a result of the lag in glacier response and regional variability. The coldest interval of the Little Ice Age in the Northern Hemisphere was AD 1570- 1730. What caused the Little Ice Age is not entirely clear. Reduced solar output associated with the Maunder Minimum in sunspot activity (1645-1715) likely played a role, as did increased volcanic activity. Long instrumental records for stations in Europe and the eastern United States indicate that the warming trend that ended the Little Ice Age began at least by the mid-nineteenth century. The time series of global annual averaged surface air temperature from instrumental records shows a significant temperature rise of about 0.7 o C from 1880 through 2007. Both hemispheres have participated in this warming, but it is most pronounced in the Northern Hemisphere. Warming in turn encompasses both land and ocean regions, being stronger over land . Warming has been smallest in the tropics and largest in northern high latitudes. Warming is in turn strongest during winter. The general temperature rise has not been continuous, however, and four basic phases may be identified in the global record:

137 1 1880-1920, during which there was an oscillation within extreme limits of about 0.3 o C but no trend. 2 1920-mid-1940s, during which there was considerable warming of approximately 0.4 o C; this warming was most strongly expressed in northern high latitudes. 3 Mid-1940s-early 1970s, during which there were oscillations within extreme limits of about 0.4 o C, with the Northern Hemisphere cooling slightly on average and the Southern Hemisphere remaining fairly constant in temperature. Regionally, northern Siberia, the eastern Canadian Arctic and Alaska experienced a mean lowering of winter temperatures by 2-3 o C between 1940 and 1949 and 1950 and 1959; this was partly compensated by a slight warming in the western United States, Eastern Europe and Japan. 4 Mid-1970s-2008, during which there was a marked overall warming of about 0.5 o C, but with strong regional variability. Based on balloon soundings and assessments from satellite sounders, lower tropospheric temperatures over the period 1958 to the present have increased at slightly higher rates than at the surface. This interpretation, however, must acknowledge discontinuities and biases in the time series introduced by changing satellites, orbit decay, drift and other factors. There is evidence that balloon soundings may have a cooling bias. Global mean surface temperatures during the past decade reached their highest levels on record and probably for the last millennium. In the NASA GISS analysis used to compile Figure 13.7, the warmest year on record was 2005, with 2007 and 1998 tied for second warmest. Rankings based on other global temperature analyses (e.g., from the Climatic Research Unit of the UK) differ somewhat, but tell the same basic story of very warm conditions for the past decade. The key spatial feature of change over the past decade is very strong warming over northern high latitudes. This is especially apparent in autumn and winter and over the Arctic Ocean. It is linked to both changes in atmospheric circulation and declining sea ice extent. Regarding the latter, anomalous areas of open water in autumn and winter allow for large heat fluxes from the ocean surface to the lower atmosphere. Note also the strong warming over the Antarctic Peninsula. One of the manifestations of recent warming is a longer growing season. For example, in central England, the growing season (defined as daily mean temperature <5 o C for five days in succession) lengthened by 28 days over the twentieth century and was about 270 days in the 1990s compared with around 230-250 days in the eighteenth to nineteenth centuries. In the Arctic, there is strong evidence of links between recent warming and regional transitions from tundra to shrub vegetation. A further tendency of the past 50 years or so is a decrease in the diurnal temperature range; night-time minimum temperatures increased by 0.8 o C during 1951- 1990 over at least half of the northern land areas compared with only 0.3 o C for daytime

138 maximum temperatures. This appears to be mainly a result of increased cloudiness, which, in turn, may be a response to increased greenhouse gases and tropospheric aerosols. However, the linkages are not yet adequately determined. Precipitation changes are much more difficult to characterize. The period since 1900 has seen an overall increase in precipitation north of about 30 o N. By contrast, since the 1970s, there have been decreases over much of the tropics and subtropics. However, these general features mask strong seasonal, regional and temporal variations. As an example of this complexity, the variations in tropical and subtropical precipitation overland areas through the mid-1990s. Since the mid-twentieth century, decreases in precipitation dominate much of the region from North Africa eastward to Southeast Asia and Indonesia. Many of the dry episodes are associated with El Niño events. Equatorial South America and Australasia also show ENSO influences. The Indian monsoon area shows wetter and drier intervals; the drier periods are evident in the early twentieth century and during 1961-1990. As a further example of complexity, West African records for the twentieth century show a tendency for both wet and dry years to occur in runs of up to 10 to 18 years. Precipitation minima were experienced in the 1910s, 1940s and post-1968, with intervening wet years, in all of sub-Saharan West Africa. Throughout the two northern zones outlined, means for 1970-1984 were generally less than 50 percent of those for 1950-1959, with deficits during 1981-1984 equal to or exceeding those of the disastrous early 1970s' drought. The deficits continued into the 1990s. It has been suggested that the severe drought is related to weakening of the tropical easterly jet stream and limited northward penetration of the West African southwesterly monsoon flow. However, Sharon Nicholson attributes the precipitation fluctuations to contraction and expansion of the Saharan arid core rather than to north-south shifts of the desert margin. In Australia, rainfall changes have been related to changes in the location and intensity of subtropical anticyclones and associated changes in atmospheric circulation. Winter rainfall decreased in southwestern Australia while summer rainfall increased in the southeast, particularly after 1950. Northeastern Australia shows decadal oscillations and large inter-annual variability. Winter and summer fluctuations in precipitation for England and Wales. There is wide interannual variability and some large decadal shifts are evident. There are also longer-term changes. For example, winters have been wetter from about 1860 onward compared with the earlier part of the record. Changes also depend on season - while winter rainfall increased from 1960 to the end of the record, summer precipitation generally decreased over the same time. Records for individual stations show that even over relatively short distances there may be considerable differences in the magnitude of anomalies, especially in an east-west direction across the British Isles. The late twentieth and early twenty-first century has seen more frequent climatic extremes. For example, Britain has experienced several major droughts during this period (1976, 1984, 1989-

139 1992 and 1995); seven severe winter cold spells occurred between 1978 and 1987 (compared with only three in the preceding 40 years); and several major windstorms (1987, 1989 and 1990) were recorded. The driest 28-month spell (19881992) recorded in Britain since 1850 was followed by the wettest 32-month interval of the twentieth century. Europe experienced unprecedented heatwaves in 2003 and 2008. In the United States, recent decades saw a marked increase in the inter-annual variability of mean winter temperatures and total precipitation. The year 1983 saw the most intense El Niño event for a century, followed by a comparable event in 1998. There is also some evidence of an increase in the frequency of intense hurricanes (Category 4 and 5). 5.4 National Action Plan on Climate Change (NAPCC) The National Action Plan on Climate Change (NAPCC) was released by the Prime Minister on 30th June 2008. It outlines a national strategy that aims to enable the country to adapt to climate change and enhance the ecological sustainability of India's development path. It stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability to the impacts of climate change. 5.4.1
Principles of NAPCC • Protecting the poor through an inclusive and sustainable development strategy, sensitive to climate change • Achieving national growth and poverty alleviation objectives while ensuring ecological sustainability • Efficient and cost-effective strategies for end-use demand-side management • Extensive and accelerated deployment of appropriate technologies for adaptation and mitigation • New and innovative market, regulatory, and voluntary mechanisms for sustainable development • Effective implementation through unique linkages – with civil society, LGUs, and public- private partnerships
There are
eight —National Missions‖ which form the core of the
National Action Plan.
They focus on promoting understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation. The
eight
National Missions on climate change
are: 1 .
National Solar Mission 2 . National Mission for Enhanced Energy Efficiency
140 3 . National Mission on Sustainable Habitat 4 . National Water Mission 5 . National Mission for Sustaining the Himalayan Eco-system 6 . National Mission for a Green India 7 . National Mission for Sustainable Agriculture 8 . National Mission on Strategic Knowledge for Climate Change 1 .
National Solar Mission (
NSM) The NSM was launched in January 2010, with the objective of establishing India as a global leader in solar energy, by creating the policy conditions for solar technology diffusion across the country as quickly as possible. The initial target of NSM was to install 20 GW solar power by 2022. This was upscaled to 100 GW in early 2015. Numerous facilitative programmes and schemes under the Mission have driven the grid connected solar power installed capacity from 25 MW in the year 2010- 11 to about 36.32 GW as on 31st October 2020. An additional 58.31 GW solar power capacity is currently under installation/ tendering process. Objectives The objective of the National Solar Mission is to establish India as a global leader in solar energy, by creating the policy conditions for its diffusion across the country as quickly as possible. The Mission adopts a three-phase approach, Phase 1 (up to 2012 - 13), Phase 2 (2013 - 17) and Phase 3 (2017 - 22). The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. 2 . National Mission for Enhanced Energy Efficiency (NMEEE) NMEEE aims to strengthen the market for energy efficiency by creating conducive regulatory and policy regime and has envisaged fostering innovative and sustainable business models to the energy efficiency sector. The Mission is implemented since 2011. NMEEE consists of four initiatives to enhance energy efficiency in energy intensive industries: • Perform, Achieve and Trade (PAT) • Market Transformation for Energy Efficiency (MTEE) • Energy Efficiency Financing Platform (EEFP) • Framework for Energy Efficient Economic Development (FEEED) 3 . National Mission on Sustainable Habitat
141 The National Mission on Sustainable Habitat was approved by the Prime Minister's Council for Climate Change in June 2010. The key deliverables of the Mission include: • Development of sustainable habitat standards that lead to robust development strategies while simultaneously addressing climate change related concerns • Preparation of city development plans that comprehensively address adaptation and mitigation concerns • Preparation of comprehensive mobility plans that enable cities to undertake long-term, energy efficient and cost-effective transport planning • Capacity building for undertaking activities relevant to the Mission 4 . National Water Mission A National Water Mission will ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within

states. The Mission will take into account the provisions of the National Water Policy and develop a framework to optimize water use by increasing water use efficiency by 20 per cent through regulatory mechanisms with differential entitlements and pricing. It will seek to ensure that a considerable share of the water needs of urban areas are met through recycling of waste water, and ensuring that the water requirements of coastal cities with inadequate alternative sources of water are met through
adoption of new and appropriate technologies such as low temperature desalination
technologies that allow for the use of ocean water. NWM has identified five goals which are mentioned below: • Comprehensive water data base in public domain and assessment of the impact of climate change on water resource • Promotion of citizen and state actions for water conservation, augmentation and preservation • Focused attention to vulnerable areas including over-exploited areas • Increasing water use efficiency by 20 per cent • Promotion of basin level integrated water resources management 5 . National Mission for sustaining the Himalayan Eco-system This particular mission sets the goal to prevent melting of the Himalayan glaciers and to protect biodiversity in the Himalayan region. The Himalayan ecosystem as a national mission will focus on the rapid generation of four types of national capacities, which deal with:
142 • Human and knowledge capacities • Institutional capacities • Capacities for evidence-based policy building and governance • Continuous self-learning for balancing between forces of Nature and actions of mankind The mission attempts to address some important issues concerning • Himalayan Glaciers and the associated hydrological consequences • Biodiversity conservation and protection • Wildlife conservation and protection • Traditional knowledge societies and their livelihood and • Planning
for sustaining the Himalayan Ecosystem 6 . National Mission for a Green India
The Cabinet Committee on Economic Affairs approved a proposal of the Ministry of Environment and Forests for a National Mission for a Green India (GIM) as a Centrally Sponsored Scheme. GIM puts “greening” in the context of climate change adaptation and mitigation. Greening is meant to enhance ecosystem services such as carbon sequestration and storage (in forests and other ecosystems), hydrological services and biodiversity; as well as other provisioning services such as fuel, fodder, small timber and non- timber forest products (NTFPs). The Mission aims at responding to climate change by a combination of adaptation and mitigation measures, which would help: • Enhancing carbon sinks in sustainably managed forests and other ecosystems • Adaptation of vulnerable species/ecosystems to the changing climate • Adaptation of forest-dependent communities The objectives of the Mission are: • Increased forest/tree cover on 5 m ha of forest/non-forest lands and improved quality of forest cover on another 5 m ha (a total of 10 m ha) • Improved ecosystem services including biodiversity, hydrological services and carbon sequestration as a result of treatment of 10 m ha • Increased forest-based livelihood income of about 3 million households living in and around the forests • Enhanced annual CO 2 sequestration by 50 to 60 million tonnes in the year 2020 7 .
National Mission for Sustainable Agriculture
143 National Mission for Sustainable Agriculture (
NMSA) has been made operational from the year 2014-15, it aims at making agriculture more productive, sustainable, remunerative and climate resilient by promoting location specific integrated /composite farming systems; soil and moisture conservation measures; comprehensive soil health management; efficient water management practices and mainstreaming rain-fed technologies. 8 . National Mission on Strategic Knowledge for Climate Change
The National Mission on Strategic Knowledge for Climate Change (NMSKCC) seeks to build a vibrant and dynamic knowledge system that would inform and support national action for responding effectively to the objective of ecologically sustainable development. 5.5
Green Building

While there are several different definitions of Green Building out there, it is commonly accepted as the planning, design, construction, and processes of buildings with several central, foremost reflections: energy use, water use, indoor environmental quality, material section and the building's effects on its site. A parallel concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally. It is a holistic concept that begins with the understanding that the built environment can have both a positive and negative impact on the natural environment as well as the people living in the buildings every day. Green building is an attempt to reduce the positive and negative of these effects throughout the life cycle of a building. Other related topics include sustainable design and green architecture. Sustainability can be defined as meeting the needs of current generations, without compromising the ability to meet the needs of future generations. The U.S. EPA says "Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building." 5.5.1 Green building concept The `Green Building' concept is gaining importance in various countries, including India. These are buildings that ensure that waste is minimized at every stage during the construction and

144 operation of the building, resulting in low costs, according to experts in the techniques associated with the `Green Building' include measures to prevent erosion of soil, rainwater harvesting, use of solar energy, preparation of landscapes to reduce heat, reduction in usage of water, recycling of waste-water and use of world-class energy-efficient practices. Green building is a whole-system approach to the design and construction of buildings that conserve and build energy, water, and material resources and are more healthy, safe and comfortable. Many think of solar panels when they think of "green" buildings. Green building responds to the realization that the way we are building everything from houses to skyscrapers is not sustainable. Many health problems today arise from poor indoor air quality and exposure to toxins contained in commonly used construction products. Green building practices can eliminate these health-damaging conditions. 5.5.2 Green buildings in India A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. IGBC is a leading green building movement in the country. The Indian Bureau of Energy Efficiency (BEE) launched the Energy Conservation Building Code (ECBC). The code is set for energy efficiency standards for design and construction with any building of minimum conditioned area of 1,000 m 2 and a connected demand of power of 500 KW or 600 KVA. The energy performance index of the code is set from 90 kW·h/sqm/year to 200 kW·h/sqm/year where any buildings that fall under the index can be termed as "ECBC Compliant Building" 5.5.3 Green building materials Renewable sources: Forests Reuse from waste: old plumbing, doors, etc. Solar Tiles: Exist to simply protect a building. They spend a large portion of the day absorbing energy from the sun. Paper Insulation: Made from recycled newspapers and cardboard then filled with chemical foam. Insect-resistant &fire retardant Wool brick: Obtained by adding wool and a natural polymer found in seaweed to the clay of the brick, 37% more strength than burnt bricks. Resistant for cold and wet climate Sustainable Concrete: Crushed glass, Wood chips or slag – a byproduct of steel manufacturing. Reduces the emission of CO 2

145 5.5.4 Benefits of Green building • Energy Efficiency • Water Efficiency • Efficient Technologies • Easier Maintenance • Return on Investment • Improved Indoor Air Quality • Waste Reduction • Temperature Moderation • Water Conservation • Economical Construction For Poor • Healthier Lifestyles and Recreation • Improved Health. 5.5.5 Examples of green buildings in India • ITC Green Centre, Gurgaon • Patni (i-GATE) Knowledge Center, Noida • Olympia Tech Park, Chennai • Indira Paryavaran Bhawan 5.6 GRIHA Rating Norms The GRIHA full form is Green Rating for Integrated Habitat Assessment. This tool of rating the habitats helps people to assess the overall performance of their dwelling places, precisely buildings. This takes into consideration the various benchmarks that are nationally accepted. A building has a life cycle. The rating system observes how a building performs throughout its life cycle. Special emphasis is put on holistic environmental performance and its evaluation. Thus, a set of standards are established. Those buildings that abide by these standards get marked as 'green buildings. GRIHA is actually a Sanskrit word that means 'abode'. This takes into consideration the interaction of human habitats with the surrounding environment. Now, this interaction can happen in more than one way. Construction of the building marks the start of the life cycle. While the building is demolished completely, it is marked as the end of the life cycle. However, buildings consume huge amounts of resources throughout their life cycle. These resources are materials, energy, and water, among others.

146 Wastes are produced by these buildings directly as municipal wastes and indirectly as the emissions from the process of electricity generation. GRIHA is a system that aims to minimize the resource consumption and waste generation of the buildings. This way, the ecological impact of the same is also reduced. The UPSC syllabus covers the aims and advantages of implementing GRIHA on the overall ecological balance of the planet. GRIHA considers that once the resource consumption and waste generation rates are measured, they can be easily managed. Thus, the GRIHA system quantifies the related aspects of resource consumption, renewable energy adoption, and waste generation. International Recognition of the GRIHA In the international context, the GRIHA rating system serves as an innovative tool in the hands of the United Nations for the purpose of sustainable development. This acts as a significant tool for the implementation of renewable energy in the construction sector with the help of 'The Climate Reality Project'. The "Common Carbon Metric" is considered to be a major tool in this context that helps in data collection on international building energy. For the purpose of data collection, inputs are taken from the GRIHA. Indian Implementation of the GRIHA The Indian government accepts the GRIHA standards as a much-needed standard for the ecological balance in the country. Let's take the example of the Maharashtra government. This government provides incentives to the occupants and developers of projects that comply with the GRIHA standards.

147 GRIHA has been adopted by the Government of Delhi Cabinet as well as by the cabinets of other major states. 5.6.1 The benefits of GRIHA On a broader scale, this system, along with the activities and processes that lead up to it, will benefit the community at large with the improvement in the environment by reducing GHG (greenhouse gas) emissions, reducing energy consumption and the stress on natural resources. Some of the benefits of a green design to a building owner, user, and the society as a whole are as follows: • Reduced energy consumption without sacrificing the comfort levels • Reduced destruction of natural areas, habitats, and biodiversity, and reduced soil loss from erosion etc. • Reduced air and water pollution (with direct health benefits) • Reduced water consumption • Limited waste generation due to recycling and reuse • Reduced pollution loads • Increased user productivity • Enhanced image and marketability Table 5.1: GRIHA rating system

GRIHA v.2019 Section Criterion No. Criterion Name Maximum Points 1. Sustainable Site Planning 1 Green Infrastructure 5 2 Low Impact Design 5 3 Design to Mitigate UHIE 2 2. Construction Management 4 Air and Soil Pollution Control 1 5 Top Soil Preservation 1 6 Construction Management Practices 2 3. Energy Efficiency 7 Energy Optimization 12 8 Renewable Energy Utilization 5 9 Low ODP and GWP Materials 1 4. Occupant Comfort 10 Visual Comfort 4

148 11 Thermal and Acoustic Comfort 2 12 Maintaining Good IAQ 6 5. Water Management 13 Water Demand Reduction 3 14 Wastewater Treatment 3 15 Rainwater Management 5 16 Water Quality and Self-Sufficiency 5 6. Solid Waste Management 17 Waste Management-Post Occupancy 4 18 Organic Waste Treatment On-Site 2 7. Sustainable Building Materials 19 Utilization of Alternative Materials in Building 5 20 Reduction in GWP through Life Cycle Assessment 5 21 Alternative Materials for External Site Development 2 8. Life Cycle Costing 22 Life Cycle Cost Analysis 5 9. Socio-Economic Strategies 23 Safety and Sanitation for Construction Workers 1 24 Universal Accessibility 2 25 Dedicated Facilities for Service Staff 2 26 Positive Social Impact 3 10. Performance Metering and Monitoring 27 Commissioning for Final Rating 7 28 Smart Metering and Monitoring 0 29 Operation and Maintenance Protocol 0 Total Points 100 11. Innovation 30 Innovation 5 Grand Total Points 100 + 5 Rating Threshold GRIHA V 2019 Rating Thresholds GRIHA Rating 25-40 41-55 56-70 71-85

149 86 or more 5.7

COPs A conference of the parties (COP; French: Conférence des Parties, CP) is the supreme governing body of an international convention (treaty, written agreement between actors in international law). It is composed of representatives of the member states of the convention and accredited observers. Scope of the COP is to review the "implementation of the Convention and any other legal instruments that the COP adopts and take decisions necessary to promote the effective implementation of the Convention". Conventions with a COP include: • Basel Convention • Chemical Weapons Convention • Convention on Biological Diversity • 2012 Hyderabad Biodiversity Conference (COP11) • 2022 United Nations Biodiversity Conference (COP15) • Convention on the Conservation of Migratory Species of Wild Animals • Convention on International Trade in Endangered Species of Wild Fauna and Flora • Kyoto Protocol • Minamata Convention on Mercury • Ramsar Convention • Rotterdam Convention • Stockholm Convention on Persistent Organic Pollutants • Treaty on the Non-Proliferation of Nuclear Weapons • United Nations Convention to Combat Desertification • United Nations Convention against Corruption • United Nations Framework Convention on Climate Change • United Nations Climate Change conference • WHO Framework Convention on Tobacco Control Location Session Conference Sharm el-Sheikh, Egypt COP 27 Sharm el-Sheikh Climate Change Conference - November 2022

150 Location Session Conference Glasgow, United Kingdom of Great Britain and Northern Ireland COP 26 Glasgow Climate Change Conference – October-November 2021 Madrid, Spain COP 25 UN Climate Change Conference - December 2019 Katowice, Poland COP 24 Katowice Climate Change Conference – December 2018 Bonn, Germany COP 23 UN Climate Change Conference - November 2017 Marrakech, Morocco COP 22 Marrakech Climate Change Conference - November 2016 Paris, France COP 21 Paris Climate Change Conference - November 2015 Lima, Peru COP 20 Lima Climate Change Conference - December 2014 Warsaw, Poland COP 19 Warsaw Climate Change Conference - November 2013 Doha, Qatar COP 18 Doha Climate Change Conference - November 2012 Durban, South Africa COP 17 Durban Climate Change Conference - November 2011 Cancun, Mexico COP 16 Cancún Climate Change Conference - November 2010 Copenhagen, Denmark COP 15 Copenhagen Climate Change Conference - December 2009
151 Location Session Conference Poznan, Poland COP 14 Poznan Climate Change Conference - December 2008 Bali, Indonesia COP 13 Bali Climate Change Conference - December 2007 Nairobi, Kenya COP 12 Nairobi Climate Change Conference - November 2006 Montreal, Canada COP 11 Montreal Climate Change Conference - December 2005 Buenos Aires, Argentina COP 10 Buenos Aires Climate Change Conference - December 2004 Milan, Italy COP 9 Milan Climate Change Conference - December 2003 New Delhi, India COP 8 New Delhi Climate Change Conference - October 2002 Marrakech, Morocco COP 7 Marrakech Climate Change Conference - October 2001 Bonn, Germany COP 6-2 Bonn Climate Change Conference - July 2001 The Hague, Netherlands COP 6 The Hague Climate Change Conference - November 2000 Bonn, Germany COP 5 Bonn Climate Change Conference - October 1999 Buenos Aires, Argentina COP 4 Buenos Aires Climate Change Conference - November 1998 Kyoto, Japan COP 3 Kyoto Climate Change Conference - December 1997
152 5.8 Summary The most fundamental measure of the earth's climate state is the global averaged surface air temperature. It is influenced by a variety of climate forcing factors operating on a suite of timescales. Climate variations over timescales of millions of years can be linked to plate tectonics. The great Ice Ages and interglacial that have characterized the past two million years can be linked to periodicities in the earth's orbit around the sun, influencing the seasonal distribution of solar radiation over different parts of the surface. The observed increase in global mean surface air temperature over the past 100 years may be attributed primarily to human- induced increases in atmospheric carbon dioxide and other greenhouse gases, partly compensated by the cooling effects of aerosol loading. These are known as radiative forcings in that they alter the globally averaged radiation budget at the top of the atmosphere. Solar variability, another radiative forcing, has played a minor role since the mid-twentieth century. The general rise in global mean surface temperature over the past 100 years contains inter-annual to multi-decadal variations. These reflect natural internal variability in the coupled atmosphere-ocean-land system as well as transient radiative forcings such as large volcanic eruptions (e.g ., Mt. Pinatubo). The magnitude of the response of global temperature to a radiative forcing of given magnitude or set of forcings in combination, depends on the climate feedbacks. Positive feedbacks dominate and hence act to amplify the temperature response to a forcing. In terms of human-induced climate change, the most important are the fast water vapor and ice-albedo feedbacks. Climate projections through the twenty-first century, assuming a variety of emission scenarios for greenhouse gases and aerosols, indicate a mean global temperature increase in the range of 2-4 o C by the year 2100, together with sea-level rises of 200-500mm. Given the rapid growth of greenhouse gas concentrations in recent decades, the effects of ice sheet dynamics and other wild cards in the system, these may be underestimates. The Arctic will eventually become free of sea ice in summer. Warming will also be accompanied by continued shrinking of glaciers, ice caps and permafrost, changes in the hydrologic cycle, atmospheric circulation, and vegetation. 5.9 Questions/ Self-Assessment questions 1 . Briefly describe different record of climate change. 2 . What is national action plan on climate change (NAPCC)? 3 . What are the principals of NAPCC? 4 . What do you know about the green building? 5 . What are the benefits of green building? 6 . What are the benefits of GRIHA rating? 7 . Define COPs? Mentioned some important COP.
153 5.10 Select Readings/ Suggested Readings 1 . https://www.grihaindia.org/griha-rating 2 . https://www.themightyearth.com/concept-of-green-building-and-benefits/ 3 . https://dst.gov.in/sites/default/files/NMSKCC_mission%20document%201.pdf 4 . https://dst.gov.in/climate-change-programme 5 . http://moef.gov.in/wp-content/uploads/2018/07/CC_ghosh.pdf 6 . https://vikaspedia.in/energy/policy-support/environment-1/climate-change 7 . https://static.pib.gov.in/WriteReadData/specificdocs/documents/2021/dec/doc202112101. pdf

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Course: Solid Waste and Hazardous Waste Management Contents Netaji Subhas Open University P.G. Environmental Science PGES-CC-203

1 UNIT 1: Waste Management 1.1 Objectives 1.2 Introduction 1.3 Types of waste 1.4 Waste to Energy 1.5 Incineration 1.6 Bio-methanation 1.7 Landfill 1.8 Summary 1.9 Questions/ Self-Assessment questions 1.10 Select Readings/ Suggested Readings 1.1 Objectives • To know the types of waste and their brief characteristics • To get knowledge about waste to energy concept • To know about the incineration and landfill process in waste management 1.2 Introduction Waste is an unavoidable by-product of most human activity. Economic development and rising living standards in the Asian and Pacific Region have led to increases in the quantity and complexity of generated waste, whilst industrial diversification and the provision of expanded health-care facilities have added substantial quantities of industrial hazardous waste and biomedical waste into the waste stream with potentially severe environmental and human health consequences. The Chapter discusses the generation, treatment, disposal and management of the growing volume of waste, which poses formidable challenges to both high and low-income countries of the region. A substantial increase in volume of wastes generation began in the sixteenth century when people began to move from rural areas to cities as a result of industrial revolution. This migration of people to cities led to population explosion that in turn led to a surge in the volume and variety in composition of wastes generated in cities. It was then that materials such as metals and glass began to appear in large quantities in municipal waste stream. The large population of people in cities and communities gave rise to indiscriminate littering and open dumps. These dumps in turn formed breeding grounds for rats and other vermin, posing significant risks to public health. The unhealthy waste management practices resulted in several outbreaks of epidemics with high death tolls. Consequently, in the nineteenth century public officials began to dispose waste in a controlled manner in other to safe guard public health.

2 Most developed countries passed through a period when they were developing environmentally. Today, however, most of these countries have effectively addressed much of the health and environmental pollution issues associated with wastes generation. In contrast, the increasing rate of urbanisation and developments in emerging countries is now leading to a repeat of the same historical problems that developed countries have had to address in the past. 1.3 Types of waste 1.3.1 Generation and Characteristics:

A clear appreciation of the quantities and characteristics of the waste being generated is a key component in the development of robust and cost-effective solid waste management strategies. Although amongst some of the more developed countries within the region the quantification and characterization of waste forms the basis for management and intervention, elsewhere little priority is given to the systematic surveying of waste arising and the quantities, characteristics, seasonal variations and future trends of waste generation are poorly understood. Although there is a lack of comprehensive or consistent information, at the country level, some broad trends and common elements are discernible. In general, the developed countries generate much higher quantities of waste per capita compared to the developing countries of the region. However, in certain circumstances the management of even small quantities of waste is a significant challenge.

For example, in the small islands of the South Pacific subregion, small populations and modest economic activity have ensured that relatively low quantities of waste are generated. However, many of these countries, particularly small atoll countries such as Kiribati, Tuvalu and the Marshall Islands, face considerable waste management challenges due to their small land areas and resultant lack of disposal options. Throughout the region, the principal sources of solid waste are residential households and the agricultural, commercial, construction, industrial and institutional sectors. Currently total waste generated in India is around 42 million tons annually. Waste generation varies from 200-600 kg/capita/day and collection efficiency ranges from 50-90 %. A breakdown of solid waste types and sources is provided in Table 1. For the purposes of this review these sources are defined as giving rise to four major categories of waste like municipal solid waste, industrial waste, agricultural waste and hazardous waste. Each of these waste types is examined separately below. 1.3.2 Municipal Solid Waste Municipal solid waste (MSW) This type of the waste is generated from households, offices, hotels, shops, schools and other institutions. The major components are food waste, paper, plastic, rags, metal and glass, although demolition and construction debris is often included in collected waste, as are small quantities of hazardous waste, such as electric light bulbs, batteries, automotive parts and discarded medicines and chemicals.

3 Table 1.1: Type and Source of waste

Source Typical waste generators Types of solid waste Residential Single and multifamily dwellings

Single

and multifamily dwellings Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g. bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes

Industrial Light and heavy manufacturing, fabrication, construction sites, power and chemical plants Housekeeping wastes, packaging, food wastes, construction and demolition materials,

hazardous wastes, ashes, special

wastes. Commercial Stores, hotels, restaurants, markets, office buildings, etc Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes,

hazardous wastes Institutional Schools, hospitals, prisons, government
centres
Same as commercial
Construction and
demolition
New construction sites, road repair, renovation sites, demolition of buildings Wood, steel, concrete, dirt, etc.
Municipal services Street cleaning, landscaping, parks, beaches, other recreational areas,
water and wastewater treatment plants
Street sweepings, landscape and tree trimmings, general wastes from parks, beaches, and other recreational
area, sludge
Process Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing
Industrial process wastes, scrap materials, off-specification products, slag, tailings Agricultural Crops, orchards, vineyards, dairies, feedlots, farms Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides) Generation rates for MSW vary from city to city and from season to season and have a strong correlation with levels of economic development and activity. High-income countries (such as Australia, Japan, Hong Kong, China, Republic of Korea, and Singapore) produce between 1.1 and 5.0 kg/capita/day; middle-income countries (such as Indonesia, Malaysia and Thailand) generate between 0.52 and 1.0 kg/capita/day, whilst low-income countries (such as Bangladesh, India, Viet Nam and Myanmar) have generation rates of between 0.45 and 0.89 kg/capita/ day.
Figure 1 shows
MSW generation by the high, middle and low-income countries of the region.
Taken as a whole, the Asian and Pacific Region currently produces some 468 million tonnes of MSW each day and this is expected to more than double by 2050(World Bank
4 1999). The current estimate for waste generation may be considered as extremely conservative; the actual levels are probably more than double this amount. The Waste collection is a critical step in managing waste, yet rates vary largely by income levels, with upper-middle- and high-income countries providing nearly universal waste collection. Low-income countries collect about 48 percent of waste in cities, but this proportion drops drastically to 26 percent outside of urban areas. Across regions, Sub-Saharan Africa collects about 44 percent of waste while Europe and Central Asia and North America collect at least 90 percent of waste.It is graphically represented in figure 1 .
Differences in the characterization and reporting of waste types also differ with some municipal authorities including construction and demolition waste and industrial waste as part of the municipal waste stream.
Figure 1.1: Municipal Solid Waste Generation in Different Groups of Countries in the Region
5 Figure 1.2: Waste collection rates with respect to income level (percent)[Source :World Bank 2022] Waste composition differs across income levels, reflecting varied patterns of consumption. High-income countries generate relatively less food and green waste, at 32 percent of total waste, and generate more dry waste that could be recycled, including plastic, paper, cardboard, metal, and glass, which account for 51 percent of waste. Middle- and low-income countries generate 53 percent and 57 percent food and green waste, respectively, with the fraction of organic waste increasing as economic development levels decrease. In low-income countries, materials that could be recycled account for only 20 percent of the waste stream. Across regions, there is not much variety within waste streams beyond those aligned with income. All regions generate about 50 percent or more organic waste, on average, except for Europe and Central Asia and North America, which generate higher portions of dry waste.
6 Figure 1.3:Waste composition [Source :World Bank 2022] It is a frequent misconception that technology is the solution to the problem of unmanaged and increasing waste. Technology is not a panacea and is usually only one factor to consider when managing solid waste. Countries that advance from open dumping and other rudimentary waste management methods are more likely to succeed when they select locally appropriate solutions. Globally, most waste is currently dumped or disposed of in some form of a landfill. Some 37 percent of waste is disposed of in some form of a landfill, 8 percent of which is disposed of in sanitary landfills with landfill gas collection systems. Open dumping accounts for about 31 percent of waste, 19 percent is recovered through recycling and composting, and 11 percent is incinerated for final disposal. Adequate waste disposal or treatment, such as controlled landfills or more stringently operated facilities, is almost exclusively the domain of high- and upper- middle-income countries. Lower-income countries generally rely on open dumping; 93 percent of waste is dumped in low-income countries and only 2 percent in high-income countries. Three regions openly dump more than half of their waste—the Middle East and North Africa, Sub-Saharan Africa, and South Asia. Upper-middle-income countries have the highest percentage of waste in landfills, at 54 percent. This rate decreases in high-income countries to 39 percent, with diversion of 36 percent of waste to recycling and composting and 22 percent to incineration. Incineration is used primarily in high-capacity, high-income, and land-constrained countries.

7 Figure 1.4: Global treatment and disposal of waste (percent)[Source :World Bank 2022] Based on the volume of waste generated, its composition, and how it is managed, it is estimated that 1.6 billion tonnes of carbon dioxide (CO2) equivalent greenhouse gas emissions were generated from solid waste treatment and disposal in 2016, or 5 percent of global emissions. This is driven primarily by disposing of waste in open dumps and landfills without landfill gas collection systems. Food waste accounts for nearly 50% of emissions. Solid waste–related emissions are anticipated to increase to 2.38 billion tonnes of CO 2 -equivalent per year by 2050 if no improvements are made in the sector. 1.3.3 Industrial waste Industrial Solid Waste Industrial solid waste in the Asian and Pacific Region, as elsewhere, encompasses a wide range of materials of varying environmental toxicity. Typically this range would include paper, packaging materials, waste from food processing, oils, solvents, resins, paints and sludges, glass, ceramics, stones, metals, plastics, rubber, leather, wood, cloth, straw, abrasives, etc. As with municipal solid waste, the absence of a regularly up-dated and systematic database on industrial solid waste ensures that the exact rates of generation are largely unknown. Industrial solid waste generation varies, not only between countries at different stages of development but also between developing countries . In People's Republic of China, for example, the generation ratio of municipal to industrial solid waste is one to three. In Bangladesh, Sri Lanka and Pakistan, however, this ratio is much less. In high-income, developed countries, such as Australia and Japan, the ratio is one to eight. However, based on an average ratio for the region, the industrial solid waste generation in the region is equivalent to 1 900 million tonnes per annum. This amount is expected to increase substantially and at the current growth rates, it is estimated that it will double in less than 20 years. As the existing industrial solid waste collection, processing and disposal systems of many countries are grossly inadequate, such incremental growth will pose very serious challenges (ESCAP 1997).

8 1.3.4 Agricultural waste Agricultural Waste and Residues Expanding agricultural production has naturally resulted in increased quantities of livestock waste, agricultural crop residues and agro-industrial by- products. Table 8.3 provides an estimate of annual production of agricultural waste and residues in some selected countries in the region (ESCAP 1997). . Among the countries in the Asian and Pacific Region, People's Republic of China produces the largest quantities of agriculture waste and crop residues followed by India. In People's Republic of China, some 587 million tonnes of residues are generated annually from the production of rice, corn and wheat alone. In Myanmar, crop waste and residues amount to some 4 million tonnes per year (of which more than half constitutes rice husk), whilst annual animal waste production is about 28 million tonnes with more than 80 per cent of this coming from cattle husbandry. 1.3.5 Hazardous Waste With rapid development in agriculture, industry, commerce, hospital and health-care facilities, the Asian and Pacific Region is consuming significant quantities of toxic chemicals and producing a large amount of hazardous waste. Currently, there are about 110 000 types of toxic chemicals commercially available. Each year, another 1 000 new chemicals are added to the market for industrial and other uses. The availability of robust data on the generation of hazardous waste for the Asian and Pacific Region is limited by the reliability of information on the quantities and types of hazardous waste produced at the country level. This is due to avariety of reasons, including the lack of qualified personnel to undertake the necessary assessment, the reluctance of industries to provide process information (including waste arising data) and a poor appreciation of the extent to which generated waste is hazardous. Where data is available, significant difficulties are encountered in seeking to draw international comparisons due to differences in classification and definition of hazardous waste from country to country within in the region. Most hazardous waste is the by-product of a broad spectrum of industrial, agricultural and manufacturing processes, nuclear establishments, hospitals and health-care facilities. Primarily, high-volume generators of industrial hazardous waste are the chemical, petrochemical, petroleum, metals, wood treatment, pulp and paper, leather, textiles and energy production plants (coal-fired and nuclear power plants and petroleum production plants). Small- and medium-sized industries that generate hazardous waste include auto and equipment repair shops, electroplating and metal finishing shops, textile factories, hospital and health-care centres, dry cleaners and pesticide users. The principal types of hazardous waste generated in the Asian and Pacific Region, include waste solvents, chlorine bearing waste and pesticide organophosphate-herbicide-urea-fungicide bearing waste. In particular, solvents are extensively used in the region and, as a consequence, large quantities of waste solvents are produced. 1.3.6 Construction and demolition waste (C&D) C&D waste, also referred to as DLC (demolition, land clearing and construction waste), refers to waste generated by construction and demolition activities. It generally includes materials such as brick, painted wood, drywall, metal, cardboard, doors, windows, wiring, etc. It excludes materials from land clearing on areas not previously developed. C&D waste can come from

9 residential sources such as house renovations or from non-residential sources for example the construction or demolition of office buildings. 1.3.6.1

Management of

Construction and Demolition Waste Schedule I of the construction and demolition waste management rules, specifies the management of construction and demolition waste. It details out guidance on storage, collection, transportation, processing, and disposal and also the use of the recycled products. Reuse, processing, and recycling have been emphasized. Large generators have to be incentivized for setting up in-situ processing facility. For large facilities, say for million plus cities, processing should be done through appropriate technology which minimizes process residues for landfilling, e.g., "wet" process, which can retrieve sand grade material (4.75 mm to 75 μ) from soil and other fine inert material. Schedule II provides for further use of processed C&D products in operation of sanitary landfill. It must be clarified that while processed C&D waste shall be utilized in sanitary landfill for MSW of the city or region, residues from C&D waste processing or recycling industries shall be landfilled in the sanitary landfill for MSW. 1.3.6.2

STORAGE COLLECTION TRANSPORTATION AND DISPOSAL OF

Construction and Demolition WASTE Schedule I details out the compliance criteria for storage and processing or recycling facilities for C&D waste: 1. The concerned department in the State Government dealing with land shall be responsible for providing suitable sites for setting up of the storage, processing and recycling facilities for construction and demolition and hand over the sites to the concerned local authority for development, operation and maintenance, which shall ultimately be given to the operators by Competent Authority and wherever above Authority is not available, shall lie with the concerned local authority. 2. The Local authority shall co-ordinate (in consultation with Department of Urban Development of the State or the Union territory) with the concerned organizations for giving necessary approvals and clearances to the operators. 3. Construction and demolition waste shall be utilized in sanitary landfill for municipal solid waste of the city or region as mentioned at Schedule I of these rule. Residues from construction and demolition waste processing or recycling industries shall be land filled in the sanitary landfill for solid waste. 4. The processing or recycling shall be large enough to last for 20-25 years (project based on- site recycling facilities). 5. The processing or recycling site shall be away from habitation clusters, forest areas, water bodies, monuments, National Parks, Wetlands and places of important cultural, historical or religious interest. 6.

A buffer zone of no development shall be maintained around solid waste processing and disposal facility,

exceeding five Tonnes per day of installed capacity.

This will be maintained within the total area of the solid waste processing and disposal facility. The

10 buffer zone shall be prescribed on case to case basis by the local authority in consultation with concerned State Pollution Control Board. 7.

Processing or recycling site shall be fenced or hedged and provided with proper gate to monitor incoming vehicles or other modes of transportation. 8. The approach and or internal roads shall be concreted or paved so as to avoid generation of dust particles due to vehicular movement and shall be so designed to ensure free movement of vehicles and other machinery. 9. Provisions of weigh bridge to measure quantity of waste brought at landfill site, fire protection equipment and other facilities as may be required shall be provided. 10. Utilities such as drinking water and sanitary facilities (preferably washing/bathing facilities for workers) and lighting arrangements for easy landfill operations during night hours shall be provided and Safety provisions including health inspections of workers at landfill sites shall be carried out made. 11. In order to prevent pollution from processing or recycling operations, the following provisions shall be made, namely: a. Provision of storm water drains to prevent stagnation of surface water; b. Provision of paved or concreted surface in selected areas in the processing or recycling facility for minimizing dust and damage to the site. c. Prevention of noise pollution from processing and recycling plant: d. provision for treatment of effluentif any, to meet the discharge norms as per Environment (Protection) Rules, 1986. 12. Work Zone air quality at the Processing or Recycling site and ambient air quality at the vicinity shall be monitored. 13. The measurement of ambient noise shall be done at the interface of the facility with the surrounding area, i.e., at plant boundary. 14. The following projects shall be exempted from the norms of pollution from dust and noise as mentioned above: For construction work, where at least 80 percent construction and demolition waste are recycled or reused in-situ and sufficient buffer area is available to protect the surrounding habitation from any adverse impact. 15. A vegetative boundary shall be made around Processing or Recycling plant or site to strengthen the buffer zone. 1.4

Waste to Energy

Waste to energy (WtE) refers to the process of generating energy in the form of heat or

electricity from

MSW. Energy from MSW can be achieved through: i. thermal processes like incineration or combustion of refuse derived fuel (RDF).

ii. biological processes like bio methanation and

further conversion into electrical power or automotive fuel (compressed biogas). Solid Waste management RULES, 2016: guidance ON WASTE TO ENERGY

As

per SWM Rules, 2016: Clause 15: Duties and responsibilities of local authorities:

11

Facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development from time to time and standards prescribed by
the
Central Pollution Control Board. Preference shall be given to decentralised processing to minimize transportation cost and environmental impacts
such as- b)
waste to energy processes including refused derived fuel for combustible fraction of waste or supply as feedstock to solid waste-based power plants or cement kilns.
Clause 18: Duties of the industrial units located within one hundred km from the refused derived fuel and waste to energy plants based on solid waste
All industrial units using fuel and located within one hundred km from a solid waste based refused derived fuel plant shall make arrangements
within six months from the date of notification of these rules to replace at least five percent of their fuel requirement by refused derived fuel so produced.
Clause 21.
Criteria for waste to energy process. 1.
Non-recyclable waste having calorific value of 1500 K/cal/kg or
more shall not be disposed of on landfills and shall only be utilised for generating energy
either or through refuse derived fuel
or by giving away as feed stock
for preparing refuse derived fuel. 2.
High calorific wastes shall be used for co-processing in cement or thermal power plants. 3. The
local body or an operator of facility or an agency designated by them proposing to set up
waste to energy plant of more than five tons per day processing capacity
shall submit an application in Form-I
to
the
State
Pollution Control Board or Pollution Control Committee,
as
the case may be,
for authorisation. 4. The State Pollution Control Board or Pollution Control Committee,
on receiving such application for setting up waste to energy facility, shall examine the same and grant permission within sixty days. 1.4.1
Waste to energy (WtE) In the
Integrated Solid Waste Management Hierarchy: The integrated solid waste management (ISWM) hierarchy
indicates that recovery of energy from waste is preferable only after considering the potential for recovery of material.
Valuable energy is sought to be recovered after ensuring that all possible reduce, recycle, and recover mechanisms have been adopted.
12 Figure 1.5: Waste management hierarchy Proven WtE
technologies include incineration of MSW with recovery of energy, either as heat or converted to electricity and production of high calorific value RDF, which is fast gaining acceptance.
However, stringent norms specifying quality standards and conditions for its utilisation are awaited from the Ministry of Environment, Forest and Climate Change (MoEFCC). There are various other
technologies under discussion, such as pyrolysis and gasification, which are not yet proven under Indian conditions
for treatment of MSW. 1.5
Incineration Incineration is a waste treatment process that involves combustion of
waste
at very high temperatures in the presence of oxygen
and results in the production of ash, flue gas, and heat.
Incineration is
a feasible technology for combustion of unprocessed or minimum processed refuse and for the segregated fraction of high calorific value waste.
Technical Aspects of Processing and Treatment of municipal solid

waste 279 . The potential for energy generation depends on the composition, density, moisture content, and presence of inert in the
waste. In practice,
about 65%–80 % of the energy content of the organic matter can be recovered as heat
energy, which can be utilised either for direct thermal applications or for producing power via steam turbine generators. Besides the
potential for energy use, incineration of MSW helps to reduce landfill volumes. Incineration is an option especially where other better options of processing of waste are not feasible and land for landfilling and other waste processing methods is scarce. Key Criteria for Municipal Solid Waste Incineration
MSW Incineration projects are appropriate only if the following overall criteria are fulfilled:
13 • A mature and well-functioning waste management system has been in place for a number of years; •
Incineration is especially relevant for the dry bin content in a two-bin system. For unsegregated waste, pre-treatment is necessary; •
The lower calorific value (LCV)32 of waste must be at least 1,450 kcal/kg (6
MJ/kg) throughout all seasons. The annual average LCV must not be less than 1,700 kcal/kg (7
MJ/
kg);33 • The furnace must be designed in line with best available technologies to ensure stable and continuous operation and complete burnout of the waste and flue gases. MSW is usually incinerated in a grate incinerator. Uniform combustion of waste
is dependent on the
grate design •
The supply of waste should be stable and amount to at least 500
TPD of segregated waste; •
Produced electricity or stream can be sold on a sustainable basis (e.g., feeding into the general grid at adequate tariffs). •
It is possible to absorb the increased treatment cost through management charges and tipping fees. • Skilled staff
can be recruited and maintained. •
Since the capital investment is very high,
the planning framework of the community should be stable enough to allow a planning horizon of 25 years or more. •
Pre-feasibility study for the technology lead to positive conclusions for the respective community. • Strict monitoring systems are proposed and
followed. 1.6
Bio-methanation Bio-methanation
is the anaerobic (in the absence of free oxygen) fermentation of biodegradable matter in an enclosed space under controlled conditions of temperature, moisture, pH, etc. The waste mass undergoes decomposition due to microbial activity,
thereby generating biogas comprising mainly of methane and carbon dioxide (
CO_2), and also digested sludge, which is almost stabilised but may contain some pathogen. Due to the anaerobic environment, hydrogen sulphide (H_2S) is generated with varying percentage depending on the sulphur content in the system (in the form of protein, sulphate, etc.). Like composting, biomethanation is one of the most technically viable options for Indian municipal solid waste (MSW) due to the presence of high organic and moisture content.
Simple small to medium scale systems have been developed in India, especially for cattle manure; these plants are called Gobar Gas Plants.
According to the Ministry of New and Renewable Energy (MNRE), 4.3
million family type biogas plants have been installed in India. Toilet linked biogas plants have been installed at family, community, and institutional levels. Application of biomethanation for MSW can be seen broadly in three categories: (i) small biogas plants for canteen waste; (ii) medium-sized digesters for market waste (flower, fruit, vegetable, slaughterhouse, etc.); (iii) and large-scale plants.
14 1.6.1
Merits
of Biomethanation Process • Energy generation, the produced biogas can be used for cooking or for the production of electricity and heat. •

Biogas may also be cleaned by removing CO2 and H2S. The resulting methane enriched biogas containing more than 90% methane (CH4) is somewhat like compressed natural gas (CNG). However, for this gas to be used as automotive fuel, the percentage of CO2 has to be less than 5%, which corresponds to methane percentage of 95% or more. H2 S has to be less than 10 parts per million (ppm) for use in automobiles. Use of this fuel is more benign for the environment than using petroleum- based automotive fuels. Like composting , biomethanation also leads to reduced landfill requirement, thus extending the life of existing landfills. •

Biomethanation of biodegradable organic material would result
in stabilised sludge which can be used as a soil conditioner
and fertiliser.

However, pathogen kill or inactivation may not be complete during anaerobic digestion with the relatively short hydraulic retention time (HRT) designed for optimisation of biogas production.

Therefore, aerobic composting of the sludge is recommended to pass the material through
temperature cycle of above 60°C–70°C for at least 2 days. • Although the total system of biomethanation is more cost intensive than the total system of open aerobic composting, biomethanation has certain advantages with respect to much less odour and bird menace. The time frame (cycle time) is also less, so that less land is required for the same capacity. These two can be a big advantage where the only available sites are close to habitation. This way, biomethanation can be compared to in- vessel composting, which is again more expensive than open aerobic composting. 1.6.2

General Process Involved in Biomethanation

Generally the overall process can be divided into four stages: o pre-treatment
o
anaerobic fermentation o collection of biogas and its usage o residue treatment Pre-treatment:

Most digestion systems require pre-treatment of waste to obtain a homogeneous feedstock. For anaerobic fermentation, pre-processing involves separation of non- digestible material either through source segregation or through mechanical sorting at the biogas plant facility.

Source segregation results in less contaminated sludge compost. The separation ensures the removal of
undesirable or recyclable material such as glass, metals, stones, etc.

The waste is shredded before it is fed into the digester for better fermentation
especially when the incoming material has large pieces or whole items.

Anaerobic Fermentation (
Digestion):

15 Anaerobic fermentation happens in three steps brought about by different groups of microbes: hydrolysis (hydrolytic bacteria), acidogenesis (acidogenic bacteria), and finally bio methanation (methanogenic bacteria).

Normally the digesters (fermenters) are designed as single stage or single phase, where all the three processes take place in micro environments within the single vessel. Later, the concept of biphasic fermenters was developed where the process up to acidogenesis happens in the first phase in a slightly lower pH range and the methanogenesis happens in the second phase at near neutral pH range. This mode is supposed to be more efficient from the point of pH as well as time management because of the flexibility to optimise each of these reactions. However, for MSW, the normal practice is to use suspended particulate fermenter configuration in one digester or two digesters in tandem. In the latter case, the efficiency as well as effluent quality improves. The size of the fermenter (digester) depends on the input volume of the substrate (feed material for microbial action) in suspension and the HRT. There are other digester configurations which have been discussed later in this chapter. Inside the digester, the feed is diluted to achieve the desired solids content and remains in the digester for a designated retention time. For dilution, a varying range of water sources can be used such as clean water, sewage, or re-circulated liquid from the digester effluent. Usually, the solids concentration is around 6%–10%, but some of the well-known systems have more than 20% total solids; such systems are called dry fermentation or digestion. In batch mode, solids concentration of even 40% can be used.

A heat exchanger can be fitted for better utilisation of heat in the whole system, especially for maintaining the desired temperature range in the digesting vessel.

Gas Recovery: The
biogas obtained may be scrubbed to ensure automotive quality CNG-like gas (CO 2 less than 5% and H 2 S less than 10 ppm).

Biogas may also be used for generating electricity. Residue Treatment: The digested sludge
from the digester
is dewatered and the liquid recycled for use in the dilution of incoming feed. The biosolids are dewatered to 50%–55% total solids with a screw press, filter press, or other types of dewatering systems and aerobically cured to obtain a compost product. 1.6.3 Operating Parameters for

Bio methanation

Certain physical parameters should be controlled in the digester to enhance microbial activity and increase efficiency of the system. These parameters include the following: (a)

Temperature: Temperature affects bacterial growth and hence the amount of biogas produced.

Treatment of waste in anaerobic reactors is normally carried out within two ranges: around 25°C–40°

C (ideally 35°C–37°C) known as mesophilic range, and higher than 45°C (ideally 55°C–60°C) known as thermophilic range.

At higher temperatures (thermophilic range)

16 • The rate of digestion is faster, and thus shorter retention times are required; • Smaller reactor volumes are required for treating the same amount of waste; • There is higher rate and efficiency of hydrolysis of the suspended particulate matter • Destruction of pathogens is more efficient. (b)

pH: The anaerobic digestion process is limited to a relatively narrow pH band from 6.0

pH to 8.5 pH approximately, especially that the methanogenic bacteria are very sensitive to pH (close to neutral pH around 7.0). (

c)

Moisture: The moisture content of waste is important as explained above. (d)

Toxicity: A number of compounds are toxic to anaerobic microorganisms. Methanogens are commonly considered to be the most sensitive to toxicity. (

e) Carbon-to-nitrogen

ratio: Optimum carbon-to-nitrogen (

C/N) ratio in anaerobic digesters is 20:30.

A high C/N ratio is an indication of rapid consumption of nitrogen by methanogens and results in lower gas production. On the other hand, a lower C/N ratio causes ammonia accumulation and pH values exceeding 8.5, which is toxic to methanogenic bacteria.

Optimum

C/N ratios of the digester materials can be achieved by mixing material of high and low C/N ratios, such as organic solid waste (high in carbon) and sewage or animal manure (high in nitrogen). (f)

Organic

loading rate: Organic loading rate is the frequency and speed at which the substrate is added to the digester. For each plant of a particular size, there is an optimal rate at which the substrate should be loaded.

Beyond this optimal rate, further increases in the feeding rate will not lead to a higher rate of gas production. Agitation or consistent stirring of the contents in the digester also plays an important role in determining the amount of biogas produced. (g)

Retention time: The required retention time for completion of the reactions varies with differing technologies, process temperature, and waste composition. The retention time for

waste

treated in a mesophilic digester range from 20 to 30 days.

Lower retention times are required in digesters operated in the thermophilic range.

A high solids reactor operating in the thermophilic range has a retention time of

about 14 days. 1.6.4

Utility of

Biogas produced in bio methanation plants The percentage of methane (CH_4) varies with the efficiency of the anaerobic digestion and the composition of the substrate. With cattle manure, about 55%–60% methane is obtained; whereas with water hyacinth and some food waste, 70% methane is obtained. Biogas is also water saturated (100% humidity). The calorific value of biogas is 5,000–6,000 kilocalories per cubic meter (kcal/m^3) depending on the methane percentage. The biogas, by virtue of its high calorific value, has tremendous potential to be used as fuel for power generation through either internal combustion engines or gas turbines. Broadly, biogas can be used for the following purposes: • Cooking or heating fuel. • Motive power (e.g., biogas pump). • Electrical power.

17 • Gaseous automotive fuel. After stripping carbon dioxide (CO_2), hydrogen sulphide (H_2S), and moisture called compressed biogas (CBG). Since the last couple of years, interest is rapidly growing in CBG. 1.6.5

Pipeline Injection Purified and CBG can be injected into PNG line. Certain scale is required for this conversion, especially for the removal of CO2 and compression to the desired pressure. Practically, this can be done for large biogas plants or battery of biogas plants where the biogas generation is at least 500 m3 per hour (12,000 m3 per day). 1.6.6 Electricity Generation Electricity can be generated from biogas for on-site processing or for distribution through the local electric power grid. Internal combustion engines and gas turbines are the most commonly used for biogas to power generation projects. Unlike automotive use, the CO 2 is not scrubbed, and H 2 S has to be removed to the extent of 50 parts per million (ppm). Although this means lower efficiency, removal of CO 2 requires a certain minimum scale depending on the method of stripping. Their flexibility, especially for small generating capacities, makes them the only electricity generating option for smaller gas volumes. 1.7

Landfill

Landfilling

is the term used to describe the process by which solid waste and solid waste residuals are placed in a landfill.

In the past, the term sanitary landfill was used to denote a

landfill in

which the waste placed in the landfill was covered at the end of each day's operation. Today, sanitary landfill refers to an engineered facility for the disposal of MSW designed and operated to minimize public health and environmental impacts. Landfills for individual waste constituents such as combustion ash, asbestos, and other similar wastes are known as monofills. Landfills for the disposal of hazardous wastes are called secure landfills. Those places where waste is dumped on or into the ground in no organized manner are called uncontrolled land disposal sites or waste dumps.

18

Figure 1.6: A typical Sanitary landfill

Types of Municipal Solid Waste to be accepted at landfills waste categories suitable for sanitary landfills are the following:

i)

Non-biodegradable and inert waste by nature or through pre-treatment. ii)

Commingled

waste (mixed waste) not found suitable for waste processing.

iii)

Pre-processing and post-processing rejects from waste processing sites. iv) Non-hazardous waste not being processed or recycled.

Sanitary landfilling is

not

mandated or required

for the following waste streams in the municipal solid waste (

MSW): (i) Biodegradable waste or garden waste. (ii) Dry recyclables (iii) Hazardous waste or industrial waste (to be disposed in hazardous waste sites with special containment).

Hazardous wastes have to be disposed of in special facilities– e.g., treatment, storage, and disposal facilities (TSDF)–that are designed for the respective types of waste. MSW having limited contamination of hazardous materials– e.g., aerosols, household chemicals, used batteries, contaminated containers like paint, etc. can be disposed of in a sanitary landfill with adequate liner systems (see requirements in SWM Rules, 2016). However, in line with this manual, such wastes should be segregated at source and managed appropriately, minimising their disposal in sanitary landfills.

Landfilling of construction and demolition (C&D) waste, where processing options are not available, will be done in a separate landfill or cell

where the waste can be stored and mined

19 for future use in earthwork or road projects.

C&D waste can be used as a daily cover or for road construction at the MSW sanitary landfill. 1.7.1 Essential Components of Municipal Sanitary Landfills The term sanitary landfill is used herein

to describe a unit operation

for final disposal of 'Municipal Solid Waste' on land, designed and constructed with the objective of minimising impact to the environment

and according to the SWM Rules. •

A liner system at the base and sides of the

sanitary

landfill

which prevents migration of leachate or gas to the surrounding soil. • A leachate collection and control facility which collects

and extracts

leachate from within and from the base of the
sanitary landfill and then treats the leachate. • A gas collection and control facility (optional for small
sanitary
landfills) which collects and extracts gas from within and from the top of the
sanitary
landfill and then treats it or uses it for energy recovery. •
A final cover system at the top of the
sanitary
landfill which enhances surface drainage, prevents infiltrating water, and supports surface vegetation. • A surface water drainage system which collects and removes all surface runoff from the
sanitary
landfill site. • An environmental monitoring system which periodically collects and analyses air, surface water, soil, gas, and groundwater samples around the
sanitary landfill site; and •
A
closure and post-closure plan which lists the steps that must be taken to close and secure a
sanitary
landfill site once the filling operation has been completed and the activities for long-term monitoring and operation and maintenance (O&M) of the completed sanitary landfill are functional. 1.8
Summary It is agreed that wastes are a direct result of human interaction and activities. Nevertheless, there seems to be several opinions as to what constitute a waste. Several researchers however agreed that wastes are materials whose owners no longer have a need for. Therefore, it is obvious that wastes is indeed subjective in meaning, as the term is open to several interpretations and also influenced by personal opinion. Nevertheless, it is important to provide a definition or at least a guide for the purposes of policies and legislations. This is evident from the fact that, it is the knowledge of what specifically constitute a waste and the categories of wastes that determines how wastes are dealt with or managed. Waste management involves a process whereby wastes are collected, transported and disposed of in the best possible way of limiting or eliminating the harmful effect of wastes. This aspect of environmental management is as important as other public amenities or infrastructures without which the life of contemporary man would be extremely difficult. This is because studies have shown a direct link between air, water and land pollution and diseases such as lung cancer, heart disease, cholera and hepatitis. In addition, climate change and eutrophication are a direct result of water and air pollution. Little wonder why there is a huge disparity in the life expectancy of people
20 in developed and developing countries. Since factors such as population increase and the coming together of people to form communities lead to increase waste generation. Efforts should be directed towards making projections far ahead in order to ensure that new and existing settlements are adequately planned so as to accommodate possible increase in the volume of waste generation in future. Effectively planning ahead will prevent indiscriminate disposal and other harmful practices so as to prevent the build-up of open dumps and breeding ground for rats and other vermin which poses health risk. 1.9 Questions/ Self-Assessment questions 1. What are the different types of waste? Define Waste management? 2. What are the factors of BIO- Methane generation? 3. 3.What are the essential components of Municipal solid waste landfill? 4. What do you understand by the term Waste management hierarchy? describe with diagram. 5. Define Construction & Demolition waste mentioning its collection and disposal. 6. What do you understand by Waste to Energy? 1.10 Select Readings/ Suggested Readings 1. Waste management Books An Overview by Amrita Chakraborty, SBS Publishers and Distributors Pvt Ltd. 2. Sewage Disposal and Air Pollution Engineering by Santosh Kumar Garg. 3. Urban Mining and Sustainable Waste Management by Sadhan Kumar Ghosh. 4. Hazardous Waste Management (McGraw-Hill Series in Water Resources and Environmental Engineering) by Michael D. LaGrega , Phillip L. Buckingham, et al. 5. Geoenvironmental Engineering - Site Remediation, Waste Containment and Emerging Waste Management Techonolgies: Site Remediation, Waste Containment, and Emerging Waste Management Technologies by H D Sharma & Krishna R Reddy .
21 UNIT 2: Municipal solid waste management 2.1 Objectives 2.2 Introduction 2.3 Classification
of Solid waste 2.4 Solid waste Management? 2.5 Properties of Solid waste 2.6 Collection of Municipal Solid waste 2.7 The Landfill Method of Solid Waste Disposal 2.8 Generation and Composition of Landfill Gases 2.9 Summary 2.10 Questions/ Self-Assessment questions 2.11 Select Readings/ Suggested Readings 2.1 Objectives After successfully completing this unit, you will be able to: ▪ learn about the different class of solid waste, ▪ outline different properties of solid waste ▪ know the collection mechanism of solid waste ▪ learn about detail of landfill method of solid waste disposal
2.2 Introduction What is
solid waste?
Solid wastes are all the wastes arising from human and animal activities that are normally solid and

are discarded as useless or unwanted.

It composes the heterogeneous mass of throwaways from residence and commercial activities as well as the more homogeneous accumulation of a single industrial activity. Based on the different sources of wastes it is broadly classified into 3 types • Municipal waste • Industrial waste • Hazardous waste

22 2.3 Classification of Solid waste Classification, So the four sources are residential waste, which is a waste generated from the household activity and consists of leftover food, paper, plastic, clothes, cardboard. Now, these residential waste or household waste is majorly classified again. In earlier days the classification was organic and inorganic. So organic means is a biodegradable and inorganic were known as non-biodegradable or recyclable one. Now a day even under Swachh Bharat Mission also it a very clearly mentioned that the waste generated from residential places, there are of two types. One is dry waste, dry waste including the dry material like paper, plastic cardboard, rubber, leather, clothes or inert content, construction, demolition waste. This is the dry waste, i.e., it does not have much moisture content and once the special type is wet waste which is including cooked, uncooked both kinds of waste or such kind of waste which is produced from the kitchen area that is called wet waste. 2.4 Solid waste Management? It may be defined as the application of techniques that will ensure the orderly execution of the function of collection, processing and disposal of solid waste. These three functions are called the 3 functional elements of solid waste management. Collection refers to the gathering of solid waste from places (residence, commercial, industrial establishment, public places). Processing refers to activity applied to solid waste to prepare it; disposal refers to the placing of solid waste in the ultimate resting place. 2.4.1 Quantification and Composition of solid

waste As an essential requirement each ULB should assess the quantity and composition of waste generated to plan for and design MSWM systems effectively. The quantity and composition of MSW generated in the ULB determine collection, processing, and disposal options that could be adopted. They are dependent on the population, demographic details, principal activities in the city or town, income levels, and lifestyle of the community. Waste generation is strongly dependent on the local economy, lifestyle, and infrastructure. It has been well established that waste generation of an area is proportional to average income of the people of that area. It is also observed that generation of organic, plastic, and paper waste is high in high income areas. An assessment states that

the per capita waste generation is increasing by about 1.3% per year.

With an urban growth rate of 3.0%–3.5% per year, the annual increase in waste quantities may be considered at 5% per year. Impacts of increasing ULB jurisdiction should also be considered while assessing future waste generation rates. Several studies were conducted by Central Pollution Control Board (CPCB) over the last 2 decades to arrive at waste generation details and composition of MSW generated in the country. Summaries of the several findings are listed below: • 1996: The characterization studies carried out by National Environmental Engineering Research Institute (NEERI) in 1996 indicate that MSW contains large organic fraction (30%–40%); ash and fine earth (30%–40%); paper (3%–6%); along with plastic, glass, and metal (each less than 1%). The calorific value of refuse ranges between 800 and

23 1,000 kilocalorie per kilogram (kcal/kg) and carbon-to-nitrogen (C/N) ratio ranges between 20 and 30. Study revealed that quantum of waste generation varies between 0.2 and 0.4 kg/capita/day in the urban centres and goes up to 0.5 kg/capita/ day in metropolitan cities. The study was carried out in 43 cities of varying sizes, as detailed out in Table 2.1. The results were presented in a report published by NEERI “Strategy Paper on Solid Waste Management in India” (1996). • 1999-2000:

The study conducted by CPCB through Environment Protection Training and Research Institute (EPTRI) in 1999–2000 in 210 Class I cities and 113 Class II towns indicated that Class I cities generated 48,134 tons per day (TPD) of MSW while Class II towns generated 3,401 TPD of MSW. The study revealed that waste generation rate in Class I cities was approximately 0.34 kg/capita/ day while the waste generation rate in Class II towns was found to be 0.14 kg/capita/day. • 2004-2005: NEERI’s study “Assessment of Status of Municipal Solid Wastes Management in Metro Cities and State Capitals” in 2004–2005 assessed 59 cities (35 metro cities and 24 state capitals). Studies have revealed that waste generation rate varies from 0.12 to 0.60 kg/capita/day. Analysis of physical composition indicates that total compostable matter in the waste is 40%–60%, while recyclable fraction is 10%– 25%. The moisture content in the MSW is 30%– 60%, while the C/N ratio is 20–40. 2.5 Properties of Solid waste

The properties of solid waste are important in evaluating alternative equipment needs, systems

and management programs and plans especially with respect to the implementation of disposal and resource and energy-recovery options. 2.5.1

Physical composition The physical composition of solid wastes including (1) Identification of the individual components that make up municipal solid wastes (2) Analysis of Calorific value (3) Moisture content (4) Density of Solid wastes are also discussed in this section. 2.5.2 Individual component Components that typically makeup most of the MSW and their relatives are mentioned in the table2.1 below. Although any kind of component can be selected, those listed in the table have

Year Composition Biodegradables Paper Plastic/ Rubber Metal Glass Rags Other Inerts 1996 42.21 3.63 0.60 0.49 0.60 - - 45.13 2005 47.43 8.13 9.22 0.50 1.01 4.49 4.016 25.16

24

been selected because they are readily identifiable, are consistent with component categories reported in the literature and are adequate for the characterization of solid wastes for most applications . Table 2.1: Components of solid waste 2.5.3

Calorific value Calorific value of waste is defined as

the amount of heat generated from combustion of a unit weight of the waste, expressed as kilojoule per kilogram (kJ/kg). The calorific value is determined experimentally using

a

bomb calorimeter, in which the heat generated from the combustion of a dry sample is measured

at a constant temperature of 25°C. Since the test temperature is below the boiling point of water, the combustion water remains in the liquid state. However, during combustion the temperature of the combustion gases remains above 100°C, so that the water resulting from combustion is in the vapour state. 2.5.4

Moisture Content Moisture content of MSW is usually expressed as the weight of moisture per unit weight of wet material.

In the wet-mass method of measurement the moisture in a sample is expressed as a percentage of the wet-mass of the material, in the dry-mass method it is expressed as a percentage of the dry-mass of the material. It is expressed as follows: Component Range (%) Typical (%) Yard waste 0-10 10 wood 1-3 2 Food waste 5-25 17 paper 10-40 33 cardboard 3-10 8 plastics 2-8 5 textiles 0-3 2 rubbers 0-1 .5 leather 0-2 .5 Misc. organics 0-4 2 glass 4-15 5 Tin cans 1-7 5 Nonferrous 0-1 1 ferrous 1-3 1 Dirt, ashes etc. 0-10 8

25 Moisture Content (%) = $h - h h \times 100$ Were,

Wet weight: Initial weight of sample with moisture content Dry weight: Weight of the sample after drying the sample to remove moisture

A typical range of moisture content is 20%–45%, representing the extremes of waste characteristics in an arid climate and in the wet

season of a region having large precipitation.

Values greater than 45% are however

not uncommon. Moisture increases the weight of MSW, and therefore the cost of collection and

transportation also increase. To prevent an increase in weight,

waste should be insulated from rainfall or other extraneous water. Moisture content is

a critical determinant in the economic feasibility of incineration processes since energy (i.e., heat) must be supplied for evaporation of water and in raising the temperature of the water vapour. Moisture content is generally

found to be high in wastes containing a higher proportion of food wastes. 2.5.5

Density of Waste The density of waste (mass per unit volume, kg/m 3) determines the storage and transportation volume requirements.

MSW density in India is typically around 450–500 kg/m 3 .

Hence the densities of solid

waste varies markedly with geographic location , season of the year and length and time of storage

so great care should be taken while selecting the typical values . Chemical Composition Knowledge about the chemical composition of solid waste is important in evaluating alternative processing and energy recovery options. If solid wastes are to be used as fuel, the four most important properties to be known are: 1. Proximate analysis • Moisture (loss at 105°C for 1h) • Volatile matter (additional loss on ignition at 950°C) • Ash (residue after burning) • Fixed Carbon (reminder) 2. Fushing point of ash 3.

Ultimate analysis percentage of C (Carbon), H (Hydrogen) , O (Oxygen) , N (Nitrogen) , S (Sulfur) and ash 4.

Heating Value (energy value) 2.5.6

Bio-Chemical Characteristics

Chemical characteristics of waste are essential in determining the efficacy of any treatment process. • Chemical characteristics:

These include pH; nitrogen, phosphorus, and potassium (N- P-K); total organic carbon; C/N ratio; and calorific value. • Biochemical characteristics: These include

carbohydrates, proteins, natural fiber, and biodegradable factor.

26 • Toxicity: Toxicity profile of MSW includes heavy metals, persistent organic pollutants, pesticides, and insecticides. Toxicity characteristic leaching procedure (TCLP) is used for ascertaining the toxicity profile of MSW. 2.6

Collection of

Municipal Solid waste Collection of solid waste in urban areas is difficult and complex because the generation of residential, commercial and industrial solid waste is a diffuse process that takes place in every home, every apartment building and every commercial and industrial facility as well as in the streets, parks, and even vacant areas of every community. The like development of suburbs all over the country has further complicated the collection task. 2.6.1 Type of solid Waste collection services Various types of collection services now used for municipal, commercial, and industrial sources. The most common municipal collection systems are curb, alley and backyard collection. The collection service provided to large apartment buildings, residential complexes and commercial and industrial activities typically cantered on the use of large movable and stationary containers. Curb Service: The house owner is responsible for placing the solid waste containers at the curb on the scheduled day. The workers come, collect, and empty the container and put back at the curb. Curb collection has gained popularity because labor cost for collection can be minimized. In the future it appears that the use of large containers which can emptied mechanically with an articulated containers pick up mechanism will be the most common method used for the collection of municipal wastes. Alley Service: The containers placed at the alley line from where they are picked up by workers from refuse vehicle who deposit back the empty container. Set out set back service: Set out man go to the houses to collect containers and empty them in the refuse vehicles. Another group of persons returns them to the house owner’s yard. Backyard Service: The workers with the vehicles carry a bin, wheel-borrow to the yard and empty the solid waste container in it. See Figures .

27 Figure 2.1: Typical example of mechanized collection vehicle with mechanical articulated pickup mechanism used for the collection of domestic source waste. Figure 2.2: Typical example of mechanized collection vehicle with mechanical articulated pickup mechanism used for the collection of domestic source waste. 2.6.2 Types of collection systems Solid waste collection system may be classified from several point of view such as the mode of operation, the equipment used, and the types of waste collected. In this text collection, system has been classified according to their mode of operation. • Hauled – container systems • Stationary- container systems Hauled Container Systems (HCS)

28 Hauled Collection system in which the containers used for the storage of waste are hauled to the processing, transfer or disposal site, emptied and returned to either their original location or some other location. Fig.2.3 Stationary – Container System (SCS) Stationary Collection system in which the containers used for the storage of wastes remain at the point of waste generation, except when moved for collection. There are two main types of stationary- container systems: (1) those in which self-loading compactors are used, and (2) those in which manually loaded vehicles are used. Fig.2.4 Hauled Container System and equipment Hauled Container Systems are ideally suited for the removal of wastes from sources, where the rate of generation is high, because relatively large containers are used. The use of large containers eliminates time as well as the unsightly accumulations and unsanitary conditions associated with the use of numerous smaller containers. Another advantage of hauler container system is flexibility: Containers of many different sizes and shapes are available for the collection of all types of waste. Figure 2.3: Hauled Container System

29 Figure 2.4: Stationary Container system There are generally two methods of collecting solid waste in residential areas: the curb side or alley method and the backyard collection method. In the curb side or alley side method residences are required to place the solid waste in containers at the curb or alley during designated collection days. The number of collection days per week varies. Vehicle V_h is $V_h = (V_d / r)$ If the total discarded volume of solid wastes on collection day is V_{dc} , the total number of trips is also given by $N_t = (V_{dc} / V_d) = (V_{dc} / V_h r)$ r = compaction ratio V_h = volume of collection Vehicle. V_d = Volume of solid waste collected per pickup location Analysis of collection systems: $t_{net} = m+u+d_l+s+h$ $N_t = [(1-W) H - t_1 - t_2]/t_{net}$ t_{net} = Total time required to complete one collection station m = time taken to mount the container in the in the collection vehicle u = time taken to unload the empty container at the collection point. s = time taken to unload the filled container at the destination point N_t = No. of Trips. H= Total allotted time during a work day W = Time wasted on non-job-related activities. t_1 = Time taken by the collection vehicle to travel from the dispatch station to the first collection point. t_2 = time taken by the collection vehicle to the travel from the last collection point to the dispatch station. Stationary Container system:

30 $t_{net} = (P+d_l) C_l + s + h$ $d_l = \{dbc(C_l - 1)\} / C_l$ P = Time taken to load the solid waste from the container to the collection vehicle. C_l = The no. of container location. dbc= Average driving time between container location. 2.7 The Landfill Method of Solid Waste Disposal

Landfilling

is the term used to describe the process by which solid waste and solid waste residuals are placed in a landfill.

In the past, the term sanitary landfill was used to denote a

landfill in

which the waste placed in the landfill was covered at the end of each day’s operation. Today, sanitary landfill refers to an engineered facility for the disposal of MSW designed and operated to minimize public health and environmental impacts. Landfills for individual waste constituents such as combustion ash, asbestos, and other similar wastes are known as monofills. Landfills for the disposal of hazardous wastes are called secure landfills. Those places where waste is dumped on or into the ground in no organized manner are called uncontrolled land disposal sites or waste dumps.

Landfills are

physical facilities used for the disposal of residual solid wastes in the surface soils of earth.

Sanitary landfill is

an engineered facility for the disposal of MSW, designed and operated to minimize public health and environmental impacts.

Landfillingistheprocessbywhichresidualsolidwasteisplacedinalandfill.Itincludes: • Monitoring of the incoming waste stream • Placement and compaction of waste • Installation of landfill environmental monitoring and control facilities.

31 2.7.1 Landfilling terms: Cell is the volume of material placed in a landfill during one operation. Lift is a complete layer of cells over the active area of landfill. Bench (or terrace) is used to maintain the slope stability of the landfill , for placement of surface water drainage channels and for the location of landfill gas recovery piping . Landfill gas is a mixture of gases found within the landfill . It is mainly consists of CH 4 & CO 2 .

32 Leachate is the liquid that collects at the bottom of a landfill . It is a result of percolation of precipitation and uncontrolled runoff. It can also include water initially contained in the waste as well as infiltrating groundwater. Environmental Monitoring involves the activities associated with collection and analysis of water and air samples, that are used to monitor the movement of Landfill gases and leachate at the landfill site. The general features of a sanitary landfill are illustrated in previous figures. Some terms commonly used to describe the elements of a landfill are defined as follows: ● The term cell is used to describe the volume of material placed in a landfill during one operating period, usually 1 day. A cell includes the solid waste deposited and the daily cover material surrounding it. ● Daily cover usually consists of 6 to 12 in of native soil or alternative materials such as compost, foundry sand, or auto shredder fluff that are applied to the working faces of the landfill at the end of each operating period. Historically, daily cover was to prevent rats, flies, and other disease vectors from entering or exiting the landfill. Today, daily

33 landfill cover is used primarily to control the blowing of waste materials, to reduce odors, and to control the entry of water into the landfill during operation. ● A lift is a complete layer of cells over the active area of the landfill. Typically, landfills comprise a series of lifts. ● A bench (or terrace) is typically used where the height of the landfill will exceed 50 to 75 ft. ● Benches are used to maintain the slope stability of the landfill, for the placement of surface water drainage channels, and for the location of landfill gas recovery piping. The final lift includes the landfill cover layer. ● Landfill liners are materials (both natural and man-made) that are used to line the bottom area and below-grade sides of a landfill Liners usually consist of successive layers of compacted clay or geosynthetic materials designed to prevent migration of landfill leachate and landfill gas. ● The final landfill cover layer is applied over the entire landfill surface after all landfilling operations are complete. Landfill covers consist of successive layers of compacted clay and/or geosynthetic material designed to prevent the migration of landfill gas and to limit the entry of surface water into the landfill. ● The liquid that forms at the bottom of a landfill is known as leachate. In general, leachate is a result of the percolation of precipitation, uncontrolled runoff, and irrigation water into the landfill. Leachate will also include water initially contained in the waste. Leachate contains a variety of chemical constituents derived from the solubilisation of the materials deposited in the landfill and from the products of the chemical and biochemical reactions occurring within the landfill. ● Landfill gas is the term applied to the mixture of gases found within a landfill.The bulk of landfill gas consists of methane (CH4) and carbon dioxide (CO2), the principal products of the anaerobic biological decomposition of the biodegradable organic fraction of the MSW in the landfill. ● Environmental monitoring involves the activities associated with collection and analysis of water and air samples used to monitor the movement of landfill gases and leachate at the landfill site. Landfill closure is the term used to describe

the steps that must be taken to close and secure a landfill site once the filling operation has been completed. ● Postclosure care refers to the activities associated with the long-term maintenance of the completed landfill (typically 30 to 50 years). Remediation refers to those actions necessary to stop and clean up unplanned contaminant releases to the environment. 2.7.2 Landfill Siting Considerations ● One of the most difficult tasks faced by public agencies and private waste management firms in implementing an integrated waste management program is the siting of new

34 landfills. Factors that must be considered in evaluating potential sites for the long-term disposal of solid waste include: ▪ Haul distance ▪ Location restrictions ▪ Available land area ▪ Site access 2.7.3 Landfilling Methods: 2.7.3.1 Excavated cell/trench Method ● It

is ideally suited to areas where an adequate depth of cover material is available at the site and where water table is not near the surface. ●

The soil excavated is used for daily and final cover. ● Excavated cells are typically square and trenches are long ditches.

35 2.7.3.2 Area Method ● It

is used when the terrain is unsuitable for excavation. ● High-groundwater conditions necessitate the use of this type. ●

Cover material must be hauled by truck or earthmoving equipment from adjacent land or from borrow-pit areas. ●

Compost produced from MSW can be used as intermediate cover material. 2.7.3.3 Canyon/depression Method ● Canyons, ravines, dry borrow pits, and quarries are used. ●

Control of surface drainage often is critical factor in the development of canyon/depression sites. ●

Filling for each lift starts at the head end of the canyon and ends at the month, so as to prevent the accumulation of water behind the landfill. ● Cover material is excavated from the canyon walls or floor before the liner is installed. There are generally two methods of sanitary land filling: the area method and the trench method. The area method is used when it is impossible to excavate, especially when the groundwater is high. In this method, a berm is constructed and the solid wastes are simply dumped on the ground, spread in layers of about 0.5 m, and compacted. Another layer of 0.5 m is then placed on top of the previous layer and also compacted. Layering and compacting are repeated until a height of 2 to 3 m is reached. At this point and at the end of a working day a cover of ISO to 300 mm of earth is compacted on the top of the height. This cover is called a daily cover.

36

37 Figure 2.5: Methods of landfilling (a) Area method (b) Trench Method ● Locate the term "earthen levee or berm" in Figure. To the right of this berm is a completed unit of compacted solid waste or fill shown shaded. This unit is called a cell. Another cell to the right of the previous cell is then filled and compacted in" the same way. The cell filling then proceeds to the right until the entire horizontal span is filled. In the figure a total of five horizontal cells are filled in the span. ● Cells are then further constructed on top of the previous cells to complete another horizontal span of cells. After a horizontal span is completely filled, another span of horizontal cells may then be compacted on top of the previous span of horizontal cells. ● The span of cover between the upper and lower span of cells is called the intermediate cover. The vertical dimension of the entire span of a series of horizontal cells, including the intermediate cover as indicated in the figure, is called a lift. A partially filled second lift is shown in the figure. ●

There is no limit to the number of lifts that can be

filled as long as the side slope of the resulting heap does not exceed a certain criterion. This slope is normally limited to a maximum of I vertical to 4 horizontal. When, the limit of the filling is reached, a final compacted cover of about 0.6 m over the entire heap of fill is installed. A cap system is then also installed on top of the final cover. ● The area method is used when it is impossible to excavate, especially when the groundwater is high. The cover materials, however, may have to be imported off site. When it is possible to excavate, the trench method is used. This method has the benefit of having the cover material right at the site from the earth excavated from the trench.

38 The method begins by excavating a trench as shown in Figure. The width of the trench must allow free and easy movement of the compacting equipment and vehicles. Other than the addition of excavation, the method of filling, compacting, and covering are exactly the same as in the area method. 2.7.4 Concerns with landfilling ● The uncontrolled release of landfill gases that might migrate off-site and cause odour and other potentially dangerous conditions. ● The impact of the uncontrolled discharge of landfill gases on the greenhouse effect in the atmosphere. ● The uncontrolled release of leachate that might migrate to underlying groundwater or to surface streams. ● The breeding and harboring of disease vectors in improperly managed landfills. ● The health and environmental impacts associated with the release of the trace gases found in landfills arising from the hazardous materials that were often placed in landfills in the past. 2.7.5 Federal and State Regulations for Landfills Solid Waste Processing:

39 Processing the 2nd fundamental function of solid waste management. It can be done at the point of generation (on-site processing) or at the central processing facility. The unit operation in a central facility involves: ✓ Screening ✓ Air classifying ✓ Magnetic separation (Shredding) 2.8 Generation and Composition of Landfill Gases ● A solid waste landfill can be conceptualized as a biochemical reactor, with solid waste and water as the major inputs, and with landfill gas and leachate as the principal outputs. Material stored in the landfill includes partially biodegraded organic material and the other inorganic waste materials originally placed in the landfill. ● Landfill gas control systems are employed to prevent unwanted movement of landfill gas into the atmosphere. The recovered landfill gas can be used to produce energy or flared under controlled conditions to eliminate the discharge of harmful constituents to the atmosphere. Generation of the Principal Landfill Gases The generation of the principal landfill gases is thought to occur in five sequential phases • Phase 1 – initial adjustment • Phase 2 – transition phase • Phase 3- Acid phase • Phase 4 – methane fermentation phase • Phase 5 – maturation phase

40 Figure 2.6: Generalized phases in the generation of landfill gases (I—Initial Adjustment, II— Transition Phase, III—Acid Phase, IV—Methane Fermentation, and V— Maturation Phase) I. Initial adjustment phase o Biological decomposition occurs under aerobic conditions, because a certain amount of air is trapped within the landfill.

41 o The principle source of aerobic and anaerobic microorganisms responsible for waste decomposition is the soil material used as intermediate cover. o Wastewater treatment plant sludge disposed of to landfills and recycled leachate are other sources of microorganisms. Phase I is the initial adjustment phase, in which the organic biodegradable components in municipal solid waste begin to undergo bacterial decomposition soon after they are placed in a landfill. In Phase I, biological decomposition occurs under aerobic conditions because a certain amount of air is trapped within the landfill. The principal source of both the aerobic and the anaerobic organisms responsible for waste decomposition is the soil material that is used as a daily and final cover. Digested wastewater treatment plant sludge, disposed of in many MSW landfills, and recycled leachate are other sources of organisms. ● In Phase II, identified as the transition phase, oxygen is depleted and anaerobic conditions begin to develop. As the landfill becomes anaerobic, nitrate and sulfate, which can serve as electron acceptors in biological conversion reactions, are often reduced to nitrogen gas and hydrogen sulfide. Measuring the oxidation/reduction potential can monitor the onset of anaerobic conditions. Reducing conditions sufficient to bring about the reduction of nitrate and sulfate occur at about –50 to –100 mV.

42 ● In Phase III, known as the acid phase, the bacterial activity initiated in Phase II is accelerated with the production of significant amounts of organic acids and lesser amounts of hydrogen gas. The first step in the three-step process involves the enzyme mediated transformation (hydrolysis) of higher- molecular-mass compounds (e.g., lipids, organic polymers, and proteins) into compounds suitable for use by microorganisms as a source of energy and cell carbon. The second step in the process (acidogenesis) involves the bacterial conversion of the compounds resulting from the first step into lower- molecular weight intermediate compounds as typified by acetic acid (CH_3COOH) and small concentration of fulvic and other more complex organic acids. ● CO_2 is the principal gas generated during Phase III. Smaller amounts of hydrogen gas (H_2) will also be produced. The microorganisms involved in this conversion, described collectively as non-methanogenic, consist of facultative and obligate anaerobic bacteria. These microorganisms are often identified in the literature as acidogens or acid formers. ● Because of the acids produced during Phase III, the pH of the liquids held within the landfill will drop. The pH of the leachate, if formed, will often drop to a value of 5 or lower because of the presence of the organic acids and the effect of the elevated concentrations of CO_2 within the landfill. The biochemical oxygen demand (BOD_5), the chemical oxygen demand (COD), and the conductivity of the leachate will increase significantly during Phase III due to the dissolution of the organic acids in the leachate. Also, because of the low pH values in the leachate, a number of inorganic constituents, principally heavy metals, will be solubilized during Phase III. Many essential nutrients are also removed in the leachate in Phase III. If leachate is not recycled, the essential nutrients will be lost from the system. It is important to note that if leachate is not formed, the conversion products produced during Phase III will remain within the landfill as sorbed constituents and in the water held by the waste as defined by the field capacity.

43 ● In Phase IV, known as the methane fermentation phase, a second group of microorganisms, which converts the acetic acid and hydrogen gas formed by the acid formers in the acid phase to methane (CH_4) and CO_2, becomes more predominant. In some cases, these organisms will begin to develop toward the end of Phase III. The bacteria responsible for this conversion are strict anaerobes and are called methanogenic. Collectively, they are identified in the literature as methanogens or methane formers. In Phase IV, both methane and acid fermentation proceed simultaneously, although the rate of acid fermentation is considerably reduced because the acids and the hydrogen gas produced by the acid formers have been converted to CH_4 and CO_2 in Phase IV, the pH within the landfill will rise to more neutral values in the range of 6.8 to 8. In turn, the pH of the leachate, if formed, will rise, and the concentration of BOD_5 and COD and the conductivity value of the leachate will be reduced. With higher pH values, fewer inorganic constituents are solubilized; as a result, the concentration of heavy metals present in the leachate will also be reduced.

44 ● Phase V, known as the maturation phase, occurs after the readily available biodegradable organic material has been converted to CH_4 and CO_2 in Phase IV. As moisture continues to migrate through the waste, portions of the biodegradable material that were previously unavailable will be converted. The rate of landfill gas generation diminishes significantly in Phase V, because most of the available nutrients have been removed with the leachate during the previous phases and the substrates that remain in the landfill are slowly biodegradable. The principal landfill gases evolved in Phase V are CH_4 and CO_2. Depending on the landfill closure measures, small amounts of nitrogen and oxygen may also be found in the landfill gas. During the maturation phase, the leachate will often contain higher concentrations of humic and fulvic acids, which are difficult to process further biologically. Table 2.2: Typical Percentage Distribution of Landfill Gases during the First 48 Months

45 Table 2.3: Typical Concentrations of Trace Compounds Found in Landfill Gas at 66 California MSW Landfills. Source: Adapted from CIWMB (1988). 2.8.1 Principal Landfill Gas Constituents Gases found in landfills include ammonia (NH_3), carbon dioxide (CO_2), carbon monoxide (CO), hydrogen (H_2), hydrogen sulfide (H_2S), methane (CH_4), nitrogen (N_2), and oxygen (O_2). As shown in Table 2.2,

methane and carbon dioxide are the principal gases produced from the anaerobic decomposition of the biodegradable organic waste components in MSW. When methane is present in the air in concentrations between 5 and 15 percent, it is explosive. Because only limited amounts of oxygen are present in a landfill when methane concentrations reach this critical level, there is little danger that the landfill will explode. However, methane mixtures in the explosive range can be formed if landfill gas migrates off-site and is mixed with air. The concentration of these gases that may be expected in the leachate will depend on their concentration in the gas phase in contact with the leachate.

46 Trace Landfill Gas Constituents Summary data on the concentration of trace compounds found in landfill gas samples from 66 landfills are reported in Table 2.3. In another study conducted in England, gas samples were collected from three different landfills and analyzed for 154 compounds. A total of 116 organic compounds were found in landfill gas (Young and Heasman, 1985). Many of the compounds found would be classified as VOCs. The data presented in Table 2.3 are representative of the trace compounds found at most MSW landfills. The presence of these gases in the leachate that is removed from the landfill will depend on their concentration in the landfill gas in contact with the leachate. It should be noted that the occurrence of significant concentrations of volatile organic compounds in landfill gas is associated with older landfills, which accepted industrial and commercial wastes that contained VOCs. In newer landfills in which the disposal of hazardous waste has been banned, the concentrations of VOCs in the landfill gas have been extremely low. Even at these low concentrations, some landfill operators must install emission control facilities for VOCs to achieve compliance with air quality protection standards imposed by health-based risk assessment (Deipser and Stegmann, 1994; Pohland et al., 1993; Pohland et al., 2000; Reinhart, 1993; Thomas and Barlaz, 1999) . Composition of Leachate ● When water percolates through solid waste that are undergoing through decomposition both biological materials and chemical constituents are leached into solution. Typical data on the characteristics of leachate are reported in Table 2.4 for both new and mature landfills. Because the range of the observed concentration values for the various constituents reported in Table 2.4 is rather large, especially for new landfills, great care should be exercised in using the typical values that are given.

47 Table 2.4: Typical Data on the Composition of Leachate from New and Mature [Source: Developed from Bagchi (1990), County of Los Angeles and Engineering Science, Inc. (1969), Ehrig (1989), SWPCB (1954), and SWRCB (1967).] * Except pH, which is unit less. † Representative range of values. Higher maximum values have been reported in the literature for some of the constituents. ‡ Typical values for new landfills will vary with the metabolic state of the landfill. 2.9 Summary 2.10 Questions/ Self-Assessment questions 1. Solid waste from a new industrial park is to be collected in large container (drop boxes), some of which will be used in conjunction with stationary compactors. Based on traffic studies at the similar parks it is estimated that the average time to drive from the garage to the first container (t 1) and from the last container (t 2) to the garage each day will be 15 and 20 min., respectively. If the average time required to drive between containers is 6 min and the one-way distance to the disposal site is 25 km (speed limit:88 km/h),

48 determine the number of containers that can be emptied per day, based on 8-h work day. 2. Solid waste from a new industrial park is to be collected in large container (drop boxes), some of which will be used in conjunction with stationary compactors. Based on traffic studies at the similar parks it is estimated that the average time to drive from the garage to the first container (t 1) and from the last container (t 2) to the garage each day will be 15 and 20 min., respectively. If the average time required to drive between containers is 6 min and the one-way distance to the disposal site is 25 km (speed limit:88 km/h), determine the number of containers that can be emptied per day, based on 8-h work day? 3. Describe Stationary container and Hauled Container system with diagram. 4. Describe the various landfilling method with diagram. mention the various composition of municipal solid waste. Define lechate and monofill. 5. What is sanitary landfill. Describe sanitary landfill with proper diagram showing different components. 6. Describe different Phases of landfill along with the diagram showing different gases formed in the landfill. 2.11 Select Readings/ Suggested Readings 1. Environmental Engineering: A Design Approach by Arcadio P. Sincero, Gregoria A. Sincero. 2. Waste management Books an Overview by Amrita Chakraborty, SBS Publishers and Distributors Pvt Ltd. 3. Sewage Disposal and Air Pollution Engineering by Santosh Kumar Garg. 4. Urban Mining and Sustainable Waste Management by Sadhan Kumar Ghosh. 5. Hazardous Waste Management (McGraw-Hill Series in Water Resources and Environmental Engineering) by Michael D. LaGrega , Phillip L. Buckingham, et al. 6. Geo-environmental Engineering - Site Remediation, Waste Containment and Emerging Waste Management Techonolgies: Site Remediation, Waste Containment, and Emerging Waste Management Technologies by H D Sharma & Krishna R Reddy .

49 UNIT 3: Biomedical Waste (Generation, Handing & Management) 3.1 Objectives 3.2 Introduction 3.3 Classification of Bio-Medical Wastes 3.4 Necessity of Biological Waste Management 3.5 Segregation of Bio-Medical Wastes 3.6 Transportation to Final Disposal Sites 3.7 Treatment of Biomedical Wastes 3.8 Disposal of Biomedical Waste 3.9 Summary 3.10 Questions/ Self-Assessment questions 3.11 Select Readings/ Suggested Readings 3.1 Objectives After completion of the this chapter we will able • To classify the biomedical waste • To learn why the management of biological waste is required • To know the rules of BMW management in India • To get knowledge of segregation, transportation and treatment of the BMW 3.2 Introduction Since beginning, the hospitals

are known for the treatment of sick persons but we are unaware about the adverse effects of the garbage and filth generated by them
on human body and environment. Now it is a well-established fact that hospital waste is a
potential health hazard to the health care workers, public and flora and fauna of the area. The term
Bio Medical
Waste includes
any waste
which is generated during the diagnosis, treatment or immunisation of human beings or animals
or research activities
pertaining
there
on or in the production of testing of biological
or in health camps.
50 Figure 3.1: Biomedical waste 3.3 Classification of Bio-Medical Wastes Bio Medical wastes consists different components among which everything is not hazardous. So, these can be broadly classified in two sections a) Non-Hazardous Waste: About 75-90% of total bio medical wastes are non-hazardous. b) Hazardous Waste: About 10-25% of total bio medical wastes are considered hazardous. And within this hazardous waste 10-25% are infectious waste (e.g., sharps, liquid waste etc.), and remaining are non-infectious waste (e.g.,
radioactive waste, discarded glass, chemical waste, cytotoxic waste, incinerated waste) 3.4
Necessity of Biological Waste
Management Inadequate management of waste produced in health care facilities causes a direct health hazard on the general public, the health care workers and on the environment. There is an obligation for the supervision of biomedical waste to abate the risk of contamination outside the hospital for waste handlers, scavengers and those living in the locality of hospitals. Management is also required due to the risk of air, water, and soil pollution, or due to unsuitable incineration emissions and ash. It plays a vital role in removal of the discarded drugs that can be repacked and traded off. 3.4.1 Steps of Bio Medical Waste Management As previously discussed, all hospital generated waste are not hazardous equally, so all components don't need same kind of handling and management criteria. Steps involved in BMW management are shown below –
51 3.4.2 BMW Management in India Until fairly recently, BMW management was not generally considered an issue. In the 1980s and 1990s, concerns about exposure to human immunodeficiency virus (HIV) and hepatitis B virus (HBV) led to questions about potential risks inherent in medical waste. Thus, hospital waste generation and its appropriate management and disposal is a major concern due to its risk threat to the health of patients, immediate hospital staff and to the overall general population. Thus, it becomes important for the health care establishments to segregate, disinfect and dispose this waste using appropriate and available eco-friendly methods. In 20th July 1998 the Bio Medical Waste (Handling & Management) Rules was first published in The Gazette of India by Ministry of Environment and Forests (MoEF) of India. But with the advancement of medical world in diagnosis and treatments, the rules and guidelines were updated later on and the latest revision of Bio Medical Waste (Handling and Management) Rules, 2016 (with Amendments in 2018) is followed for efficient handling and management of BMW in India. 3.4.3 Bio Medical Waste (Handling and Management) Rules, 2016 Key Features i) This rule is applied
to all persons who generate, collect, receive, store, transport, treat, dispose or handle
of bio medical waste in any form including; Segregation Collection & Storage Transportation Treatment & Disposal Figure 3.2: Steps of Bio Medical waste management
52 Table 3.1: Sources of BMW • Hospital • Nursing homes • Clinics • Dispensaries • AYUSH hospitals • Veterinary institutions • Animal house • Pathological laboratories • Blood banks • Clinical establishments, research or educational institutions • Forensic laboratories • Research labs •
Health camps • Medical/ surgical camps • Vaccination camps • Blood donation camps • First aid rooms of schools
ii) The rules has been expanded to include camps such as vaccination camps, blood donation camps, surgical camps or any other healthcare activity. iii) Phase-out the use of chlorinated plastic bags, gloves (excluding blood bags)and gloves by the 27th March, 2019. iv) Microbiological waste, blood samples, blood bags and laboratory waste have to be disinfected at the health care facility before disposal to CBWTF or disposed off in a manner as prescribed by guidelines on Safe management of wastes from health care activities and WHO Blue Book, 2014 or WHO. v) Classification of biomedical waste has been reduced to 4 categories, that was hitherto 10. This may enhance the segregation efficiency. vi) Simplified procedure for authorization by the regulatory authority. The period of validity of authorization is matched with the validity period of consent orders. One time authorization for non-bedded HCFs. Table 3.2: Comparison Between BMW Rules 2011 and BMW Rules 2016 BMW (Management and Handling) Rules, 1998 & revised in 2011

Bio-Medical Waste Management Rules, 2016 Reasons and likely implications Title Bio-Medical Waste (Management and Handling) Rules, 2011 Bio-Medical Waste Management Rules, 2016.
The word 'Management' includes Handling.
Application These rules apply to all persons who
generate, collect, receive, store, transport, treat, dispose, or handle bio medical waste in any form.
These rules
shall apply to all persons who
generate, collect, receive, store, transport, treat, dispose, or handle bio-medical waste in
Modified to bring more clarity in the application. Clarified that vaccination camps, blood donation camps, surgical camps or any
53 any form and shall not apply to: • Radioactive wastes • Municipal solid wastes • Lead acid batteries • Hazardous wastes • e-waste • Hazardous microorganisms. other health care activity undertaken outside the health care facility, will be covered. Duties of the Health care facilities including CBWTF
Every occupier of an institution generating biomedical
waste which includes a
hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathological laboratory, blood bank
to take all
steps
to ensure
that such waste is handled without any adverse effect to human health and
the environment.
Additions: Healthcare facilities (HCF) shall make a provision within the premises for a safe, ventilated and secured location for storage of segregated biomedical waste To ensure that there shall be no secondary handling, pilferage of recyclables or inadvertent scattering or spillage by animals and the BMW from such place or premises can be directly transported in to the CBWTF Pre-treat the lab/ microbiological waste, blood samples and blood bags through disinfection or sterilization on-site in the manner as prescribed by WHO guidelines on Safe management of wastes from health care activities and WHO Blue Book, 2014 and then sent to the CBWTF for final Disposal This is to prevent the possible microbial contamination. Phase out use of chlorinated plastic bags, gloves within two years from the date of notification of these rules Will eliminate the emission of dioxin and furans from burning of such wastes. Provide training to all its healthcare workers and others involved in handling of BMW at the time of induction and thereafter at least once every year Will improve the management of BMW including collection, segregation. Immunize all its healthcare workers and others involved To protect the health of workers
54 in handling of BMW for protection against diseases including Hepatitis B and Tetanus
Establish a Bar-Code System for bags or containers containing
BMW to be sent out of the premises
Will improve the segregation, transportation and disposal system. Also, will eliminate pilferage on the way of BMW to disposal facility. Existing incinerators shall
achieve the standards for retention time in secondary chamber and Dioxin and Furans within two years
from the date of this notification Will improve the environment in the vicinity of treatment facility. Duties of the operator of a CBWTF Nil Same as the duties of HCFs and additionally they shall ensure timely collection of bio-medical waste from the HCFs, assist the HCFs in conduct of training Specific responsibility on the operator of a common bio- medical waste treatment and disposal facility will be make them clear to their duties Table 3.3: Schedules and Forms of Biomedical Waste Management Rules Schedules Schedule I
Bio-medical
wastes categories and their segregation, collection, treatment, processing and disposal options
Schedule II 1. Standards for incinerators a. Operating Standards b. Emission Standards c. Stack Height 2. Operating and Emission Standards for Disposal by Plasma Pyrolysis or Gasification a. Operating Standards b. Air Emission Standards and Air Pollution Control Measures c. Disposal of Ash Vitrified Material 3. Standards for autoclaving of bio-medical waste 4. Standards of microwaving 5. Standards for deep burial 6. Standards for efficacy of chemical disinfection 7. Standards for dry heat sterilization
55 8. Standards for liquid waste Schedule III List of prescribed authorities and the corresponding duties Schedule IV Part A Label for bio-medical waste containers or bags Schedule IV Part B Label for transporting bio-medical waste bags or containers Forms Form I Accident reporting Form II Application for authorisation or renewal of authorisation Form III Authorisation Form IV Annual report Form V Application for filing appeal against order passed by the prescribed authority
Table 3.4:
Categories of Bio-Medical Wastes

Categories Bio Medicals Waste components
Category 1 Human Anatomical Waste (
Human tissues, organs, body parts) Category 2 Animal Waste (Animal tissues, organs, body parts carcasses, bleeding parts, fluid,
blood and
experimental animals used in research,
waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses) Category 3 Microbiology & Biotechnology
Waste (
Wastes from laboratory cultures,
stocks or specimens of micro- organisms
live or attenuated vaccines, human and animal cell culture
used in research
and
infectious agents from research and industrial laboratories, wastes
from production of
biological, toxins, dishes and devices used for transfer of cultures)
Category 4
Waste sharps (Needles, syringes, scalpels, blades, glass, etc.
that may cause
puncture and cuts.
This includes
both used
and
unused sharps) Category 5 Discarded Medicines and Cytotoxic drugs (Wastes
comprising of outdated, contaminated and discarded medicines) Category 6 Soiled Waste
56 (Items contaminated with
blood, and
body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)
Category 7 Solid Waste (Wastes generated from disposable items
other than
the
waste sharps
such as tubings, catheters, intravenous sets etc).
Category 8 Liquid Waste (Waste generated from laboratory and
washing, cleaning, house- keeping and disinfecting activities). Category 9 Incineration Ash (Ash from incineration of any bio-medical waste)
Category 10
Chemical Waste (Chemicals used in
production of biological, chemicals used in disinfection, as insecticides, etc.) 3.5
Segregation
of Bio-Medical
Wastes For efficient and economical management of Bio Medical Waste Segregation of different categories of waste at source is very much important. For this purpose, different colour coded containers are used for source segregation of wastes. 3.5.1 Benefits of Segregation • Minimizes the quantity of infectious / hazardous waste that
needs special handling and treatment • Prevents the mixture of medical waste like sharps with the general municipal waste •
Reduces the risks of exposure to hazardous health care waste for workers and hence reduce the chance of spread of infection/ injuries • Reduces the cost of treatment of waste and its disposal as a result segregation helps in saving resources. Table 3.5: Colour coding and Segregation of waste Colour Code Waste Category
Type of Bag/ Container Materials
57 Yellow a. Human Anatomical Waste b. Animal Anatomical Waste c. Soiled Waste d. Expired/Discarded Medicines e. Chemical Waste f. Chemical Liquid Waste g.
Discarded linen, mattresses, beddings contaminated with blood or body fluid
routine mask and gown. h. Microbiology, Biotechnology and other clinical laboratory
waste Yellow coloured non- chlorinated plastic bags Separate collection system leading to effluent treatment system

Red Contaminated Wastes (Recyclable) • Tubes • IV bottles •
Catheters • Urine Bags • Syringes (Without needles) • Gloves Red coloured non- chlorinated plastic bags or containers White Translucent • Waste sharps including metals (both used, discarded and contaminated) •
Needles • Syringes with fixed needles, needles from needle tip cutter or burner • Scalpels / Blades • Any other contaminated sharp object that may cause puncture and cuts Puncture proof, leak-proof, tamper-proof containers
58
Blue • Glassware's (Broken or discarded or contaminated glass with medicine vials, ampoules without those contaminated with cytotoxic drugs) • Metallic body implants Puncture proof, leak proof box or containers with blue coloured or blue markings 3.5.2 Placement of Bins • Infectious waste containers should not be placed in areas where no infectious waste is generated (such as visitor's waiting areas, visitors' toilets, reception, administrative offices, medical records department, etc.). • In areas where both infectious and non-infectious wastes are generated, both containers should be strategically placed near each other so as to facilitate segregation. • Sharps container should be within arm's length of the healthcare professionals giving the injections. Placing waste containers too far away can increase the risk of needle-stick injuries. • Sharps container to be either wall mounted or placed on a table. • Infectious and sharps bins should not generally be placed by the patient beds except for isolation wards. • The nurse's trolley should have provision for the yellow bin (for contaminated swabs or dressings), red bin (syringes, etc.) and a sharps container (needle) and hub cutters in case they are used. • Location of the waste bins should be in the nurses' station, treatment room, or in other areas that patients and visitors cannot access. • If the Healthcare facility recycles non-hazardous general waste, marked containers for recyclables such as paper, packaging, plastic bottles and aluminium cans should be strategically located. Figure 3.3: Colour coded bins with Bio Hazards Symbol
59 • Chemical waste containers should be in areas where chemical waste is generated, such as pharmacy, laboratory and engineering. • Container for Expired drugs can be placed in Pharmacy as a central storage area from where it can be returned to the manufacturers or handed over to CBWTF, whichever is the policy of the HCF. • Any colour other than that used for BMW and according to the state policy, appropriate bins should be used for general waste. 3.5.3 Storage of Bio Medical Wastes The waste may be temporarily stored at the central storage area of the hospital and from there it may be sent in bulk to the site of final disposal once or twice a day depending upon the quantum of waste. During transportation following points should be taken care of: • Ensure that waste bags/containers are properly sealed and labelled. • Bags should not be filled completely, so that bags can be picked up by the neck again for further handling. Hand should not be put under the bag. At a time only one bag should be lifted. • Manual handling of waste bags should be minimized to reduce the risk of needle prick injury and infection. • BMW should be kept only in a specified storage area. • After removal of the bag, clean the container including the lid with an appropriate disinfectant. Waste bags and containers should be removed daily from wards / OPDs or even more frequently if needed (as in Operation Theatres, ICUs, labour rooms). Waste bags should be transported in a covered wheeled containers or large bins in covered trolleys. No untreated bio-medical waste shall be kept stored beyond a period of 48 hours. 3.6 Transportation to Final Disposal Sites Transportation from health care establishment to the site of final disposal in a closed motor vehicle (truck, tractor-trolley etc.) is desirable as it prevents spillage of waste on the way.
60 Vehicles used for transport of BMW must have the "Bio-Hazard" symbol and these vehicles should not be used for any other purpose. 3.7 Treatment of Biomedical Wastes Biomedical waste treatment refers to the procedures to eliminate the harmful effects of the waste. There are numerous treatment options which maximize safety during management and disposal of the waste. It also reduces environmental hazards. Incineration, Autoclaving, irradiation and chemical treatments are the most used methods for management and cleansing of biomedical waste. Figure 3.5: Bio Hazard Symbol Figure 3.4: Hazardous & Cytotoxic wastes
61 Table 3.6: Treatment Process of various category of waste 3.7.1 Incineration It is a treatment process used to transform pathological and pharmaceutical waste into ash, flue gases and heat. Functioning temperature for incineration should be in the range of 800-1400 degree Celsius. It reduces the bulk of waste by 90-95% and thus decreases harmful effects on the surroundings. Advantages Suitable for organic and combustible waste to inorganic, incombustible matter Results in a significant reduction of waste volume and weight. Disadvantages Generation of combustion by-products into the environment. Generation of residual ash. 3.7.2 Autoclaving It is a method of steam sterilization and is the most common substitute to incineration. Autoclaving necessitates a temperature of 121 degree Celsius and pressure of about 15 pounds per square inch (psi) for 20-30 minutes. This action is applied to inactivate the contagious agents and to sterilize the apparatus used in clinical services. It is less expensive and carries no recognized health impacts. Advantage Waste Category Treatment & Disposal Category 1 Incineration /deep burial Category 2 Incineration /deep burial Category 3 Local autoclaving/deep burial Category 4 Disinfection (chem. treatment/autoclaving) and mutilation/shredding Category 5 Incineration Category 6 Incineration/ autoclaving Category 7 Disinfection by chem. treatment, autoclaving Category 8 Disinfection by chem. Method and discharge into drains. Category 9 Disposal in municipal landfills Category 10 Chemical Treatment and discharge into drains for liquids and landfills for solids.

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Produce significantly less air pollution emissions than high-heat thermal processes, low capital and operational cost. Disadvantage Volatile and semi-volatile organic compounds, chemotherapeutic waste, mercury, chemical waste and radiological waste cannot be treated. Odours can be a problem around autoclaves if there is insufficient ventilation. 3.7.3 Chemical treatment This treatment is frequently used to decontaminate liquid waste, so that it can be disposed-off nearby. It makes use of a number of techniques such as oxidation, reduction, precipitation and pH neutralization to transform waste into less dangerous substances. Chlorine, sodium hydroxide or calcium oxide can be used agreeing to the nature of waste. Advantage No combustion and no by-products are produced. Waste becomes unrecognizable. Disadvantage Potential problem of chemical hazard. Shredding or milling of waste is usually necessary before disinfection. Only the surface of intact solid waste items will be disinfected. 3.7.4 Irradiation These methods are at present being used in waste treatment procedures which include gamma, electron-beam, ultraviolet and X-rays. Irradiation sterilizes waste in a sealed off chamber by uncovering it to a radioactive cobalt-60 which gives out gamma rays that are lethal to micro- organisms. It is very costly as associated to other methods and protections must be taken to guard workers from detrimental effects of radiations such as cancer, radiation sickness or even death. Advantage Fatal to microorganisms Disadvantage Expensive. Requires dedicated space. Requires post shredding. Some contaminated surfaces may face away from the radiation source. 3.8 Disposal of Biomedical Waste Land disposal is usually employed for remediation of waste which is decontaminated by appropriate treatment approaches. This technique is generally used in developing countries which includes the throwing away of waste into a landfill. Land-filling should be conducted at places where groundwater level is low and which are far from flooding sources. Radioactive wastes are commonly dumped in the oceans far away from human inhabitations. Every state and local government has its own rules and regulations for dumping of sanitized waste.

63 Advantage Scientifically sound design. Doesn’t affect the environment. Disadvantage Completed landfill areas can settle and requires maintenance. Requires proper planning, design, and operation. 3.9 Summary Waste generation should be curtailed for the protection of environment and overall public health. People must be alerted to the issues connected to biomedical waste and should contribute in the programs structured for waste minimization. The medical employees must be taught to create alertness and foster accountabilities for inhibition of exposure and unsafe disposal to the waste. Medical personnel should rigorously follow all the rules and regulations instigated by concerned governing bodies. BMWM should be a collective teamwork with dedicated government backing, worthy BMW practices tracked by both health-care workers and HCFs, continuous monitoring of BMW practices, and resilient legislature. It is our essential right to live in clean and safe environment. The proper handling and management of wastes can only lead us to a safer and cleaner environment in future. 3.10 Questions/ Self-Assessment questions 1. Define and explain the term " biomedical wastes”. 2. How are bio-medical wastes endangering biological life including the human? 3. Explain the term "colour coding" as is used in relation to the biomedical wastes, and how dose it helps in safe disposal of biomedical waste? 4. write in brief on the following: (i) Autoclaving method of disposal of biomedical waste (ii) Irradiation method of disposal of BMW. 5. How are hazardous solid and liquid waste disposed-off by incineration. 3.11 Select Readings/ Suggested Readings • Central Pollution Control Board. (2017). Bio-Medical Waste. [online] Available at: http://cpcb. nic.in/Bio_medical.php • Healthcare-waste.org. (2017). Health Care Waste Management. [online] Available at: https:// www.healthcare-waste.org/ • Ministry of Environment. Forest & Climate Change. (2017). [online] Available at: http://envfor. nic.in/ • Health impacts of health-care waste. World Health Organization. [Online].Available from: URL: http: www.who.int/water_sanitation_ health/medicalwaste/020to030. pdf?ua=1 • Health-care waste. World Health Organization. 2015. [Online]. Available from: URL: http:// www.who.int/mediacentre/factsheets/ fs253/en/

64 • Environmentally Sound Management of Medical Wastes in India” Endeavour of GEF, UNIDO, MoEFCC and State Governments of Gujarat, Karnataka, Maharashtra, Odisha and Punjab.

65 UNIT 4: E-waste 4.1 Objectives 4.2 Introduction 4.3 What is E-waste? 4.4 Sources 4.5 Classification of E-waste 4.6 Composition 4.7 E-waste Generation 4.8 Environmental & Health Issues 4.9 E-Waste (Management) Rules, 2016 4.10 Responsibilities of Manufacturer 4.11 Responsibilities of Producer 4.12 Responsibilities of Bulk Consumers 4.13 Storage of E-Waste 4.14 Treatment & Disposal 4.15 Summary 4.16 Questions/ Self-Assessment questions 4.17 Select Readings/ Suggested Readings 4.1 Objectives After completion of this chapter we will able • To know what is E-waste and its sources • To know the composition and types of e-waste • To identify the major effects of e-waste • To know about the rules and regulations of E-waste management 4.2 Introduction Advances in the field of science and technology brought about industrial revolution in the 18th Century and the information and communication revolution in the 20th Century has brought

66 enormous changes in the way we organize our lives, our society, our economies, industries and institutions. These developments enhanced the quality of our lives but led to manifold problems including the problem of massive amount of hazardous waste and other wastes generated from electric and electronic products. Basel Convention - According to the Basel Convention,

wastes are substances or objects, which are disposed of or are intended to be disposed of, or are required to be disposed of by the provisions of national
laws. Figure 4.1: E-waste 4.3 What is
E-
waste? E-waste or waste electrical and electronic equipment (WEEE)
are broadly describes loosely discarded, batteries, surplus, obsolete, broken, electrical or electronic devices which are at the end of their useful life and need to be disposed or dismantled to recover some valuable components. The problem of e-waste has become an immediate and long term concern as its unregulated and improper accumulation and recycling can lead to major environmental problems endangering not only human and animal health but also environment health due to toxic and other dangerous materials available in them.
Its quantum is increasing yearly, and disposal of e-waste is becoming a global environmental and public health issue. According to a study,12 India generates annually about 3,80,000 tonnes of e-waste, which is expected to increase manifold. The study also reveals that only about 6% of e-waste is recycled, of which 95% is operated through the informal sector. While mainly interested in precious metals (such as copper, silver, and platinum), recyclers are also interested in glass, plastic, and batteries within these devices. Currently applied processes for recycling WEEE
are largely unscientific and environmentally unsound, hence posing serious health threats.
It will be a challenge to reorganize the recycling of WEEE to establish recycling methods that protect both workers and the environment.
67 4.4
Sources Electrical and electronics devices generating e- waste are from IT & telecommunication equipment and consumer electrical / electronic products such as refrigerators, washing machines, computer and its accessories, monitors, printers, keyboards, central processing units, typewriters, mobile phones and chargers, remotes, compact discs, headphones, batteries, LCD/Plasma TVs, i-pods, air conditioners, dryers, fridge, VCRs, Stereos, Copiers, fax machines, video games, presenters, music system and other household appliances etc. many of which contain toxic materials. 4.5 Classification of E-
waste Table 4.1: E-waste is classified into two categories according to their characteristics under Schedule I of
E-
Waste Management Rules, 2016 Waste Category Waste Stream Type of E- Waste Category I Information technology and telecommunication equipment Centralised data processing: Mainframes, Minicomputers; Personal Computing: Personal Computers (Central Processing Unit with input and output devices); Personal Computing: Laptop Computers (Central Processing Unit with input and output devices); Personal Computing: Notebook Computers, Notepad Computers; Printers including cartridges; Copying equipment; Electrical and electronic typewriters; User terminals and systems; Facsimile; Telex; Telephones; Pay telephones; Cordless telephones; Cellular telephones and Answering systems Category II Consumer electrical and electronics Television sets (including sets based on (Liquid Crystal Display and Light Emitting Diode technology); Refrigerator; Washing Machine; Air- conditioners excluding centralized air conditioning plants; Fluorescent and other mercury containing lamps.
68 4.6
Composition The composition of e-waste is diverse and falls under ‘hazardous’ and ‘non-hazardous’ categories. Broadly, it consists of ferrous and non-ferrous metals, plastics, glass, wood and plywood, printed circuit boards, concrete, ceramics, rubber and other items. • Iron & Steel - 50% • Plastics - 21% • Non-ferrous metal - 13% • Mercury, Arsenic, Lead etc. – Remaining 4.7 E-waste Generation India processed more than 3.4 lakh tonnes of electronic waste in 2020-2021 compared to 69,414 tonnes in 2017-18. The country has increased the collection and processing of e-waste by four times in four years. However, only 11 per cent of the waste is being recycled in the country. The Central Pollution Control Board (CPCB) data reveals that the generation of e-waste has been increasing over the past few years. India generated 1,014,961.2 tonnes of e-waste in 2019- 2020, ranking third after USA and China. Electronic waste is becoming a critical public health emergency and environmental issue. Table 4.2: Pollutants in E-Waste Pollutants Occurrence Arsenic Semiconductors, diodes, microwaves, LEDs (Light- emitting diodes), solar cells Barium Electron tubes, filler for plastic and rubber, lubricant additives Brominated flame- proofing agent Casing, circuit boards (plastic), cables and PVC cables Cadmium Batteries, pigments, solder, alloys, circuit boards, computer batteries, monitor cathode ray tubes (CRTs) Chrome Dyes/pigments, switches, solar Cobalt Insulators Copper Conducted in cables, copper ribbons, coils, circuitry, pigments

69 Lead Lead rechargeable batteries, solar, transistors, lithium batteries, PVC (polyvinyl chloride) stabilizers, lasers, LEDs, thermoelectric elements, circuit boards Liquid crystal Displays Lithium Mobile telephones, photographic equipment, video equipment (batteries) Mercury Components in copper machines and steam irons; batteries in clocks and pocket calculators, switches, LCDs Nickel Alloys, batteries, relays, semiconductors, pigments PCBs (polychlorinated biphenyls) Transformers, capacitors, softening agents for paint, glue, plastic Selenium Photoelectric cells, pigments, photocopiers, fax machines Silver Capacitors, switches (contacts), batteries, resistors Zinc Steel, brass, alloys, disposable and rechargeable batteries, luminous substances 4.8 Environmental & Health Issues The e-waste contains a number of toxic components that can cause serious damage to environment and human and animal health if not properly discarded in an environmentally sound manner. Effects of some of the chemicals found in e-waste on human health are given below: Brominated flame retardants: Brominated flame retardants (BFRs) have routinely been added to consumer products for several decades in a successful effort to reduce fire-related injury and property damage. Recently, concern for this emerging class of chemicals has risen because of the occurrence of several classes of BFRs in the environment and in human biota. The widespread production and use of BFRs; strong evidence of increasing contamination of the environment, wildlife, and people; and limited knowledge of potential effects heighten the importance of identifying emerging issues associated with the use of BFRs. These do not decompose easily in the environment, and long term exposure can cause impaired memory function and learning. Pregnant women exposed to brominated flame retardants have been shown to give birth to babies with behavioral problems as it interferes with estrogen and thyroid functioning. Lead: Lead is a naturally-occurring element that can be harmful to humans when ingested or inhaled, particularly to children under the age of six. Found in most computer monitors and televisions, lead exposure leads to intellectual impairment in children and serious damages to human

70 reproductive systems, the nervous system and blood. Lead poisoning can cause a number of adverse human health effects, but is particularly detrimental to the neurological development of children. Cadmium: The kidney is the critical target organ for the general population as well as for occupationally exposed populations. Cadmium is known to accumulate in the human kidney for a relatively long time, from 20 to 30 years, and, at high doses, is also known to produce health effects on the respiratory system and has been associated with bone disease. Found in rechargeable batteries for laptop computer and other electronic devices, can cause damage to kidneys and bones. Cadmium can be bio-accumulate in the environment and is extremely toxic to human, in particular adversely affecting kidneys and bones. Mercury: Elemental and methyl mercury are toxic to the central and peripheral nervous systems. The inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested. Neurological and behavioral disorders may be observed after inhalation, ingestion or dermal exposure of different mercury compounds. Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction. Kidney effects have been reported, ranging from increased protein in the urine to kidney failure. Mercury (Hg), which is used in lightening devices in flat screen monitors and televisions can cause damage to the breast milk. Hexavalent Chromium Compounds: Hexavalent chromium is a toxic form of the element chromium. Hexavalent chromium compounds are man-made and widely used in many different industries. A known carcinogen, these are used in the creation of metal housing which are typical of many electronic products. It can cause lung cancer, irritation or damage to the nose, throat, and lung (respiratory tract), irritation or damage to the eyes and skin etc. Plastic compounds: Poly vinyl chloride (PVC) cabling is used for printed circuit boards, connectors, plastic covers and cables. When burnt or land-filled, these PVCs release dioxins that have harmful effects on human reproductive and immune systems. 4.9 E-Waste (Management) Rules, 2016: E-Waste (Management) Rules, 2016 comes into force from the 1st day of October, 2016. This rule is applicable

to every manufacturer, producer, consumer, bulk consumer, collection centres, dealers, e-retailer, refurbisher, dismantler and recycler involved in manufacture, sale, transfer, purchase, collection, storage and processing of e-waste or electrical and electronic equipment

listed in Schedule I (Table 5.1) mentioned earlier, including their components, consumables, parts and spares which make the product operational but shall not apply to the followings

71 a) Used lead acid batteries as

covered under the Batteries (Management and Handling) Rules, 2001 made under the Act;

b) Micro enterprises as defined in the Micro, Small and Medium Enterprises Development Act, 2006 (27 of 2006); c) radio-active

wastes

as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there

under. 4.10 Responsibilities of Manufacturer ‘Manufacturer’ means a person or an entity or a company which has facilities for manufacture of electrical and electronic equipment. As per E waste rule responsibility of Manufacturer are – • Collect e-waste generated during the manufacture and channelise it for recycling or disposal; • Apply for an authorisation in Form 1 (a) from the concerned State Pollution Control Board; •
Ensure that no damage is caused to the environment during storage and transportation of
e-waste; •
Maintain records of the e-waste generated, handled and disposed; •
File annual returns
in Form-3, to the concerned State Pollution Control Board on or before the 30th day of
June following the financial year to which that return relates. 4.11
Responsibilities of Producer ‘
Producer’ means any person who, irrespective of the selling technique used
such as dealer, retailer, e-retailer, etc.; i) Manufactures and offers to sell electrical and electronic equipment and their components or consumables or parts or spares under its own brand; or ii) Offers to sell under its own brand, assembled electrical and electronic equipment and their components or consumables or parts or spares
produced by other manufacturers or suppliers; or iii) Offers to sell imported electrical and electronic equipment
and their components or consumables or parts or spares. The responsibilities of Producer are- • Collection and channelization of e-waste generated from the ‘end-of-life’ products with the targets prescribed in Sch. III in EPR – Authorisation. • The mechanism used for authorised dismantler or recycler shall be as per EPR - Authorisation. • For disposal in Treatment, Storage and Disposal Facility, a pre-treatment is necessary to immobilise the mercury and reduce the volume of waste.
72 • EPR should comprise of general scheme for collection of e-waste from the market placed earlier, such as through dealer, collection centres, Producer Responsibilities origination, through buy-back arrangement, exchange scheme, deposit refund system etc. and channelizing to authorised recyclers. • Providing contact details such as address, e-mail address, toll-free telephone numbers or helpline numbers to consumer(s) or bulk consumer(s) through their website and product user documentation so as to facilitate return of end-of-life electrical and electronic equipment; • Creating awareness through media, publications, advertisements, posters, or by any other means of communication. • Maintaining records in Form-2 • Filing
annual returns in Form-3, to the CPCB on or before the 30th day of June following the financial year to which that return relates. •
Producer shall apply to the CPCB for authorisation in Form 1, for Authorisation. 4.12 Responsibilities of Bulk Consumers ' Bulk Consumer' means bulk users of electrical and electronic equipment such as Central Government or State Government Departments, public sector undertakings, banks, educational institutions, multinational organizations, international agencies, partnership and public or private companies. •
Consumers or bulk consumers
shall ensure that e-waste generated by them is channelised through collection centre or dealer of authorized • producer or dismantler or recycler or through the designated take back service provider of the producer to authorised dismantler or recycler; •
Bulk consumers shall maintain record of e-waste generated by them
in Form-2 and make such records available for scrutiny by the concerned State Pollution Control Board; •
Consumers or bulk consumers shall ensure that such
end-of-life electrical and electronic equipment are not admixed with e-waste containing
radioactive material as covered under the provisions of the Atomic Energy Act, 1962 (33 of 1962) and rules made there under; • Bulk consumers shall
file annual returns
in Form-3, to the concerned State Pollution Control Board on or before the 30th day of
June following the financial year to which that return relates.
In case of the bulk consumer with multiple offices in a State, one annual return combining information from all the offices shall be filed
to the concerned State Pollution Control Board on or before the 30th day of
June following the financial year to which that return relates.
73 4.13 Storage of E-Waste
Every manufacturer, producer, bulk consumer, collection centre, dealer, refurbisher, dismantler and recycler
may store the e-waste for a period not exceeding
one hundred and eighty

days and shall maintain a record of collection, sale, transfer and storage of wastes and make these records available for inspection,

Provided that the concerned State Pollution Control Board may extend the said period up to three hundred and sixty five days in case

the waste needs to be specifically stored for development of a process for its recycling

or reuse. 4.14

Treatment & Disposal The methods followed in general of which some are not recommended are: 1. Land filling: It is widely used methods for disposal of e-waste. In this method, trenches are made on the flat surfaces by removing soil from the trenches and waste material is buried in it, which is covered by a thick layer of soil. Secure landfill is made using modern technique. Here they are provided with some facilities like, impervious liner made up of plastic or clay, leachate collection basin that collects and transfer the leachate to wastewater treatment plant. The degradation processes in landfills are very complicated and run over a wide time span and can be many years. 2. Incineration: In this controlled and complete combustion process, the waste material is burned in specially designed incinerators at a high temperature (900-1000oC). Advantage of incineration of e-waste is the reduction of waste volume and the Utilization of the energy content of combustible materials. In this method some environmentally hazardous organic substances are converted into less hazardous compounds. 3. Recycling of e-waste: Fridge, washing machines, TVs, Monitors & CRT, keyboards, laptops, modems, telephones, hard drives, floppy drives, Compact disks, mobiles, fax machines, printers, CPUs, memory chips, connecting wires & cables can be recycled. Recycling involves dismantling i.e., removal of different parts of e-waste containing dangerous substances like PCB, Hg, separation of plastic, removal of CRT, segregation of ferrous and nonferrous metals and printed circuit boards. Strong acids are used to remove precious metals such as copper, gold, palladium. The value of recycling from the element could be much higher if appropriate technologies are used. 4. Re-use: It constitutes direct second-hand use or use after slight modifications to the original functioning equipment. It is commonly used for electronic equipment like computers, cell phones etc. Inkjet cartridge is also used after refilling. Old working computers can be donated to schools or organization working in the field of education. Computers beyond repairs can be returned back to the manufacturers. This method also reduces the volume of e-waste generation. The better option is to avoid its generation. To achieve this, buy back of old electronic equipment shall be made mandatory. This can considerably reduce the volume of e- waste generation.

74 4.15 Summary E-waste is a relatively new segment in the global problem of waste removal. It is also the fastest growing segment worldwide in discarded waste. This growing problem in the world is largely ignored or misunderstood. Many people do not understand what it is or how it affects them, the world, or the environment. Consumers in developed nations are quick to replace their devices because of continuous technological advances. This upgrading leads to an excess of unused electronic devices. What is done with old computers and phones is what is contributing to the E-waste problem. Some people understand the importance of properly disposing of these old units, but many more still throw them in the garbage or incinerators. Most developed nations in the world have laws and regulations requiring that E-waste not be disposed of in landfills or be incinerated. Cities and states have set up programs across the United States where consumers can drop off used electronic devices to be properly disposed of. The best method of disposal is to recycle this equipment. Many people do not understand that the parts in old devices can be reused in new products. There is a popular mantra used by many recycling advocates, "Reduce, Reuse, and Recycle." This slogan has widely been promoted with plastics and glass, but its message is also applicable to the disposal of E-waste. Many electronic stores offer services to help customers bring in old electronics or parts so as to dispose of them safely and properly. 4.16 Questions/ Self-Assessment questions 1. Write a brief note on E-waste management. Why is it important to Recycle E-waste. 2. What items can be considered e-waste? 3. What is E-waste? What is the Electronic Waste Recycling Act? 4. What is the 2006 Universal Waste Law? 5. write in brief about the treatment and disposal of E waste. 6. What are the guidelines and Responsibilities of the producer of the E-waste? 7. What are the Pollutants originated from E-waste field and what are their sources. 8. What are the environmental and health hazard caused by the E-waste. 4.17 Select Readings/ Suggested Readings 1. Sewage Disposal and Air Pollution Engineering by Santosh Kumar Garg, Khanna Publisher 2. E-waste Management Challenges and Opportunities in India by Varsha Bhagat Ganguly. 3. Electronic waste Management by G H Eduljee, R M Harrison, Royal Society of Chemistry. 4. E -Waste management rule 2016.

75 UNIT 5: Fly ash 5.1 Objectives 5.2 Introduction 5.3 What is Fly ash? 5.4 Characteristics & Composition of Fly ash 5.5 QUALITY OF FLY ASH 5.6 Utilization of Fly Ash 5.7 Guide lines for disposal of Fly ash 5.8 Summary 5.9 Questions/ Self-Assessment questions 5.10 Select Readings/ Suggested Readings 5.1 Objectives After completion of this chapter we will able • To learn about the fly ash, its characteristic and composition. • To Learn about the utilization of Fly ash • To know about the guide lines for Fly ash disposal 5.2 Introduction Management of huge quantity of ash (fly ash, bottom ash and pond ash) generated from coal fired Thermal Power Plants (TPPs) is a serious environmental challenge. Ash generation from coal or lignite based thermal power plants, has increased from 40 million tonne per year in 1993-94, to more than 200 million tonne per year in 2017-18 and is projected to increase to 275 million Tons / year by 2032. The ash generation in coal and lignite based thermal power plants in various forms such as dry ash, bottom ash, pond ash and mound ash that are required to be managed in such a manner that it does not affect the environment. Utilisation of ash for reclamation of low-lying areas and abandoned quarries is recognised as an alternate option and therefore, MoEF&CC has issued a notification to address utilisation off ash for various purposes including these two options The Ministry of Environment, Forest and Climate Change (MoEF&CC) issued the Fly Ash notification on 14th September, 1999, which has subsequently been amended in 2003, 2009 and 2016. The Fly Ash notification (1999) mandates the use of fly ash for the purpose of
76 manufacturing ash-based products such as cement, concrete blocks, bricks, panels or any other material and for construction of roads, embankments, dams or for any other construction activity within a radius of 300 km from thermal power stations (TPPs). Besides, it also mandates use of fly ash in mines backfilling or stowing of mines within a distance of 50 km. Figure 5.1: Fly ash 5.3 What is Fly ash? Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases. It is
a highly toxic particulate matter captured from the flue gas of an incinerator by the air pollution control system;
over 61 million metric tons (68 million tons) of fly ash were produced in 2001. Fly ash is generally considered as a waste material, that is produced as a byproduct of coal combustion process. Fly ash production has increased up to 900 million tonnes per year by 2008 and it is anticipated to increase upto about 2000 million tonnes in year 2020 (Malhotra 2008). In India alone, about 226.13 million tons in the year 2019-20 and it is predicted to be around 300-400 million tons by the year 2025. About 43 percent of this ash is re-used for various applications while the rest is being dumped as waste. Disposal of fly ash in open dumps cause massive environmental problems such as ground water contamination, spills of bulk storage and ground pollution by heavy metals. It may create various health problems. Therefore, utilization of fly ash as a useful product is essential in today's world for a sustainable coal industry. 5.4 Characteristics & Composition of Fly ash Size and Shape: Fly ash is typically finer than Portland cement and lime. Fly ash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 and 100
77 micron (Figure 6.2). These small glass spheres improve the fluidity and workability of fresh concrete. Fineness is one of the important properties contributing to the pozzolanic reactivity of fly ash. Figure 5.2: Micro structure of Fly ash Chemistry: Fly ash consists primarily of oxides of silicon, aluminum iron and calcium. Magnesium, potassium, sodium, titanium, and sulfur are also present to a lesser degree. When used as a mineral admixture in concrete, fly ash is classified as either Class C or Class F ash based on its chemical composition. American Association of State Highway Transportation Officials (AASHTO) M 295 [American Society for Testing and Materials (ASTM) Specification C 618] defines the chemical composition of Class C and Class F fly ash. Class C ashes are generally derived from sub-bituminous coal sand consist primarily of calcium alumino-sulfate glass, as well as quartz, tricalcium aluminate, and free lime (CaO). Class C ash is also referred to as high calcium fly ash because it typically contains more than 20 percent CaO. Class F ashes are typically derived from bituminous and anthracite coals and consist primarily of an alumino-silicate glass, with quartz, mullite, and magnetite also present. Class F, or low calcium fly ash has less than 10 percent CaO. The detail compounds with different class of fly ash is given in Table 6.1. Table 5.1: Composition of different class of Fly Ash Compounds Fly Ash Class F Fly Ash Class C Portland cement SiO 2 55 40 23 Al 2 O 3 26 17 4 Fe 2 O 3 7 6 2 CaO (Lime) 9 24 64 MgO 2 5 2 SO 3 1 3 2 Color. Fly ash can be tan to dark gray, depending on its chemical and mineral constituents. Tan and light colors are typically associated with high lime content. A brownish color is typically associated with the iron content. A dark gray to black color is typically attributed to elevated unburned carbon content. Fly ash color is usually very consistent for each power plant and coal source.

78 Figure 5.3:Colour variation of a typical sample of fly ash Chemical composition of fly ash relates directly to the mineral chemistry of the parent coal and any additional fuels or additives used in the combustion or post-combustion processes. The pollution control technology that is used can also affect the chemical composition of the fly ash. Electric generating stations burn large volumes of coal from multiple sources. Coals may be blended to maximize generation efficiency or to improve the station environmental performance. The chemistry of the fly ash is constantly tested and evaluated for specific use applications. Some stations selectively burn specific coals or modify their additives formulation to avoid degrading the ash quality or to impart a desired fly ash chemistry and characteristics. 5.5 QUALITY OF FLY ASH Quality requirements for fly ash vary depending on the intended use. Fly ash quality is affected by fuel characteristics (coal), co-firing of fuels (bituminous and sub-bituminous coals), and various aspects of the combustion and flue gas cleaning/collection processes. The four most relevant characteristics of fly ash for use in concrete are loss on ignition (LOI), fineness, chemical composition and uniformity. LOI is a measurement of unburned carbon (coal) remaining in the ash and is a critical characteristic of fly ash, especially for concrete applications. High carbon levels, the type of carbon (i.e., activated), the interaction of soluble ions in fly ash, and the variability of carbon content can result in significant air entrainment problems in fresh concrete and can adversely affect the durability of concrete. AASHTO and ASTM specify limits for LOI. However, some state transportation departments will specify a lower level for LOI. Carbon can also be removed from fly ash. Some fly ash uses are not affected by the LOI. Filler in asphalt, flowable fill, and structural fills can accept fly ash with elevated carbon contents. Fineness Fineness of fly ash is most closely related to the operating condition of the coal crushers and the grind ability of the coal itself. For fly ash use in concrete applications, fineness is defined as the percent by weight of the material retained on the 0.044 mm (No. 325) sieve. A coarser gradation can result in a less reactive ash and could contain higher carbon contents. Limits on fineness are addressed by ASTM and state transportation department specifications. Fly ash can be processed by screening or air classification to improve its fineness and reactivity. Some non-concrete applications, such as structural fills are not affected by fly ash fineness. However, other applications such as asphalt filler are greatly dependent on the fly ash fineness and its particle size distribution.

79 5.6 Utilization of Fly Ash 5.6.1 HIGHWAY APPLICATIONS i. FLY ASH IN PORTLAND CEMENT CONCRETE Overview. Fly ash is used in concrete admixtures to enhance the performance of concrete. Portland cement contains about 65 percent lime. Some of this lime becomes free and available during the hydration process. When fly ash is present with free lime, it reacts chemically to form additional cementitious materials, improving many of the properties of the concrete. Benefits. The many benefits of incorporating fly ash into a PCC have been demonstrated through extensive research and countless highway and bridge construction projects. Benefits to concrete vary depending on the type of fly ash, proportion used, other mix ingredients, mixing procedure, field conditions and placement. Some of the benefits of fly ash in concrete: • Higher ultimate strength • Improved workability • Reduced bleeding • Reduced heat of hydration • Reduced permeability • Increased resistance to sulfate attack • Increased resistance to alkali-silica reactivity (ASR) • Lowered costs • Reduced shrinkage • Increased durability Cautions. Care should be taken when using fly ash in concrete due to: • Potential for decreased air entraining ability with high carbon fly ash may reduce durability • Reduced early strength • Reduced heat of hydration in colder climates. ii. FLY ASH IN STABILIZED BASE COURSE Overview. Fly ash and lime can be combined with aggregate to produce a quality stabilized base course. These road bases are referred to as pozzolanic-stabilized mixtures (PSMs). Typical fly ash contents may vary from 12 to 14 percent with corresponding lime contents of three to five percent. Portland cement may also be used in lieu of lime to increase early age strengths. The resulting material is produced, placed, and looks like cement stabilized aggregate base Benefits. PSM bases have advantages over other base materials: • Use of locally available materials

80 • Provides a strong, durable mixture • Lower costs • Autogenous healing • Increased energy efficiency • Suitable for using recycled base materials • Can be placed with conventional equipment Cautions. PSM bases require attention to: • Seasonal limitations. • Traffic loading before completes curing. • Proper sealing and protection with asphalt or other surface treatment is required to improve skid resistance. iii. FLY ASH IN FLOWABLE FILL Overview. Flowable fill is a mixture of coal fly ash, water, and portland cement that flows like a liquid, sets up like a solid, is selfleveling, and requires no compaction or vibration to achieve maximum density. In addition to these benefits, a properly designed flowable fill may be excavated later. For some mixes, an optional filler material such as sand, bottom ash, or quarry fines, is added. Flowable fill is also referred to as controlled low-strength material, flowable mortar, or controlled density fill. It is designed to function in the place of conventional backfill materials such as soil, sand, or gravel and to alleviate problems and restrictions generally associated with the placement of these materials. The benefits of using flowable fill include: • Allows placement in any weather, even under freezing conditions • Achieves 100 percent density with no compactive effort • Fills around/under structures inaccessible to conventional fill placement techniques • Increases soil-bearing capacities • Prevents post-fill settlement problems • Increases the speed and ease of backfilling operations • Decreases the variability in the density of the backfilled materials • Improves safety at the job site and reduces labor costs • Decreases excavation costs • Allows easy excavation later when properly designed Cautions. When using flowable fill, care must be taken to: • Anchor lighter weight pipes to prevent floating • Provide confinement before initial set of the material • Evaluate corrosion of metal pipe at interface of soil iv. FLY ASH IN STRUCTURAL FILLS/EMBANKMENTS Overview.

81 Fly ash can be used as a borrow material to construct fills and embankments. When fly ash is compacted in lifts, a structural fill is constructed that is capable of supporting highway buildings or other structures. Fly ash has been used in the construction of structural fills/embankments that range from small fills for road shoulders to large fills for interstate highway embankments. Benefits: When used in structural fills and embankments, fly ash offers several advantages over soil and rock: • Cost-effective where available in bulk quantities • Eliminates the need to purchase, permit, and operate a borrow pit • Can be placed over low bearing strength soils • Ease of handling and compaction reduce construction time and equipment costs Cautions: Be aware that: • State or local environmental regulations may require consideration of the potential impacts to ground water at adjoining properties. • Requires dust control and erosion prevention measures. v. FLY ASH IN SOIL IMPROVEMENT Overview: Fly ash is an effective agent for chemical and/or mechanical stabilization of soils. Soil density, water content, plasticity, and strength performance of soils. Typical applications include: soil stabilization, soil drying, and control of shrink-swell. Benefits. Fly ash provides the following benefits when used to improve soil conditions: • Eliminates need for expensive borrow materials • Expedites construction by improving excessively wet or unstable subgrade • By improving subgrade conditions, promotes cost savings through reduction in the required pavement thickness • Can reduce or eliminate the need for more expensive natural aggregates in the pavement cross-section Cautions. The most important considerations for soil improvement projects are: • The rate of the hydration reaction upon exposure to water • Soil moisture content at the time of compaction • Fly ash with a sulfate content greater than 10 percent may cause soils to expand more than desired • In many cases, leaching tests may be required by local and state agencies. vi. FLY ASH IN ASPHALT PAVEMENTS Overview:

82 Fly ash can be used as mineral filler in HMA paving applications. Mineral fillers increase the stiffness of the asphalt mortar matrix, improving the rutting resistance of pavements, and the durability of the mix. Benefits: Fly ash will typically meet mineral filler specifications for gradation, organic impurities, and plasticity. The benefits of fly ash include: • Reduced potential for asphalt stripping due to hydrophobic properties of fly ash. • Lime in some fly ashes may also reduce stripping. • May afford a lower cost than other mineral fillers. vii. FLY ASH IN GROUTS FOR PAVEMENT SUBSEALING Overview: Grouts are proportioned mixtures of fly ash, water, and other materials used to fill voids under a pavement system without raising the slabs (sub-sealing), or to raise and support concrete pavements at specified grade tolerances by drilling and injecting the grout under specified areas of the pavement. Benefits. Fly ash grouts can: • Be used to correct undermining without removing overlying pavement • Be accomplished quickly with minimum disturbance to traffic • Develop high ultimate strength Cautions: Fly ash grouts: • Require curing period before extremely heavy loading because of low early strength • Require confinement of the grout mixture under pavement 5.7 Guide lines for disposal of Fly ash 5.7.1 Current Practice for Handling & Disposal of Fly ash & Bottom ash (within the power plant) Fly ash is collected in dry form from ESP hopper and disposed either in dry form or through wet slurry form. While, bottom ash collected at the bottom of boiler and is disposed in wet slurry form into the ash ponds. Following technologies are conventionally used for handling & disposal of flyash and bottom ash collected from ESPs hoppers and boiler bottom respectively within the plant or upto the ash pond area: I. Dry Pneumatic conveying II. Dry (moist) Conveying system through belt conveyor/tube belt conveyor III. High concentration slurry disposal system IV. Medium concentration slurry disposal system V. Lean concentration slurry disposal system Amongst the above technologies, Dry Pneumatic conveying, medium concentration slurry disposal system, High concentration slurry disposal system, and Dry (moist) Conveying system

83 through belt conveyor/tube belt conveyor are preferable as compared to Lean concentration slurry disposal system. The dry ash is typically conveyed pneumatically from the ESP or filter fabric hoppers to storage silos where it is kept dry, pending utilization or further processing, or to a system where the dry ash is mixed with water and conveyed (sluiced) to an on-site storage pond. Fly ash is stored in silos, domes and other bulk storage facilities. Fly ash can be transferred using air slides, bucket conveyors and screw conveyors, or it can be pneumatically conveyed through pipelines under positive or negative pressure conditions. Dry fly ash collected is also be suitably moistened with water and wetting agents, as applicable, using specialized equipment (conditioned) and hauled in covered dump trucks for special applications such as structural fills. Water conditioned fly ash can also be suitably stockpiled at jobsites. Exposed stockpiled material must be kept moist or suitably covered to prevent fugitive emission. The dry bottom ash removal and its transportation is certainly more environment friendly, compared to that of wet ash removal and transport system. 5.7.2 Reclamation of Low-Lying area using Ash Filling of Low-lying areas inside the plant premises and outside within 300 km. of power plant may be taken up using ash. Low lying area reclamation with ash should be taken up adopting standard practices as per 2015 technical specification mentioned in NTPC Policy. Following steps should be taken up prior to initiate low lying area developmental activities. Preconditions: Consent from land owner: Consent/ permission should be obtained in writing from the land owner before start of work. Permission from Regulatory authority: Power plant/ land owner/ agency shall obtain statutory permission from regulatory authorities such as SPCB as per the requirement. Prevention of pollution: Suitable methods should be adopted and necessary arrangement should be made to prevent pollution during excavation of pond ash at ash pond, filling area and during transportation of ash. 5.7.3 Soil Cover on the top of ash fill As per the MOEF&CC gazette notification of ash utilization dated 14-09-1999 and as amendment on dated 27-08-2003 and 03-11-2009, the soil required for soil cover shall be excavated from land fill site itself and kept separately before taking for ash filling. If it is not possible to do so, only the minimum quantity of soil required for the purpose of cover shall be excavated from the soil borrow area. The voids so created due to removal of soil shall be filled up with ash with proper compaction and covered at top with soil cover. About 300-500 mm thick soil layer shall be placed over the ash fill area. This should be done as an integral part of low lying area development work. A. Preparation of filling area The entire area meant to receive the ash and earth filling shall be stripped by minimum 150 mm. The exact depth of stripping shall be decided by the Engineer-in-Charge depending upon nature of top soil and the vegetation present. All organic matter, vegetation, roots, stumps, bushes, rubbish, swamp materials, etc. shall be removed from the site. The stripping material

84 and other unsuitable materials as referred above shall be kept away from the area to be filled up so that these do not get mixed up with filling material and disposed off to a place as decided by the Engineer-in-Charge. B. Levelling All existing undulations, holes, cavities and excavations made for plate load rests and other soil investigations, etc. shall be filled with pond ash having requisite moisture content. The ash thus filled shall be compacted with the help of vibratory rollers so as to achieve dry density of not less 95% as per I.S–2720 (Part-VII). This would result in a levelled surface upon which layer wise filling of compacted ash can be done. 5.7.4 Excavation of pond ash from borrow area Borrow Area-location The location and permissible depth of excavation of the Borrow areas for pond ash shall be got specifically approved from concerned Thermal Power Station. The boundaries and permissible depth of excavation so approved shall be strictly followed and no deviation shall be allowed. Similarly, routes for movement of all ash transportation vehicles, water tankers, equipment, etc. shall be got approved from Thermal Power Station. These shall be strictly followed and no deviation shall be allowed. The excavation surfaces and surface of waste materials shall be left in a reasonably smooth and even condition. All the excavations within the ash pond shall be at a minimum slope of 4 (Horizontal): 1(Vertical). 5.7.5 Filling with pond ash Placement After the area has been prepared and levelled, pond ash excavated from Borrow areas having required moisture content shall be placed in layers not exceeding 300 mm in compacts thickness. The placing operations shall be such that in strips of 10-15 m of the material when compacted in the fill will be blended sufficiently to produce specified degree of compaction and stability. No stones, cobbles or rock fragments, having maximum dimensions more than 100 mm shall be placed in the fill. Stones and cobbles shall be removed either at the borrow pit site before it is used as soil cover. Procedure The material shall be placed in the fill in continuous horizontal layers, stretching right across the whole section, not more than 300 mm in compacted thickness and rolled as herein specified. The length of one layer shall not exceed 150 meters at one stretch. The layers shall be compacted in strips overlapping not less than 600 mm, if the rolled surface of any fill is found to be too wet for proper compaction, it shall be raked up, allowed to dry, or shall be worked with a harrow or any other approved equipment to reduce the moisture content to the required amount and then it shall be re-compacted before the next layer of ash is placed. Ash surfaces are likely to become dry in short intervals especially during hot and dry weather and hence enough moisture shall be added between difference passes to ensure proper compaction Compaction The compaction of each layer shall be carried out so as to achieve maximum in–situ dry density 95% of maximum dry density (MDD) of the material found out as per I.S 2720 (Part VII). To

85 achieve maximum compaction level use of vibratory rollers shall be made. Required number of passes shall be made so as to achieve desired compaction. Number of passes required shall be verified through trials tests before actual execution of work. The broad specifications of vibratory rollers required for the purpose is as follows: a) Static Weight = 6 to 10 t b) Static Linear Load = 20 – 35 kg/cm c) Frequency = 18 – 30 Hz (1100 to 1800 vibrations/ minute) d) Amplitude of vibrations = 0.5 mm to 1.5 mm Moisture control So far as practicable, the materials shall be brought to the proper moisture content in the borrow area before excavation. If additional moisture is required, it shall be added at the fill site by sprinkling water before rolling the layer. Thermal Power Plant shall make arrangements for supply of water to the borrow areas as well as to the fill area. If the moisture content is more than requirement, the material shall be spread and allowed to dry before rolling. The moisture content shall be at most uniform throughout the layer of material and ploughing or other methods of mixing to obtain uniform distribution. If the moisture content is more or less than the range of the required moisture content, or if it is not uniformly distributed throughout the layer, rolling shall be stopped, and shall be started again only when the above conditions are met with. Fill materials shall be placed only when the weather conditions are satisfactory to permit accurate control of the moisture content in the materials. Placement of earth cover in filing area Earth cover shall be laid simultaneously with the laying of compacted ash layers and on side slopes. As in the case of ash layers, compacted thickness of earth layers shall not be exceeding 300 mm. As far as top cover of earth is concerned, after the area has been covered with compacted ash up to 500 mm below the required finished level of the area, a compacted layer of 500 mm thickness of suitable earth shall be placed over ash surface. This cover shall be placed in layers, each layer shall be of 250 mm in compacted thickness. The combined excavation and placing operations shall be such that the materials when compacted in the fill will be blended sufficiently to produce specified degree of compaction on stability. No stones, cobbles or rock fragments, having maximum dimensions more than 25 mm shall be placed in the earth cover. Such stones or cobbles shall be removed either at the borrow pit or before it is used as Soil Cover. 5.7.6 Disposal of fly ash in voids of abandoned mines As per notifications 1999 and 2009, power plant shall undertake or approve stowing of mines without using at least 25% of fly ash on weight-to-weight basis, of the total stowing materials used. Mine void filling on pilot basis is being carried out at the power plants of NTPC Ltd., Bhushan Steel and NALCO in Odisha with prior permission from MoEF & CC and OSPCB. Based on their experience and study conducted by CMPDIL, Ranchi for NTPC Talcher, following methodology is suggested for filling of mine voids with flyash.

86 The power plant authority shall carry out following study prior to taking up ash disposal activities in mine void to ensure no change/damage/deterioration in water quality and hydrology in and around the proposed area: • Ash Characterisation and Leachate Study. • Techno-Economic Feasibility Study for disposal of ash into the Quarry • Topographical Survey of Pipeline Corridor & Mine Void area • Feasibility of transportation of ash to mine void • Geotechnical study of the Pipeline Corridor & Mine Void area • Pre and post filling mine water quality including leachability of metals 5.8 Summary It has been recognized worldwide that the utilization of an enormous amount of fossil fuels has created various adverse effects on the environment, including acid rain and global warming. An increase in the average global temperature of approximately 0.56 K has been measured over the past century (global warming). Gases with three or more atoms that have higher heat capacities than those of O2 and N2 cause the greenhouse effect. Carbon dioxide (CO2) is a main greenhouse gas associated with global climate change. The disposal, management and proper utilization of waste products has become a concern for the scientists and environmentalists. Proper management of solid-waste fly ash from thermal power plants is necessary to safeguard our environment. Because of high cost involved in road transportation for the dumping of fly ash, it is advisable to explore all its possible applications. Fly ash is a potential source of pollution not only for the atmosphere but also for the other components of the environment. Deposition in storage places can have negative influences on water and soil because of their granulometric and mineral composition as well morphology and filtration properties. This waste has found application in domestic and wastewater treatment, purification, paint and enamel manufacturing. In future, large-scale application of this waste product may be possible for recovery of heavy metals, reclamation of wasteland, and floriculture. The detailed investigations carried out on fly ash elsewhere as well as at the Indian Institute of Science show that fly ash has good potential for use in highway applications. Its low specific gravity, freely draining nature, ease of compaction, insensitiveness to changes in moisture content, good frictional properties, etc. can be gainfully exploited in the construction of embankments, roads, reclamation of low-lying areas, fill behind retaining structures, etc. On the other hand, it can safely be concluded that fly ash, which till recent years has been treated as a waste product of thermal power stations, is in fact a valuable resource material. 5.9 Questions/ Self-Assessment questions 1. hat is Fly Ash? what is the various composition of fly ash? 2. What are the utilization of Fly ash as construction material? 3. Describe in details about the various methods of disposal of fly ash.

87 4. Write short notes on guideline of the Fly ash Disposal. 5.10 Select Readings/ Suggested Readings

88 UNIT 6: Plastic waste 6.1 Objectives 6.2 Introduction 6.3 What is

Plastic waste? 6.4 Excerpts from the Plastic Waste Management Rules, 2016 6.5 Composition of Plastics 6.6 Plastic waste Management 6.7 Recycling of Plastic
Waste 6.8 Biodegradable plastics / Bio -Plastics 6.9 Summary 6.10 Questions/ Self-Assessment questions 6.11 Select Readings/ Suggested Readings 6.1 Objectives After completion of this chapter you will able • To take a detailed look on plastic waste management rules, 2016 • To give knowledge about the composition of plastic • To chalk out the management and recycling process of plastic waste 6.2 Introduction Plastic is omnipresent, it's inarguably the backbone of globalisation. Due to fabrication of aspired shape and specification suited for potential customers, there is a growing demand in packaging, agriculture, automobiles and biomedical. They are essential to the modern age due to growth in information technology and smart packaging system. Rapid population growth, urbanization, combined with industrial growth has together led to critical waste management issues around the world. More often than once, concurrent development in economic prosperity and industrialization conflict with environmental concerns. According to US Environmental Protection Agency, since the 1960s use of plastic has grown substantially, and resultantly, the portion of plastic waste has also increased from 1% of the total municipal solid waste stream to approximately 13%. According to a report by the United Nations Environment Programme, approximately 400 million tonnes single-use plastic (SUP) waste is generated yearly (that accounts to 47 per cent of the aggregate plastic waste) and approximately fifty per cent of this quantity is for disposal purposes, purchases that are discarded within a year.
89
The disposal of plastic waste is legislated under the Plastic Waste Management Rules, 2016. These rules specify the responsibilities of urban local bodies (ULBs) for managing plastic waste. However, most of the discarded plastics find their way into the municipal waste streams. Figure 6.1:Plastic Waste 6.3
What is Plastic waste? Plastic waste is a growing concern and the drivers behind it look set to continue. Although recently there has been a slight decrease in plastic production, this is unlikely to be maintained. Plastic is a highly useful material and its applications are expected to increase as more new products and plastics are developed to meet demands. The increased use and production of plastic in developing and emerging countries is a particular concern, as the sophistication of their waste management infrastructure may not be developing at an appropriate rate to deal with their increasing levels of
plastic waste. 6.4 Excerpts from the Plastic Waste Management Rules, 2016
Plastic
Waste Management
Rules, 2016 were notified by
Ministry of Environment, Forest and Climate Change
vide G.S.R. 320 (E), dated
the 18th March, 2016,
inter alia, providing for collection, segregation, processing, treatment and disposal of the plastic waste in an environmentally sound manner, restriction on thickness of plastic sheet or like, prohibition on identified use, extended producer responsibility, marking and labeling requirement, registration of manufacturer, producer, importer, brand owner and plastic waste processor, reducing
the
plastic waste generation.
90 6.4.1 Clause 4:
The manufacture, importer stocking, distribution, sale and
use of
carry bags, plastic sheets or like, or cover made of plastic sheet
and
multilayered packaging, shall be subject to the following conditions, namely:-
a)
Carry bags
and plastic packaging
shall either be in natural shade which is without any added pigments or made using only those pigments and colourants which are in conformity with Indian Standard: IS 9833:1981 titled as "List of pigments and colourants for use in plastics in contact with foodstuffs, pharmaceuticals and drinking water", as amended from time to time.
b) Carry bags made of recycled plastic
or products made of recycled plastic shall not be used for storing, carrying, dispensing or packaging
ready to eat
or drink food stuff'. c)
Carry bag made of virgin or recycled plastic, shall not be less than

fifty microns in thickness. d) Plastic sheet or like, which is not an integral part of
multi-layered
packaging and
cover made of plastic sheet used for packaging, wrapping the commodity shall not be less than fifty microns in thickness except where the thickness of such plastic sheets impair the functionality of the product.
e) The manufacturer shall not sell or provide or arrange plastic to be used as raw material to a producer, not having valid registration from the concerned State Pollution Control Boards or Pollution Control Committee. f) Sachets using plastic material shall not be used for storing, packing or selling gutkha, tobacco and pan masala. g)
Recycling of plastic waste
shall conform to the Indian Standard: IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time.
h)
The provision of thickness shall not be applicable to carry bags made up of compostable plastic.
Carry bags made from compostable plastics
shall conform to the Indian Standard: IS 17088:2008 titled as Specifications for Compostable Plastics, as amended from time to time.
The manufacturers or seller of compostable plastic carry bags shall obtain a certificate from the Central Pollution Control Board before marketing or selling. i) Plastic material, in any form including Vinyl Acetate - Maleic Acid - Vinyl Chloride Copolymer,
shall not be used in any package for packaging gutkha, pan masala and tobacco in all forms. 6.4.2 Clause 5
The plastic waste management by the urban local bodies in their respective jurisdiction shall be as
under: a)
Plastic waste, which can be recycled, shall be channelized to registered plastic waste recycler and recycling of plastic shall conform to the Indian Standard: IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time. b) Local bodies shall encourage the use of plastic waste (
preferably the plastic waste which cannot be further recycled)
for road construction as per Indian Road Congress guidelines
91 or energy recovery or waste to oil etc.
The standards and pollution control norms specified by the prescribed authority
for these technologies shall be complied with. c) Thermo set plastic waste shall be processed and disposed off as per the guidelines issued from time to time
by the Central Pollution Control Board. d) The inert from recycling or processing facilities of plastic waste shall be disposed of
in compliance with the Solid Waste Management Rules, 2000
or as amended from time to time. 6.4.3
Clause 6:
Responsibility of local body. 1. Every local body shall be responsible for development and setting up of
infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste either on its own or by engaging agencies
or producers. 2. The local body shall be responsible for setting up, operationalisation and co-ordination of the waste management system and for performing the associated functions, namely: a) Ensuring segregation, collection, storage, transportation, processing and disposal of plastic waste. b) Ensuring that no damage is caused to the environment during this process. c) Ensuring channelization of recyclable plastic waste fraction to recyclers. d) Ensuring processing and disposal on non-recyclable fraction of plastic waste in accordance with the guidelines issued by the Central Pollution Control Board. e) Creating awareness among all stakeholders about their responsibilities. f) Engaging civil societies or groups working with waste pickers. g) Ensuring that open burning of plastic waste does not take place. 3. The local body for setting up of system for plastic waste
management
shall seek assistance of producers and such system shall be set up within one year from the date of final publication of these rules in the Official
Gazaette of India. 4. The local body to frame bye-laws incorporating the provisions of these rules. 6.4.4 Clause 8:
Responsibility of
waste generator: 1. The waste generator shall- a) Take steps to minimize generation of plastic waste and
segregate plastic waste at source
in accordance with the Solid Waste Management
Rules, 2000

or as amended from time to time.
b) Not litter the plastic waste and ensure segregated storage of waste at source and handover segregated waste to urban local body or gram panchayat or agencies appointed by them or registered
waste pickers', registered recyclers or waste collection agencies. 2. All institutional generators of plastic
waste, shall segregate and store the waste generated by them
in
accordance with the
Municipal Solid Waste (Management and Handling) Rules, 2000
notified vide S.O. 908(E) dated the 25th September, 2000 under the Act
or amendment from time to time
and handover segregated wastes to authorized waste
92 processing or disposal facilities or deposition centers either on its own or through the authorized waste collection agency. 3. All waste generators shall pay such user fee or charge as may be specified in the bye-laws of the local bodies for plastic waste management such as waste collection or operation of the facility thereof, etc. 4. Every person responsible for organising an event in open space, which involves service of food stuff in plastic or multilayered packaging shall segregate and manage the waste generated during
such events
in accordance with the
Municipal Solid Waste (Management and Handling) Rules, 2000
notified vide S.O. 908(E) dated the 25 th September, 2000 under the Act
or amendment from time to time. 6.4.5 Clause 9:
Responsibility of producers 1. The producers, within a period of six months from the date of publication of these rules, shall work out modalities for waste collection system based on Extended Producers Responsibility and involving State Urban Development Departments, either individually or collectively, through their own distribution channel or through the local body concerned. 2.
Primary responsibility for collection of used multi-layered plastic sachet or pouches or packaging is of Producers, Importers and Brand Owners who introduce the products in the market. They need to establish a system for collecting back the plastic waste generated due to their products. This plan of collection to be submitted to the State Pollution Control Boards while applying for Consent to Establish or Operate or Renewal. The Brand Owners whose consent has been renewed before the notification of these rules shall submit such plan
within one year from the date of notification of these rules
and
implement with two years thereafter. 3. Manufacture and use of
non- recyclable multi-layered
plastic if any should be phased out in Two years' time. 4.
The producer, within a period of three months from the date of final publication of these rules in the Official Gazette shall apply to
the Pollution Control Board or the Pollution Control Committee, as the case may be,
of the States or the Union Territories administration concerned, for grant of registration. 5. No producer shall on and after the expiry of a period of Six Months from the date of final publication of these rules in the Official Gazette manufacture or use any plastic or
multi- layered
packaging for packaging of commodities without registration from the concerned State Pollution Control Board or the
Pollution Control Committees. 6. Every producer shall maintain a record of details of the person engaged in supply of plastic used as raw material to manufacture carry bags or plastic sheet or like or cover made of plastic sheet or multi-layered packaging. 6.5
Composition of
Plastics Plastics comprise of polymers which are distinct for each product. The most common are polyethylene terephthalate (PET), high-density polyethylene (HDPE), and low-density
93 polyethylene (LDPE) as classified by Bureau of Indian Standards (BIS) and others mentioned in the box below. The Society of the Plastics Industry (SPI) has established the SPI resin identification coding system as a set of symbols placed on plastics to identify the polymer type. The code is used internationally and its primary purpose is to allow efficient separation of different polymer types for recycling. Table 6.1: Classification of plastic based on Bureau of Indian Standards [Source: BIS, CPCB] • Recyclable plastics (thermoplastics): PET, HDPE, LDPE, PP, PVC, PS, etc. •Non-recyclable plastics (thermoset and others): Multilayer and laminated plastics, polyurethane foam (

PUF),

bakelite, polycarbonate, melamine, nylon, etc. Extensive use of plastic leads to the generation of huge quantities of plastic wastes that may account for 1%–10% (by volume) of the total municipal solid wastes (MSW). India produces approximately 8 million tonnes of plastic products every year (2008). Plastic is used for several purposes (wrapping material, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, building materials, etc.). Plastic cannot be recycled

94 indefinitely and, eventually, all plastic products end up as waste since virgin plastic material can be recycled 2–3 times only and the plastic material deteriorates due to thermal pressure after each recycling. Plastics are also highly resistant to biodegradation. 6.6 Plastic waste Management Following the integrated solid waste management (ISWM) hierarchy, reuse and recycling of plastic waste are the preferred methods for managing plastic wastes after reduction. However, as mentioned, plastics cannot be recycled indefinitely; each recycling cycle reduces the strength and utility of the plastic. Energy recovery from plastics

shall be considered when recycling is no longer possible. Plastic waste is accepted as fuel in cement kilns; residence times and temperatures are adequate to preempt the production of dioxins and furans. Incineration of plastic wastes for energy recovery may also be considered under strictly controlled and monitored conditions. Reusing plastic waste to form polymer blended bitumen roads is an accepted method for final disposal of plastics in India. Landfilling of plastics should be avoided. 6.7

Recycling of Plastic Waste To a large extent, plastics are recyclable. Recycled polymers exhibit lower properties and performance than virgin polymers, and are useful only for lower value applications. Recycling of plastics without prior separation by resin produces a material with mechanical properties similar to timber. Hence, it is often used as a replacement for timber in certain applications. A

management Conventional processing technology Technology under review Incineration cement plants Liquid Polymer blended bitumen roads Figure 6.2: Flowchart for options for Plastic Waste Management

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higher quality of recycled plastics is achieved when separation by resin is carried out prior to the remolding step. 6.7.1 Steps Involved in the Recycling Process Collection: Plastic waste should be collected from the door step from all MSW generators along with other reusable and recyclable non-biodegradable wastes and should be sorted out at intermediate sorting facilities or at the MSW processing facility. Segregation: Plastic waste should be segregated from the rest of the recyclable waste based on different types of plastic, requiring different recycling processes. Processing: After collection and segregation, post-consumer waste (used plastic waste) should be given away to recycling industry at a pre-negotiated price by the municipality. In cases where the municipal authority has already given the contract to a private operator to process MSW, plastic waste may be allowed to be processed or sold to the recycling industry by the operator following good industrial practices. 6.7.1.1

Co-processing and Co-incineration of plastic waste as Alternative Fuel and Raw Material (AFR) in Cement Kilns

The Central Pollution Control Board (CPCB) has prescribed guidelines on co-processing of plastic waste as an alternative fuel. The defined protocol is summarized below in Table7.2 . Table 6.2: Central Pollution Control Board Guidance on Protocol for Co- processing of Plastic Waste SR. NO . ITEM DESCRIPTION ACTION TO BE TAKEN BY 1 Collection of plastic waste Concerned municipal authority should create a system for collection of plastic wastes from dustbins or dhalaos through PPP mode or any other feasible method. Municipal corporation, municipality, municipal council, and cantonment board 2 Segregation & pre- processing of plastic waste Collected plastics can be reprocessed or sorted into recyclable and non-recyclable fractions. The non-recyclable plastic wastes will be transported to nearest cement kilns and power plant for co- processing by concerned municipal authority in consultation with SPCB or PCC. Municipal corporation, municipality, municipal council, and cantonment board 3 Identification of cement factory Mapping of cement kilns and power plant for accepting co-processing of plastic waste in the same state or neighbouring state. An agreement shall be signed between municipal corporations and cement kilns. SPCB, PCC, and municipal authorities

96 4 Modification for feeding plastic waste in cement kilns or power plants Cement industry or power plant is to set up storage facility, shredder, conveyor belt, one hopper, one winch machine, and one double- flap damper. Concerned cement industries or power plant 5 Setting-up of laboratory for plastics waste analysis Cement industry or power plant shall set up a minimum laboratory facility to analyse plastic wastes before co-processing. The instrumentation includes thermogravimetric analyser; bomb calorimeter; and C, H, N, S analyser. Concerned cement industry or power plant 6 Monitoring of emission by cement industry or SPCBs Cement industry or power plant shall monitor the stack emission with respect to routine parameters and hazardous air pollutants. Concerned cement industry, power plant, and SPCB or PCC 7

Forwarding progress report to CPCB Cement industry or power plant shall forward quarterly progress report of co-processing of plastic waste to CPCB. Concerned cement industry, power plant, and SPCB or PCC 6.7.1.2 Other Plastic Waste Disposal Options Use of Waste Plastic in Construction of i. Bituminous Roads The use of plastic waste in bitumen roads has been found to have several advantages including decreasing the susceptibility of the road to infiltration. There are also no observed deleterious impacts on the strength or properties of the road. Process Description: • Waste plastic bags collected from roads, garbage trucks, dumpsites, compost plants, waste pickers, waste buyers, and households can be utilised in this process. Here plastic waste is sorted as per its thickness and type. Polyethylene with a thickness greater than 60 microns is sent for recycling; polyethylene below 60 microns is to be used in this process. Plastic waste should be cleaned by de-dusting or washing if required. • Collected plastic is cut and sized into fine pieces. • Lower micron plastic mixes easily with bitumen at higher temperatures (160°C–170°C). Bitumen is heated up to its melting temperature (160°C–170°C). Finely sized plastic pieces are added slowly to the hot bitumen, and the mixture is stirred for about 20–30 minutes at the same • temperature. Polymer–bitumen mixtures of different compositions are prepared and tested for their application in road construction.

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ii.

Conversion of Plastic Waste into Liquid Fuel The conversion of plastic waste into liquid fuel has been considered as a possible solution for the disposal of plastic waste, however, it is still at its nascent stage. A research-cum- demonstration plant in Nagpur, Maharashtra converts waste plastics into liquid fuel. The process adopted is based on random de-polymerisation of waste plastics into liquid fuel in presence of a catalyst. The entire process is undertaken in closed reactor vessels followed by condensation. Waste plastics while heating up to 270°C to 300°C convert into liquid–vapour state, which is collected in condensation chambers in the form of liquid fuel while the tarry liquid waste is topped-down from the heating reactor vessel. Organic gas is generated, which is vented due to lack of storage facility. However, the gas can be used in dual fuel diesel- generator set for generation of electricity. This technology is at an experimental stage and may be considered only after it is well established as a technically, financially, and environmentally viable option of plastic waste processing or disposal.

iii.

Incineration of Plastic Waste In cases where material recovery is not feasible, incineration with energy recovery is an accepted technology internationally for plastic waste disposal, with provision for adequate pollution abatement safeguards. Inappropriate operating conditions can cause the release of several harmful gases including dioxins and furans from chlorinated and brominated plastic waste. However, it is to be noted that achieving the requisite temperature and retention time in incinerators, coupled with an appropriate flue gas scrubbing or treatment system will ensure the safety of such technologies. 6.8

Biodegradable plastics / Bio -Plastics Biodegradable plastics or Bio plastics means that plastics, other than compostable plastics, which undergoes complete degradation by biological processes under ambient environment (terrestrial or in water) conditions, in specified time periods, without leaving any micro plastics, or visible, distinguishable or toxic residue, which has adverse environment impacts, adhering to laid down standards of Bureau of Indian Standards and certified by Central Pollution Control Board. Biodegradable plastics consist of various polymers from different origins with different chemical structures and properties, and each requires specific conditions to fully biodegrade. There are more than 20 kinds of biodegradable plastics, including polymers from natural biomass, polymers produced from bacterial productions, polymers chemically synthesized using agricultural resources, and polymers chemically synthesized using fossil-fuel resources . The different types of degradable plastics, even photo- and oxo-degradable plastics, are often marketed as “green”, “eco-friendly” and “natural”, or generally described as “biodegradable” materials.

98 6.9 Summary Plastic is undeniably one of the most used materials in the world. However, the current condition of handling plastic waste is causing irreversible harm to the environment, and this impact has caused environmentalists to hastily call off the use of plastics altogether. Shifting to alternatives, when plastic has penetrated so deep into our daily lives is not a viable solution. Various methods of plastic waste management have been adopted, but there are still prominent flaws in majority of them which can only be avoided through exhaustive restructuring of the entire methodology. The awareness of the Government about the waste management scenario, and their strict intervention is required to improve prevalent conditions. The various measures that can be taken by the government to better manage and dispose of plastic used by industries as well as households have been mentioned earlier. Also, improvements can be made in the current procedures for plastic waste management by increasing awareness from an elementary level with the cooperation of educational institutions, establishing city waste disposal units at a larger scale, and also study ways to manufacture biodegradable plastics in order to eliminate the problems at a manufacturing level itself. Further research is needed to minimize the plastic waste. 6.10 Questions/ Self-Assessment questions 1. What is Plastic waste? 2. What do you understand by Plastic Waste Management? Draw a Flowchart showing the waste management procedure. 3. Give the detail classification of Plastics with proper examples. Showing proper examples. 4. What are the roles and responsibilities of a plastic waste Generator and Producers. 5. What is the disposal option for plastic waste? 6. What are the various uses of plastic waste as construction material? 6.11 Select Readings/ Suggested Readings 1. Waste management Books an Overview by Amrita Chakraborty, SBS Publishers and Distributors Pvt Ltd. 2. Plastics Waste Management: Processing and Disposal 2nd Edition, by Murali Srinivasan Natamai Subramanian. 3. Urban Mining and Sustainable Waste Management by Sadhan Kumar Ghosh. 4. Hazardous Waste Management (McGraw-Hill Series in Water Resources and Environmental Engineering) by Michael D. LaGrega , Phillip L. Buckingham, et al. 5. Geoenvironmental Engineering - Site Remediation, Waste Containment and Emerging Waste Management Techonolgies: Site Remediation, Waste Containment, and Emerging Waste Management Technologies by H D Sharma & Krishna R Reddy. 6. Integrated Solid Waste Management: A Lifecycle Inventory Paperback by P. White, M. Dranke, P. Hindle.
99 7. Plastic Waste management rule 2022.

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Course: Risk & Disaster Management and Environmental Safety Contents

Netaji Subhas Open University P.G. Environmental Science PGES-CC-204 1 Unit 1: An Introduction to Disaster Management 1.1 Objectives 1.2 Introduction 1.3 Types of Disasters 1.4 International Decade for Natural Disaster Reduction (IDNDR) 1.5 Evolution of Disaster Management in India 1.6 Role of information science and technology for natural disaster risk reduction 1.7 Natural Disaster Mitigation Vis-À-Vis Risk and Vulnerability 1.8 Risk Assessment and methodologies 1.9 Industrial safety measures and management 1.10 Chemical and industrial Hazard: Do's & Dont's 1.11 Fire safety protocols 1.12 Fire: Do's & Dont's 1.13 Summary 1.14 Questions/ Self-Assessment questions 1.15 Selected Readings/ Suggested Readings 1.1 Objectives After completing this unit, we will be able to: • Understand different types of disaster • Evolution of Disaster Management in India • Interaction of Hazards, Vulnerability and Disaster Risk • Learn about various hazards such as flood, landslide earth quake, flood etc • Understand disaster risk and mitigation 1.2 Introduction The term "DISASTER" owes its origin to French word "Disaster", which a combination of two words "Des" meaning "Bad" and "Aster" meaning "Star" thus the term Disaster refers to "Bad or Evil Star". In earlier days disasters were an outcome or outburst of some unfavorable star. Ideally, a disaster may be defined, or an event concentrated in time and solace which threatens a society or a relative self-sufficient subdivision of a society with major unwanted consequences as a result of the collapse of precautions which had hitter to been culturally accepted as adequate.

2 Disaster according to ' Disaster Management Act 2005' means a catastrophic, mishap, calamity on grave occurrences in any area, arising from natural or manmade causes or by accident on negligence which results in substantial loss a life or human suffering or damage to and destruction of property on damage to or degradation of environment and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area.

Disasters
combine two elements: hazard, and the vulnerability of affected people. "A disaster occurs when a hazard exposes the vulnerability of individuals and communities in such a way that their lives are directly threatened or sufficient harm has been done to their community's economic and social structure to undermine their ability to survive. “Disaster is the exposure of a group of people to a hazard, leading to
a serious disruption
of
the functioning of a society and
causing human,
material, economic or environmental losses which exceed the
ability of the affected
community
or society to cope.
A disaster results from a combination of hazards and
vulnerability that exceeds the capacity of a society to reduce the potential negative consequences of risk.
It
is
often described as
a result of the combination of: the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences. Disaster impacts may
include loss of life, injury,
disease and other negative effects on human physical, mental and social well-being,
together
with damage to property, destruction of assets,
loss of services, social and economic disruption and environmental
degradation.
To understand Disaster Management, it is necessary to understand the concepts of Vulnerability, Risk, Hazard, Capacity and Disaster that are embedded in the process of Disaster Management (
NIDM 1).
These have been discussed below. 1.2.1 Hazards
Hazard may be defined as “
a
dangerous condition or event, that threat or have the potential for causing
injury to life or damage to property or the environment.”
A hazard
may be any event that threatens life and property and disrupts normal life. Hazards can be both natural as well as man-made. • Natural Hazards: These are extreme events caused by physical forces working on or within the earth’s surface. Examples of natural hazards include earthquakes, volcanoes, floods, cyclones, droughts etc. Because natural hazards are created by physical forces, it is not possible to stop them. However, by proper planning and policymaking, the risk to these hazards can be drastically reduced. • Man-Made Hazards (Unnatural Hazards): These hazards are caused by human agencies either through negligence or for vindictive purposes. Examples of Unnatural Hazards include terrorism, fire, accidents etc. Through raising awareness, better education, and better urban and rural management, these hazards can be tackled and removed. 1.2.2 Vulnerability 1
https://nidm.gov.in/PDF/pubs/Handbook_NodalOfficer.pdf
3

Vulnerability is a very relative concept. It refers to the inability of an individual, group, society, or a nation to deal with disasters effectively. It has been observed that when a disaster strikes any region, the people most affected are more likely to be poor, women, children, and old. These are the groups that are referred to as vulnerable. Many factors like economic, social, and political affect the capacity of people to deal with disasters. For example, low income groups are more likely to live in areas that are exposed to disaster risk and more thus more likely to bear the brunt of any such event. Conversely, when a disaster strikes, it is the poor who have a paucity of resources to deal with it. In the past, Vulnerability has been limited to physical susceptibility; however, understanding of this concept is now becoming more comprehensive, to include susceptibility, exposure, coping capacity, adaptive capacity, social inequalities, and physical, institutional, and economic weaknesses. However, Anderson and Woodrow (1990) categorize vulnerability into three areas namely: • Physical/ Material Vulnerability: For example, poor people who have few physical/ material resources usually suffer more from disaster than rich people. People who are poor often live on marginal lands; they don't have any savings or insurance; they are in poor health. These factors make them more vulnerable to disaster and mean that they have harder time surviving and recovering from a calamity than people who are better off economically. • Social/Organizational: Experience shows that people who have been 'marginalized' in social, economic or political terms are vulnerable to suffering from disasters whereas groups which are well organized and in which there is a high commitment to each other suffer less when catastrophe strikes. For example, deep divisions can lead to conflict and war. Conflict on resources due to poverty can also lead to violence. A second area of vulnerability then, is the social/organizational and economic realm. • Attitude and Motivational Vulnerability - Experience also shows that the people who do not have confidence in their ability to affect change and feel defeated by events they cannot control, are harder hit by disasters. This is in contrast to those who have a sense of their ability to bring about the changes they desire. 1.2.3

Capacity Capacity can be defined as "resources, means and strengths which exist in households and communities and which enable them
to
cope with, withstand, prepare for,
prevent, mitigate or quickly recover from a disaster".
People's capacity can also be taken into account. Capacities could be
classified into physical and socio-economic capacities. •
Physical Capacity: People whose houses have been destroyed by the cyclone or crops have been destroyed by the flood can salvage things from their homes and from their farms. Some family members have skills,
which enable them to find employment if they migrate, either temporarily or permanently. •
Socio-economic Capacity: In most disasters, people suffer their greatest losses
in the physical and material realm. Rich people have the capacity to recover soon because of their wealth.
In fact, they are seldom hit by disasters
because they live in safe areas and their
4 houses are built with stronger materials. However, even when everything is destroyed, they have the capacity to cope up with it. Hazards are always prevalent, but the
hazard becomes a disaster only when
the frequency or likelihood
of a hazard
and the vulnerability of the community increases the risk of being severely affected. 1.2.4

Risk Risk is a measure of the expected losses (deaths, injuries, property, economic activity etc.)
due to a hazard of a particular magnitude
occurring in a given area over a specific time period.
A community/locality is said to be at 'risk' when
it is exposed to hazards and is likely to be adversely affected by its
impact.

Thus, Disaster risk can be explained most simply as the function of a specific hazard, physical exposure of elements at risk and human vulnerability. A fundamental principle of strategic disaster management is recognizing that risk and trying to minimize it. Risk management comprises risk assessment and analysis, and the implementation of strategies and specific actions to control, reduce and transfer risks. It is widely practiced by organizations to minimize risk in investment decisions and to address operational risks such as those of business disruption, production failure, environmental damage, social impacts and damage from fire and natural hazards. 1.2.5

Interaction of Hazards, Vulnerability and Disaster Risk

Hazards in themselves do not constitute disasters. The magnitude of a disaster is usually described in terms of the adverse effects which a hazard has had on lives, property and infrastructure; environmental damage; and the costs attached to post disaster recovery and rehabilitation. In other words there
is
a direct link between the capacity of those affected to withstand, cope and recover from the adverse effects of a hazard using only their own resources, and what constitutes disaster risk.
In simpler words
disaster risk is the product of the combination of three elements – vulnerability, coping capacity and hazard. The following notation illustrates this interaction: Risk = Hazard (H) x Vulnerability (V) / Capacity (C) 1.3
Types of Disasters Primarily disasters are triggered by natural hazards or human-induced or result from a combination of both. The human-induced factors can greatly aggravate the adverse impacts of a natural disaster. Even at a larger scale, globally, the UN Inter-Governmental Panel on Climate Change (IPCC) has shown that human-induced climate change has significantly increased both the frequency and intensity of extreme weather events. While heavy rains, cyclones, or earthquakes are all natural, the impacts may, and are usually, worsened by many factors related to human activity. The extensive industrialization and urbanization increase both the probability of human-induced disasters, and the extent of potential damage to life and property from both natural and human- induced disasters. The human society is also vulnerable to Chemical, Biological, Radiological, and
5 Nuclear (CBRN) threats and events that might escalate to emergencies/ disasters (
National Disaster Management Plan,2019). 1.3.1
Natural Hazards The widely accepted classification system used by the Disaster Information Management System of DesInventar (
http://www.desinventar.net/definitions.html)
classifies disasters arising from natural hazards into five major categories and is used globally for the Sendai targets monitoring:
Table 1.1: Categories of Natural Hazards (Sources: NDMA, 2019) S. No .
Family Main Event Short Description/ Secondary Disaster 1 Geophysical Earthquake/Mass movement of earth materials Landslides following earthquake Urban fire triggered by earthquakes Liquefaction-the transformation of (partially) water-saturated soil from a solid state to a liquid state caused by an earthquake
Mass movement of earth materials, usually down Slopes Surface displacement of earthen materials due to ground shaking triggered by earthquakes Volcano Surface displacement of earthen materials due to ground shaking triggered by volcanic eruptions A type of geological event near an opening/vent in the Earth's surface including volcanic eruptions of lava, ash, hot vapour, gas, and pyroclastic material. Ash fall; Lahar - Hot or cold mixture of earthen material flowing on the slope of a volcano either during or between volcanic eruptions. Lava Flow Pyroclastic Flow - Extremely hot gases, ash, and other materials of more than 1,000 degrees Celsius that rapidly flow down the flank of a volcano (more than 700 km/h) during an
eruption Tsunami
Tsunamis are difficult to categorize they are essentially an oceanic process that is manifested
6
S. No . Family Main Event Short Description/ Secondary Disaster
as a coastal water-related hazard. A series of waves (with long wavelengths when traveling across the deep ocean) that are generated by a displacement of massive amounts of water through underwater earthquakes, volcanic eruptions or landslides. Tsunami waves travel at very high speed across the ocean but as they begin to reach shallow water they slow down, and the wave grows steeper. 2
Hydrological • Flood •Landslides •Wave Action Avalanche, a large mass of loosened earth material, snow, or ice that slides, flows or falls rapidly down a mountainside under the force of gravity Coastal Erosion - The temporary or permanent loss of sediments or landmass in coastal margins due to the action of waves, winds, tides, or anthropogenic activities Coastal flood - Higher-than-normal water levels along the coast caused by tidal changes or thunderstorms that result in flooding, which can last from days to weeks Debris Flow, Mud Flow, Rock Fall - Types of landslides that occur when heavy rain or rapid snow/ice melt send large amounts of vegetation, mud, or rock downslope by gravitational forces Flash Flood Hydrological - Heavy or excessive rainfall in a short period of time that produce immediate runoff, creating flooding conditions within minutes or a few hours during or after the rainfall
Flood Hydrological - A general term for the overflow of water from a stream channel onto normally dry land in the floodplain (riverine flooding), higher-than normal levels along the coast and in lakes or reservoirs (coastal flooding) as well as ponding of water at or near the point where the rain fell (flash floods)
7
S. No . Family Main Event Short Description/ Secondary Disaster Wave Action:

Wind-generated surface waves that can occur on the surface of any open body of water such as oceans, rivers and lakes, etc. The size of the wave depends on the strength of the wind and the travelled distance (fetch). 3
Meteorological
Hazard caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that may last
for minutes to days •
Cyclone, Storm Surge, Tornado, Convective Storm, Extra-tropical Storm, Wind • Cold Wave, Derecho • Extreme Temperature, Fog, Frost, Freeze, Hail, Heat wave • Lightning, Heavy rain • Sandstorm, Dust-storm • Snow, Ice, Winter Storm, Blizzard 4
Climatological Unusual, extreme weather conditions related to long- lived, meso- to macroscale atmospheric from intra-seasonal to multi-decadal (long-term) climate variability processes ranging Drought Extreme hot/cold conditions Forest/Wildfire Fires Glacial Lake Outburst Flood (GLOF) Subsidence 5 Biological Exposure to germs and toxic substances Epidemics: viral, bacterial, parasitic, fungal, or prion infections Insect infestations Animal stampedes 1.3.2 Human-Induced Disasters The NPDM 2009 notes that rise in
population, rapid
urbanization
and industrialization, development within high-risk zones, environmental degradation, and climate change
aggravates the
vulnerabilities to various kinds of disasters. Due to inadequate disaster preparedness, communities, and animals are at increased risk from many kinds of human-induced hazards arising from accidents (industrial, road, air, rail, on river or sea, building collapse, fires, mine flooding, urban flooding, oil spills, etc.). Hazards due to CBRN threats and events rank very high among the
8 causes that are human induced acts. Terrorist activities and secondary incidences arising from intentional or non - intentional activities also add to these risks and calls for adequate preparedness and planning. 1.3.3
Floods Floods are among the most frequent and costly natural disasters. Conditions that cause floods include heavy or steady rain for several hours or days that saturates the ground. Flash floods occur suddenly due to rapidly rising water along a stream or low-lying area.
A flood is an excess of water (or mud) on land that's normally dry and is a situation wherein the inundation is caused by high flow, or overflow of water in an established watercourse, such as a river, stream, or drainage ditch; or
ponding of water at or near the point where the rain fell.
This is a duration type event. A flood can strike anywhere without warning, occurs when a large volume of rain falls within a short time
India is highly vulnerable to floods. Out of the total geographical area of 329 million hectares (mha), more than 40 mha is flood prone.
Floods are a recurrent phenomenon, which cause huge loss of lives and damage to livelihood systems, property, infrastructure and public utilities. It is a cause for concern that flood related damages show an increasing trend.
9 Figure 1.1: Flood Hazard zonation of India (BMPTC, 2019)

10 1.3.3.1 Types of Floods Flash Floods: Floods occurring within six hours, mainly due to heavy rainfall associated with towering cumulus clouds, thunderstorms, tropical cyclones or during passage of cold weather fronts, or by dam failure or other river obstruction. This type of flood requires a rapid localized warning system. River Floods: Floods caused by precipitation over a large catchment's area, melting of snow or both. Built up slowly or on a regular basis, these floods may continue for days or weeks. The major factors of these floods are moisture, vegetation cover, depth of snow, size of the catchment's basin, etc. Coastal Floods: Floods associated with cyclonic activities like Hurricanes, Tropical cyclones, etc. generating acatastrophic flood from rainwater which often aggravate wind-induced storm and water surges along the coast. Urban Flood: As land is converted from agricultural fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization decreases the ability to absorb water 2 to 6 times over what would occur on natural terrain. During periods of urban flooding, streets can become swift moving rivers, while basements can become death traps as they fill with water. Ice Jam: Floating ice can accumulate at a natural or human-made obstruction and stop the flow of water thereby causing floods. Flooding too can occur when there the snow melts at a very faster rate. Glacial Lake Outbursts Flood (GLOF): Many of the big glaciers which have melted rapidly and gave birth to the origin of a large number of glacier lakes. Due to the faster rate of ice and snow melting, possibly caused by the global warming, the accumulation of water in these lakes has been increasing rapidly and resulting sudden discharge of large volumes of water and debris and causing flooding in the downstream. 1.3.3.2 Causes of Floods Inadequate capacity of the rivers to contain within their banks the high flows brought down from the upper catchment areas following heavy rainfall, leads to flooding. The tendency to occupy the flood plains has been a serious concern over the years. Because of the varying rainfall distribution, many a time, areas which are not traditionally prone to floods also experience severe inundation. Areas with poor drainage facilities get flooded by accumulation of water from heavy rainfall. Excess irrigation water applied to command areas and an increase in ground water levels due to seepage from canals and irrigated fields also are factors that accentuate the problem of water- logging. The problem is exacerbated by factors such as silting of the riverbeds, reduction in the carrying capacity of river channels, erosion of beds and banks leading to changes in river courses, obstructions to flow due to landslides, synchronisation of floods in the main and tributary rivers and retardation due to tidal effects (NIDM).

11 The primary causes for Floods are: • Intense rainfall when the river is flowing full. • Excessive rainfall in river catchments or concentration of runoff from the • tributaries and river carrying flows in excess of their capacities. • Cyclone and very intense rainfall when the EL Nino effect is on a decline. • Synchronization of flood peaks in the main rivers or their tributaries. • Landslides leading to obstruction of flow and change in the river course. • Poor natural drainage system. • Backing water in tributaries at their confluence with the main river. 1.3.4 Landslide Landslides are among the major hydro-geological hazards that affect large parts of India, especially in the Himalaya, the northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats and the Vindhyas.

Table: Probability of Landslides occurrence in India Region Incidences of Landslides Himalaya High to very high North-eastern Hills High Western Ghats and the Nilgiris Medium to high Vindhayachal Low

12 Figure 1.2: Landslide incidence map of India (Source: BMTPC)

13 Landslides are caused mainly by two factors – pre-disposing causal geofactors and the triggering factors (e.g., rainfall, earthquake, sudden slope cutting etc.). The pre-disposing causal geo factors such as variation in topographic gradient, topographic shape, aspect (direction of slope), geomorphology and its prevalent processes, geology, structure, lithology of the overburden material, changes in land use, and land cover are the main controlling geofactors which are instrumental in causing the landslides, including its varying types of movements, material and magnitudes. In India, the landslide prone areas represent a wide spectrum of topography, geology and geomorphic set up and thus cause landslides of varying types, magnitudes and failure mechanisms. All sorts of landslide failure mechanisms – deep-seated, shallow translational slides, flows involving varying material, movement type and magnitudes are observed in India which are strongly influenced by prevalent topography, geology and geomorphology of the terrain (BMTPC 2019). The landslides can be rapid or slow and occur in a wide variety of geological environs including under water. The secondary or domino/ cascading effects of landslides can also be very disastrous. Waves generated by landslides entering rivers, lakes, reservoirs and other water bodies have caused substantial damage to engineering and civil infrastructures in many parts of the world. The artificial landslide debris-dammed lakes can flood upstream areas and also on breaching can generate Landslide Lake Outburst Flow (LLOF) having enormous amount of discharge and energy that can suddenly trigger flash flood or inundation in downstream, low-lying areas and can also trigger many new landslides due to toe cutting and excessive rate of erosion by the flowing debris- laden flood discharge downstream along the narrow mountainous rivers. The examples of such type of cascading hazards are plenty in Indian Himalayas (e.g., the deluge of 2013 in Uttarakhand) (BMTPC 2019). Landslide types based on process of failure Based on process types, there are five types of landslides i.e., Fall, Topple, Slide, Spread, Flow and Subsidence. 1.3.1 Fall: is a very rapid to extremely rapid movement which starts with detachment of material from steep slopes such as cliffs, along a surface on which little or no shear displacement takes place. The material then descends through the air by free falling, bouncing or rolling onto the slopes below. • The detachment of soil or rock from a steep slope along a surface on which little or no shear displacement takes place. • Movement very rapid to extremely rapid. • Free fall if slope angle exceeds 76 degrees and rolling at or below 45 degrees. 1.3.2 Topple: involves overturning of material. It is forward rotation of the slope mass about a point or axis below the centre of gravity of the displaced mass. Topples range from extremely slow to extremely rapid movements. • The forward rotation out of the slope of a mass or a rock about a point or axis below the centre of gravity of the displaced mass.

14 • Movement varies from extremely slow to extremely rapid. • Driven by gravity and sometimes by water or ice in cracks in mass. . 1.3.3 Slide: movement of material along a recognizable shear surface e.g., translational and rotational slides. • Downslope movement of a soil or mass occurring dominantly on surfaces of or on relatively thin zones of intense shear strain. • The sign of ground movement are cracks of the original ground. Modes of Sliding: • Translational / planar slides • Wedge slides • Rotational slide 1.3.4 Flow: is a landslide in which the individual particles travel separately within a moving mass. • Spatially continuous movement, in which surfaces of shear are shortlived, closely spaced and usually not preserved. • Flows are differentiated from slides, on the basis of water content, mobility and evolution of movement. Features for recognition of flows are • Crown may have few cracks. • The main scarp typically has serrated or funnel shaped upper part; is long and narrow, bare and commonly striated. • Flanks are steep and irregular in the upper part; may have levees built up in the middle and lower parts. • The body has flowlines, follow drainage ways, is sinuous, and is very long compared to width. • The toe spreads laterally in lobes; if dry, may have steep front 1.3.5 Spread • Sudden movement on water- bearing seams of sand or silt overlain by homogeneous clays or loaded by fills. • May result from liquefaction or flow of softer material 1.3.6 Slump It is a type of rotational failure on slopes. The trees bends or fall backwards on towards the slope 1.3.7 Creep Very slow rates of slope movements, usually a few millimeter per year, that is imperceptible in nature) are covered under this category

15 1.3.5 Indian Volcanoes The lone active volcano in India is the "Barren Island Volcano" falling in the Southeast Asia volcanic belt. It lies about 135 km ENE of Port Blair, the capital of Andaman and Nicobar Group of Islands (12.29°N: 93.85°E) and occupies only 10 sq km area. The Barren

Island rises from a depth of about 2250 m from the sea floor and stands out 355 m above the sea level. From west side it looks like a truncated cone girdled by precipitous cliffs all around. Except in its central part, Barren Island is covered with thick vegetation similar to other parts of Andaman and Nicobar Group of islands and closely related to Myanmar, Indonesia and Malayan Flora. No human habitation is ever reported from this Island. 1.3.6

Earthquake An earthquake

is a phenomenon that occurs without warning and involves violent shaking of the ground and everything

over it. It results from the release of accumulated stress of the moving lithospheric or crustal plates. The earth's crust is divided into seven major plates, that are about 50 miles thick, which move slowly and continuously over the earth's interior and several minor plates. Earthquakes are tectonic in origin; that is the moving plates are responsible for the occurrence of violent shakes. The occurrence of an earthquake in a populated area may cause numerous casualties and injuries as well as extensive damage to property (

NDMA 2). Earthquake, a geological disaster, is a phenomenon of sudden shaking of earth's curst due to natural causes (rock displacements, landslide, avalanche, volacanic eruption, meteoritic impact, sub- marine sea faulting, etc). Apart from the natural causes, this disaster can also occur due to human activities such as, explosions due to chemical blasts or nuclear blasts or rock burst due to mining activities, and reservoir induced earthquakes. Earthquakes result from crustal strain, volcanism, landslides, and collapse of caverns. Stress accumulates in response to tectonic forces until it exceeds the strength of the rock. The rock then breaks along a preexisting or new fracture called a fault. The rupture extends outward in all directions along the fault plane from its point of origin (focus). The rupture travels in an irregular manner until the stress is relatively equalized. If the rupture disturbs the surface, it produces a visible fault on the surface. Earthquakes are recorded by seismograph consisted of seismometer, a shaking detector and a data recorder. The moment magnitude of an earthquake is conventionally reported, or the related and mostly obsolete Richter magnitude, with magnitude 3 or lower earthquakes being mostly imperceptible and magnitude 7 causing serious damage over large areas. Intensity of shaking is measured on the modified Mercalli scale. In India Medvedev-Sponheuer-Karnik scale, also known as the MSK or MSK-64, which is a macroseismic intensity scale, is used to evaluate the severity of ground shaking on the basis of observed effects in an area of the earthquake occurrence. Due to earthquake seismic waves are generated and measurements of their speed of travel are recorded by seismographs located around the planet (NIDM). 2 https://ndma.gov.in/Natural-Hazards/Earthquakes
16 Figure 1.3: Earthquake Hazard zonation of India (BMPTC)
17 1.3.7
Tsunami Tsunamis are a series of waves usually generated by movement of the sea floor. These movements are caused by different types of geophysical phenomena such as earthquakes, landslides and volcanic eruptions. The word tsunami is a Japanese word, represented by two characters: tsu, meaning, "harbor", and nami meaning, "wave". Tsunamis are move at a speed equal to the square root of the product of gravity and the depth of the water. The tsunami waves behave very differently in deep water than in shallow water as their speed is related to the water depth. Tsunami waves form only a small hump, barely noticeable and harmless, which generally travels at a very high speed of 500 to 1,000 km/h. The tsunami's speed diminishes as it travels into shallower water to only tens of kilometers an hour, consequently increasing the wave height. Because of this shoaling effect, a tsunami, imperceptible at sea, may grow to be several meters or more in height near the coast forming the large destructive waves. Tsunamis are most commonly generated by earthquakes in marine and coastal regions. Major tsunamis are produced by large (greater than 7 on the Richter scale), shallow focus (> 30km depth in the earth) earthquakes associated with the movement of oceanic and continental plates. They frequently occur in the Pacific, where dense oceanic plates slide under the lighter continental plates. When these plates fracture they provide a vertical movement of the seafloor that allows a quick and efficient transfer of energy from the solid earth to the ocean. When a powerful earthquake (magnitude 9.3) struck the coastal region of Indonesia in 2004, the movement of the seafloor produced a tsunami in excess of 30 meters (100 feet) along the adjacent coastline killing more than 240,000 people. From this source the tsunami radiated outward and within 2 hours had claimed 58,000 lives in Thailand, Sri Lanka, and India (
INCOIS 3). The Government of India has put in place an Early Warning System for mitigation of such oceanogenic disasters under the control of Indian National Center for Ocean Information Services (INCOIS), Hyderabad. A state-of-the-art early warning centre was established with the necessary computational and communication infrastructure that enables reception of real-time data from sensors, analysis of the data, generation and dissemination of tsunami advisories following a standard operating procedure. Seismic and sea-level data are continuously monitored in the Early Warning Centre using custom-built software application that generates alarms/alerts in the warning centre whenever a pre-set threshold is crossed. Tsunami warnings/watches are then generated based on pre-set decision support rules and disseminated to the concerned authorities for action, as per pre-decided standard operating procedure. The efficiency of this end-to-end system was proved during the large under-sea earthquake of 8.4 M that occurred on September 12, 2007 in the Indian Ocean. The 2004 tsunami also prompted National Disaster Management Authority (NDMA) to formulate Tsunami Risk Management Guidelines to outline inter-agency roles and responsibilities, tsunami risk preparedness, mitigation and response. 3 https://tsunami.incois.gov.in/TEWS/stsunamihistory.jsp
18
Historical Tsunamis in India • 12 Apr, 1762 (Earthquake in Bay of Bengal) • 31 Dec, 1881 (Car Nicobar Earthquake) • 27 Aug, 1883 (Eruption of Karkatoa volcano (Sunda Strait) Indonesia) • 26 Jun, 1941 (Andaman Earthquake) • 27 Nov, 1945 (Makran Earthquake) • 26 Dec, 2004 (Sumatra Earthquake) • December 2004:
Tsunami in Indian Ocean

The Tsunami of 26th December 2004 caused extensive damage to life and property in the states of Tamil Nadu, Kerala, Andhra Pradesh, UTs of Puducherry and Andman & Nicobar Islands (A & NI). The Tsunami disaster had badly affected the fishermen community who not only lost their near and dear ones but also lost their means of livelihood. A population of 26.63 lakhs in 1396 villages in five states and UTs was affected by this disaster. Almost 9395 people lost their lives and 3964 people were reported missing and feared dead. Most of the
missing persons were from Andaman & Nicobar Islands. 1.3.8
Cyclone Cyclones
are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation.
Cyclones are usually accompanied by violent storms and bad weather. The air circulates inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere. Cyclones are classified as: (i) extra tropical cyclones (also called temperate cyclones); and (ii) tropical cyclones. The word
Cyclone is derived from the Greek word Cyclos meaning the coils of a snake.
It was coined by Henry Peddington because the tropical storms in the Bay of Bengal and the Arabian Sea appear like coiled serpents of the sea. 1.3.4.1 Classifications Cyclones are classified as extra tropical cyclones (also called temperate cyclones); and tropical cyclones. The World Meteorological Organisation (WMO, 1976) uses
the term 'Tropical Cyclone'
to cover weather systems in which winds exceed 'Gale Force' (minimum of 34
knots or 63 kph). Tropical cyclones are the progeny of ocean and atmosphere, powered by the heat from the sea; and driven by easterly trades and temperate westerlies, high planetary winds and their own fierce energy. In India, cyclones are classified by: • Strength of associated winds, • Storm surges • Exceptional rainfall occurrences.
19 Cyclones that develop in the regions between the Tropics of Capricorn and Cancer are called tropical cyclones. Tropical cyclones are large-scale weather systems developing over tropical or subtropical waters, where they get organized into surface wind circulation. Cyclones are given many names in different regions of the world – They are known as typhoons in the China Sea and Pacific Ocean; hurricanes in the West Indian islands in the Caribbean Sea and Atlantic Ocean; tornados in the Guinea lands of West Africa and southern USA.; willy-willies in north-western Australia and tropical cyclones in the Indian Ocean. The criteria below has been formulated by the Indian Meteorological Department (IMD), which classifies the low pressure systems in the Bay of Bengal and the Arabian Sea on the basis of capacity to damage, which is adopted by the WMO. Type of Disturbances Wind Speed in Km/h Wind Speed in
Knots Low Pressure Less than 31 Less than 17 Depression 31-49 17-27 Deep Depression 49-61 27-33 Cyclonic Storm 61-88 33-47 Severe Cyclonic Storm 88-117 47-63 Super Cyclone More than 221 More than 120 1
knot - 1.85 km per hour Cyclones are classified into five different levels on the basis of wind speed. They are further divided into the following categories according to their capacity to cause damage: Cyclone Category Wind Speed in Km/h Damage Capacity 01 120-150 Minimal 02 150-180 Moderate 03 180-210 Extensive 04 210-250 Extreme 05 250 and above Catastrophic
20 1.4
International Decade for Natural Disaster Reduction (IDNDR)
The United Nations General Assembly
designated
the 1990s as the International Decade for Natural Disaster Reduction (
IDNDR) 4 .
The
Programme Forum 1999 was held 5-9 July 1999, in Geneva, Switzerland. This forum addressed the major concerns in disaster risk management related to education, capacity development, social impact and vulnerability, civil society and public-private partnership, economic and health aspects in disaster reduction, land use planning and environmental protection. The aim of IDNDR was that all countries should have: a)
Comprehensive national assessments of risks from natural hazards, with these assessments
considering their impact on developmental plans, b) Mitigation plans at national and/or local levels, involving long term prevention and preparedness and community awareness, and c) Ready access to global, regional, national and local warning systems and widespread dissemination of such warnings. For further more details you can download proceedings of the programme: https://www.preventionweb.net/files/31468_programmeforumproceedings.pdf?_gl=1*3sw1s7*_ga*OTk2OTAzOTI2
LjE2NjUwNDA4Nzg.*_ga_D8G5WXP6YM*MTY2NTA0MDg3Ny4xLjAuMTY2NTA0MDg3Ny4wLjAuMA.. 4 United Nations General Assembly Session 44 Resolution 236. A/RES/44/236 22 December 1989. Retrieved 2008- 09-18.

21 Figure 1.4: The document discusses several success stories on public awareness practices, effective early warning systems and improved defence against earthquake, flood and cyclone. The decade was intended to reduce, through concerted international action, especially in developing countries, loss of life, property damage and social and economic disruption caused by natural disasters. To support the activities of the decade, a Secretariat was established at the United Nations Office in Geneva, in close association with UNDRO. 1.5 Evolution of Disaster Management in India In India, the phrase
disaster management does not find place in any of the lists of the 7th schedule.
So far, the primary responsibility for
the management of disaster has been of the state governments with assistance from the central government
as per the recommendations of the Finance Commission. In a sort of firsts, the National Centre for Disaster Management (NCDM) was established in 1995. This center later became the National Institute of Disaster Management (NIDM). The responsibility for handling disasters remained with the Ministry of Agriculture till 2001. However, in August 1999, the government of India set up
a High-Powered Committee 5 under the chairmanship of Mr. J. C. Pant.
This was just prior to the devastating cyclone in Odisha. The J C Pant committee recommended the setting up of a Disaster Management Ministry, but this did not fructify in the form recommended. Thereafter in February 2001, just after the Gujarat earthquake,
an All Party National Committee on
Disaster Management was set up under the chairmanship of the Prime Minister.
This committee 5 https://www.preventionweb.net/files/1633_ch3.pdf
22 recommended the creation of the NDMA under the Ministry of Home Affairs (MHA) and therefore in June 2002, in deference to the recommendations of the Pant committee, the responsibility of handling Disaster Management was transferred to the MHA. Later the 2004 Indian Ocean Tsunami shook the conscience of the nation and
the government decided to enact a law on
disaster management to provide for requisite
institutional mechanism for drawing up and monitoring the implementation of the
disaster management plans, ensuring measures by various wings of Government for
prevention and
mitigating effects of disasters and
for undertaking a holistic, coordinated and prompt response to any disaster situation.
The Disaster Management Act, 2005
was enacted and notified on December 26, 2005.
It
provides
for the “effective management of disasters and for matters connected therewith or incidental thereto”.
Disaster studies: Indian Scenario India due to its unique geographical conditions is exposed to a wide range of disasters both natural and anthropogenic, each region is exposed to specific type of disaster. While suggesting a holistic approach to DM, the High Power Committee (HPC) discussed three cases that merit special consideration on the geo-physical considerations: a) Himalayan region b) Coastal tracts, and c) Riverine areas. From the point of view of administrative and logistical perspectives, the North East Region also requires specialized approach. Similarly, the Union Territories, remote Islands and offshore marine assets need to be treated differently given the specific administrative and logistical challenges. Therefore, there are six special categories
which are given below: Table 1.2: Regions/Areas Involving Multiple States Requiring Special Attention (Source: NDMP 2019) S. No. Region Hazard Type 1 Himalayan Region Earthquakes, Landslides, Glacial Lake Outburst, Floods & Flash floods, Cloudburst, Forest fire, cold wave etc. 2 Coastal Region Cyclones, Tsunami, Landslides,
Geological and shoreline changes, Rip currents, Sea level rise, Coastal flooding, Storm surges and flooding, Flooding from heavy rainfall events, Saline ingress,
heat wave 3 Riverine Areas Heavy rainfall, Riverine flooding and food shortages during droughts 4 North East Region Earthquake, Floods, Landslide and Forest Fires 5
Union Territories, Islands and Marine Assets located in one or more State and UTs UTs and
islands
are all at risk from multiple hazards especially that of sea surges, high velocity wind, cyclones, earthquakes, and tsunami. 6 Arid
and Semi-Arid Regions Drought, Heat Wave

23 Figure 1.5: Multi hazard map of India (Source: https://nidm.gov.in/easindia2014/err/pdf/country_profile/India.pdf) 1.6 Role of information science and technology for natural disaster risk reduction Infrastructure development is not a one-time event; rather, it is a continual and growing process. On the one hand, exploitation of technological innovations with state-of-the-art next-generation networks and a plethora of software applications on the horizon is absolutely critical for disaster management Continuum management; on the other hand, it is equally important that stakeholders involved in the DM at various levels understand these wide range of available technological platforms in generic terms, so a comprehensive understanding is required. In this framework, the goal of this Chapter is to explore the evolving technological backdrop in very broad terms.
24 1.6.1 Role of information science and technology for natural disaster risk reduction Science, Technology & Innovation has a role in all phases of DM: • To evaluate disaster risks for preparedness, response, and mitigation • To communicate disaster risks and their management options to all stakeholders including the people • To develop plans to mitigate contributors to the risks • To use technologies for risk-reduction, mitigation, and response • To develop decision support systems for planning and response • To develop early warning systems • To develop emergency communication systems etc. Figure 1.6: The phases of the disaster management cycle and examples of related Activities.
25 1.7 Natural Disaster Mitigation Vis-À-Vis Risk and Vulnerability 1.7.1 Disaster Mitigation Disaster Mitigation is the cornerstone of emergency management. According to
DM ACT 2005, “
mitigation” means
measures aimed at reducing the risk, impact or effects of a disaster or threatening
disaster
situation. 1.7.1.1
Types of
disaster mitigation Disaster mitigation measures may be structural (e.g., flood dikes,
techno-legal measures, mitigation projects etc.)
or non-structural (e.g., land use zoning,
planning, policy etc.).
Mitigation activities should incorporate the measurement and assessment of the evolving risk environment.
Activities may include the creation of comprehensive, pro-active tools that help decide where to focus funding and efforts in
risk reduction.
Other examples of
mitigation measures include: •
Hazard mapping • Adoption and enforcement of land use and zoning practices • Implementing and enforcing building codes • Flood plain mapping • Reinforced tornado safe rooms • Raising
of homes in flood-prone areas • Disaster mitigation public awareness
programs •
Mitigation Projects (like National Cyclone Risk Management Project, Earthquake Risk Mitigation Project etc.) • Insurance programs 1.7.1.2 What is Disaster
Risk According to the terminology of
UNDRR,
disaster risk is defined as “
the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period
of time, determined probabilistically as a function of
hazard,
exposure, vulnerability and capacity.
For example, when a settlement is established on the shores of a river, hydrologists can identify and characterise flood hazard by carrying out a hydraulic analysis. According to the UNDRR definition, a
hazard is characterised by its "location, intensity or magnitude, frequency and probability”.
In some countries, such hazard areas outline the geographic extent of floods that have a 100 year period of possible return. Any people, assets, infrastructure, and ecosystems located inside the area are all exposed to potential damage from floods. The degree of potential damage is then characterised by the area's vulnerability. For example, this can be defined by the physical structure of a building, as well as by the social and
26 economic characteristics of a system. Additionally, hazard vulnerability can be characterized by the capacities of a society to cope with a hazard.

Figure 1.7: Disaster Risk (Source: UN Spider) Elements at risk are the property, resources, people and infrastructure likely to be affected adversely during disasters, referring to all animate and inanimate objects likely to suffer harm in the event of a disaster. Besides these tangible elements, intangible elements also need to be accounted for, such as the mental health of sufferers, the impact on the environment, cultural impact of migrations, etc. Figure 1.8: An example of identification of element of risk. Risk Hazard Exposure Vulnerability

27 1.8 Risk Assessment and methodologies

Risk assessment is necessary

to determine the nature and extent of risk by analyzing potential hazards and evaluating existing conditions of vulnerability that could

pose a potential threat or harm to people, property, livelihoods and the environment on which they depend. 1.8.1 Conducting a Risk Assessment The first step in preparing for hazards is to conduct a local risk assessment, which helps identify the potential impacts of hazards on a community's physical, social, economic, and environmental assets. When done correctly, the assessment helps decision makers and stakeholders understand the most locally significant hazards and unique risks, including current and possible future vulnerabilities. Just as important, risk assessment supports the development of mitigation measures to reduce future risk. While specific approaches may vary depending on available capabilities and resources, the outcome, conclusion, or end goal of any meaningful risk assessment should be implementation of the community's risk reduction and mitigation strategies. 1.8.2 Tool for Risk Assessment One of the tools that can be used for risk assessment is as follows: Figure 1.9:

Illustration showing phases of a risk assessment, retrieved from Technical guidance on comprehensive risk assessment and planning in the context of climate change, UNDRR (2022) [

Source: https://www.preventionweb.net/understanding-disaster-risk/component-risk/disaster-risk]. 1.8.3 Risk Analysis The tool is based on determining the risk by analyzing the vulnerabilities and capacities of the community related to each hazard. On the basis of analysis the risk is determined for a particular hazard in a ranking order. While conducting the risk assessment one should keep the following points in mind: ❖ Determine the risk by ranking

28 ❖ Ask the community about the hazard which poses the highest risk. ❖ Explore the reasons due to which a particular hazard poses the risk. Figure 1.10: The concept of Risk Analysis 1.8.4 Risk Evaluation Risk evaluation, (DMTP, 1994) is the "social and political judgement of the importance of various risks by the individuals and communities. This involves trading off perceived risks against potential benefits and also balancing scientific judgements against other factors and beliefs." By evaluating the risk of various hazards to which the country is liable or potentially liable, it becomes practicable to formulate strategies to mitigate the impact of hazards in a cost-effective way. If a community is especially vulnerable to a particular type of disaster severe risk treatment measures may be required to reduce the disaster risk to acceptable levels. 1.8.5 Hazard risk evaluation and management Hazard assessment refers to prioritizing disasters based on its frequency and analysis of the estimated losses. This can be carried out by taking the help of elderly people of the village. The community can analyze the losses that they had incurred during various disasters and learn the best practices carried out. This is an important activity as it forms the basis for preparedness and mitigation plans. • The community can identify both natural as well as human induced hazards to which their area is prone to. • The community can be asked to review and analyze the occurrence of past disasters and hazards. • Group discussions along with the elderly population, teachers and children can be held focusing on the disasters and hazards faced by the community for the past one year to past fifteen years, kind and nature of disasters and hazards faced, experience in the last hazard faced, warning issued, damage caused, response to the disaster, relief and rehabilitation process, traditional methods of coping of the community, gaps in management of the hazard, lessons learnt.

29 1.8.6 Tools for Hazard Assessment Some of the tools that can be used for hazard assessment are as follows: i. Hazard Mapping: It is a visual representation of the village by the community. It is a rough spatial overview and sketch of the area and specific locations, which are vulnerable to various hazards. ii. Historical Profile or Timeline: This tool is used to gather information about what happened in the past. It helps in getting an insight in past hazards, changes in their nature, intensity and behavior. It helps to understand the present situation in the community and establish the link between hazards and vulnerabilities. iii. Seasonal Calendar: It involves making a calendar showing different events primarily the time of occurrence of hazards throughout the annual cycle. Hazard Janua ry Februa ry Marc h Apr il Ma y Jun e Jul y Augu st Septemb er Octob er Novemb er Decemb er Cold Wave Heat Wave Earthqua ke Flood Drought Epidemic Landslid es *GLOF Industria l Accident Any other *Glacier Lake Outburst iv. Hazard Matrix: This tool aims at gathering comphrensive information about the past hazards. It helps in having an insight about the future hazards on the basis of gaps and lacunae in the management of past hazards and disasters. Hazard Intensity Early Warning Given or not Warning Sign Speed of Onset Frequency Time Duration Impact

30 Cold Wave Heat Wave Earthquake Flood Drought Epidemic Landslides *GLOF Industrial Accident Any other 1.9 Industrial safety measures and management

India is developing as a key global player in industrial and technology sector. Rapid industrialization has increased the hazard, risk and vulnerability of the industry and the environment 6 .

Industrial hazards are threats to people and life-support systems that arise from the mass production of goods and services. When these threats exceed human coping capabilities or the absorptive capacities of environmental systems, they give rise to industrial disasters. Factors which contribute to industrial disasters included: the improper storage of flammable, explosive, or toxic chemicals, including radioactive materials; uncontrolled release of untreated chemicals, reaction products, or energy from a chemical reaction; and the presence of people near enough to the chemical or energy release to be exposed and/or injured 7 . Some major industrial incidents are: • Bhopal Gas Tragedy, 1984 • Bombay Docks Explosion, 1944 • Jaipur Oil Depot Fire, 2009 • Korba Chimney Collapse, 2009 • Mayapuri Radiological Incident, 2010 • Ahmedabad chemical factory blast,2020 • OIL's Natural Gas well fire, Baghjan, Assam, 2020 • LG Polymers gas leak, Visakhapatnam, 2020 • Shakti Paper Mill Gas leak, Chhattisgarh, 2020 1.10 Chemical and industrial Hazard: Do's & Dont's 6 https://nidm.gov.in/PDF/modules/chemical.pdf 7 https://www.cdc.gov/niosh/nioshtic-2/00188052.html

31 Before Chemical and industrial Hazard 8 • Avoid housing near the industries producing or processing poisonous chemicals, if possible. • The people living near industrial units should gather information about the nature of industrial units located near their houses. • Read literature, leaflets, newsletters and televisions / radio publishing about the properties and characteristics of hazardous chemicals. • Participate in all the capacity building programmes organized by the government/ voluntary organizations/ industrial units. • Take part in preparing disaster management plan and identify safe shelter along with safe and easy access routes. • Prepare a family disaster management plan and explain it to all the family members. • Make the family aware of the basic characteristics of various poisonous chemicals and the first aid required to treat them. After Chemical and industrial Hazard 9 • When you notice any chemical leak/accident evacuate calmly and quickly against the wind direction. • Keep a wet handkerchief or piece of cloth on face during evacuation. • As far as possible try to attract other's attention on your way to the scene of chemical disaster. • Avoid visiting and become audience to the risky areas. • Don't be obstacle to the people who are managing the disaster. • Keep the sick, elderly, weak, handicapped and other people who are unable to evacuate inside house and close all the doors and windows tightly. • Inform Fire & Emergency Services, Police and medical services from safe location by calling101, 100 and 108 respectively. • Obey any instruction of the District authorities who will be doing their best to ensure the safety of you, your family and society as a whole and also try to save the property and the environment. • Provide correct and accurate information to government official. • Turn on local radio/ TV channels for advice from District Emergency Operation Centre/health authorities • Inform others on occurrence of event at public gathering places (like school, shopping centre, theatre etc.). • Wait for other instructions by authorised people after reaching at safe place. • Don't pay attention to the rumours and don't spread rumours. 8 http://gsdma.org/Content/chemical-and-industrial-disaster-4236 9 http://gsdma.org/Content/chemical-and-industrial-disaster-4236

32 1.11 Fire safety protocols Chemical reaction between oxygen in the atmosphere and some sort of fuel gives Fire. The fire triangle is Oxygen, fuel, and heat. Combustion happens when fuel reacts with oxygen to release heat energy Fuel +O 2 (Oxygen) CO 2 +H 2 O + Heat energy Combustion that results in a flame is very fast and is called burning. 1.11.1.1 Classification of Fires 1. Fires are classified according to the type of fuel that is burning. 2. If you use the wrong type of fire extinguisher on the wrong class of fire, you might make matters worse. 3. It is very important to understand the four different fire (fuel) classification Class A: • Wood • paper, cloth • trash • plastics—solids that are not metals Class B: • Flammable liquids—gasoline

33 • Oil • Grease • Aceton Includes flammable gases. Class C: • Electrical—energized electrical equipment (as long as it's "plugged in" or supply ON) Class D: • Metals—potassium • Sodium • Aluminum • Magnesium • Requires Metal-X, foam, and other special extinguishing agents 3.6.2 Types of Fire Extinguishers: Different types of fire extinguishers are designed to fight different classes of fire The are three most common types of fire extinguishers are: • Water (APW) • Carbon Dioxide (CO 2) • Dry Chemical Powder (ABC, BC, DC) Steps to use a Dry Chemical Powder Type Fire Extinguisher: There are four important steps you must know to correctly use a fire extinguisher. The PASS method can help you to easily remember those steps.

34 1.12 Fire: Do's & Dont's

In Case of a fire 10 : • Raise an alarm and inform the Fire Brigade. • Do not panic; Stay calm. • Unplug all electrical appliances. • Try to extinguish the fire with available equipment. • Close the doors and other openings. Place a wet cloth under the doors to stop the smoke from spreading. Use a wet cloth to cover your mouth to filter inhalation. • Exit immediately if the fire is out of control. • Do not go back for your possessions. • In case of burn injuries due to fire, pour water over burn until pain subsides. If you are trapped by a fire 11 : • Stay close to the floor if smoke permeates your location. • Before opening a door, check it for heat. Use the back of your hand to test the temperature at the top of the door, the knob and the frame before opening. If it is hot, do not open. • If you are unable to escape through a door, use a window. However, if it is too high to jump from a window, try to attract attention by waving something. • If you can leave the room, close the door behind you - this will slow down the progress of the fire. Crawl low. • If your clothes catch fire, drop to the ground and roll to extinguish flames. In case you hear the fire alarm 12 : • Leave the premises by the nearest available exit. • Close all doors and windows behind you. • Do not use lifts. Use staircases. • On arrival of the fire service, help them to help you. • Give way to fire engines to enable them to reach the spot quickly. • Don't Park your vehicles close to fire hydrants/underground static water tanks. • Guide firemen to water sources i.e., tube wells, ponds, static tanks, etc. 10

https://ndma.gov.in/sites/default/files/PDF/pocketbook-do-dont.pdf 11

https://ndma.gov.in/sites/default/files/PDF/pocketbook-do-dont.pdf 12

https://ndma.gov.in/sites/default/files/PDF/pocketbook-do-dont.pdf

35 1.13 Summary Disasters are the environmental realities of this living world. The International Decade for Natural Disaster Reduction (1990s)

was dedicated to promoting solutions to reduce risk from natural hazards. The

journey of IDNDR though HFA to SFDRR, has witnessed in India, a legal and institutional process, alongwith evolution of integrated and holistic approach to disaster risk reduction. The paradigm shift from relief and response centric to prevention and mitigation centric approach has percolated both ways bottom up as well as top down, convergence of which is now in pace at various levels and across sectors which is the call of the time. India is among the world's most disaster prone areas nations. Of the 36 States and Union Territories, as many as noted as 27 are highly-disaster prone. With growing technology and scientific advances the possibility of occurrence, time, place and severity of the strike can be reasonably and in some cases accurately predicted.

A flood is an overflow of an expanse of water that submerges land. Flood is defined as a covering by water of land which is

not normally covered by water. In the sense of "flowing water",

the word may also be applied to the inflow of the tide. Flooding may result from the volume of water within a body of water, such as a river or lake,

which overflows or breaks levees, with the result that some of the water escapes its usual boundaries.

India has the highest mountain chain on earth, the Himalayas, which are formed due to collision of Indian and Eurasian plate, the northward movement of the Indian plate towards China causes continuous stress on the rocks rendering them friable, weak and prone to landslides and earthquakes. Cyclones

are caused by atmospheric disturbances around a low-pressure area distinguished by swift and often destructive air circulation.

Cyclones are usually accompanied by violent storms and bad weather. The air circulates inward in an anticlockwise direction in the Northern hemisphere and clockwise in the Southern hemisphere. 1.14 Questions/ Self-Assessment questions Short answer type question a) Define vulnerability b) Differentiate between hazard and disaster c) What is disaster risk d) Discuss the role of information science and technology for natural disaster risk reduction e) Mention some of the basic do and don't during fire emergencies. Long answer type question a) Discuss in detail different categories of Natural Hazards? b) What do you earn by landslide: Discuss its types based on process of failure?

36 1.15 Selected Readings/ Suggested Readings 1. Disaster Management Act - 2005 2. hp://www.desinventar.net/definions.html 3. https://ndma.gov.in/sites/default/files/PDF/DM_act2005.pdf 4. https://www.publicsafety.gc.ca/cnt/mrgnc-mngmnt/dsstr-prvntn-mtgtn/bt-dsstr-mtgtn- en.aspx 5. National Disaster Management Plan,2019. 6. United Nations General Assembly Session 44 Resolution 236. A/RES/44/236 22 December 1989. Retrieved 2008-09-18. 7. BMTPC 2019. Vulnerability Atlas of India (Earthquake, Windstorm, Flood, Landslide, Thunderstorm Maps and Damage Risk to Housing) 3 rd Edition March, 2019 8. https://ndma.gov.in/Natural-Hazards/Earthquakes 9. https://www.cdc.gov/onehealth/basics/index.html 10. https://www.un-spider.org/risks-and-disasters/disaster-risk-management 11. https://nidm.gov.in/PDF/modules/chemical.pdf 12. https://www.cdc.gov/niosh/nioshtic-2/00188052.html

37 Unit 2: Environmental safety and Health protocols 2.1 Objectives 2.2 Introduction 2.3 One Health Approach 2.4 National and International agreements 2.5 Factors affecting Emergency Management 2.6 Emergency Management Principles 2.7 Elements of Emergency Management Programme 2.8 Crisis and Emergency Risk Communications (CERC) 2.9 Summary 2.10 Questions/ Self-Assessment questions 2.11 Selected Readings/ Suggested Readings 2.1 Objectives After completing this unit, we will be able to: • Define public health emergency and disaster management • Understand common terms related to Public Health Emergency and Disaster Management • Identify the factors that affect the management of public health emergencies. • Identify the principles of incident management. • Identify the elements of an emergency management programme. • Describe the Threat and Hazard Identification and Risk Assessment (THIRA) tool. • Identify principles of crisis and Emergency Risk Communications (CERC). 2.2 Introduction Emergency is a type of event or imminent threat that produces or has the potential to produce a range of consequences, and which requires coordinated action, usually urgent and often non- routine. Emergencies have effects that may be considered on a continuum from local emergencies with limited consequences to wide-area disasters with catastrophic consequences. Incidents or events are often referred to as emergencies, with the terms used interchangeably, but not all incidents or events are emergencies (World Health Organization)

38 Public Health Emergency means an occurrence or imminent credible threat of an illness or health condition, whether natural or man-made, which results or may result in substantial injury or harm to the public health from infectious disease, biological toxins, chemical agents, nuclear agents, radiation hazard or situations involving mass casualties or natural disasters. Emergency
management is
the organization and management of resources and responsibilities for dealing with all elements of emergencies.
It involves the establishment of plans, structures and accountabilities to engage across government, the voluntary and private sectors for a comprehensive and coordinated approach to the emergency management cycle. 2.3 One Health Approach One Health Approach refers to the interface for coordination, collaboration and communication between human, animal, and the environment sectors for disease prevention and control in particular zoonotic diseases, anti-microbial resistance (AMR), etc. Figure 2.1: Concept of One Health (Source: CDC) One Health is an approach that recognizes that the health of people is closely connected to the health of animals and our shared environment. One Health is not new, but it has become more important in recent years. This is because many factors have changed interactions between people, animals, plants, and our environment.

39 Human populations are growing and expanding into new geographic areas. As a result, more people live in close contact with wild and domestic animals, both livestock and pets. Animals play an important role in our lives, whether for food, fiber, livelihoods, travel, sport, education, or companionship. Close contact with animals and their environments provides more opportunities for diseases to pass between animals and people. The earth has experienced changes in climate and land use, such as deforestation and intensive farming practices. Disruptions in environmental conditions and habitats can provide new opportunities for diseases to pass to animals. The movement of people, animals, and animal products has increased from international travel and trade. As a result, diseases can spread quickly across borders and around the globe. These changes have led to the spread of existing or known (endemic) and new or emerging zoonotic diseases, which are diseases that can spread between animals and people. Every year, millions of people and animals around the world are affected by zoonotic diseases. 2.4 National and International agreements 2.4.1 International Health Regulations (IHR) 2005 It is an international legal instrument that is binding on 196 countries across the globe, including all 194 Member States of WHO. The WHO includes all UN Member States and two non-UN members, Niue and the Cook Island. It presents a shared responsibility for global health security, to prevent, protect against, control and provide a public health response to the international spread of disease and events which: • Are commensurate with and restricted to public health risks, and • Avoid unnecessary interference with international traffic & trade. IHR (2005) requires that all countries have the ability to do the following: • Detect: Make sure surveillance systems and laboratories can detect potential threats • Assess: Work together with other countries to make decisions in public health emergencies • Report: Report specific diseases, plus any potential international public health emergencies, through participation in a network of National Focal Points • Respond: Respond to public health events IHR (2005) also includes specific measures countries can take at ports, airports and ground crossings to limit the spread of health risks to neighboring countries, and to prevent unwarranted travel and trade restrictions (CDC).

40 2.4.1.1 Functions of IHR (2005) • Establishes a process for international collaboration and decision-making during public health emergencies. • Requires reporting of specific diseases plus any potential international public health emergencies regardless of origin or source. • Establishes a global network of 24x7 National Focal Points (NFP). • Establishes core capacities for surveillance and response for all countries at all levels (local, regional, national). One of the most important aspects of IHR (2005) is the requirement that countries detect and report events that may constitute a potential public health emergency of international concern (PHEIC). 2.4.1.2 Potential Public Health Emergency of International Concern (PHEIC) The International Health Regulations (IHR) 2005 defines Public Health Emergency of International Concern (PHEIC) as "an extraordinary event which is determined to constitute a public health risk to other States through the international spread of disease; potentially require a coordinated international response". Who declares a PHEIC? The responsibility of determining whether an event is within this category lies with the WHO Director-General and requires the convening of a committee of experts—the IHR Emergency Committee. Committee members are selected based on expertise, geographic and gender diversity. This committee advises the Director-General on the recommended measures to be promulgated on an emergency basis, known as temporary recommendations, which require reviews every 3 months. When is a PHEIC declared? The IHR decision instrument poses 4 critical questions: • Is the public health impact of this event serious? • Is the event unusual or unexpected? • Is there a significant risk of international spread? • Is there a significant risk of international trade or travel restrictions? Any outbreak that meets two or more of the four criteria needs to be notified to WHO under Article 6 of the IHR (2005). Once a WHO member country identifies an event of concern, the country must assess the public health risks of the event within 48 hours. If the event is determined to be notifiable under the IHR, the country must report the information to WHO within 24 hours. Some diseases always require reporting under the IHR, no matter when or where they occur, while others become notifiable when they represent an unusual risk or situation.

41 Always Notifiable: • Smallpox • Poliomyelitis due to wild-type poliovirus • Human influenza caused by a new subtype • Severe acute respiratory syndrome (SARS) Other Potentially Notifiable Events • May include cholera, pneumonic plague, yellow fever, viral hemorrhagic fever, and West Nile fever, as well as any others that meet the criteria laid out by the IHR. • Other biological, radiological, or chemical events that meet IHR criteria Since IHR (2005) was put into place, WHO has declared the following PHEICs: • H1N1 influenza (2019–2010) • Polio (2014–Present) • Ebola (2014–2016) & (2019–2020) • Zika virus (2016) • COVID-19 (2020–Present) • Monkeypox (2022–Present) When a PHEIC is declared, WHO helps coordinate an immediate response with the affected country and with other countries around the world. 2.4.2 Sustainable Development Goals The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States in 2015, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (SDGs), which are an urgent call for action by all countries - developed and developing - in a global partnership. They recognize that ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth – all while tackling climate change and working to preserve our oceans and forests. The 17 Goals were adopted by all United Nations Member States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the goals.

42 Figure 2.2: Pictorial representation of SDG's Individual Goals The seventeen goals of SDG are as follows • Eliminate Poverty • Erase Hunger • Establish Good Health and Well-Being • Provide Quality Education • Enforce Gender Equality • Improve Clean Water and Sanitation • Grow Affordable and Clean Energy • Create Decent Work and Economic Growth • Increase Industry, Innovation, and Infrastructure • Reduce Inequality • Mobilize Sustainable Cities and Communities • Influence Responsible Consumption and Production • Organize Climate Action • Develop Life Below Water • Advance Life on Land • Guarantee Peace, Justice, and Strong Institutions • Build Partnerships for the Goals

43 Goals specific to Public Health Emergency and Disaster Management: According to the UN Office for Disaster Risk Reduction (UNDRR), several goals of SDGs (and their respective targets) are relevant for public health emergency and disaster management. This includes Goals 1, 2, 3, 4, 6, 9, 11, 13, 14, 15. 2.4.3

Sendai Framework

The Sendai Framework for Disaster Risk Reduction 2015-2030 (Sendai Framework) was the first major agreement of the post-2015 development agenda and provides Member States with concrete actions to protect development gains from the risk of disaster. The Sendai Framework works hand in hand with the other 2030 Agenda agreements, including The Paris Agreement on Climate Change, The Addis Ababa Action Agenda on Financing for Development, the New Urban Agenda, and ultimately the Sustainable Development Goals.

Figure 2.3:

Sendai Framework for Disaster Risk Reduction 2.4.3.1 Priorities of SANDAI

Framework: •
Understanding disaster risk •
Strengthening disaster risk governance to manage
disaster risk • Investing in
disaster risk reduction for resilience •
Enhancing
disaster preparedness for effective response
and to “Build Back Better”
in recovery,
rehabilitation, and reconstruction
44
Priority 1.
Understanding disaster risk
Disaster risk management should be based on an
understanding of disaster risk in all its dimensions
of
vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment.
Such knowledge can be used for risk assessment, prevention, mitigation, preparedness and
response.
Priority 2.
Strengthening disaster risk governance to manage disaster risk Disaster risk governance at the national, regional and global levels is
very important
for prevention, mitigation, preparedness, response, recovery, and rehabilitation. It fosters collaboration and partnership.
Priority 3.
Investing in disaster risk reduction
for resilience
Public and private investment in disaster risk prevention and reduction through structural and non-structural measures are
essential to enhance the
economic, social, health and cultural resilience of persons, communities, countries and their assets, as well as the environment.
Priority 4.
Enhancing
disaster
preparedness for effective response and to “Build Back Better”
in recovery, rehabilitation and reconstruction
The
growth of
disaster risk
means there is a
need to strengthen
disaster preparedness for response, take action
in anticipation of events, and ensure capacities are in place for effective response and recovery at all levels.
The recovery, rehabilitation and reconstruction phase is a critical opportunity to build back better, including through integrating
disaster risk reduction into development measures. 2.4.4
Disaster Management Act, 2005
Disaster Management Act (2005) was enacted on 23 rd December 2005
and provides
effective management of disasters and for matters connected there with or incidental thereto.
Under
the
Disaster Management Act 2005,
National Disaster Management Authority (NDMA)
is mandated

to lay down the policies, plans and guidelines for
Disaster Management.
National Institute of Disaster Management (
NIDM) has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy
in the field of disaster management.
For a specialized
response to a threatening disaster situation or emergencies both natural and man-made such as those of CBRN origin, the Act has mandated the constitution of a National Disaster Response Force (NDRF).
Table 2.1:Chapters of DM act 2005 CHAPTERS SECTIONS PARTICULARS
45 CHAPTERS-I 01-02 PRELIMINARY CHAPTERS-II 03-13 THE NATIONAL DISASTER MANAGEMENT AUTHORITY CHAPTERS-III 14-24 STATE DISASTER MANAGEMENT AUTHORITY CHAPTERS-IV 25-34 DISTRICT DISASTER MANAGEMENT AUTHORITY CHAPTERS-V 35-40 MEASURES BY THE GOVERNMENT FOR DISASTER MANAGEMENT CHAPTERS-VI 41 LOCAL AUTHORITIES CHAPTERS- VII 42-43 NATIONAL INSTITUTE OF DISASTER MANAGEMENT CHAPTERS- VIII 44-45 NATIONAL DISASTER RESPONSE FORCES CHAPTERS-IX 46-50 FINANCE, ACCOUNTS AND AUDIT CHAPTERS-X 51-60 OFFENCES AND PENALTIES CHAPTERS-XI 61-79 MISCELLANEOUS 2.4.5
National Disaster Management Plan 2019 The National
Disaster Management Plan (NDMP)
provides a framework and direction to the government agencies for all phases of
disaster management cycle. The NDMP is a “dynamic document” in the sense that it will be periodically improved keeping up with the emerging global best practices and knowledge base in disaster management. It is in accordance with
the provisions of the DM Act 2005, the guidance given in the National Policy on Disaster Management (NPDM) 2009, and the established
national practices.
46 2.4.6
Prime Minister’s Ten Point Agenda on Disaster Risk Reduction (DRR) The Prime Minister, Shri Narendra Modi, enunciated a Ten-Point Agenda in his inaugural speech at the Asian Ministerial Conference on Disaster Risk Reduction (AMCDRR) 2016, held in New Delhi during November 2016, which has also been incorporated in the
National Disaster Management Plan 2019.
The ten key elements consist of the following: •
All development sectors must imbibe the principles of disaster risk management • Risk coverage must include all, starting from poor households to SMEs to multi-national corporations to nation states •
Women’s leadership and greater involvement should be central to disaster risk management • Invest in risk mapping globally to improve global understanding of Nature and disaster risks •
Leverage technology to enhance the efficiency of disaster risk management efforts • Develop a network of universities to work on disaster-related issues • Utilise the opportunities provided by social media and mobile technologies
for disaster risk reduction • Build on local capacity and initiative to enhance disaster risk reduction • Make use of every opportunity to learn from disasters and, to achieve that, there must be studies on the lessons after every disaster • Bring about greater cohesion in international response to disasters
47 2.4.7
Epidemic Diseases Act 1897 Amended in 2020 The Act specifies that the central government may regulate: • Detention of any person intending to travel from the port, during an outbreak. • The amendment expanded the powers of the central government to regulate the inspection of any bus, train, goods vehicle, ship, vessel, or aircraft leaving or arriving at any land port or port or aerodrome. • Protection for healthcare personnel and damage to property: No person can: (i) commit or abet the commission of an act of violence against a healthcare service personnel, or (ii) abet or cause damage or loss to any property during an epidemic. These offences are cognizable and non-bailable. 2.5 Factors affecting Emergency Management Each emergency is unique; however, there are a variety of factors that are important to consider for all events (NIDM 2022): • Type, magnitude, location, and impact of the event. • Availability of human and material resources to address the event. • Legal and policy environments and mandates. • Strengths and limitations of emergency response and management agencies. • Degrees of resilience in individuals, social systems, and health service agencies. 2.6 Emergency Management Principles Figure 2.4: Emergency Management Principles (Source: WHO 2020)

48 Applying the Emergency Management Principles can help avoid some of the common challenges of response. The principles include: • An all-hazards approach- i.e., incident management processes and structures, with transparent decision-making processes, supported by hazard-specific response plans developed in response to a comprehensive risk assessment. • Modular, scalable, or adaptable IMS management structures that can be expanded or contracted to deal with changes in the scope and context of the emergency. • Support for joint involvement of multiple jurisdictions, sectors, and organizations in making and implementing joint management decisions (unified management). Unified management can be described as a team approach to managing complex, multi-agency, or multi-jurisdictional emergencies that allows all agencies with complementary geographical or functional responsibilities in the emergency response to establish a common set of objectives, strategies, and operations. • Clear lines of accountability, with all personnel in work units of no greater than seven people reporting to only one supervisor, even if working within a matrix of teams within the PHEOC. • Clearly defined roles and responsibilities for staff that are consistent with their established competencies and supported by specific training in PHEOC functions and operations. • Clearly articulated authorities, threat thresholds, and procedures for activation, escalation, and deactivation of emergency operations. • Clearly articulated policies and procedures for communication between international, national, subnational, and local PHEOCs or event management entities. • Common terminology, functions, and technology at all levels of the response structure to support interoperability. • Capacity for integration or involvement with partner and stakeholder agencies, including international partners through joint (unified) management or active liaison. • Sufficient capacity to manage public communications opportunities, including traditional and social media, in culturally suitable ways to support effective risk communication, social mobilization, and community engagement. Application of the principles of emergency management can help with: • Confident decision making • Reliable and rapid processing of data and information to support planning and decision making • Rapid deployment of the right resources • Effective human resource and financial management

49 2.7 Elements of Emergency Management Programme A comprehensive emergency management program has commonly recognized elements (Figure below): • Risk assessment includes hazard identification, vulnerability or threat assessment, and surveillance and monitoring of potential or evolving threats. • Prevention and mitigation involve measures to prevent identified risks or introduce measures to reduce their impact. It may include disease detection and outbreak prevention and control, vaccination of populations, food and water safety, environmental protection program, community education, and social mobilization. •
Preparedness is
the knowledge and capacities of governments, response and recovery agencies, communities, and individuals
that enable them to anticipate, respond to, and
effectively recover from the effects of a wide range of likely, imminent, or current events. • The response involves utilizing preparedness resources, undertaking activities to react to an event, and managing the event proactively. Response activities may include the situation assessment, mobilization of resources, enhanced surveillance, contact tracing, and environmental health intervention and monitoring. • Recovery refers to the restoration of damaged infrastructure, damaged resources, routine surveillance, monitoring activities, community infrastructure, resilience, evaluation of response outcomes, the conduct of an after-action review, and implementation of an action plan to mitigate risks and improve future responses. Figure 2.5: Elements of Emergency Management Programme Risk Assessment Prevention and Mitigation Preparedness Response Recovery

50 2.8 Crisis and Emergency Risk Communications (CERC) Why is CERC important? Even when a crisis is predicted, it might take some time to launch a thorough response. Resources must be provided, the situation must be appraised, and monitored for emerging or secondary threats and persons and materials must get past any logistical or safety hurdles to reach the impacted region. However, individuals who are impacted and at imminent risk are prepared to act right away and need information on the situation and immediate safety measures. Under extremely difficult time restrictions, the CERC framework and its principles can assist in giving the public the knowledge they need to make the best options and accept the imperfection of choice. What we say, when we say, and how we say it, may have a genuine and discernible impact on the wellness of our communities. Fully integrating CERC ensures that scarce resources are well handled and can contribute the most to each stage of an emergency response (NIDM 2022). The six principles of effective emergency and risk communications are as follows: i. Be First: Crises are time-sensitive. Communicating information quickly is crucial. For members of the public, the first source of information often becomes the preferred source. ii. Be Right: Accuracy establishes credibility. Information can include what is known, what is not known, and what is being done to fill in the gaps. iii. Be Credible: Honesty and truthfulness should not be compromised during crises. iv. Express Empathy: Crises create harm, and the suffering should be acknowledged in words. Addressing what people are feeling and the challenges they face, builds trust and rapport. v. Promote Action: Giving people meaningful things to do calms anxiety, helps restore order, and promotes some sense of control. vi. Show Respect: Respectful communication is particularly important when people feel vulnerable. Respectful communication promotes cooperation and rapport. 2.8.1 Role of CERC The right message from the right person at the right time can save lives. The aim of CERC is to arm people with the knowledge they require to choose life-saving actions in dire circumstances. The psychological processes of those who are impacted by, responding to, or witnessing a crisis are central to CERC's design. To assist people in coping and rebuilding CERC principles are essential. In settings that might otherwise be chaotic, effective communication aids in bringing a feeling of order and comprehension. Organizations may accomplish their goals, uphold the public's trust, manage their limited resources, and most importantly, avoid and lessen sicknesses and accidents, with the help of effective communication. Be first, be accurate, be believable, demonstrate empathy, encourage action, and treat people with respect at every stage of an effective response.

51 2.9 Summary Each emergency is unique, however, there are a variety of factors that are common for all events and should be considered in planning and operations. The principles of emergency management include: • All hazard approach • Modular and scalable IMS • Policies and procedures • Joint work with partners • Common terminology • Accountability and manageable size • Common structures, functions and technology • Clearly defined roles and responsibilities • Communication and engagement with community Elements of Emergency Management are: • Risk Assessment • Prevention and Mitigation • Preparedness • Response • Recovery Response to public health emergencies requires management processes and structures that support the following: • Confident and competent decision-making and operational execution. • Reliable and rapid processing of data and information into action plans. • Rapid deployment of resources. • Effective human and financial resourcing and accountability. 2.10 Questions/ Self-Assessment questions Short answer type question 1. Discuss role of Crisis and Emergency Risk Communications (CERC) during a disaster. 2. What is factor affecting Emergency management. Long answer type question

52 1. Discuss some of the major national and international agreements related to public health emergency and disaster management. 2. Discuss in detail the elements of Emergency Management 2.11 Selected Readings/ Suggested Readings 1. CDC – One Health https://www.cdc.gov/onehealth/basics/index.html 2. CDC- International Health Regulations (IHR) https://www.cdc.gov/globalhealth/healthprotection/ghs/ihr/index.html 3.
UNDRR:
https://www.undrr.org/implementing-sendai-framework/what-sendai- framework 4.
NDMP 2019.
https://ndma.gov.in/sites/default/files/PDF/ndmp-2019.pdf 5.
WHO 2020 https://openwho.org/courses/PHEOC-
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0 Course: General Practical CONTENTS Unit 1. Determination of Physicochemical properties of water .... 1 1.1 Determination of Water pH .... 1 1.2 Dissolved Oxygen (DO) .... 4 1.3 Biochemical Oxygen Demand (B.O.D.) .... 7 1.4 Chemical Oxygen Demand (COD) .... 11 1.5 Free Carbon dioxide .... 13 1.6 Salinity .... 14 1.7 Conductivity .... 16 1.8 Transparency (Secchi-Disc method) .... 17 1.9 Sulphate .... 19 1.10 Phosphate .... 20 1.11 Nitrate Nitrogen (NO_3^--N) .... 23 1.12 Ammoniacal Nitrogen (NH_3-N) .... 25 1.13 Water Sodium .... 27 1.14 Water Potassium .... 29 Unit 2. Determination of Soil properties .... 31 2.1 Soil pH.. 31 2.2 Organic matter .... 33 2.3 Soil Potassium .... 35 2.4 Soil Nitrogen .... 37 2.5 Soil Phosphorus .... 39 Unit 3. Study of pond biota.. 43 3.1 Phytoplankton.. 43 3.2 Zooplankton .... 58 3.3 Macrophytes .... 67 Unit 4. Table of Figures .... 81 Unit 5. References .... 83 Netaji Subhas Open University P.G. Environmental Science PGES-P105

1 Unit 1. Determination of Physicochemical properties of water 1.1 Determination of Water pH 1.1.1 Aim To determine the pH of the given liquid sample using i. pH paper and ii. Digital pH meter. And also, to evaluate to which extent the provided sample is acidic or basic. 1.1.2 Introduction The pH of a solution is measured as a negative logarithm of hydrogen ion concentration and the concept of pH was made known by Sorenson (1909). At a given temperature, the intensity of the acidic or basic character of a solution is indicated by pH. pH is expressed as the negative logarithm of the hydrogen ion concentration in moles per litre at a

given temperature. pH values from 1 to 7 are diminishing acidic (1, very acidic), 7 to 14 increasingly alkaline (14, very alkaline) and 7 is neutral at 25 o C (Figure 1). Figure 1: pH Scale The pH of natural water usually lies in the range of 4 to 9 and mostly it is slightly basic because of the presence of bicarbonates and carbonates of alkali and alkaline earth metals. pH value is directed largely by the carbon dioxide (CO_2), bicarbonate and carbonate equilibrium. It may be affected by humic substances, by changes in the carbonate equilibrium due to the bioactivity of plants and in some cases by hydrolysable salts, while the alkalinity or acidity measures the total resistance to the pH change or buffering capacity. The pH gives the hydrogen ion activity. The pH influences the chemical and biological properties of liquid and plays an important role in this determination. It is used in several calculations in analytical work and its adjustment to an appropriate value is necessary for many analytical procedures. pH can be measured calorimetrically, for rough estimation (pH paper) or electrometrically, for accurate/ appropriate measurement (hydrogen electrode/ Digital meter). In dilute solution, the hydrogen ion activity is approximately equal to the concentration of hydrogen ion. In water solutions, the product of the molar concentrations of hydrogen and hydroxyl ions is equal to a dissociation constant (Kw). Knowing the value of the constant and

2 the concentration of hydrogen ions makes it possible to calculate the concentration of hydroxyl ions and vice versa. At 25 o C, the value of Kw is 10^{-1} . $[H^+][OH^-] = K = 1.0 \times 10^{-14}$ at 25 o C or $[H^+] = [OH^-] = 1.005 \times 10^{-7}$ A logarithmic form is, $[-\log_{10}(H^+)][-\log_{10}(OH^-)$ or pH + pOH = pK_w 1.1.3 Methods of estimation of pH a. Colorimetric method In this method, the pH of the solution is estimated through the use of pH paper. This method gives an approximate value of pH, it only gives a rough overview of the pH of the solution. Figure 2: Different types of pH paper pH can be measured in this method by following these steps: i. Stared the collected sample solution very well ii. Dip the pH paper in the sample using a forceps for 2-3 sec iii. Compare the colour with that of the colour given on the wrapper/box of the pH paper strip iv. Note down the pH of the sample along with its temperature. b. Electrometric method 1.1.3.1 Principle In this method, the pH is determined by measurement of the electromotive force (emf) of a cell and this emf is measured by a digital pH meter. A digital pH meter is a portable battery-operated unit with an indicator glass electrode (an electrode responsive to hydrogen ions), immersed in the test solution and

a calomel reference electrode. This system is based on the fact that a change of 1 pH unit produces an electric charge of 59.1 mV

at 25°C; as the pH measurement is operated on a potentiometric scale so the measuring instrument is also calibrated 3 potentiometrically with a similar setup using a standard buffer solution having an assigned pH value. 1.1.3.2 Apparatus and equipments a. pH meter: The instrument must contain a potentiometer, a glass electrode, a reference electrode and a thermometer/ temperature probe. The balanced circuit is completed when both the electrodes are immersed in the test solution. b. Reference electrode: It consists of a half cell that provides a standard electrode potential. Generally, calomel silver chloride electrodes are used as a reference electrode. c. Glass electrode: The glass electrode is a very thick-walled glass bulb, made of low melting point glass of high electrical conductivity, blown at the end of a glass tube. This bulb contains an electrode, which has a constant potential, e.g., a platinum wire inserted in a solution of H + hydrochloric acid saturated with quinhydrone. The bulb is placed in the liquid where pH is to be determined. d. Beakers: Preferably use polyethylene or tetrafluoroethylene (TFE) beakers, which are completely inert to highly corrosive materials. 1.1.3.3 Reagents and standards a. pH 4 buffer solution: Dissolve 10.12 g potassium hydrogen phthalate (C 8 H 5 KO 4) in distilled water and makeup to 1 L. b. pH 7 buffer solution: Dissolve 1.361 g anhydrous potassium dihydrogen phosphate (KH 2 PO 4) and 1.42 g anhydrous disodium hydrogen phosphate (Na 2 HPO 4), which have to be dried at 110 o C. Dissolve and dilute up to 1L with
boiled and cooled distilled water. c. pH 9.2 buffer solution: Dissolve 3.81 g Borax (Na 2 B 4 O 7 . 10H 2 O)
and make up to 1L with previously boiled and cooled distilled water. 1.1.3.4 Calibration Remove the electrodes from the water and rinse with double distilled or demineralised water prior to use. Dry the electrodes by gentle wiping with a soft tissue. Calibrate the electrode system against a freshly prepared standard buffer solution of known pH (pH 4.0, 7.0 and 9.2). For routine analysis, commercially available buffer tablets, powders or solutions of tested quality also are permissible. In preparing buffer solutions from solid salts, dissolve all the material; otherwise, the pH calibration will be incorrect. Prepare and calibrate the electrode system with buffer solutions with pH approximating that of the sample, to minimise error resulting from the nonlinear response of the electrode. Calibration of the instrument should be done according to the manufacturer's instructions. 1.1.3.5 Procedure a. Remove the electrodes from storage solutions and rinse with distilled water before use. b. Bring the sample and the buffer solution to the room temperature c. Give adequate time to warm up the instrument d. Dry the electrodes by gently blotting with soft tissue paper, and standardised the instrument using the dedicated buffer solution with known pH. Before replacing the electrode from one buffer to another make sure it was rinsed and blot with tissue paper. Figure 3: Digital pH meter
4 e. For sample analysis, stir the sample to ensure homogeneity and establish equilibrium between electrodes and sample then measure pH. Try to triplicate the same sample to eliminate the human error. f. For buffered samples (or those with high ionic strength), condition the electrodes after cleaning by dipping them into the same sample, and read pH. g. With poorly buffered solutions (dilute), equilibrate electrodes by immersing them
in three or four successive portions of samples. Take a fresh sample
and record the pH. 1.1.3.6 Calculation The pH value is directly obtained from the instrument. Report the value to the nearest 0.1 unit, along with the temperature of the sample. 1.1.3.7 Result Sample No. Replica pH obtain Mean 1 R1 x = + + 3 R2 y R3 z 2 3 1.2 Dissolved Oxygen (DO) 1.2.1 Aim The experiment aims to quantify dissolved oxygen present in the given water sample(s) by using Winkler's method with Azide modification. 1.2.2 Introduction Green living organisms make the earth's atmosphere O 2 reach through converting the CO 2 to O 2 . All living organisms are dependent upon that oxygen in one form or the other to maintain the metabolic processes that produce energy for growth and reproduction. Aerobic processes are of great interest, which need free oxygen for wastewater treatment. Dissolved Oxygen (DO) is also important in the precipitation and dissolution of inorganic substances in water. Oxygen quantities in water enreach mainly by the diffusion from the air, photosynthesis by aquatic living organisms and some oxygens came from chemical process. The process of diffusion is very less because of the low solubility of oxygen (solubility of atmospheric oxygen in freshwater ranges from 14.6 mg/L at 0°C to about 7.0 mg/L at 35°C under normal atmospheric pressure) in water, the photosynthetic process is more effective to make the oxygen available in the water. Analysis of DO is a key test in water pollution control and wastewater treatment processes because of the following illustrations:
5 1.2.3 Methods of estimation Quantification of Dissolved Oxygen will be done through Winkler's method with Azide modification. 1.2.3.1 Principal Available
Oxygen (D.O.) levels in natural and wastewaters are dependent on the physical, chemical and
biochemical activities prevailing in the water body. The estimation of D.O. is a key test in monitoring water pollution and waste treatment process control. Compared to other various improved techniques and equipment, the Winkler's (or iodometric) method is found to be the most precise and reliable titrimetric procedure to estimate D.O. in the water body. It is mainly based on two oxidation-reduction reactions. Oxygen present in the sample rapidly oxidises the dispersed divalent manganous hydroxide to its higher valance, which is precipitated as a brown hydrated oxide after the addition of strong alkali NaOH/KOH and KI. Upon acidification, manganese reverts to a
divalent state and liberates iodine from KI equivalent to the original D.O. content. The liberated iodine is titrated against N/40 sodium thiosulphate (Na 2 S 2 O 3) using starch as an indicator.

The chemical reactions involved in the method are given below: i. MnSO 4 + 2KOH/2NaOH → Mn(OH) 2 (White precipitation) + K 2 SO 4 / Na 2 SO 4 ii. 2Mn(OH) 2 + O 2 + High alkali → 2MnO(OH) 2 (Brown precipitation) iii. MnO(OH) 2 + 2H 2 SO 4 (Strong acid) → Mn(SO 4) 2 + 3H 2 O Mn(SO 4) 2 + 2KI → MnSO 4 + K 2 SO 4 + I 2 (Free iodine) iv. 2Na 2 S 2 O 3 .5H 2 O + I 2 → Na 2 S 4 O 6 + 2NaI + 10H 2 O v. 2NaN 3 + H 2 SO 4 → 2HN 3 + Na 2 SO 4 vi. HNO 2 + HN 3 → N 2 + N 2 O + H 2 O 1.2.3.2 Apparatus and equipment a) B.O.D. bottles, capacity 300 mL b) Sampling device for collection of samples c) Pipette (2, 2, 1 c.c.) and Burette (50 c.c.) d) Conical flask (250 c.c.), beaker (500 c.c.) and measuring cylinder (100 c.c.) 1.2.3.3 Reagents a) Manganese sulphate: Dissolve 480 g of MnSO 4 .4H 2 O or 400 g MnSO 4 .2H 2 O or 364 g MnSO 4 .H 2 O in distilled

to 1000 mL. Filter it, if necessary. This solution should not give colour with starch when added to an acidified solution of KI. DO levels is very essential to assess the quality of raw water and to keep a check on stream pollution. DO test is the basis of B.O.D. test which is an important parameter to evaluate pollution potential of wastes. DO is necessary for all aerobic biological wastewater treatment processes. DO test is used to control the amount of oxygen in boiler feed waters either by chemical or physical methods to reduse the chances of corosion. Figure 5: B.O.D. bottle Figure 4: Burette

6 b) Alkali iodide-azide reagent: Dissolve 480 g of NaOH and 150 g of KI or 700 g of

KOH and 135 g of NaI in distilled water and dilute to 1000mL. Add 10g sodium azide, (NaN 3) dissolved in 40 mL of distilled water. This solution should not give colour to starch solution when diluted and acidified. c) Sulphuric acid: Concentrated sulphuric acid (H 2 SO 4); Specific gravity, 1.8 (98% pure) d) Starch indicator [2%]: Dissolve 2 g of soluble starch powder and 0.2 g of salicylic acid as a preservative in 100 mL of boiling distilled water. Continue boiling for a few minutes, cool and then use. e) Stock solution of sodium thiosulfate [0.1N]: Dissolve 24.82 g of sodium thiosulfate (Na 2 S 2 O 3 .5H 2 O) in distilled water. Preserve by adding 0.4 g of solid NaOH and dilute to 1000 mL. f) Standard sodium thiosulfate [0.025N or N/40]: Dilute 250 mL of stock Na 2 S 2 O 3 solution to 1000 mL with freshly boiled and cooled distilled water. 1.2.3.4 Procedure a) Surface water samples should be collected very carefully in narrow-mouth glass-stoppered B.O.D. bottles of 250 to 300 mL capacity. Let the bottle deep into the water at least 1ft below the surface, overflow for some time and then stopped the bottle under the water so that no air bubbles could form and entraining or dissolving atmospheric oxygen could be avoided. Depth was recorded. The dissolved oxygen should be estimated immediately after the collection of water sample. b) Add 2 mL of MnSO 4 very carefully and slowly followed by 2 mL of alkali-iodide-azide reagent up to the brim, after removing the stopper of the sample bottle.

The tip of the pipette should be below the liquid level while adding

these reagents and always use a separate pipette for each solution. Use stopper immediately. Rinse the pipettes before putting them in reagent bottles. c) Mix well by inverting the bottle 2-3 times and allowing the brownish coloured precipitate to settle leaving 150 mL clear supernatant. The precipitate is white if the sample contains very less oxygen, and becomes increasingly brown with rising oxygen content. d) After the settling, add 2 mL of conc. H 2 SO 4 . Replace the stopper and mixed up vigorously and repeatedly by inverting the bottle till precipitate goes into the solution with the appearance of a clean deep straw yellow/brown colour solution. e)

Take 100 mL of this solution in a conical flask and titrate against standard Na 2 S 2 O 3 [

N/40 or 0.025N] solution till the brown/ straw colour of the sample become pale yellow colour. Add 2 mL starch as an indicator. Titration continued to the first disappearance of blue colour which appeared immediately after adding starch solution and recording the burette reading. It was repeated 3 to 4 times for quality assurance. 1.2.3.5 Calculation DO mg/L = 0.025 ×( )×8 × 1000 2 × (1 –) 1 Where, V= Volume of MnSO 4 + Alkaline iodide used for fixation V 1 = Volume of B.O.D. bottle

7 V 2 = Volume of sample titrated N.B. 1 c.c. of 0.025N Na 2 S 2 O 3 = 0.0001 g of O 2 1.2.3.6 Result No. of observation Initial burette reading (mL) Final burette reading (mL) Difference (mL) Mean (mL) 1. 2. 3. 1.3 Biochemical Oxygen Demand (B.O.D.) 1.3.1 Aim To determine the amount of Biochemical oxygen demand (B.O.D.) produced by the given sample(s) to qualify the polluted water. 1.3.2 Introduction Biochemical oxygen demand (B.O.D.) is the amount of dissolved oxygen (DO) needed (i.e., demanded) by aerobic biological organisms to break down the organic material present in a given water sample or liquid media at a certain temperature over a specific time period. In the laboratory oxygen requirement for aerobic oxidation of decomposable organic and inorganic materials present in water, polluted and wastewater is being estimated under control temperature and incubation period. The test is widely used to determine, i) the degradation of pollutants in water bodies and their self-purification capacity, and ii) the pollution load of wastewaters. The B.O.D. value is most commonly expressed in milligrams of oxygen consumed per litre (mg/L) of the sample during 5 days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water. B.O.D. values for classification of raw untreated water are given below: Table 1: B.O.D. values for classification of raw untreated water Types of water B.O.D. (mg/L) Pure water (Distilled water) 0 Drinking water source without conventional treatment but with chlorination 2≥ Drinking water source with conventional treatment 3≥ Domestic sewage ≥100 Sewage after primary and secondary purification 10 to 20

8 1.3.3 Methods of estimation B.O.D. is estimated through the titrimetric method. 1.3.3.1 Principal The B.O.D. test is performed to determine the degree of pollution or strength of sewage and industrial water. Oxygen uptake of a sample varied due to microbial activity and its population and organic matter quantity. The methodology of B.O.D. test is to compute a difference between the initial and final oxygen concentration of the samples after incubation. A minimum of 1.5 L of sample is required for the test. DO is estimated by iodometric titration. Generally, the temperature is controlled at 20ºC and the test is conducted for 5 days under the dark condition to avoid photosynthesis, as 70 to 80% of the carbonaceous wastes are oxidized during this period. The test can be performed at any other temperature provided the correlation between BOD_5 20ºC is established under the same experimental condition (for example BOD_5 , 27ºC) is equivalent to BOD_3 , 27ºC for Indian conditions. While reporting the results, the incubation period in days and temperature of ºC are essential to be mentioned. 1.3.3.2 Apparatus and equipment a. B.O.D. bottles of 300 mL capacity (clean with a detergent, rinse thoroughly and drain before use) b. B.O.D. Incubator or water bath to be controlled at 20ºC or any desired temperature of 1ºC. Exclude all light to prevent photosynthetic production of DO. 1.3.3.3 Reagents and standers All reagents listed in DO estimation are used for BOD. a. Manganous sulfate solution b. Alkaline iodide solution c. Concentrated H_2SO_4 d. Starch solution (freshly prepared) as an indicator e. Sodium thiosulfate solution 0.025N as a titrant In addition, following reagents are required if dilution needed a. Phosphate buffer: Dissolve 8.5 g of potassium dihydrogen phosphate (KH_2PO_4), 21.75 g of di-potassium hydrogen orthophosphate (K_2HPO_4), 33.5 g of sodium phosphate dibasic heptahydrate (

$Na_2HPO_4.7H_2O$) and 1.7g of ammonium chloride (NH_4Cl); in distilled water and dilute up to 1000 mL.

The pH should be 7.2 without further adjustment. Discard the reagent if there is any sign of biological growth. b. Magnesium sulphate: Dissolve 22.5 g of $MgSO_4.7H_2O$ in about 700 mL of distilled water and dilute to 1 Litre. c. Calcium chloride: Dissolve 27.5 g of anhydrous calcium chloride ($CaCl_2$) in about 700 mL of distilled water and dilute to 1 Litre. Figure 6: B.O.D. Incubator

9 d. Ferric chloride: Dissolve 0.25 g of $FeCl_3.6H_2O$ in about 700 mL of distilled water and dilute to 1 L. e. Acid and alkali solutions 1N: Prepare 1N H_2SO_4 and 1N NaOH or neutralization of caustic or acidic sample. f. Nitrification inhibitor: 2-chloro-6-(trochloromethyl) pyridine [Nitrification inhibitor 2570-24 (2.2% TCMP), Hach Co. equivalent] g. Glucose-glutamic acid solution: Dry reagent grade glucose and glutamic acid at 103ºC for 1h. Dissolve 150 mg glucose and 150 mg of glutamic acid in distilled water and dilute to 1000 mL. Prepare fresh immediately before use. 1.3.3.4 Sample collection, preservation and storage Composite samples are collected and kept at or below 4ºC during compositing. Samples for B.O.D. may degrade significantly during storage. Minimise reduction of BOD by analysing samples promptly or by cooling them to near freezing temperature during storage, it helps to minimise the microbial activity. The maximum holding time recommended between collection and analysis is 48 hours. Warm chilled samples to 20-27ºC ± 3ºC before analysis. State storage time and condition as part of results. 1.3.3.5 Procedure a. Place the desired volume of distilled water in a 5-litre flask (usually, about 3 litres of distilled water will be needed for each sample). b.

Add 1 mL each of phosphate buffer, magnesium sulphate solution, calcium chloride solution and ferric chloride solution for every litre of distilled water. c. Seed the sample with 1–2

mL of settled domestic sewage. d. Saturate the dilution water in the flask by aerating with a supply of clean compressed air

for at least 30 minutes. e. Highly alkaline or acidic samples should be neutralised to pH 7. f. Destroy the chlorine residual in the sample by keeping

the sample exposed to air for 1 to 2 hours or by adding a few mL of sodium sulphite solution.

g. Take the sample in the required concentrations. The following general guidelines for dilution range are as follows: 0.1% to 1% : Strong trade waste 1% to 5 % : Raw or settled sewage 5% to 25% : Treated effluent 25% to 100% : River water or freshwater h. Add the required quantity of sample (calculate for 650 mL dilution water the required quantity of sample for a particular concentration) into a 1000 mL measuring cylinder. Add the dilution water up to the 650 mL mark. i. Mix the contents in the measuring cylinder. j. Add this solution to two B.O.D. bottles, one for incubation and the other for determination of initial dissolved oxygen in the mixture. k. Prepare in the same manner for other concentrations and all the other samples. l. Lastly, fill the dilution water alone into

two B.O.D. bottles. Keep one for incubation and the other for

determination of initial dissolved oxygen. m. Place the set of bottles to be incubated in a B.O.D. incubator for 5 days at 20°C. Care should be taken to maintain the water seal over the bottles throughout incubation.

10 n. Determine

the initial dissolved oxygen contents in the other set of bottles and note down the results. o. Determine the dissolved oxygen content in the incubated bottles at the end of 5 days and note down the results. 1.3.3.6 Calculation Measurement of DO mg/L = 0.025 × ( ) × 8 × 1000 2 × (1 –) 1 Where, V= Volume of MnSO 4 + Alkaline iodide used for fixation V 1 = Volume of B.O.D. bottle V 2 = Volume of sample titrated N.B. 1 c.c. of 0.025N Na 2 S 2 O 3 = 0.0001 g of O 2 After calculating the DO of both the initial and incubated sample B.O.D. is calculated through the following equation: B.O.D. as O 2 mg/L = (1 – 2)×100 % Where, D 1 = DO of the sample immediately after preparation, mg/L D 2 = DO of the sample after the incubation period, mg/L 1.3.3.7 Result No. of observation Initial burette reading (mL) Final burette reading (mL) Difference (mL) Mean (mL) DO Immediate DO 1. 2. 3. DO after incubation 1. 2. 3. Sample no. or description Dilution D.O. content mg/L B.O.D.mg/L (5 days 20 o C) Initial (D 1) Final (D 2) 1. 2. 3.

11 1.4 Chemical Oxygen Demand (COD) 1.4.1 Aim To estimate the Chemical oxygen demand (C.O.D.) of the supplied sample. 1.4.2 Introduction The Chemical oxygen demand (COD) test estimates the oxygen requirement equivalent of organic matter that is prone to oxidation with the help of a strong oxidizing chemical. It is an important, rapidly measured parameter as a means of measuring organic strength for streams and polluted water bodies. The test is useful in studying the performance evaluation of wastewater treatment plants and monitoring relatively polluted water bodies. COD determination has the advantage over BOD determination. COD results can be obtained in 3-4 h as compared to 3-5 days requirement of BOD test. Further, the test is relatively easy, precise, and unaffected by interferences as in the BOD test. The basic limitation of the test lies in its inability to differentiate between the biologically oxidisable and biologically inert materials and to find out the system rate constant of aerobic biological stabilization. 1.4.3 Methods of estimation Closed reflux (titrimetric) method using C.O.D. digester 1.4.3.1 Principal The closed reflux method using metallic salt reagent is very much economical but required Complete homogenization. The majority of organic matter is oxidized with chromic acid. The sample is refluxed in ampules and culture tubes in a strongly acidic medium with premeasured potassium dichromate solution (K 2 Cr 2 O 7) for a specific time. After completion of digestion, the remaining unreduced K 2 Cr 2 O 7 is titrated with ferrous ammonium sulphate [(FAS); NH 4 Fe(SO 4) 2 ,6H 2 O] to determine the amount of potassium dichromate consumed which is equivalent to the oxidisable matter present in the solution. Moreover, for performing the tests and handling the instrument, instructions furnished by the manufacturer are to be followed. Measurement of sample volume and reagent volume is critical. 1.4.3.2 Apparatus and equipment a. Digestion vessels with premixed reagents and other accessories are commercially available. b. Borosilicate culture tubes 16 x 100 mm, 20 x 150 mm or 25 x 150 mm with TF and lined screw caps c. Borosilicate ampule 10 mL cap – 19 to 20 mm diameter d. C.O.D. digester 1.4.3.3 Reagents and standers a. Standard potassium dichromate (K 2 Cr 2 O 7) digestion solution (0.01667M): Dissolve 4.903 g of

K 2 Cr 2 O 7 , primary standard grade, previously dried at 150ºC for 2 hours in 500

mL distilled water, add 167 mL of conc. H 2 SO 4 and 33.3 g of mercuric sulphate (Hg 2 SO 4) then volume make up to 1000 mL. b. C.O.D. acid reagent: add mercuric sulphate (Hg 2 SO 4) to conc. H 2 SO 4 at the rate of 5.5 g of Hg 2 SO 4 /kg H 2 SO 4 . Let stand 1 to 2 days to dissolve and mix. Figure 7: C.O.D. digester

12 c. Ferroin indicator solution: Dissolve 1.485 g of 1, 10-phenanthroline monohydrate and 695 mg of

FeSO 4 .7H 2 O in distilled water and dilute to 100 mL. d. Standard ferrous ammonium sulphates (FAS) titrant, (approximately 0.1M): Dissolve 39.2 g

of

Fe(NH 4) 2 (SO 4) 2 .6H 2 O in distilled water. Add 20 mL

of concentrated H 2 SO 4 , cool and dilute to 1000 mL. Standardise this solution daily against the standard K 2 Cr 2 O 7 solution. 1.4.3.4 Procedure a. Blend sample if the suspended matter is present. b. Wash culture tubes and caps with 20% H 2 SO 4 before first use. c. Refer to the following to select analytical parameters for the proper sample and reagent volume (Table 2). Table 2: Sample and reagent quantities for various digestion vessels Digestion vessel type Sample (mL) Digestion Solution (mL) C.O.D. Acid reagent (mL) Final Volume (mL) Culture Tubes: 16× 100 mm 5.00 1.50 3.5 7.5 20× 150 mm 2.50 3.00 7.0 15.0 25× 125 mm 10.0 6.00 14.0 30.0 Standard 10mL Ampules 2.50 1.50 3.5 7.5 d. Place the sample in a culture tube or ampule and add digestion solution. e. Carefully run COD acid reagent down inside of the vessel and tightly cap the tubes or seal ampules. Invert several times for proper mixing. f. Place tubes or ampules in preheated reaction block of COD digestor. g. Reflux for 2 h at 150°C behind a protective shield. Cool to room temperature. Remove caps and put TFE covered magnetic stirrer. h. Titrate while stirring with FAS using 1 or 2 drops of ferrous indicator. i. The endpoints are from blue-green to reddish-brown. j. Reflux and titrate blank similarly with distilled water. 1.4.3.5 Calculation COD as mg O 2 /L = (–)× ×8000 Where, A= mL of FAS used for blank B= mL of FAS used for sample M= molarity of FAS 8000= milliequivalent weight of oxygen × 1000 mL/L

13 1.4.3.6 Result No. of observation Burette reading Volume of FAS used Sample Initial Final 1 2 3 Blank 1.5 Free Carbon dioxide 1.5.1 Aim To determine free carbon dioxide available in the supplied water sample. 1.5.2 Introduction Carbon dioxide is present in the aquatic bodies in the form of dissolved gas. Carbon dioxide enters the aquatic bodies from the atmosphere and the direct inflows of groundwater, bacterial decomposition and through the respiratory processes by organisms. Surface water normally contain less than 10 ppm free carbon dioxide, while some groundwater may easily exceed that concentration. Carbon dioxide is readily soluble in water. Over the ordinary temperature range (0-30 o C) the solubility is about 200 times that of oxygen. Calcium and magnesium combine with carbon dioxide to form carbonates (-CO 3 2-) and bicarbonates (- HCO 3 -). Microscopic plant life suspended in the water, phytoplankton, as well as large rooted plants, utilize carbon dioxide in the photosynthesis of plant materials; starches, sugars, oils, and proteins. The carbon in all these materials comes from the carbon dioxide in water. When the oxygen concentration in water containing organic matter is reduced, the carbon dioxide concentration rises. The rise in carbon dioxide makes it more difficult for fish to use the limited amount of oxygen present. To take on fresh oxygen, fish must first discharge the carbon dioxide in their bloodstreams and this is a much slower process when there is a high concentration of carbon dioxide in the water itself. 1.5.3 Methods of estimation Titremetric method 1.5.3.1 Principal Free CO 2 reacts with sodium hydroxide to form sodium carbonate and is estimated by potentiometrically or by the development of the pink colour characteristic of phenolphthalein indicator at the equivalence pH of 8.3 completion of the reaction is identified. 1.5.3.2 Apparatus and equipment a. Burette b. Conical flask

14 c. Measuring cylinder 1.5.3.3 Reagents and standers a. Sodium Hydroxide (0.05 N): Dissolve 2 g of NaOH in 1 L of distilled water. b. Phenolphthalein indicator: 1 g of phenolphthalein was dissolved in 50% ethyl alcohol. 1.5.3.4 Procedure a. Take 50 mL of the water sample in conical flasks. b. Add 2-3 drops of phenolphthalein indicator. The colour changes to pink indicates the absence of free CO 2 . c. In case the sample remains colourless, titrate it with 0.05 N NaOH. d. At the endpoint, a pink colour appears. Calculate free CO 2 . 1.5.3.5 Calculation 2 / = × × . . 2 × 1000 1.5.3.6 Result No. of observation mL of Sample taken Burette reading Volume of NaOH used Difference (mL) Mean (mL) Initial (mL) Final (mL) 1 2 3 1.6 Salinity 1.6.1 Aim To find out how much saline is the given water sample. 1.6.2 Introduction Salinity is the total amount of salts dissolved in water collectively and expressed as weight in grams per kilogram (g/kg) or parts per thousand ‰. The salts in water include such as common ions such as Ca 2+ , Mg 2+ , K + , Na + , and Cl - . These ions occur naturally or are added as pollutants to the environment. So, it is an ecological factor of considerable importance. Seawater typically has a mass salinity of around 35 g/kg, in freshwater, it varies from 0.15 to 0.40 g/kg. Rainwater before touching the ground typically has a salinity of 20 mg/L or less. The total salinity can be determined from the concentration of the chloride ion since the ratios of sodium to chloride to magnesium to calcium and any other major constituent remain constant. Although chlorides are not harmful, concentrations beyond 250 mg/L impart an unusual taste to water resulting in its unacceptable from an aesthetic point of view for drinking purposes. A high chloride concentration harms metallic pipes and causes siltation, as well as agricultural plants and aquatic animals.

15 1.6.3 Methods of estimation The salinity of the water samples can be estimated by the volumetric method or argentometric method. 1.6.3.1 Principal A silver nitrate (AgNO 3) solution of known concentration is used to precipitate down the chlorides in a water sample. The argentometric method is suitable for relatively clear waters when 0.15 to 10 mg chlorides are present in the portion titrated. Chloride is determined in a neutral or slightly alkaline solution by titration with standard silver nitrate, using potassium chromate as an indicator. Silver chloride is precipitated quantitatively before red silver chromate is formed.

Wherever the colour of the sample interference with the chromate endpoint in the argentometric method, the pretreatment with hydrogen peroxide (1-2 mL for about 25 mL sample, added before adding the indicator) may be used. Reactions involve in this argentometric method are as follows: Cl – + Ag + = AgCl (white ppt) 2 Ag + + CrO 4 2- = Ag 2 CrO 4 (red ppt) 1.6.3.2 Apparatus a. Conical flux b. Buratte 1.6.3.3 Reagents a. Silver nitrate standard solution (0.0141N): Dissolve 2.395 g of silver nitrate (AgNO 3) in distilled water preferably double distilled water and dilute it to 1,000 mL. Store in a brown glass bottle. 1.00 mL = 500 µg Cl – standardization of titrant with standard sodium chloride must be carried out without any dilution. b. Standard sodium chloride (0.0141N): Dissolve 824.0 mg of NaCl (dried at 140 o C) in distilled water and dilute to 1,000 mL. 1.00 mL= 500 µg Cl – . c. Potassium chromate indicator solution: Dissolve 50 g of K 2 CrO 4 in a little distilled water. Add silver nitrate solution drop-wise until definite red precipitation starts. Let it stand for 12 h, filter and dilute to 1 litre with distilled water. 1.6.3.4 Procedure a. Take 50 ml sample into a breaker on a white surface. b. Adjust sample pH ranges between 7.0 to 10.0 by using H 2 SO 4 or NaOH solution if required. c. Add 1 mL of potassium chromate solution and titrate with silver nitrate solution with constant stirring to a brick red endpoint. d. If the volume of the titrant exceeds 25 mL then it is better to repeat the method with the smaller portion of the sample. 1.6.3.5 Calculation Chlorides as Cl - mg/L= (1 – 2)× ×35.45×1000 Where, V 1 = Volume of silver nitrate required for sample, in mL

16 V 2 = Volume of silver nitrate required for reagent blank, in mL N = Normality of silver nitrate 35.45 = Atomic weight of chlorine The experimental relationships with salinity redefined as, Salinity mg/L = 1.80655 × Concentration of chlorides (as Cl – mg/L) in water 1.6.3.6 Result No. of observation Initial burette reading (mL) Final burette reading (mL) Difference (mL) Mean (mL) 1. 2. 3. 1.7 Conductivity 1.7.1 Aim To find out how much conductive is the given water sample. 1.7.2 Introduction Conductivity is the ability of water to carry an electrical current and varies both with the number and types of ions in the solutions. It is directly related to the concentration of ionized substances in the water. Most dissolved inorganic substances (viz., chlorides, sulfides and carbonate compounds) present in water are in the ionized form and hence contribute to conductance. 1.7.3 Methods of estimation Instrumental Method 1.7.3.1 Principal This method is used to measure the conductance generated by various ions in the solution or water. It is a very important factor to study an aquatic body, high conductivity is inversely proportional to high quality and directly proportional to high nutrient availability. Which indicates the water body may become eutrophic. A sudden change in electrical conductivity in a lotic water body (flowing water body, river) can indicate a direct discharge or other sources of pollution into the water. Conductivity is temperature-dependent and the conductivity meter must be equipped with an automatic temperature correction facility otherwise require to take temperature readings separately. Conductivity measurement gives a rapid and practical estimate of the variations in the dissolved mineral contents of a water body. Conductivity is measured in millisiemens per centimetre (1 mS/m = 10 μS/cm = 10 μmhos/cm).

17 1.7.3.2 Apparatus and equipment Conductivity meter is equipped with conductivity cell and thermometer. 1.7.3.3 Reagents and standers Conductivity Water: The conductivity of the water should be less than 1 mmho/cm; To remove CO 2 from distilled water, boil the distilled water and allows it to cool. Standard potassium chloride (0.01M): Dissolve 745.6 mg of anhydrous potassium chloride (KCl) (previously dried at 105 o C for 1 hour) in conductivity water and make up to 1,000 mL at 25°C. This is the standard reference solution, which at 25°C has a specific conductance of 1,413 mmhos/cm or 141.2 μmhos/m. Store the solutions in glass stoppered Pyrex bottles. 1.7.3.4 Calibration The conductivity meter must be standardized before use by using the standard potassium chloride solution (0.01 M) with specific conductance of 1,413 μS/cm at 25°C. Standardization should be done as per manual instruction provided by the manufacturer. 1.7.3.5 Procedure a. Switch on the instrument 20-30 minutes before use for warm-up. b. Standardize the instrument by the standard KCl solution. c. Rinse the electrode with distilled water and sample. d. Measure the conductivity of the sample directly by deeping the electrode and the thermometer probe in the sample. e. Rinse the electrode very well and keep the electrode immersed in distilled water. f. The

organic material coating can be removed with alcohol or acetone followed by washing with distilled water. 1.7.3.6 Calculation The result is expressed directly in μS/cm no calculation is required. 1.8 Transparency (Secchi-Disc method) 1.8.1 Aim To measure the light penetration depth or transparency of the water body. 1.8.2 Introduction Water transparency is one of the measurements used to describe the status of a water body. Water transparency measures the depth of light penetration into the water. Water transparency depends on the number of suspended particles. These can be organic, such as phytoplankton and algae, or inorganic, such as sediments, as well as other dissolved impurities such as organic or inorganic carbonates. These particles contribute to both the colour and the transparency of Figure 8: Conductivity meter

18 the water. Algal blooms significantly reduce water transparency and contaminate onshore water. Measurement of water transparency allows calculating inputs from erosion and nutrients. By taking measurements over time in multiple locations, it is often possible to determine the source of the inputs, and if necessary, remediate the situation to improve the water quality. 1.8.3 Methods of estimation 1.8.3.1 Principal This method is widely used especially for comparing various waters or the same water at different times. As the light penetration in different water bodies is affected by various environmental characteristics, such as plankton density and particulate matter, this method could only be a useful rough index of visibility. It is best to take measurements at around mid- day by measuring the depth of disappearing and reappearing of the disk. 1.8.3.2 Apparatus and equipment Secchi disc with 5 meters 10 feet of rope marked off in 0.1-meter depth intervals. The Secchi disc should be 300 mm (±10) in diameter with a 3.0 kg (±0.5) weight suspended below the centre. 1.8.3.3 Procedure Secchi disc readings are obtained with a 20 cm diameter disk. Observations are made during mid-day, without sunglasses and from the shady side of the boat. The observer makes the reading by looking as close as possible to the water to minimize glare. a. Drop the Secchi disc down slowly until it is no longer visible and record the depth (D a). b. Bring the Secchi disc up until you can just barely see it. c. Record the depth (D b) at which the Secchi disc is again visible. d. Repeat the above procedure and average the two readings for the final Secchi disc depth. 1.8.3.4 Calculation h = + 2 1.8.3.5 Result Site No. of reading Secchi disc reading Mean (m) Depth of disappearance (m) Depth of reappearance (m) A 1 2 B Figure 9: Secchi disk

19 1.9 Sulphate 1.9.1 Aim Determine the amount of sulphate (SO 4 -) present in the given samples. 1.9.2 Introduction Sulphate ions usually occur in natural waters. Many sulphate compounds are readily soluble in water. Most of them originate from the oxidation of sulphate ores, the solution of gypsum (calcium sulphate) and anhydrite, the presence of shales, particularly those rich in organic compounds, and the existence of industrial wastes. In the weathering process, gypsum is dissolved and sulphide minerals are partly oxidised, giving rise to a soluble form of sulphate that is carried away by water. In a humid region, sulphate is readily leached from the zone of weathering by infiltrating waters and surface runoff but in semi-arid and arid regions the soluble salts may accumulate within a few tens of feet of the land surface. Where this occurs, sulphate concentration in shallow groundwater may exceed 5000 mg/L and gradually decrease with depth. Water containing magnesium sulphate at levels of about 1000 mg/L acts as cleansing in human adults. Taste threshold concentrations for the most prevalent sulphate salts are 200- 500 mg/L for sodium sulphate (N a2 SO 4), 250-900 mg/L for calcium sulphate (CaSO 4), and 400-600 mg/L for magnesium sulphate ($MgSO_4$). Essentially, on the basis of the above values, which are also allied to the cathartic effect of sulphate, a guideline value of 400 mg/L is proposed. Sulphates cause scaling in water supplies and the problem of odour and corrosion in wastewater treatment due to their reduction of H 2 S under the anaerobic condition. 1.9.3 Methods of estimation Turbidimetric Method 1.9.3.1 Principal The turbidimetric method is used for the determination of sulphate ions. Sulphate ion (SO 4 -) is precipitated in presence of an acetic acid medium containing glycerol and other organic compounds with barium chloride (BaCl 2) to form Barium sulphate (BaSO 4) crystals of uniform size colloidal form. The reaction involved is given below: 2+ + 4 → 4 (h) Light absorbance of the BaSO 4 suspension is measured by a photometer or the scattering of light by a Nephelometer. 1.9.3.2 Apparatus and equipment a. Magnetic stirrer b. Turbidimeter/Nephelometer or Colorimeter for use at 420 mm c. Stopwatch d. Nessler tubes, 100 mL e. Measuring spoon 0.2 to 0.3 mL capacity Figure 10: Nephelometer 20 1.9.3.3 Reagents and standers a. Conditioning agent: dissolve 30 g of magnesium chloride (MgCl 2 .6H 2 O), 5 g sodium acetate (CH 3 COONa.3H 2 O), 1 g of potassium nitrate, (KNO 3) and 20 mL of acetic acid, (CH 3 COOH) (99%) in 500 mL of distilled water and volume make up to 1000 mL. b. Barium chloride: crystals, 20-30 mesh c. Standard sulphate solution: Dissolve 0.1479 g of anhydrous sodium sulphate (Na 2 SO 4) in distilled water and dilute to 1000 mL. 1L = 100 μg SO 4 2- . 1.9.3.4 Calibration Prepare standard curve by carrying standard sulphate solution through the entire procedure. Space standards at 5 mg/L increment in the 0 to 40 mg/L range. 1.9.3.5 Procedure a. Measure 100 mL or a suitable portion of the sample into a 250 mL conical flask. b. Add 20 mL of conditioning reagent and mix it by placing it on a magnetic stirrer. c. Add a spoonful of barium chloride crystals and begin timing immediately. Stir at a constant speed exactly for one minute. d. After stirring pour some of the solutions into the absorption cell of the photometer and measure the turbidity at 30-second intervals for five minutes. e. Usually, maximum turbidity occurs within two minutes and the reading remains constant thereafter for 3 to 10 minutes. So, take the reading with maximum turbidity occurring within four minutes. f. To correct for sample colour and turbidity, run a blank to which BaCl 2 is not added. 1.9.3.6 Calculation Absorbance versus sulphate concentration is plotted and a curve is obtained. The concentration of sulphates in the solution is determined with the help of a calibration curve. 4 2– / = 4 2– × 1000 1.10 Phosphate 1.10.1 Aim To determine available phosphate (PO 4 3-) in the water sample 1.10.2 Introduction Phosphorus occurs in natural water and wastewaters almost solely as phosphates. These are classified as orthophosphates, condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates. They occur in solution, in particles or detritus, or the bodies of aquatic organisms. The various forms of phosphates find their way into wastewater, effluents and polluted water from a variety of sources. Larger quantities of the same compounds may be added when the water is used for laundering or other cleanings since these materials are major constituents of 21 many commercial cleaning preparations. Orthophosphates applied to agricultural or residential cultivated land as fertilizers are carried into surface water with storm runoff and to a lesser extent with melting snow. Organic phosphates are formed primarily by biological processes. They are contributed to sewage by body wastes and food residues. The presence of phosphates in water and wastewater analysis has great significance. Phosphate in small concentrations is used in water supplies to reduce scale formation.

The presence of phosphate in large quantities in freshwater indicates pollution through sewage and industrial wastes. It promotes the growth of nuisance causing microorganisms. Phosphorus is an essential nutrient for the growth of organisms and helps for the primary productivity of a body of water. 1.10.3 Methods of estimation Stannous chloride method 1.10.3.1 Principal Orthophosphate reacts with ammonium molybdate in acidic conditions to form molybdophosphoric acid. It is further reduced to molybdenum blue by adding stannous chloride or ascorbic acid as a reducing agent. The blue colour developed after the addition of ammonium molybdate is measured at 690 nm within 10-12 minutes after the development of colour by using blank. The concentration is calculated from the standard graph.

The intensity of the blue coloured complex is measured which is directly proportional to the concentration of phosphate present in the sample. 1.10.3.2

Apparatus and equipment a. Colourimeter for use at 690 nm providing 0.5 cm light path. b. Nessler tubes, 100 mL. 1.10.3.3 Reagents and standers a. Stock phosphate solution: Dissolve 219.5 mg of anhydrous KH 2 PO 4 in distilled water and dilute to 1000 mL. 1 mL = 50mg PO 4 3- P. b. Ammonium molybdate solution: Dissolve 25 g in about 175 mL of distilled water. Add carefully 280 mL conc. of H 2 SO 4 to 400 mL of distilled water. Cool and add molybdate solution and dilute to 1000 mL. c. Strong acid reagent: Add 300 mL of conc. H 2 SO 4 to 600 mL of distilled water. Add 4 mL of conc. HNO 3 , cool, dilute to 1000 mL. d. Sodium hydroxide (6N): Dissolve 24 g of NaOH and dilute to 100 mL. e. Phenolphthalein indicator: Dissolve 0.5 g in 500 mL of 95% ethyl alcohol. Add 500 mL of distilled water. Add drop-wise 0.02 N NaOH till faint pink colour appears (pH 8.3). f. Stannous chloride reagent I: Dissolve 2.5 gm of fresh stannous chloride (SnCl 2 .H 2 O) in 100 mL glycerol. Heat on a water bath to ensure complete dissolution. g. Dilute stannous chloride reagent II: Mix 8 mL of stannous chloride reagent I with 50 mL of glycerol and mix thoroughly. h. Potassium antimonyl tartrate solution: Dissolve 2.7 g of potassium antimonyl tartrate (K 2 Sb 2 C 8 H 4 O 12 · 3H 2 O) in 800 mL of distilled water and dilute to 1000 mL. i. Ascorbic acid: Dissolve 1.76 g of ascorbic acid in 100 mL of distilled water. The solution is stable for a week at 4°C.
22 j. Combined reagent: Mix 250 mL, 5N sulphuric acid, 75
mL of ammonium molybdate solution and 150 mL of ascorbic acid solution. Add 25 mL of potassium
antimonyl tartrate solution and mix well. The solution must be prepared freshly. 1.10.3.4 Calibration a. Into a series of 100 mL of Nessler tubes pipette appropriate amounts of phosphate working solution to cover the range of 5-30 mg/L or 0.3-2 mg/L P when SnCl 2 /Ascorbic acid reagent is used as a reducing agent. b. Add 4 mL of ammonium molybdate followed by 0.5 mL of stannous chloride or 8 mL of combined reagent and dilute to 100mL with distilled water and mix well. Allow standing for 10 minutes. c. Prepare blank using distilled water in the same way. d. Measure the intensity of blue coloured complex at 690 nm between 10 and 12 minutes after the development of the colour. e. Plot absorbance vs. phosphate concentration to give a straight line passing through the origin. 1.10.3.5 Procedure Orthophosphate Take a suitable volume of the sample in a Nessler tube and continue according to the procedure described for the preparation of the calibration curve. From the calibration curve, compute the concentration of phosphate in the volume of a sample taken. Calculate and express the result in mg/L PO 4 3- P. Total acid hydrolysable phosphate (Total inorganic phosphate): Take a suitable volume of the sample in a conical flask. Add 1 drop of phenolphthalein indicator. Add strong acid reagent till pink colour disappears. Add 1 mL in excess. Boil for 5 minutes, cool, and filter if necessary. Transfer it to the Nessler tube and neutralize it to phenolphthalein with NaOH. Now proceed as described in the preparation of the calibration curve. Measure the intensity of the complex at 690 nm and read the corresponding concentration from the calibration curve. Total phosphate Organically combined phosphorus and all phosphate including polyphosphate as first converted to orthophosphate by digestion as given below. Take 100 mL well-mixed sample in 150 mL conical flask. Add one drop of phenolphthalein indicator. If red colour develops, add sulphuric acid solution dropwise to just discharge the colour. Then add 1 mL of sulphuric acid solution in excess. Boil gently for at least 90 minutes, adding distilled water to keep the volume between 25 and 50 mL. Cool, add one drop of phenolphthalein indicator and neutralize to a faint pink colour with hydroxide solution. Filter if necessary and restore the volume to 100 mL to 50 mL. Now proceed as described in the preparation of the calibration curve. Read the concentration of phosphate from the calibration curve. 1.10.3.6 Calculation The concentration is calculated from the standard calibration curve.

23 1.11 Nitrate Nitrogen (NO 3 - -N) 1.11.1 Aim To determine the nitrate-nitrogen (NO 3 - -N) of the particular water sample. 1.11.2 Introduction Determination of nitrate (NO 3 -) is difficult because of its relatively complex procedures, the high probability that interfering constituents will be present and the limited concentration ranges of the various techniques. Nitrate is the most highly oxidised form of nitrogen compounds commonly present in natural water. Significant sources of nitrate are chemical fertilizers, decayed vegetable and animal matter, domestic effluents, sewage sludge disposal to land, industrial discharge, leachates from refuse dumps and atmospheric washout. Depending on the situation, these sources can contaminate streams, rivers, lakes and groundwater. Unpolluted water contains a very less amount of nitrate. Excessive concentration in drinking water is considered as hazardous for infants because it reduces nitrite in the intestinal tract causing methemoglobinaemia. In surface water, nitrate is a nutrient taken up by plants and converted into cell protein. It is very effective to promote the growth of aquatic plants and algae and causes eutrophication. 1.11.3 Methods of estimation Colourimetric estimation 1.11.3.1 Principal This method applies to the analysis of drinking, surface and saline water, and domestic and industrial wastes. Modification can be made to remove or correct turbidity, colour, salinity, or dissolved organic compounds in the sample. The reaction with the nitrate and brucine at 95 o C temperature in an acidic medium produces yellow colour that can be used for the colourimetric estimation of nitrate. The intensity of the colour is measured at 410 nm. The method is recommended only for the concentration of 0.1- 2.0 mg NO 3 - N/L. All strong oxidising and reducing agents interfere. Sodium arsenite is used to eliminate interference by residual chlorine; sulphanilic acid eliminates the interferences by nitrate-nitrogen (NO 2 -) and chloride interference is masked by the addition of excess NaCl. A high concentration of organic matter also may interfere in the determination. 1.11.3.2 Apparatus and equipment a. A spectrophotometer or filter photometer is suitable for measuring absorbance at 410 nm. b. A sufficient number of 40-50 mL glass sample tubes for reagent blanks, standards and samples. c. A water bath is suitable for use at 95°C. d. Cool water bath suitable for use at 20-25°C. 1.11.3.3 Reagents and standers a. Distilled water free of nitrite and nitrate is to be used in the preparation of all reagents and standards. b. Sodium chloride solution (30%): Dissolve 300 g of NaCl in distilled water and dilute to 1L. Figure 11:Visible spectrophotometer with double- beam

24 c. Sulfuric acid solution: Carefully add 500 mL of conc. H 2 SO 4 to 125 mL of distilled water. Cool and keep tightly stoppered to prevent absorption of atmospheric moisture. d. Brucine-sulfanilic acid reagent: Dissolve 1 g of brucine sulphate [(C 23 H 26 N 2 O 4) 2 H 2 SO 4 .7H 2 O] and 0.1 g sulfanilic acid (NH 2 C 6 H 4 SO 3 H. H 2 O) in 70 mL of hot distilled water. Add 3 mL of conc. HCl, cool, mix

and dilute to 100 mL with distilled water. Store in a dark bottle

at 5°C. Remember brucine sulfate is toxic, take care to avoid ingestion. e. Potassium nitrate stock solution (1.0 mL = 0.1 mg NO 3 - N): Dissolve 0.7218 g of anhydrous potassium nitrate (KNO 3) in distilled water and dilute to 1 L in a volumetric flask. Can be preserved with 2 mL of chloroform per litre. f. Potassium nitrate standard solution (1.0 mL = 0.001 mg NO 3 - N): Dilute 10.0 mL of the stock solution to 1 L in a volumetric flask. g. Acetic acid: Dilute glacial acetic acid (CH 3 COOH) with distilled water in a 1:3 ratio. h. Sodium hydroxide (lN): Dissolve 40 g of NaOH in distilled water. Cool and dilute to 1 litre. 1.11.3.4 Calibration Nitrate standards are prepared in the range 0.1-1.0 mg NO 3 - N /L diluting 1.00, 2.00, 4.00, 7.00- and 10.0 mL standard nitrate solution to 10 mL with distilled water. Then follows the common procedure of sample analysis. 1.11.3.5 Procedure a. Adjust the pH of the samples to approximately 7.0 with acetic acid or sodium hydroxide. If necessary, filter to remove turbidity. b. If it is necessary to correct for colour or dissolved organic matter which will cause the colour on heating, a set of duplicate samples must be run to which all reagents except the brucine-sulfanilic acid have been added. c. Pipette 10.0 mL of standards and samples or an aliquot of the samples diluted to 10.0 mL into the sample tubes. d. If the samples are saline, add 2 mL of the 30% sodium chloride solution to the reagent blank, standards and samples. For freshwater samples, sodium chloride solution may be omitted. Mix contents of tubes by swirling and place rack in the cold water bath (0- 10°C). e. Pipette 10.0 mL of sulfuric acid solution into each tube and mix. Allow tubes to come to thermal equilibrium in the cold bath. Be sure that temperatures have equilibrated in all tubes before continuing. f. Add 0.5 mL of brucine-sulfanilic acid reagent to each tube (except the interference control tubes) and carefully mix, then place the rack of tubes in the previously heated 95° C water bath for exactly 25 minutes. g. Remove the rack of tubes from the hot water bath and immerse in the cold water bath and allow to reach thermal equilibrium (20-25°C). h. Read absorbance against the reagent blank at 410 nm using a visible spectrophotometer. 1.11.3.6 Calculation Obtain a standard curve by plotting the absorbance of standards run by the above procedure against mg NO 3 - N/L. (The colour reaction does not always follow Beer’s law).

25 / = μ 3 – N obtained from the standard curve 1.11.3.7 Result Table 3: Calibration curve Standard nitrate solution in 100mL Concentration of Nitrate Absorbance 1.0 mL 0.1 mg/L or 100 μg/L 2.0 mL 0.2 mg/L or 200 μg/L 4.0 mL 0.4 mg/L or 400 μg/L 7.0 mL 0.7 mg/L or 700 μg/L 10.0 mL 1.0 mg/L or 1000 μg/L Sample no. Absorbance Nitrate nitrogen in μg from the standard curve Nitrate nitrogen in mg 1. 2. 1.12 Ammoniacal Nitrogen (NH 3 -N) 1.12.1

Aim To determine the amount of ammonia present in the given sample of water. 1.12.2 Introduction Ammonia is a product of the microbiological decay of animal and plant protein. It can be directly reused by plants to produce protein. Ammonia and ammonia compounds are applied directly as fertilizers. It appears, in surface water as well as in many groundwater. The presence of ammonia nitrogen in surface water usually indicates domestic pollution times it may be caused by industrial waste. Ammonia in groundwater is normal and is due to microbiological processes. The excess amount of ammonia present in water is very toxic to fish and other aquatic animals. The proportions of the two forms of ammonia nitrogen in surface water depend on pH which is as follows: pH 6 7 8 9 10 11 %NH 3 0 1 4 25 78 96 %NH 4 100 99 96 75 22 4 1.12.3 Methods of estimation Nesslerisation method 26 1.12.3.1 Principal A yellow-coloured compound produces when ammonia reacts

with alkaline Nessler reagent, provided the sample is clarified properly. Pretreatment with ZnSO 4 and NaOH precipitates Ca, Fe, Mg and sulphide

and removes turbidity and apparent colour. The

addition of EDTA (before Nessler reagent) or Rochelle salt solution prevents precipitation of residual Ca and Mg in the presence of alkaline Nessler reagent.

The sample containing ammonia must be analysed immediately after collection; if not 0.8

M conc. H 2 SO 4 /L should be added to the sample

stored at 4°C. The chemical reaction of the method is given below: 2Kr 2 HgI 4 + NH 3 + 3KOH → (NH 2 Hg 2 IO) + 7KI + 2H 2 O 1.12.3.2 Apparatus and equipment a. Spectrophotometer: Spectrophotometer has a range of 300 to 700 nm. b. Nessler tubes or 100 mL capacity volumetric flasks. 1.12.3.3 Reagents and standers a. Zinc sulphate: Dissolve 10 g of ZnSO 4 .7H 2 O in distilled water and volume make up to 100 mL. b. Sodium hydroxide (6N): Dissolve 24 g of NaOH and dilute to 100 mL. c. EDTA reagent: Dissolve 50 g of EDTA in 60 mL of water containing 10 g of NaOH. Cool and dilute to 100 mL. d. Rochelle salt solution: Dissolve 50 g of potassium sodium tartrate (KNaC 4 H 4 O 6 ·4H 2 O) in 100 mL of distilled water. Remove ammonia by boiling off 30 mL solution, cool and dilute to 100 mL. e. Nessler's reagent: 100 g of HgI 2 and 70 g of KI mixed well and dissolve in a small quantity of water. Add this mixture to a cooled solution of 160 g of NaOH in 500 mL of water. Dilute to 1000 mL. Keep overnight, and store supernatant in the coloured bottle. f. Standard ammonium solution: Dissolve 3.819 g of ammonium chloride (NH 4 Cl) dried at 100°C in distilled water and dilute to 1000 mL. Dilute 10 mL of the solution to 1000 mL for working standard (1 mL = 10 μg NH 3). 1.12.3.4 Calibration The calibration curve should be prepared using a suitable amount of standard solution (10 μg/mL)

in the range of 0.1 to 1.20 μg/mL for reference following the same procedure as

the sample but using the standard solution in place of the sample. 1.12.3.5 Procedure a. Add 1 mL of ZnSO 4 solution and 0.4 or 0.5 mL of NaOH with 100 mL of sample to obtain the pH of 10.5. Allow to settle and filter the supernatant through 42 No. Whatman filter paper. b. Take a suitable aliquot of sample. c. Add 3 drops of Rochelle salt solution or 1 drop of EDTA mix well. d. Add 3 mL of Nessler reagent if EDTA is used or 1 mL if Rochelle salt solution is used. Make up to 100 mL. e. Mix well and read the absorption

after 10 minutes at 410 nm using a blank prepared in the same way by taking distilled water instead of a

sample. Figure 12: Nessler tube (100mL)

27 1.12.3.6 Calculation / = μ 3 – N obtained from the standard curve 1.12.3.7 Result Table 4: Calibration curve Standard nitrate solution in 100mL Concentration of Nitrate Absorbance 1.0 mL 0.1μg/mL 2.0 mL 0.2 μg/mL 5.0 mL 0.5 μg/mL 7.0 mL 0.7 μg/mL 12.0 mL 1.2 μg/mL Sample no. Absorbance Nitrate nitrogen in μg from the standard curve Nitrate nitrogen in mg 1. 2. 1.13 Water Sodium 1.13.1 Aim Determination of sodium concentration in the supplied water sample. 1.13.2 Introduction For billions of years, sodium is washed out from rocks and soils, ending up in oceans, where it may remain for about 50.106 years. Sodium ranks sixth among the elements in order of abundance and is present in most natural water. Seawater contains approximately 11,000 ppm of sodium. Rivers contain only about 9 ppm. Drinking water usually contains about 50 mg/L of sodium. This value is higher for mineral water. Insoluble form sodium always occurs as Na + ions. The ratio of sodium to total cations is important in agriculture and human pathology. Soil permeability can be harmed by a high sodium ratio. Persons afflicted with certain diseases require water with low sodium concentration. A limiting concentration of 2 to 3 mg/L is recommended in feed water destined for high-pressure boilers. When necessary, sodium can be removed by the hydrogen-exchange process, reverse osmosis (RO) process or distillation. Sodium compounds are used in many applications, including caustic soda, fertilizers and water treatment chemicals. 1.13.3 Methods of estimation Flame Emission Photometric method

28 1.13.3.1 Principal A very little amount of sodium can be determined by flame emission photometry at 589 nm. The sample is sprayed into a gas flame and excitation is carried out under carefully controlled and reproducible conditions. The desired spectral line is isolated by the use of dedicated and specific interference filters or by a suitable slit arrangement in light-dispersing devices such as prisms or gratings. The intensity of light is measured by a phototube potentiometer. The intensity of light at 589 nm is approximately proportional to the concentration of the element. Sodium concentration was directly measured through the pre-calibrated flame photometer using the known grade of sodium standards. 1.13.3.2 Apparatus and equipment a. Flame photometer in the flame emission mode. b. Volumetric flask 100 mL 1.13.3.3 Reagents and standers a. Deionised distilled water: Use deionised distilled water or double distilled water to prepare all reagents and calibration standards and as dilution water. b. Stock sodium solution: Dissolve 2.542 g of sodium chloride (NaCl) dried at 140°C and dilute to 1000 mL with deionised distilled water, 1 mL = 1 mg Na. c. Intermediate sodium solution: Dilute 10 mL of stock sodium solution with water to 100 mL; 1 mL = 100 μg Na. Use this intermediate solution to

prepare calibration curve in sodium range of 1 to 10 mg/L. d. Standard sodium solution: Dilute 10 mL intermediate sodium solutions with water to 100 mL; 1.00 mL = 10 μg

Na. Use this solution to prepare the calibration curve in sodium range of 0.1 to 1 mg/L. 1.13.3.4 Calibration Prepare blank and sodium calibration standards in stepped amounts in any of the following applicable ranges: 0 to 1.0, 0 to 10, or 0 to 100 mg/L. Starting with the highest calibration standard and working toward the most dilute, measure emission at 589 nm. 1.13.3.5 Procedure To minimise sodium contamination store all solutions in plastic bottles. Use small containers to reduce the amount of dry element that may be picked up from the bottle walls when the solution is poured. Shake each container thoroughly to wash accumulated salt from the walls before pouring the solution. Different instruments deal with different manufacturer protocol so it is impossible to formulate detailed operating instructions. Follow the manufacturer's recommendation for selecting proper photocell and wavelength, adjusting slit width and sensitivity, appropriate fuel and air or oxygen pressures and the

steps for warm-up, correcting for interferences and flame background, rinsing of

the burner, igniting sample and measuring emission intensity. After setting up the instrument for warking stage follow the following steps to analyse the sample. a. Filter the sample with Whatman 42 filter paper or by 0.45 μm membrane filter.

Figure 13: Flame photometer

29 b. Operate in the lowest practical sodium concentration range and dilute the sample if needed. c. Repeat the operation as follows in calibration, with both calibration standards and samples enough times to secure a reliable average reading for each solution. d. Construct a calibration curve from the sodium standards, in case of direct reading. Determine the sodium concentration of the sample from the calibration curve. Where a large number of samples must be run routinely, the calibration curve provides sufficient accuracy. For internal standard measurement machine gives direct sample reading after calibration. 1.13.3.6 Calculation For direct reference to the calibration curve: mg Na/L = (mg Na/L in portion) x Dilution factor 1.14 Water Potassium 1.14.1 Aim Estimate the quantity of potassium present in the water sample. 1.14.2 Introduction Potassium ranks seventh among the elements in order of abundance, yet its concentration in most drinking water reaches up to 100 mg/L. Potassium is an essential element in both plant and human nutrition and occurs in groundwater as a result of mineral dissolution. 1.14.3 Methods of estimation Flame Emission Photometric method 1.14.3.1 Principal Trace amounts of potassium can be determined in a flame photometer at a wavelength of 766.5 nm. The sample is sprayed into a gas flame and excitation is carried out under carefully controlled and reproducible conditions. The desired spectral line is isolated by the use of dedicated and specific interference filters or by a suitable slit arrangement in light-dispersing devices such as prisms or gratings. The intensity of light at 766.5 nm is approximately proportional to the concentration of the element measured by a phototube potentiometer. Sodium concentration is directly measured through the pre-calibrated flame photometer using the known grade of potassium standards as sodium estimation. 1.14.3.2 Apparatus and equipment c. Flame photometer in the flame emission mode. d. Volumetric flask 100 mL, 1000 mL 1.14.3.3 Reagents and standards a. Reagent water deionised distilled water: Use this water for preparing all reagents and calibration of standards and as dilution water. b. Stock potassium solution: Dissolve 1.907 g of potassium chloride (KCl) dried at 110ºC

and dilute to 1000 mL with water; 1 mL = 1 mg K.

30 c. Intermediate potassium solution: Dilute 10 mL

of

stock potassium solution with water to 100 mL; 1 mL = 0.1 mg K.

Use this solution to

prepare calibration curve in potassium of 1 to 10 mg/L. d. Standard potassium solution: Dilute 10 mL of intermediate potassium solution with water to 100 mL; 1 mL = 0.01 mg K. Use this solution to prepare calibration curve in potassium range of 0.1 to 1 mg/L. 1.14.3.4 Calibration Prepare blank and potassium calibration standards in stepped amounts in any of the following applicable ranges: 0 to 1.0, 0 to 10, or 0 to 100 mg/L. Starting with the highest calibration standard and working toward the most dilute, measure emission at 766.5 nm. 1.14.3.5 Procedure To minimise potassium contamination, store all solutions in plastic bottles. Shake each container thoroughly to wash accumulated salt from the walls before pouring the solution. Follow the manufacturer's recommendation to set up the instrument in working condition. After the set-up follows the following steps to analyse the sample. a. Filter the sample with Whatman 42 filter paper or by 0.45 µm membrane filter. b. Repeat the operation as follows in calibration, with both calibration standards and samples enough times to secure a reliable average reading for each solution. c. Construct a calibration curve from the potassium standards. Determine the potassium concentration of the sample from the calibration curve. Where a large number of samples must be run routinely, the calibration curve provides sufficient accuracy. 1.14.3.6 Calculation For direct reference to the calibration curve: mg K/L = (mg K/L in portion) x Dilution factor

31 Unit 2. Determination of Soil properties 2.1 Soil pH 2.1.1 Aim Determination of pH of the given soil sample using a Digital pH meter. And also, to evaluate the extent acidity or basicity of the provided sample. 2.1.2 Introduction: The concept of pH was made known by Sorenson in 1909. At a given temperature, the intensity of the acidic or basic character of a solution is indicated by pH. pH is expressed as the negative logarithm of the hydrogen ion concentration in moles per litre at a given temperature. pH values from 1 to 7 are diminishing acidic (1, very acidic), 7 to 14 increasingly alkaline 14, very alkaline) and 7 is neutral at 25 o C. soil pH varies from acidic to basic. The majority of agricultural crop species prefer approximately neutral pH. Soil that is excessively acidic or basic is caused to reduce productivity. Most of the crops grow in the range of pH of 5.6 to 6.8, higher pH values can cause deficiency in plant nutrient. In dilute solution, the hydrogen ion activity is approximately equal to the concentration of hydrogen ion. In water solutions, the product of the molar concentrations of hydrogen and hydroxyl ions is equal to a dissociation constant (Kw). Knowing the value of the constant and the concentration of hydrogen ions makes it possible to calculate the concentration of hydroxyl ions and vice versa. At 25 o C, the value of Kw is 10 –1 . [H +] [OH -] = K = 1.0 × 10 -14 at 25 o C or [H +] = [OH -] = 1.005 × 10 -7 A logarithmic form is, [-log 10 (H +)][-log 10 (OH -) or pH + pOH = pK w 2.1.3 Methods of estimation pH Electrometric method 2.1.3.1 Principle: In this method, the pH is determined by measurement of the electromotive force (emf) of a cell and this emf is measured by a digital pH meter. A digital pH meter is a portable battery-operated unit with an indicator glass electrode (an electrode responsive to hydrogen ions), immersed in the soil water solution and a calomel reference electrode. As the pH measurement is operated on a potentiometric scale so the measuring instrument is also calibrated potentiometrically with a similar setup using a standard buffer solution having an assigned pH value.

32 2.1.3.2 Apparatus and equipment a. pH meter: The instrument must contain a potentiometer, a glass electrode, a reference electrode and a thermometer/ temperature probe. b. Beakers: Preferably use polyethylene or tetrafluoroethylene (TFE) beakers, which are completely inert to highly corrosive materials. c. Mechanical shaker 2.1.3.3 Reagents and standards a. pH 4 buffer solution: Dissolve 10.12 g of potassium hydrogen phthalate (C 8 H 5 KO 4) in distilled water and make up to 1 L. b. pH 7 buffer solution: Dissolve 1.361 g of anhydrous potassium dihydrogen phosphate (KH 2 PO 4) and 1.42 g of anhydrous disodium hydrogen phosphate (Na 2 HPO 4), which have to be dried at 110 o C. Dissolve and dilute up to 1 L with boiled and cooled distilled water. c. pH 9.2 buffer solution: Dissolved 3.81 g of borax (Na 2 B 4 O 7 . 10H 2 O) and make up to 1 L with previously boiled and cooled distilled water. Buffer tablets are also commercially available to prepare readily desire pH buffer solution. 2.1.3.4 Calibration Remove the electrodes from the water and rinse with double distilled or demineralised water prior to use. Dry the electrodes by gentle wiping with a soft tissue. Calibrate the electrode system against a freshly prepared standard buffer solution of known pH (pH 4.0, 7.0 and 9.2). 2.1.3.5 Procedure a. Remove the electrodes from storage solutions and rinse with distilled water before use. b. Bring the sample and the buffer solution to the room temperature. c. Give adequate time to warm up the instrument. d. Dry the electrodes by gently blotting with soft tissue paper, and standardising the instrument. e. Take 20 g of finely ground dried powder soil in a TFE beaker, add 40 ml of distilled water and stirred for 1 h on a mechanical shaker. f. Measure the pH of soil water suspension. Take the record of it. 2.1.3.6 Calculation The pH value is directly obtained from the instrument. Report the value to the nearest 0.1 unit, along with the temperature of the sample. 2.1.3.7 Result Sample No. Replica pH obtain Mean 1 R1 x = + + 3 R2 y R3 z 2 3 Figure 14: Mechanical Shaker

33 2.2 Organic matter 2.2.1 Aim Estimation of the organic carbon present in the soil sample. It is estimated to assess the amount of organic matter in soils. 2.2.2 Introduction Soil carbon is the most important component in soils as it affects almost all soil properties. Carbon, as soil organic matter, alters the physical, chemical and biological properties of soils. Soil organic matter refers to all decomposed, partly decomposed and undecomposed organic materials of plant and animal origin. Soil organic matter is a primary indicator of soil quality. Improvements in soil organic matter create a more favourable soil environment, leading to increases in plant growth. Higher soil organic matter levels cause the soil to retain more water which results in better crop yields, reduces soil erosion, increases plant nutrient retention and increases biological diversity. Moreover, improved aggregation of soil particles results in better soil structure, allowing for movement of air and water through the soil, as well as better root growth. Soil organic carbon contributes to the cation exchange capacity of the soil. Soil organic carbon often also provides binding sites for many anthropogenic organic chemicals, thus, minimizing the leaching of hazardous chemicals through the soil profile or making them less bioavailable, which reduces toxicity. Increased soil organic carbon enhances the biomass and diversity of the soil biota. 2.2.3 Methods of estimation Walkley-Black Method 2.2.3.1 Principal Determination of soil organic carbon is based on the Walkley-Black chromic acid wet oxidation method. Oxidizable organic carbon in the soil is oxidised by 0.167 M potassium dichromate (K 2 Cr 2 O 7) solution in concentrated sulfuric acid. The heat of the reaction raises the temperature which is sufficient to induce substantial oxidation. The excess of K 2 Cr 2 O 7 , not reduced by the organic matter, is titrated back, against a standard solution of ferrous ammonium sulphate (FAS) in presence of phosphoric acid and diphenylamine indicator. The chemical reaction is as follows: K 2 Cr 2 O 7 + H 2 SO 4 + C → K 2 SO 4 + Cr 2 (SO 4) 3 + H 2 O +CO 2 – FeSO 4 (NH 4) 2 SO 4 ,6H 2 O → FeSO 4 + (NH 4) 2 SO 4 +H 2 O FeSO 4 +(NH 4) 2 SO 4 + 6H 2 O + H 2 SO 4 → (NH 4) 2 SO 4 + Fe(SO 4) 3 + H 2 O 2.2.3.2 Apparatus and equipment a. Burette 50 mL, for the titrant solution b. Volumetric burette 10.00 mL c. Conical flasks, 500 mL d. Magnetic stirrer and bar

34 2.2.3.3 Reagents and standers a. Potassium Dichromate Standard [0.167 M (1 N)]: Dissolve 49.04 g of traceable or equivalent analytical grade K 2 Cr 2 O 7 (previously dried at 105°C for 2 hours and cooled in a desiccator to room temperature) in distilled water, and dilute the solution to a volume of 1000 mL. b. Sulfuric Acid: Concentrated (not less than 96%) c. Ortho-Phosphoric Acid, (H 3 PO 4 , 85%) d. Ferrous ammonium sulphate (0.5 M): Dissolve 196 g of analytical grade (NH 4) 2 Fe(SO 4) 2 .6H 2 O in 700 mL of distilled water, add 20 mL of concentrated sulfuric acid, cool the solution, and dilute it to a volume of 1000 mL with distilled water. Standardize this reagent daily by titrating it against 10 mL of 0.167 M potassium dichromate. e. Diphenylamine indicator (DPA) = 0.5 g of DPA is dissolved in a mixture of 20 mL of water and 100 ml concentrated H 2 SO 4 . 2.2.3.4 Procedure a. Air-dry soil sample, grind to powder form and sieve to ≤ 2.0 mm size. b. Weigh 1.0 g of air-dried soil into a 100 mL conical flask. c. Add 10 mL of 0.167 M/ 1N, K 2 Cr 2 O 7 and swirl the flask gently to disperse the soil in the solution. d. Then with care, rapidly add 20 mL of concentrated H 2 SO 4 , directing the stream into the suspension. e. Immediately swirl the flask gently until soil and reagents are mixed, then more vigorously for a total of 1 min. f. To minimize heat loss, allow the flask to stand on an insulated sheet for 10 min in a fume hood to complete the reaction. g. 20 mL of water is added to it, then add 10 mL of 85% H 3 PO 4. h. Add three to four drops of diphenylamine indicator and titrate the solution with 0.5 M FAS [(NH 4) 2 Fe(SO 4) 2 .6H 2 O] till the colour changes from violet through blue to end- point when the colour changes sharply to brilliant green. i. The volume of the FAS is noted down. j. A blank titration (i.e., without soil) is carried out in a similar manner. 2.2.3.5 Calculation (%) = (–)× 2+ × 0.003 × 100 × Where, =

Volume of titrant used for blank, mL = Volume of titrant used for sample, mL 2+ =

Concentration of standardized FAS (0.5 M) 0.003 = Carbon oxidised [1 mL of 1 N dichromate solution is equivalent to 3 mg of carbon] f = Correction factor, 1.3 [only about 77% of organic carbon is recovered by this method] W = Weight of soil taken in g

35 2.2.3.6 Result No. of observation Initial burette reading (mL) Final burette reading (mL) Difference (mL) Mean (mL) Sample 1. 2. 3. Blank 2.3 Soil Potassium 2.3.1 Aim To determine the total potassium present in the soil sample 2.3.2 Introduction Soil is a complex mixture of mineral particles, organic matter, water and air. The mineral particles come from the breakdown of rocks. As rocks break down into the particles of sand, silt and clay that make up soil, potassium and other elements are released and may become available to plants. Potassium ranks seventh among the elements in the order of abundance. Potassium is an essential element, but in excessive amounts, it acts as a cathartic. It is important to assess the quantity of potassium in the soil solution and the readily available pool to ascertain whether or not to apply potassium fertilizer. Its concentration can be measured by the flame photometric method. 2.3.3 Methods of estimation Flame Emission Photometric method 2.3.3.1 Principal Trace amounts of potassium can be determined in a flame photometer at a wavelength of 766.5 nm. The sample is sprayed into a gas flame and excitation is carried out under carefully controlled and reproducible conditions. The desired spectral line is isolated by the use of dedicated and specific interference filters or by a suitable slit arrangement in light-dispersing devices such as prisms or gratings. The intensity of light at 766.5 nm is approximately proportional to the concentration of the element measured by a phototube potentiometer. Sodium concentration is directly measured through the pre-calibrated flame photometer using the known grade of potassium standards as sodium estimation. 2.3.3.2 Apparatus and equipment a. Flame photometer in the flame emission mode b. Volumetric flask 100 mL, 1000 mL 2.3.3.3 Reagents and standers a. Reagent water deionised distilled water: Use this water for preparing all reagents and calibration standards and as dilution water.

36 b. Ammonium acetate/Acetic acid aqueous solution: 0.5 M with respect to both reagents (38.55 g of ammonium acetate and 29 mL of glacial acetic acid, diluted to 1 litre with deionised water). c. Stock potassium solution: Dissolve 1.907 g of potassium chloride (KCl) dried at 110ºC and dilute to 1000 mL with water; 1 mL = 1 mg K. e. Intermediate potassium solution: Dilute 10 mL of stock potassium solution with water to 100 mL; 1 mL = 0.1 mg K. Use this solution to prepare calibration curve in potassium of 1 to 10 mg/L. f. Standard potassium solution: Dilute 10 mL intermediate potassium solution with water to 100 mL; 1 mL = 0.01 mg K. Use this solution to prepare calibration curve in potassium range of 0.1 to 1 mg/L. 2.3.3.4 Calibration Prepare blank and potassium calibration standards in stepped amounts in any of the following applicable ranges: 0 to 100 mg/L. Starting with the highest calibration standard and working toward the most dilute, measure emission at 766.5 nm. 2.3.3.5 Procedure Follow the manufacturer's recommendation to set up the instrument in working condition. After the set-up follows the following steps to analyse the sample. a. Pass the sample of air-dried soil through a 2 mm sieve. Measure out 10 g of the sieved soil without tapping to avoid compacting. Transfer to a 100 ml polyethylene bottle, together with 50 mL of the ammonium acetate/acetic acid solution. b. Stopper the bottle, transfer to a shaker and shake for 30 minutes (275 strokes per min, 25 mm travel). c. Remove from the shaker, allow to stand for several minutes and then decant the supernatant liquid through a dry Whatman 42 filter paper. d. Set the Flame Photometer at 100 using the 100 ppm potassium solution. e. Successively aspirate the 20, 40, 60 and 80 ppm potassium standard solutions and prepare a calibration f. Determine the potassium content of the soil extract by aspirating the solution, diluting as necessary in ammonium acetate/acetic acid solution. Calculate the concentration by reference to the calibration graph, taking into account any dilution factors. 2.3.3.6 Calculation For direct reference to the calibration curve: (/) = × × 1000 × h Where, C = Concentration from the standard curve A = mL of Extraction solution added

37 2.4 Soil Nitrogen 2.4.1 Aim To estimate the amount of nitrogen present in the soil sample 2.4.2 Introduction It is important to analyse nutrients present in a soil sample so as to measure its productivity level and recommend suitable remedial measures in case of any imbalance of these nutrients. In this experiment you would learn and perform the determination of nitrogen. Nitrogen, an important plant nutrient is present in the soil in both organic as well as inorganic forms. The organic component of the soil nitrogen is present primarily as plant, animal and microbial remains and as such is unavailable to plants. It becomes available through mineralisation and organic matter decomposition processes. In fact, the organic form of nitrogen in the soil can be visualised as a reservoir of nitrogen and reflects the nitrogen supplying capacity of the soil. The inorganic component of the soil nitrogen is present in the form of ammonium (NH 4 +), nitrate (NO 3 -) and nitrite (NO 2 -) ionic form. Plants can only uptake nitrogen in the form of ammonia and nitrate. The amount of nitrogen in these forms is an indicator of the nitrogen availability for the current crop and in turn determines the immediate requirements of N-fertilizer. . 2.4.3 Methods of estimation Alkaline potassium permanganate method 2.4.3.1 Principal The easily hydrolysable and oxidisable fractions of organic nitrogen present in a soil sample can be extracted out using alkaline potassium permanganate (KMnO 4), a mild oxidising agent. For this purpose a known amount of soil sample is boiled with a measured quantity of alkaline KMnO 4 . It leads to evolution of ammonia which is absorbed in a known volume of standard sulphuric acid. A part of the acid is neutralised by ammonia and the excess is titrated with a standard solution of alkali using methyl red as an indicator. This method gives the amount of available nitrogen content as percent of the soil. This value is also expressed in terms of kg/ha. For this purpose it is assumed that 1 ha of furrow slice (0- 15 cm) of the soil weighs 2.24 million kg. If the amount of available nitrogen is found to be less than 272 kg/ha the sample is rated low, if it is 272-544 kg/ha, it is rated medium and if the available nitrogen content is more than 544 kg/ha it is rated as high. 2.4.3.2 Apparatus and equipment a. Kjeldahl flask (800 cc) b. Distillation apparatus c. Measuring cylinder d. Pipette, Burette e. Conical flask Figure 15: Kjeldahl apparatus

38 2.4.3.3 Reagents and standers a. 0.32% Potassium permanganate (KMnO 4): Take 3.2 g of KMnO 4 in a 1000 mL volumetric flask. Add some distilled water to dissolve the permanganate through gentle swirling and final volume make up to 1000 mL with distilled water carefully. b. 2.5% Sodium Hydroxide (NaOH): Take 25 g of NaOH in 1000 mL volumetric flask. Dissolve and volume make up with distilled water carefully. Remember it is an exothermic reaction. c. 0.02 M NaOH: Dissolve 0.8 g of NaOH pallets in 1000 mL water in a standard flask. Standardise by titrating against 0.01 M oxalic acid using methyl red indicator. Adjust the strength to 0.02 M. d. 0.01M H 2 SO 4 : Add 0.6 mL of concentrated H 2 SO 4 of 1.84 specific gravity to 1000 ml distilled water. e. 0.15 % Methyl red indicatior: Dissolve 0.15 g of methyl red powder

in 50 mL of 100% ethyl alcohol and make up the volume to 100 mL with water. 2.4.3.4

Procedure a. Set up the distillation apparatus according to the manufacturer direction. b. 20 g of given soil sample is measured and transfer it carefully into Kjeldahl distillation flask. c. Moisten the sample with 10 mL of distilled water. Wash down the soil adhering to the neck of the flask. d. Add 100 mL of 0.32% KMnO 4 solution and 100 mL of 2.5% NaOH solution, a few glass beads or broken pieces of glass rod also have to be added to avoid bumping to the above sample and immediately stopper the flask. e. Take 25 mL of 0.01 M H 2 SO 4 in a 150 mL conical flask and add 3-4 drops of methyl red to it. Dip the end of the delivery tube of the distillation apparatus into it. f. Heat the distillation flask steadily to distill out 100 mL of liquid ammonia in about 30 minutes time. g. Titrate the excess of standard H 2 SO 4 left in the conical flask with 0.02 M NaOH solution and note the volume used titrant. 2.4.3.5 Calculation Amount of Nitrogen in soil (per g) = (2 4 ( )– ( ))×0.00028 ( ) Where, 1 mL of 0.01M H 2 SO 4 = 0.00028 g of nitrogen Available nitrogen in ppm= Amount of nitrogen in soil (per g) × 10,000 Available nitrogen in kg/ha= Amount of nitrogen in soil (per g) × 22400 2.4.3.6 Result Weight of soil sample taken= 20 g Volume of 0.01 M H 2 SO 4 taken= 25 mL Volume of 0.02 M NaOH required for back titration= X mL

39 No. of observation Initial burette reading (mL) Final burette reading (mL) Difference (mL) Mean (mL) Sample 1. X 2. 3. The amount of available nitrogen in the given sample of soil = ... kg/ha. The soil sample on the basis of its available nitrogen value is rated as .... 2.5 Soil Phosphorus 2.5.1 Aim To determine the total available phosphorus present in the supplied soil sample 2.5.2 Introduction Phosphorus (P) exists in the soil as organic and inorganic phosphates forms. Plants readly uptake the phosphates in the form of inorganic than the other forms. Inorganic P forms are primarily mixtures of aluminium (Al-P), iron (Fe-P), and calcium (Ca-P) phosphates; the relative percentages between these three forms are a function of soil pH, with higher percentages of Al-P and Fe-P in acid soils, and higher percentages of Ca-P in neutral to alkaline soils. In soil phosphorus analysis is of two types: a) total analysis and b) fractional analysis. The P-Olsen corresponds to the second group. The fractions of this element present in the soil must be related to the response of plants to the application of a phosphate fertilizer. There are numerous methods for extracting P fractions with different sets of generated values. However, these only have meaning when they are associated with the response of the plants. In the Olsen method, phosphorus is extracted using a 0.5 M NaHCO 3 solution adjusted at a pH of 8.5. 2.5.3 Methods of estimation Olsen method 2.5.3.1 Principal The Olsen method uses NaHCO 3 extractant that can remove Ca-phosphates and phosphate adsorbed on surfaces of calcium and magnesium carbonates along with Al-phosphates. Phosphorus is extracted from the soil with 0.5 M NaHCO 3 at a nearly constant pH of 8.5. The OH - and CO 3 2- in the NaHCO 3 solution controls the activity of Ca 2+ , Al 3+ and Fe by precipitation of calcium as carbonate, and aluminium and iron as hydroxides. Soil extraction is carried out for 30 min at a soil/solution ratio of 1:20. Phosphorus extraction is affected by several analytical factors: soil/solution ratio, shaking time, shaker type, shaking bottle position, capacity and type of shaking bottles, contact time of the soil in the extractant and temperature.

40 Colour interference of the organic matter dissolved by the extractant must be removed (e.g., adding phosphate-free activated charcoal). There is no prior adjustment of the soil pH, or any attempt to remove possible interferences such as arsenate and silicate. The measurement or determination of phosphorus with spectroscopic methods is based on colour development. In the coloration process, molybdenum blue methods are the most sensitive and, as a result, they are widely used for soil extracts containing small amount of phosphate, as well as for total phosphorus determination in soils. These methods are based on the principle that, in an acid molybdate solution containing orthophosphate ions, phosphomolybdate complex is formed, which can be reduced by ascorbic acid or other reducing agents (e.g., SnCl 2) in the presence of potassium antimony tartrate to form a blue coloured heteropolymolybdic complex. Antimony accelerates the development of the blue colour and stabilizes it for up to 24 hours, and no interference of Si should be expected. The intensity of the blue colour varies with the P concentration (following Beer's Law) but is affected by other factors such as acidity, arsenates, silicates and substances which influence the oxidation-reduction conditions of the system. The concentration of P is determined by spectrophotometrically at 882 nm. 2.5.3.2 Apparatus and equipment a. Conical flask (125 mL) b. Beaker, test tube, measuring cylinder, volumetric flasks c. UV-Visible spectrophotometer, capable to measure 882 nm d. Reciprocating shaker e. Vortex mixer f. Whatman 42 filter paper 2.5.3.3 Reagents and standards a. Extracting solution (0.5 M, Sodium bicarbonate solution): 42 g of NaHCO 3 is dissolved in distilled water and make the volume upto 1000 mL, adjust the pH to 8.5 by adding 1M NaOH. b. Sulphuric acid (4M): Add 56 mL of concentrated sulphuric acid (96% or 18M) in 150 mL distilled water, cool it than volume make up to 250 mL. c. 4% Ammonium molybdate solution: Dissolved 4 g of ammonium molybdate [(NH 4) 6 Mo 7 O 24 .4H 2 O] in distilled water and make the volume up to 100 mL, stored in polyethylene or glass bottle. d. Potassium antimony tartrate solution (0.275%): Dissolve 0.275 g of potassium antimony tartrate (K 2 Sb 2 C 8 H 4 O12. 3H 2 O)

in distilled water and bring the volume up to 100 mL. e. Ascorbic acid solution (1.75%): Dissolve 1.75 g of ascorbic acid in distilled water and make up to 100 mL.

Prepare fresh daily. f. Mixed reagent, prepare fresh for every batch. Add successively with a graduated cylinder to a 500 mL beaker and homogenize after each addition: • 200 mL distilled water • 50

mL of 4 M sulphuric acid • 15 mL of ammonium molybdate solution • 30 mL of ascorbic acid solution • 5 mL of potassium

antimony tartrate solution

41 g. Standard phosphate solution (100 mg/L): Pipette 5 mL of NIST or other equivalent traceable 1000 mg/L phosphorus stock solution into a 50 mL volumetric flask and make up to volume with the extracting solution. h. Working phosphate standard (10 mg/L): Pipette out 10 mL of standard phosphate solution (100 mg/L) in to 100 mL volumetric flasks and make up to volume with the extracting solution. 2.5.3.4 Calibration Working phosphate standard series is to be prepared for the calibration curve. Pipette 0, 4, 8, 12, 16, 20 mL working phosphate standared (10 mg/L) into 100 mL volumetric flasks. Make up to the final volume with the extracting solution. The standard series is then 0, 0.4, 0.8, 1.2, 1.6 and 2.0 mg/L. pipette 3.0 mL of standard series into test tubes. Slowly add 3.0 mL of the mixed reagent by pipette. Homogenize using a vortex mixer and allow the solutions to stand for at least 1 hour for complete blue colour development. 2.5.3.5 Procedure a. Weigh 5 g of air dryed finely grind soil into a wide-mouth 125 mL capacity shaking bottle. b. Include at list one blanks c. Add 100 mL of the extracting solution and place the bottle caps. d. Add a half tea spoon of phosphate-free activated charcoal (approx. 0.5 g) for discolouration. e. Mechanically shake for 30 min at 180-200 oscillations/min, with shaking bottles placed horizontally. f. Filter through a filter paper Whatman No. 42 filter paper. g. Pipette 3 mL of the blanks and the sample extracts into test tubes. h. Slowly add 3 mL of the mixed reagent by pipette and homogenize using a vortex mixer. i. Allow the solutions to stand for at least 1 hour for the blue colour to develop its maximum. j. Measure the absorption at 882 nm through spectrophotometer. 2.5.3.6 Calculation / = (−) × × Where, a = concentration of P in sample extract, mg/L b = concentration of P in blank, mg/L V = Volume of extractant, mL W = weight of soil sample, g DF = total volume of diluted sample solution/aliquot of extract Conversion factor for reporting P 2 O 5 = 2.29 × P 2.5.3.7 Result

42 Standard phosphate solution in 100mL Concentration of phosphorus Absorbance 0.0 mL 0.0 mg/L 4.0 mL 0.4 mg/L 8.0 mL 0.8 mg/L 12.0 mL 1.2 mg/L 16.0 mL 1.6 mg/L 20.0 mL 2.0 mg/L Sample no. Description Absorbance phosphorus in mg/L from the standard curve 1. Blank 2. Sample

43 Unit 3. Study of pond biota 3.1 Phytoplankton 3.1.1 Introduction The term ‘plankton’ was first coined by Victor Hensen in 1887. Phytoplankton (‘phyto’ = plant; ‘planktos’ = made to wander) are single-celled algae, some of which are capable of moving through the use of flagella while others drift with currents. These microscopic plants range in size from 1 micrometre to 2 millimetres and float or swim in the upper 100 m of the waterbody, where they are dependent on sunlight for photosynthesis and constitute the primary producers synthesizing the basic food. In addition to light, they require basic simple inorganic chemical nutrients, such as phosphate (PO 4), nitrate (NO 3) and carbon dioxide (CO 2). Some phytoplankton, the diatoms, also require a form of silicon (silicate, SiO 4) because they have a “glass-like” shell. The important components of phytoplankton are diatoms (Bacillariophyceae), Dinoflagellates (Dinophyceae), and Blue-green algae (Cyanophyceae), Phytoflagellates (Xanthophyceae, Haptophyceae) and Nannoplankters (Chlorella, Nannochloropsis etc.). In the marine, the diatoms and dinoflagellates are the more obvious phytoplankton and come in a myriad of shapes, sizes, and forms, some of them quite beautiful. Some drift on currents while others can move around with the aid of flagella (Gymnodinium sanguineum). Some live as single cells while others form chains or colonies. 3.1.2 Characteristics of Phytoplankton The majority of the phytoplankton organisms are unicellular. The larger colonial forms process individual cells that are usually of uniform structure and appearance. Some planktonic green and blue-green algae are of filamentous organisation, and in some diatoms and dinoflagellates chains of loosely associated cells may be formed. Unicellular organisms are identified by recognizing certain cell characteristics, and ease of identification will be limited by cell size and the degree of magnification obtainable. For the identification of phytoplankton, the key points are- i. Cell shape, ii. Cell dimensions, iii. Cell wall, iv. Mucilage layers, v. Chloroplasts, vi. Flagella and vii. Reserve substances. 3.1.3 Collection of Phytoplankton There are three methods of phytoplankton sampling A. Bottle Sampler Sampling through the bottle

sampler is the recommended method to obtain an accurate picture of the quantitative composition of the phytoplankton in the water body. A bottle sampler can obtain the whole size spectrum from the large entities, like diatoms colonies to the smallest single cells. These are ideal for quantitative phytoplankton collections as required quantities of water can be collected from the desired depth. Water samples are generally used from vessels, ships or fish trawlers.

The bottle sample method is the simplest as Figure 16: Bottle plankton sampler

44

generally used for the collection of water samples from any desired depth of shallow systems like

a lake, the near sea shore water, estuaries, and mangroves. B. Plankton pumps Plankton pumps are integrating samplers that pump a continuous stream of water to the surface and the phytoplankton can then be rapidly concentrated by continuous filtration. Because the pumps can collect continuously as the tube is lowered through the water column the samples are integrated from the surface to desired depth. This method has its disadvantages, e.g., breaking up colonies, breaking off large Chaetoceros setae, and breaking into pieces long pinnate cells like Thalassiothrix spp. C. Plankton nets The easiest and quickest way of obtaining a concentrated sample of phytoplankton is to tow a cone-shaped bolting silk net through the water. The wider end of the net is kept open by a metal ring and this is attached to a tow rope. The narrow end of the net is closed by a plastic bucket or tube. When hauling is done in the water, backpressure builds up at the opening, which prevents some water from flowing in the net. A cone-shaped sleeve allows more effective filtering by reducing the volume of water entering the net. Net with fine meshes (5 or 10 μm) often filter relatively slower and smaller organisms are collected. The most useful mesh size for collecting diatoms is 25 μm. Net hauls have the advantage of a simultaneous collection and concentration of the plankton providing sufficient for species identification from various depths. The determination of the volume of water filtered through any plankton net is essential for the estimation of the standing crop. The volume of water traversed by the net is determined as an approximate value by the formula- = 2 Where, V = volume of the water filtered by the net r = radius at the mouth of the net d = distance through which the net is towed. Figure 17: Plankton sampling pumps
45 Figure 18: Plankton collection net 3.1.4 Preservation For preserving phytoplankton for a long time 5-8 % neutral formalin solution can be used although this is not very satisfactory for the delicate organism. Lugol's iodine solution is an effective preservative, especially for flagellated and ciliated phytoplankton to retain the flagella and cilia. It consists of 10 g of iodine and 20 g of potassium iodide dissolved in 200 mL of distilled water and 20 g of glacial acetic acid (added 2-3 days before use). This solution can be made up a few days ahead and stored in a dark bottle for convenience. Lugol.s iodine is added to water samples in a ratio of 1:100 volume of water. 3.1.5 Identification Counting and identification of the organisms (phytoplankton) at the same time with keys and illustrations are very difficult and recognition of species is a matter of experience and expertise. Before identification and counting person must go through the identification keys of the organisms as many as possible. Identification of phytoplankton in water samples is usually best done by using phase-contrast microscope, which reveals especially well lightly silicified structures like Chaetoceros (Figure:18) and also the organic chitin threads in Thalassiosiraceae (Figure:19). Figure 20:Thalassiosiraceae Figure 19:Chaetoceros
46 Salient features of the organisms 3.1.5.1 Diatoms (Bacillariophyceae) Diatoms are extremely widespread and occur as the dominant organisms of many diversified habitats, especially in seawater. Their importance lies in the fact that they are photosynthesizing organisms and serve as a vital primary level in the aquatic food chain. They are characterized by the following main features: a. Single-celled algae that possess a distinct nucleus (eukaryotic) b. The cell walls are silicified and show characteristic secondary structures. c. The photosynthetic pigments include chlorophylls a and c, together with the xanthophylls, and fucoxanthin. d. Food storage products include fats and chrysolaminarin. e. The motile states possess a single pantonematic flagellum. f. Frustules can be ornate and very beautiful, and due to the strength of silica, they form an important part of the fossil record. Taxonomy Diatoms are broadly divided into two major divisions based upon the structure and shape of the valves (or sculpture on their cell walls): Centrics (Order: Biddulphiales) and Pennates (Order: Bacillariales). A. Centrales: Centrales containing the centric diatoms, the valves of which are having radiating carving either central or lateral, without raphe and movement. 3.1.5.1.1 Coscinodiscus sp. Order: Thalassiosirales Family: Skeletonemataceae Genus: Skeletonema Characters: • Valves are small, lens-shaped with rounded ends and form long and slender chains, attached by external tubes or strutted processes organized in on marginal ring. • Space between cells larger than cell • Two chloroplasts per cell • Cell diameter 2 -21 μm • Resides in the neritic zone and is commonly found in brackish waters. Dominant phytoplankton of the ocean. • The organism is appealing for commercial use due to its high photosynthetic efficiency, high tolerance to pH, temperature, and salinity changes, high lipid and fatty acid content, and rapid growth.
47 Figure 21:Face vied and Side view of Coscinodiscus wailesii 3.1.5.1.2 Skeletonema sp. Order: Biddulphiales Family: Coscinodiscacеae Genus: Coscinodiscus Characters: • Cell disc-shaped, cylindrical or wedge-shaped and solitary • Distinct rosette of large areolae in the centre of the valve, areolae are in the same size (6-10 μm) • Cell diameter 30 -500 μm • Widely spread from warm water to boreal water Figure 22:Live view and diagram of Skeletonema costatum 3.1.5.1.3 Guinardia sp. Order: Rhizosoleniales Family: Rhizosoleniaceae Genus: Guinardia Characters: • Cylindrical cells form curving and sometimes spiralling chains • Girdle bands appear as collars • Numerous small chloroplasts present • Cell size: 6-45 μm width and length 250 μm • Generally present in neritic zone and probably cosmopolitan

48 Figure 23:Live view and diagram of Guinardia striata 3.1.5.1.4 Chaetoceros sp. Order: Chaetocerotales Family: Chaetocerotaceae Genus: Chaetoceros Characters: • Cells are usually elliptical in valve view and form chains that may be coiled, curved or straight. • Each frustule has four siliceous processes called mushrooms or thorns that emerge from corners of cells that allow them to stay together forming colonies. • One of the largest genera of diatoms, roughly 400 species, most of which are marine. • Some species form resting spores and/or auxospores. • Cell size: >10 µm to 50 µm width, it varies with species. • Widespread throughout the world's oceans. Some species also found in inland water. Figure 24: Live view and diagram of Chaetoceros sp. 3.1.5.1.5 Eucampia sp. Order: Biddulphiales Family: Hemiaulaceae Genus: Eucampia Characters:

49 • Cells are flat united to form elliptical chains with a characteristic blunt process. • Valves are concave in the middle so that a wide aperture between two cells is present. • Presence of many discoid chloroplasts. • Cell size: Length 10 µm to 92 µm (apical axis). • Mainly cosmopolitan and probably absent from polar regions. Figure 25:Live view and diagram of Eucampia zodiacus 3.1.5.1.6 Ditylum sp. Order: Lithodesmiales Family: Lithodesmiaceae Genus: Ditylum Characters: • Cells are solitary, prism-shaped with a three-cornered valve plane. • Generally, forms short chains very rarely form long chains. • Cells have small, numerous chloroplasts and a long identical central spine. • A circlet of short spines on the valve end present. • It produces resting spores. • Cell size: Length 80 µm to 130 µm (pervalver axis) • Mainly oceanic cosmopolitan and absent in polar waters Figure 26: Live view and diagram of Ditylum brightwellii

50 B. Pennates: The valves are not centrally constructed, arranged in relation to a median line, bilaterally symmetrical and have boat-shaped, crescent-shaped or linear structures. True raphe or hyaline median line always presents on the valve. Cells are capable of spontaneous movement in presence of raphe. 3.1.5.1.7 Thalassionema sp. Order: Thalassionematales Family: Thalassionemataceae Genus: Thalassionema Characters: • Cells form zig-zag chains and linear- rectangular in girdle view • Cells attached by mucilage pads at their ends • Linear- lanceolate in valve view • Cell size: Length 10- 80 µm (apical axis) and 2- 4 µm width • Lives in the neritic zone. Cosmopolitan in temperate to tropical water. Figure 27:Live view and diagram of Thalassionema nitzschioides 3.1.5.1.8 Asterionellopsis sp. Order: Fragilariales Family: Fragilariaceae Genus: Asterionellopsis Characters: • These are pennate diatoms. • Cells joined by valves face into star-shaped or spiralling chains. • Two chloroplasts present • Cell size: Length 30- 150 µm (apical axis) • Lives in the neritic zone. Cosmopolitan in temperate to tropical water.

51 Figure 28:Live view and diagram of Asterionellopsis glacialis 3.1.5.1.9 Pleurosigma sp. Order: Naviculales Family: Pleurosigmataceae Genus: Pleurosigma Characters: • Solitary pennate diatom • Valves are very slightly sigmoid. • The end portion is blunt. • It has 2-4 elongated chloroplast. • Oblique striae at an angle of 60 o equidistant with the transverse striae • Cell size: Length 90- 600 µm and 28- 75 µm width • Cosmopolitan distribution Figure 29:Live view and diagram of Pleurosigma galapagense 3.1.5.1.10 Navicula sp. Order: Naviculales Family: Naviculaceae Genus: Navicula

52 Characters: • Valves are elliptic-lanceolate with produced rostrate ends. • Axial area narrow • The central area slightly widened in the middle • The transverse striae are slightly radial and the longitudinal striae are equally placed. • Cell size: Length 65-77 µm and 18.5-20 µm width • Lives in the freshwater stream. Figure 30: Live view and diagram of Navicula cuspidata 3.1.5.2 Dinoflagellates (Dinophyceae/Pyrrophyceae) Dinoflagellates are the unicellular, animal-like diversified group of organisms which can move around the water with the help of their cilia or flagella. This group of organisms comes next in importance after the diatomaceae among the autotrophic planktonic organisms.

The cells contain paired flagella which arise in close proximity usually with one flagellum trailing behind the cell and lying in a groove (sulcus) and the ribbon-like transverse flagellum also lying in a groove (cingulum or girdle).

The girdle lies between the episode and the hypocone.

Wing-like extensions of the body probably assist floatation in some genera (
Dinophysis, Omithoaorous etc.).

The body of the cell is covered by an envelope (cell wall) made of cellulose, pellicle, valves or plates. The
majority of dinoflagellates are autotrophic and a few are holozoic, saprophytic or phagotrophic. In the autotrophic dinoflagellates, the products of photosynthesis are starch and lipids. Most of the dinoflagellates are harmful to other phytoplankter and aquatic organisms since they produce some toxins, which act as, poison to others. The discolouration of the water, either red, pink or brown due to the blooming of dinoflagellates is termed as 'Red tide' or red water phenomenon and this causes harmful effects on the fishery. Due to the blooming, there will be deoxygenation, high pH and sometimes bad smell also appeared. The zooplankter as well as the larval forms of fishes will try to avoid the area, otherwise, mass mortality may occur in these areas. Incidents of heavy mortality of fishes occurred several times in the Arabian sea, especially in the Lakshiidweep area due to the blooming of dinoflagellates such as species of Gonyniilax, Gymnodinium and Noctiluca.

53 Dinoflagellates are reproduced by binary fission or vegetative cell division and sexual reproduction is lacking in this class. It is divided into two subclasses i. Desmokonate and ii. Dinokonate i) Desmokonate It comprises more primitive organisms and a
much smaller group, has only two genera, viz., Prorocentrum and Exuviaella.

Both the flagella in these organisms arise from the anterior end of the cell and hence the cingulum and sulcus are absent. The cell wall is not composed of separate plates unlike in dinokontaeans but has only a longitudinal suture which divides the cell into two valves. The reproduction is by longitudinal division while the cell is motile. During division, the suture dividing the two valves separates, so that after fission, each daughter cell retains one valve from the parent.

3.1.5.2.1 Prorocentrum sp. Order: Prorocentrales Family: Prorocentraceae Genus: Prorocentrum Characters: • Laterally compressed armoured cell • Cells are shaped and sized variously from oval, tear-drop to heart-shaped. • There is no cingulum or sulcus. • Well-developed apical spine present • Chloroplast is present with two golden-brown chloroplasts situated peripherally. • Reproduces asexually by binary fission. • Cell size: Length 35-70 μm and 20- 50 μm width. Length: width ratio is usually less than two. • Lives in marine, bloom- forming and cosmopolitan species in cold temperate to tropical waters. Figure 31: Live view and diagram of Prorocentrum micans

54 3.1.5.2.2 Exuviaella sp. Order: Prorocentrales Family: Prorocentraceae Genus: Exuviaella Characters: • Flattened ellipsoid test • Anterior end with a depression through which two flagella emerge • Two chromatophores were found pale or deep green, each with a pyrenoid. • Nucleus present in the posterior position, no stigma found. • Cell size: Length 22-26 μm and 12-18 μm width • Found in both fresh and salt water. Figure 32: Diagram of Exuviaella sp. ii) Dinokonate This group differs from Desmokonate in having a cingulum which divides the cell into an anterior epicone and a posterior hypocone. The girdle houses a hand-like transverse flagellum which arises through a pore and causes the cell to spin to some extent on its axis. The sulcus is also present in this group and it runs from the posterior end of

the

cell part way forwards. The longitudinal flagellum which arises from a pore in the sulcus runs back and usually beyond the cell trailing behind in the water. 3.1.5.2.3

Dinophysis sp. Order: Dinophysiales Family: Dinophysiaceae Genus: Dinophysis Characters: • Cells are large, armored. • Species in this genus are laterally flattened, with a small cap-like epitheca and a much larger hypotheca usually about ¾ of the cell length. • The long left sulcal list (LSL) extends to nearly half of the total length of the cell.

55 • This species is usually widest at the base of the LSL. • Chloroplasts present or absent. • Reproduces asexually by binary fission • Cell size: Length 22-105 μm and 30-60 μm width. • It is common in temperate to tropical neritic waters and responsible for red tides. Figure 33: Live view and diagram of Dinophysis caudata 3.1.5.2.4 Noctiluca sp. Order: Noctilucales Family: Noctilucaceae Genus: Noctiluca Characters: • It is a very large unarmoured, kidney or balloon-shaped cell. • It has only one transverse flagellum and one striated tentacle. • It does not photosynthesize. • It has a phagotrophic food vacuole that often contains prey organisms such as diatoms and ciliates. • It reproduces sexually by the formation of Closeisogametes and asexually through binary fission. • Cell diameter: 200-2000 μm • Lives in the ocean, responsible for bioluminescent blooms. Figure 34: Live view and diagram of Noctiluca scintillans

56 3.1.5.2.5 Protoperidinium sp. Order: Peridiniales Family: Protoperidiniaceae Genus: Protoperidinium Characters: • Cells are armoured with variable shapes and size. • Many species have apical and antapical horns and/or antapical spines. • Chloroplasts are absent in most species. • Cell size: >50 μm to <100 μm • Widespread throughout the world’s oceans Figure 35: Live view and diagram of Protoperidinium crassipes 3.1.5.2.6 Gonyaulax sp. Order: Gonyaulacales Family: Gonyaulacaceae Genus: Gonyaulax Characters: • Cells are armoured. • Ovoid to fusiform cells with chloroplasts • Some species form benthic cysts • Distinguished by descending cingulum up to 6x girdle width. • Cell size: 25-136 μm • Widespread throughout the world’s oceans • Some species can produce yessotoxin.

57 Figure 36: Live view and diagram of Gonyaulax spinifera 3.1.5.2.7 Ceratium sp. Order: Gonyaulacales Family: Ceratiaceae Genus: Ceratium Characters: • Antapical and apical horns are found to be present. In total 1-4 horns are present. • Cells are heavily thicket and pale yellow to golden in colour. • Cell size: Length 65-400 μm Figure 37: Live view and diagram of Ceratium furca

58 3.2 Zooplankton 3.2.1 Introduction Zooplankton (Greek: Zoon means animal; plankton means wandering) are myriads of diverse floating and drifting animals with limited power of locomotion. The majority of them are microscopic, unicellular or multicellular forms with sizes ranging from a few microns to a millimetre or more. In addition to size variations, there are differences in morphological features and taxonomic position. The zooplankton plays an important role to study the faunal biodiversity of aquatic ecosystems also used as a bioindicator for assessment in ecological health monitoring (EHM). They include representatives of almost every taxon of the animal kingdom and occur in the pelagic environment either as adults (holoplankton) or eggs and larvae (meroplankton). By the sheer abundance of both types and their presence at varying depths, the zooplankton is utilized to assess energy transfer at secondary trophic level. They feed on phytoplankton and facilitate the conversion of plant material into animal tissue and in turn constitute the basic food for higher animals including fishes, particularly their larvae. The fishes mostly breed in areas where the planktonic organisms are plenty so that their young ones could get sufficient food for survival and growth. Zooplankton type known as "krill" is whale's favourite food and lives in cold water. The planktonic forms with calcareous or siliceous shells or tests contribute to the bottom sediments. The zooplankton is more varied as compared to phytoplankton, their variability in any aquatic ecosystem is influenced mainly by patchiness, diurnal vertical migration and seasons. Evaluation of zooplankton production in any particular area will largely depend on the use of the correct zooplankton methodology that involves the collection of samples, fixation, preservation, analysis and computation of data. 3.2.2 Characteristics of Zooplankton • They can live in both fresh and salt water. • They are bad swimmers. They move up and down in the water. • It reproduces asexually through a process called bipartition. • They look for water surfaces during the night to get food. • They stay in deeper water to get away from the sun during the day. • It is classified by size and stage of development. • It is made up of secondary and tertiary producers. • Freshwater zooplankton consists mainly of protozoa, single-celled animals and some crustaceans. 3.2.3 Collection of Zooplankton The zooplankton collection is quite similar to the collection methods of phytoplankton.

59 A. Bottle Sampler Sampling through the bottle

sampler is the recommended method to obtain an accurate picture of the quantitative composition of the zooplankton in the water body. A bottle sampler can be of 5 to 20-litre capacity (Fig. 38). It is mainly used for small forms or microzooplankton. The Von Dorn bottles or water samplers with closing mechanisms are commonly used for obtaining samples from the desired depths. It is easy to operate and the depth of sampling is well known but a very small amount of water can be filtered through this method of sampling. B. Plankton pumps Plankton pumps are integrating samplers that pump a continuous stream of water to the surface and the zooplankton can then be rapidly concentrated by continuous filtration. Because a pump with a meter scale can collect continuously with a recorded volume of water. It damages larger plankton especially the gelatinous forms, viz. medusae, ctenophores and siphonophores etc. (Fig. 39). An advantage of this method is to assess a larger known volume of water and the assessment can be done immediately again and again. Although the collection depth is limited to a few meters. C. Plankton nets The easiest and quickest way of obtaining a concentrated sample of zooplankton is to tow a cone-shaped bolting silk net through the water. The wider end of the net is kept open by a metal ring and this is attached to a tow rope. The narrow end of the net is closed by a plastic bucket or tube. When hauling is done through the water, backpressure builds up at the opening, which prevents some water from flowing through the net (Fig. 40). A cone-shaped sleeve allows more effective filtering by reducing the volume of water entering the net. Net with fine meshes of 0.2 mm often filter relatively slower and smaller organisms are collected. Usually, Heron -Tranter (HT) net is used. Remember, collection of zooplankton must be done in the early morning before sunrise or at night because zooplankton did not prevail on the surface of the water body in the presence of sunlight. The determination of the volume of water filtered through any plankton net is essential for the estimation of the diversity. The volume of water traversed by the net is determined as an approximate value by the formula Figure 39: Plankton sampling pumps Figure 38: Bottle plankton sampler

60 = 2 Where, V = volume of the water filtered by the net r = radius at the mouth of the net d = distance through which the net is towed. Figure 40: Plankton collection net 3.2.4 Preservation For preservation a long time buffered formalin of 4-5 % solution can be used both as a fixative and as a preservative. 70% ethanol or 40% isopropanol can also be used as preservatives. The ethanol is used for preserving museum specimens but it is costly and volatile. Glycerine is often added to formalin to prevent shrinkage of specimens, drying of the material and facilitating retaining colours of zooplankter. For better shelf life of the zooplankton samples, the preservative should be changed within the first 6 months. 3.2.5 Identification Species identification and naming are the very important aspects in species characterisation. Correct species identification is a prerequisite for understanding the distributional pattern, seasonal variability and community structure of zooplankton in an aquatic ecosystem. Counting and identification of the organisms at the same time with keys and illustrations is very difficult and recognition of species is a matter of experience and expertise. Before identification and counting person must go through the identification keys of the organisms as many as possible. The initial identification of common species could be done with the help of illustrated checklists. For identification of species a stereoscopic dissecting microscope, good quality glass slides, coverslips, stainless steel fine forceps, dissecting needles, pipettes and chemical reagents are required. It involves various steps such as cleaning of specimens, staining, dissection and slide preparation.

61 Essential anatomical terminology must be learned to positively identify an organism. General elements that need to be assessed for all zooplankton groups are: • body shape and size • relative length of various appendages, including antennae, legs, and setae • presence and relative sizes of spines Although several anatomical features used to differentiate species are listed in the literature, this Guide only makes mention of the key details that taxonomists use for rapid identifications. For more detailed information on certain features (e.g., cyclopoid 5th legs). Each zooplankton group has a series of major characteristics used for identification. Once you memorize what to look for the speed of processing will dramatically increase. If ever in doubt, always refer to the keys. Organisms 3.2.5.1 Rotifera 3.2.5.1.1 Brachionus sp. Order: Ploima Family: Brachionidae Genus: Brachionus Characters: •

Two small anteromedian spines; Antero intermediate and anterolateral spines are absent or highly reduced. • Two divergent posterior spines • Length of lorica 84-168 μm; maximum width of lorica is 77-134 μm. Lorica firm, stippled, with a pattern of cuticular ridges, divided into dorsal and ventral plates, somewhat compressed dorso-ventrally. • Anterolateral spines 71-88 μm • Rarely are all six occipital spines present. • Habitat: Pelagic; marine, freshwater Figure 41: Brachionus caudatus, a. Dorsal and lateral view b. Live picture

62 3.2.5.1.2 Keratella sp. Order: Ploima Family: Brachionidae Genus: Keratella Characters: • Keratella is a footless rotifer which possesses a protective covering or lorica. • Generally, spines are present on those Keratella which are born in the presence of predators such as cladocerans, asplanchna and cyclopoid copepods. • Sexual reproduction occurs periodically in response to unknown stimuli. In sexual reproduction, the female undergoes meiosis and produces 1n eggs, some of which hatch into 1n males. • Habitat: Pelagic; marine, freshwater Figure 42: Keratella quadrata, A. Dorsal view, B., C. lateral view, D. with egg, E. Live view 3.2.5.2 Arthropoda 3.2.5.2.1 Bosmina sp. Order: Cladocera Family: Bosmimidae Genus: Bosmina Characters: • Postabdominal claw with stout proximal pecten and very fine distal pecten • Sensory bristle midway between eye and tip of rostrum • There are two antennule morphotypes in B. longirostris, the hooked cornuta morph and the slightly curved pellucida morph. • Habitat: Found in the epilimnion zone and lakes with and without fish. Commonly found in dystrophic or bog lakes. • Males vary in size from 0.4-0.5 mm and females vary in size from 0.4-0.6 mm. • Reproduces by parthenogenesis, asexually. They overwinter as resting eggs and when conditions become favourable (med of July) rapid reproduction commences.

63 Figure 43: Bosmina longirostris, A. Diagram and B. Live view 3.2.5.2.2 Moina sp Order: Cladocera Family: Moinidae Genus: Moina Characters: • Body oval shaped with large anntenules • Distal forked tooth on post abdomen • Head extended, broad and round • No supraocular depression but a shallow cervical depression separating the head and the body • Eye larger, situated in the middle of the head, without ocellus • Found in small ponds or pools; sometimes saline waters • Reproduce both sexually and asexually • Size: Female: 1.8 mm. Male: 0.5–0.6 mm Figure 44: Moina macrocopa, A. Parthenogenetic female (lateral view). B. First trunk limb of female. C. First trunk limb of male. D. Ventral rims of the shells E. Live view 3.2.5.2.3 Daphnia sp Order: Cladocera Family: Daphniidae Genus: Daphnia

64 Characters: • Kidney-shaped almost transparent body covered with a carapace • The head of the organism contains both a darkly coloured compound eye and numerous antennae used for feeling and swimming. • The central portion of the body is the thorax which has four to six pairs of thoracic legs covered with setae, two-branched antennae and leaf-like limbs inside the carapace. • The anterior part of the head projects forming a larger spine towards the anterior, this spine sometimes changes shape into a short knob. • The post-abdomen is the most posterior part of the body and terminates itself in two hook-like cuticular claws used by the organism to clear debris out of the carapace. • Size: Female: 3.0–4.3 mm. Male: 1.6–2.5 mm. • Lives in mainly freshwater and densely populate most lakes and ponds. Figure 45: A. General diagram and B. Live view of Daphnia sp. 3.2.5.2.4 Diaptomus sp. Order: Copepoda Family: Diaptomidae Genus: Diaptomus Characters: • Stout, seed-shaped body • The fourth and fifth thoracic segments are also separated. • The abdomen consists of 2 segments, short, the first abdomen very large, about twice as long as it is wide. • Antennules are very long (23-25 segments), often reaching to or beyond the caudal rami. • The body narrows between the segment bearing the 5th legs and the genital segment. • 5th legs are quite large and distinct, symmetrical in females, asymmetrical in male. • The first antennae extend over the tip of the furca rami. • Size: Female: Length 1.64 – 1.69 mm. Male: Length 1.57 – 1.60 mm. • Freshwater species occur in a range of habitats such as ponds, lakes and rivers.
65 Figure 46: A. General diagram and B. Live view of Diaptomus sp. 3.2.5.2.5 Cyclops sp. Order: Copepoda Family: Cyclopidae Genus: Cyclops Characters: • Antennule of medium length with 6-17 segments • The body narrows between the segments bearing the 4th and 5th legs • Ridge present on dorsal side of rami • Length of caudal ramus about 4 times the width • Tufts of hair present on the inner margins of the cauldal rami • 5th leg has two segments, distal segment has an apical seta and a subapical spine, which is about equal in length to the segment. • Minute spinules on distal three segments of antennule • Size: Female: Length 0.9 – 1.3 mm. Male: Length 0.7 – 1.0 mm • Freshwater species occurs in a variety of habitats, such as ponds, lakes, streams and rivers.
66 Figure 47:A. General diagram and B. Live view of Cyclops sp.
67 3.3 Macrophytes 3.3.1 Introduction Macrophytes are the conspicuous plants that dominate wetlands, shallow lakes, and streams. Macroscopic flora includes the aquatic angiosperms (flowering plants), pteridophytes (ferns), and bryophytes (mosses, hornworts, and liverworts). An aquatic plant can be defined as one that is normally found growing in association with standing water whose level is at or above the surface of the soil. The presence or absence of certain macrophyte and microphyte species can depict a certain environmental state of the local environment. A lot of representatives are used in bioindication which is an important process for revealing the pollution level of the studied environment and for strategic water purification planning. These aquatic florae are interdependent and complementary. Besides bioindication, a lot of representatives are a nutrition source for many aquatic as well as terrestrial animals. In the recent era, this flora become a target of interest of scientists for bioremediation. In this context, we will learn about some identifying characters of a few common macrophytes. Depending on the connection with water and air macrophytes can be divided into: a. Free-floating macrophytes b. Floating but rooted macrophytes c. Submerged macrophytes d. Amphibian macrophytes 3.3.1.1 Free-floating macrophytes Free-floating macrophytes freely float on the surface and have no roots attached to the mud. Freely floating hydrobionts shape a dense population, covering the water surface. Such a population prevents the development of submerged aquatic plants and phytoplankton by blocking the penetration of light. These hydrophytes are maybe differently shaped, big (Eichhornia crassipes) and small (Lemna gibba, Azolla filiculoides). Some of the common free-floating macrophytes are discussed below. 3.3.1.1.1 Eichhornia sp. (Water hyacinths) Order: Commelinales Family: Pontederiaceae Genus: Eichhornia Characters: • It is a floating perennial hydrophyte. The stem is short and bentgrass, rooting at the nodes. • The leaves are formed at the end of the petioles. Petioles may be swollen into a bulbous spongy of about 10 to 30 cm long. • The stem is offset grows prostrate below the subsurface and is spongily filled with air. • The roots are fibrous strongly tinged with anthocyanin pigments and originated from submerged stems; in low water level conditions the plant gets rooted in mud.
68 • Inflorescence spikes, 4 to 10 flowers, long-stalked (up to 60 cm). Flower 6 sepals welded tube at the base, light blue to purple-blue, the upper petal with purple spots and a yellow centre. • The fruit is a membranous capsule, dehiscent trilocular containing many seeds. • Vegetative propagation by an offset which is shorter and thicker. Figure 48: A. General Diagram and B. Live view of Eichhornia crassipes 3.3.1.1.2 Pistia sp. (Water lettuce) Order: Alismatales Family: Araceae Genus: Pistia Characters: • It is a floating plant, drift, without a rod, formed of a leaf rosette, 5 to 25 cm in diameter • Short runner giving rise to daughter plants • A large network of fibrous roots dangling underwater. • The leaves in a dense rosette, sessile, broadly spatulate, fleshy, and composed of a floating airy fabric. Both sides are hairy, greyish or yellowish green. • Flowers are numerous, small and hidden at the base of the leaves, surrounded by a small room of pale green or white leafy 7 mm long. • The fruits are small elongated bays 6 to 10 mm long, containing several dark seeds. • They also propagate through vegetative by issuing numerous stolons at the end of which form daughter plants.

69 Figure 49: Pistia stratiotes, A. Plant habit; B. Inflorescence; C. Fruit; D. Seed and E. Live view of plant 3.3.1.1.3 Lemna sp. (Duckweed) Order: Arales Family: Araceae Genus: Lemna Characters: • Stem less, free-floating, aquatic, perennial plants which thrive well in most wetland areas. • They are mostly small, not exceeding 5 mm in length. • Consisting of two microscopic staminate flowers and one tiny pistillate flower in a pouch-like sac is rarely seen. • The root is hyaline, solitary and hanging, root apices are protected by root-pockets. • Propagate asexually by forming chains of new stems from vegetative buds. • Grow quickly and produce new offshoots rapidly. Scientists use this rapid-growing capability for bioremediation.

70 Figure 50: Lemna gibba, A. Diagram of different parts and B. Live view 3.3.1.1.4 Azolla sp. (mosquito fern) Order: Salvinales Family: Salvinaceae Genus: Azolla Characters: • It is a surface floating aquatic fern consisting of a short (0.8–2.5 cm), long branched, floating stem, bearing roots which hang down in the water. • The leaves are tiny scale-like and alternately arranged, each consisting of a thick aerial dorsal lobe containing green chlorophyll and a slightly larger thin, colourless, floating ventral lobe. • Branches are longer towards the base giving the plant a triangular shape. • Roots with fine lateral rootlets, appearing feathery. • Produces both male and female spores. Figure 51: Azolla pinnata

71 3.3.1.1.5 Salvinia sp. Order: Salviniales Family: Salviniaceae Genus: Salvinia Characters: • Free-floating aquatic ferns with stems just below the water surface • Floating leaves are 0.5-1.5 inch. (2.5-3.8 cm) long, oblong, and vary in colour from green to gold to brown • The upper surfaces of floating leaves bear eggbeater-shaped hairs. • This plant does not produce flowers. • Reproduces only vegetatively by plant fragments or attached plantlets Figure 52: Salvinia natans: A. General diagram, B. Live view 3.3.1.1.6 Wolffia sp. (rootless duckweed) Order: Arales Family: Araceae Genus: Wolffia Characters: • It is the smallest flowering plant in the world flourishing in temperate, subtropical, and tropical locations. • Floating on the surface of still too slowly moving waters of ponds, lakes, beaver ponds, ditches, and swamps. • This greenish-yellow tiny plant is rootless, branchless and also has no leaves. • Reproduces vegetatively in favourable conditions, it can double in size every two days. A. B.

72 Figure 53: Wolffia arrhiza: A. General diagram, B. Live view 3.3.1.2 Floating but rooted macrophytes Floating but rooted hydrophytes appear in ponds, rivers and lakes. Life and blooming of these plants take place on the water surface. Such a group of macrophytes includes Nelumbo nucifera (lotus), Victoria regia (water lily), and Ceratopteris thalictroides. Some of them are discussed below. 3.3.1.2.1 Nelumbo sp. (Lotus) Order: Proteales Family: Nelumbonaceae Genus: Nelumbo Characters: • It is a large perennial aquatic plant with large showy flowers. • Rhizomes or roots anchored under the mud and the stem erected to the surface. • Its large peltate leaves rise above the water surface on 1 to 2 m long slender and spongy petioles. leaf-stalk attaching to the centre, rather than the edge. • Its beautiful flower may be different coloured but commonly found in white petals with a pink tip. • Seeds are oval or spherical, generally 1.2–1.8 cm long, diameter 0.8 to 1.4 cm and weight 1.1–1.4 g. • Reproduce vegetatively by its thick rhizomes and fibrous root system; also by seeds. A. B.

73 Figure 54: Nelumbo nucifera: A. General Diagram, B. Live view of plant, C. Leaf 3.3.1.2.2 Nymphaea sp. (Water lily) Order: Nymphaeales Family: Nymphaeaceae Genus: Nymphaea Characters: • Rooted, aquatic perennial herb with large floating flowers and leaves. • Leaves are round, narrowly cut almost to centre, 8-10 inches across, bright green on top, reddish or purple below. • Flowers are rounded 3-6 inches wide with numerous white or pink petals and 4 greenish-white sepals. • Stalk contracts and forms a rounded spongy fruit with several seeds that mature underwater and float to the surface when ripe. • Reproduced by seeds and vegetatively by rhizomes. Figure 55: Nymphaea alba: A. General Diagram, B. Live view of plant, C. Leaf

74 3.3.1.2.3 Nymphoides sp. (Crested Floating heart) Order: Asterales Family: Menyanthaceae Genus: Nymphoides Characters: • Rhizomatous annuals or perennials • Primary fertile shoots many, anisophyllous, arising from the axils of scales on the rhizome • Secondary shoots zig-zag, sympodial, many-jointed, each joint bearing a single floating heart-shaped leaf. • Flowers golden yellow, bisexual and female, in umbellate clusters of 10 -20 at the junction of the branch and petiole • Reproduced by seeds and vegetatively by rhizomes. Figure 56: Nymphoides peltata: A. General Diagram, B. Live view 3.3.1.2.4 Trapa sp. (Water chestnut) Order: Myrtales Family: Trapaceae Genus: Trapa Characters: • Aquatic; rooted; floating; mat-forming annual in shallow or deep freshwater • Toothed floating leaves have inflated petioles and are arranged in a rosette, while its submerged leaves are feathery. • Flowers are small white coloured and have 4 petals. • Nut with 2 or 4, orthogonal, sharp spines that develop from hardened sepals; single seed • Antennule of medium length with 6-17 segments

75 Figure 57: Trapa natans: A. Diagram of plant, B. Pistil, C. Introrse stamen (dorsal and ventral), D. Style and stigma, E. Fruit, F. Live view of Plant, G. Fruits 3.3.1.3 Submerged macrophytes Submerged floating macrophytes grow under the water surface and are not in contact with the atmosphere. They are rooted in the mud. The entire surface of the plant body in macrophytes is in direct contact with water. The leaves of such plants consume CO 2 and oxygen from the water. Leaves of such macrophytes are considerably reduced in size. Cuticle, suberin and epidermis cover are undeveloped. Stomata in such hydrophyte plants are absent or present in the reduced state. Typical representatives of submerged floating macrophytes are Hydrilla, Ceratophyllum, and Utricularia. 3.3.1.3.1 Hydrilla sp. Order: Alismatales Family: Hydrocharitaceae Genus: Hydrilla Characters: • Submerged, rooted, perennial aquatic herbs • Whorls of 3-10 thin, rough leaves at the node, small spines give the leaf margin a toothed appearance, midribs red and often spiny. • Usually rooted in water up to 6 m (20 ft) deep; little branching in deep water but dense near to water surface • Female flowers are small, white, 6 parted, and occur from leaf axils; male flowers are green in colour and resemble an inverted bell.

76 • The whole plant is covered with mucilage. It prevents epiphytic growth and protects the plant against the rotting effect of water • Reproduced vegetatively by tubers and vegetative winter buds (turions), fragments root at nodes. Figure 58: Hydrilla verticillata: A. General diagram, B. Live view of Plant 3.3.1.3.2 Utricularia sp. (Bladderwort) Order: Scrophulariales Family: Lentibulariaceae Genus: Utricularia Characters: • It is an annual or perennial submerged or free-floating carnivorous aquatic plant. • These carnivorous plants have bladder traps interspersed among photosynthetic leaves. • The leaves are highly segmented and submerged looking like green roots. • Can reproduce by seeds or by vegetative reproduction is by re-sprouts from stem fragments or rhizomes.

77 Figure 59:Utricularia mangshanensis: A. Whole plant, B. Anterior view of flower, C. Posterior view of flower, D. Lateral view of flower, E. Dorsal view of calyx, F. Bract and bracteoles, E. Upper lobe of corolla with stame, H. Live view of plant 3.3.1.3.3 Vallisneria sp. Order: Alismatales Family: Hydrocharitaceae Genus: Vallisneria Characters: • They are long, slender, tape-like grasses usually present in freshwaters. • Roots are reduced, fibrous and anchor in the soil. • Leaves are thin and long tape-like structures, it helps the plant sustain the water current and maximum absorption of sunlight. No stomata present. • The whole plant is covered over mucilage, protecting it from water.

78 Figure 60: Vallisneria gigantean: A. General Diagram B. Live view of plant 3.3.1.3.4 Ceratophyllum sp. (Coontail) Order: Nymphaeales Family: Ceratophyllaceae Genus: Ceratophyllum Characters: • Rootless aquatic macrophyte with a cosmopolitan distribution • Leaves are whorled, 1-4 times dichotomously branched, minutely toothed at irregular intervals. • Flowers minute, solitary, axillary, unisexual, male and female flowers are found at different nodes on the same plant. • The fruit is a small nut 4–5 mm long, usually with three spines, two basal and one apical. Figure 61: Ceratophyllum demersum: A. General Diagram, B. Live view of plant

79 3.3.1.4 Amphibian macrophytes Amphibian plants grow in shallow waters. Their roots, stems and leaves are rooted in the water. But some blooming sprouts blossom above the water surface. These plants are adapted to the water and terrestrial life conditions. Air parts of these hydrobionts have mesophytic characteristics, when submerged parts develop completely hydrophytic. Cuticle develops in the aerial part of the plant. Stomata are limited to the upper and lower parts of aerial leaves. 3.3.1.4.1 Marsilea sp. Order: Salviniales Family: Marsileaceae Genus: Marsilea Characters: • Terrestrial or aquatic herbs with long creeping rhizome • Rhizomes are light brown to green, thick with short tan hairs at the ends and internodal roots, embedded in the muddy soil. • It is typically perennial but sometimes appears annual. • The land leaves are on erect, terete, 5–13 centimetres long petioles. Figure 62: Marsilea crenata: A. General diagram, B. Live view of plant 3.3.1.4.2 Ipomea sp Order: Solanales Family: Convolvulaceae Genus: Ipomoea Characters: • Grows in water or on moist soil, annual plant. • Stems are hollow, up to 3 m long or more, rooting at the nodes, floating in aquatic situations. • Flowers are showy, funnel form like morning-glory blooms, solitary or in few-flowered clusters at leaf axils. Petals five, connate and white to pinkish. • Sepals five, mostly free • Reproduced through seeds or by planting cuttings of the stem shoots

80 Figure 63: Ipomea aquatic: A. General diagram, B, Live view of Plant

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Course: General Practical Contents Netaji Subhas Open University P.G. Environmental Science PGES_P205

1 Unit 1: Macroscopic and microscopic identification of igneous, sedimentary and metamorphic rocks, common minerals; Study of fossils with reference to paleo- environment Rock The earth's crust is composed of rocks. A rock is an aggregate of one or more minerals. Rock may be hard or solf and in varied colours. For example, granite is hard, soapstone is soft. Gabbro is black and quartzite can be milky white. Rocks do not have definite composition of mineral constituents. Feldspar and quartz are the most common minerals found is rocks. Definition of different types of rocks Definition or Rocks: Rock can be defined as a material made of mineral particles bonded together. Rock is a hard and clastic substance. Therefore, rocks are aggregate of minerals. Rocks are classified according to their origin— (a) Igneous Rock: The Latin word 'Ignis' means fire. Igneous rocks are actually of fiery origin. They are made by the cooling and solidification of hot molten, material either magma within the earth's crust or lava or the earth's surface. Ex. Granite, Basalt, Dolerite. Igneous rocks are of two types— i) Extrusive rock ii) Intrusive rock. (b) Sedimentary Rock: The Latrin word 'Sedere' means 'Setting down'. Deposition of eroded materials of pre-existing rocks by natural agents like river glacier, wind at distant places below the river, lake, sea or oceans under water in layers and solidification of these sediments (deposited particles) in layers from sedimentary rocks. Ex. Coal, Shale, Sandstone, Limestone, Conglomerate, Laterite. Sedimentary rocks are either of classic or non-classic origin.

2 (c) Metamorphic Rock : The Greek word ‘meta’ means ‘altered’ and ‘morpho’ means form. Due to temperature or pressure a pre-existing either igneous or sedimentary rock changes into a new form of rock which is called metamorphic rock. Ex. Slate, Phyllite, Quartzite, Gneiss, Marble. Schist, metamorphic rock can be either foliated or non-foliated. 1.1 Identification of Igneous rocks 1.1.1 Aim To give knowledge to the learners to identify different types of igneous rocks along with their distinct characters. 1.1.2 Introduction A rock is a substance made up of one or more different minerals. Thus, an essential part of rock identification is the ability to correctly recognize the major (or most abundant) minerals within a given rock sample. This is often described as the rock’s mineralogy. Another important component in rock identification is to correctly interpret the rock texture. Technically, texture is the size, shape, and grain-to-grain relationships between minerals in a rock. For the purposes of this and the next two labs, texture really implies genesis, or how the rock formed. All rocks can be placed into one of three major rock groups based on their texture; igneous, sedimentary or metamorphic rocks. Recognition of the texture of a rock allows one to properly place the rock into its appropriate rock group. Igneous rocks form from the cooling and crystallization of molten rock. When minerals grow directly from a liquid the boundaries between adjacent minerals tend to penetrate each other, forming a very strong, interlocking pattern similar to that of pieces in a jigsaw puzzle. Given this and the fact that igneous rocks are composed of relatively hard silicate minerals, igneous rocks are very hard rocks that have been used as important building materials by people for thousands of years. 1.1.3 Mineralogy of Igneous Rocks All igneous rocks originally form from partial melting of the earth’s crust, or even, the earth’s upper mantle. Since both crust and upper mantle are composed largely of silicate minerals (minerals that contain both silicon and oxygen) igneous rocks also consist mostly of silicate minerals. In the early 1900’s a Canadian Petrologist by the name of N. L. Bowen first published the sequence of silicate minerals and the order in which they crystallize from a magma. This sequence of minerals is now referred to as Bowen’s Reaction Series (Figure 1). Bowen also proposed that a single magma body (a single liquid) may be capable of producing different types of igneous rocks through a process called fractional crystallization. As a magma body raises towards the surface minerals that crystallize from the magma may sink to the bottom of the magma chamber (or fractionate) and be left behind by the raising liquid. This would change the chemistry of the raising liquid causing it to crystallize different minerals on its way toward

3 the surface. In this way a very hot, very deep magma body would first crystallize olivine, which would sink to the bottom and be left behind. The raising and cooling magma body would then crystallize augite and calcium-rich plagioclase, which would sink and be left behind. Next would come hornblende and calcium-sodium plagioclase, then biotite and sodium-rich plagioclase and finally, as the magma nears the surface, the last minerals in Bowen’s sequence would crystallize out from the, largely cooled and solidified magma body. In Lab 3 we identified the major silicate minerals by first placing them into subclasses based on the arrangement of Si-O tetrahedra and metals present in the silicate mineral. For the purpose of this lab it is more convenient to classify the various silicate minerals based on their chemical composition. Ferromagnesian silicate minerals are those that contain high amounts of the metals iron, magnesium and/or calcium in them. These metals tend to make ferromagnesian silicates dark in color (dark gray to black). So igneous rocks that contain high percentages of ferromagnesian silicates tend to be dark colored. Nonferromagnesian silicate minerals are those that contain little or no iron, magnesium or calcium in them. Instead, they tend to have have sodium, potassium and/or aluminum in their chemical make up. These metals produce silicate minerals that have light colors (white, light gray or pink). Igneous rocks that contain high percentages of nonferromagnesian silicates tend to be light colored. Figure 1.1: The Bowen’s Reaction Series with ferromagnesian silicate minerals in bold-italic text and nonferromagnesian silicate minerals in normal text. 1.1.4 Identification of Igneous Rocks Identification of igneous rocks involves determining the major minerals (mineralogy) of the rocks and their texture. Determination of the mineralogy is aided by the color of the rock. Remember that ferromagnesian silicates are dark colored minerals and nonferromagnesian minerals are light in color. Very dark colored rocks (sometimes called ultramafic igneous rocks) consist primarily of the mineral olivine and are dark green. Dark colored rocks (mafic igneous rocks) are dark gray to nearly black. Both ultramafic and mafic igneous rocks consist

4 entirely of ferromagnesian silicate minerals. Medium colored igneous rocks (or intermediate igneous rocks) contain about half ferromagnesian silicates and about half nonferromagnesian silicates. Coarse-grained intermediate igneous rocks are said to have a "salt and pepper" appearance. Light colored igneous rocks, those dominated by nonferromagnesian silicates silicates are called felsic igneous rocks and are either pink or light gray. All igneous rocks that form from the slow cooling of magma are collectively called Plutonic igneous rocks. Because of the slow cooling, all Plutonic igneous rocks have a coarse-grained or phaneritic texture. All igneous rocks that form from the quick cooling of lava are collectively called Volcanic igneous rocks. Volcanic igneous rocks that form from lava flows generally have a porphyritic or a mixed coarse-grained (phenocrysts) and fine-grained (groundmass). In addition, basalt lavas tend to be rather gassy and so some basalt rocks may have a vesicular texture. Any time lava cools so quickly that no minerals get a chance to form then glass can be created. Some glasses are nonvesicular (obsidian) and some glasses may have been very gassy (scoria or pumice). Compacted volcanic ash or very hot volcanic ash that wields itself together due to extreme heat has a pyroclastic texture and is called tuff. All glasses, whether nonvesicular, vesicular or ash, contain NO minerals. 1

1 a) Granite i. Light coloured with spots of white, pink and black. Moderate to coarse grained, moderate to high specific gravity. ii. Composed of quartz, feldspar, mica. It is a hard, compact, massive. b) Basalt i. Dark black/grayish black, very fine grained, moderate to high specific gravity. ii. Composed of pyroxene, biotite. It is hard massive and compact. c) Dolerite i. Dark coloured, moderate grained, moderate to high specific gravity. ii. Composed of pyroxene, feldspar. It is hard, massive and compact have interfingering texture. Figure 1.2: Different types of igneous rocks [Source: https://www.sciencefacts.net/igneous- rocks.html]

2 Table 1.1: Keys to identify the Igneous rocks Grain Size Usual Color Other Composition Rock Type fine dark glassy appearance lava glass Obsidian fine light many small bubbles lava froth from sticky lava Pumice fine dark many large bubbles lava froth from fluid lava Scoria fine or mixed light contains quartz high-silica lava Felsite fine or mixed medium between felsite and basalt medium-silica lava Andesite fine or mixed dark has no quartz low-silica lava Basalt mixed any color large grains in fine- grained matrix large grains of feldspar, quartz, pyroxene or olivine Porphyry coarse light wide range of color and grain size feldspar and quartz with minor mica, amphibole or pyroxene Granite coarse light like granite but without quartz feldspar with minor mica, amphibole or pyroxene Syenite coarse light to medium little or no alkali feldspar plagioclase and quartz with dark minerals Tonalite coarse medium to dark little or no quartz low-calcium plagioclase and dark minerals Diorite coarse medium to dark no quartz; may have olivine high-calcium plagioclase and dark minerals Gabbro coarse dark dense; always has olivine olivine with amphibole and/or pyroxene Peridotite coarse dark dense mostly pyroxene with olivine and amphibole Pyroxenite coarse green dense at least 90 percent olivine Dunite very coarse any color usually in small intrusive bodies typically, granitic Pegmatite

3 1.2 Identification of Sedimentary rocks 1.2.1 Aim To give knowledge to the learners to identify different types of sedimentary rocks along with their distinct characters. 1.2.2 Introduction The word 'sedimentary' is derived from the Latin word sedimentum, which means settling. Rocks (igneous, sedimentary and metamorphic) of the earth's surface are exposed to denudational agents, and are broken up into various sizes of fragments. Such fragments are transported by different exogenous agencies and deposited. These deposits through compaction turn into rocks. This process is called lithification. In many sedimentary rocks, the layers of deposits retain their characteristics even after lithiflcation. Hence, we see a number of layers of varying thickness in sedimentary rocks like sandstone, shale etc. Depending upon the mode of formation, sedimentary rocks are classified into three major grops: (i) mechanically formed—sandstone, conglomerate, limestone, shale, loess etc. are examples; (ii) organically formed—geyserite, chalk, limestone, coal etc. are some examples; (iii) chemically formed—chert, limestone, halite, potash etc. are some examples. 1.2.3 Identifying characters of some sedimentary rocks a) Shale: i) Yellowish green/Grey/Brown/Greenish brown. Very fine grain size, moderate specific gravity. ii) Composed of clay minerals, gives smell of clay when water is applied, it is non clastic rock. b) Sandstone: i) White, light yellowish white, mixture, reddish brown medium to fine grain, moderate specific gravity. ii) Composed of sand and quartz, clastic surface, rough surface. c) Limestone: i) Black/Grey/Greyish white/Mixture/Reddish Brown, medium to fine grain, moderate specific gravity. ii) Composed of calcite, non clastic and reacts with HCl, can be scratched by knife. d) Conglomerate: i) Yellowish brown/White/Pinkish white, coarse grain, moderate specific gravity. ii) Composed of pebbles, sand/quartz, clastic texture. e) Laterite: i) Brown, orange, reddish brown, red, medium grained, moderate to high specific gravity. ii) Composed of bauxite, limestone, quartz, vesicular structure with spots of nodules, clastic rock, very rough surface.

4 Figure 1.3: Different types of sedimentary rocks [https://www.sciencefacts.net/sedimentary- rocks.html] Table 1.2: Keys to identify the Sedimentary rocks Hardness Grain Size Composition Other Rock Type hard coarse clean quartz white to brown Sandstone hard coarse quartz and feldspar usually very coarse Arkose

5 hard or soft mixed mixed sediment with rock grains and clay gray or dark and "dirty" Wacke/ Greywacke hard or soft mixed mixed rocks and sediment round rocks in finer sediment matrix Conglomerate hard or soft mixed mixed rocks and sediment sharp pieces in finer sediment matrix Breccia hard fine very fine sand; no clay feels gritty on teeth Siltstone hard fine chalcedony no fizzing with acid Chert soft fine clay minerals splits in layers Shale soft fine carbon black; burns with tarry smoke Coal soft fine calcite fizzes with acid Limestone soft coarse or fine dolomite no fizzing with acid unless powdered Dolomite rock soft coarse fossil shells mostly pieces Coquina very soft coarse halite salt taste Rock Salt very soft coarse gypsum white, tan or pink Rock Gypsum 1.3 Identification of Metamorphic rocks 1.3.1 Aim To give knowledge to the learners to identify different types of metamorphic rocks along with their distinct characters. 1.3.2 Introduction The word metamorphic means 'change of form'. These rocks form under the action of pressure, volume and temperature (PVT) changes. Metamorphism occurs when rocks are forced down to lower levels by tectonic processes or when molten magma rising through the crust comes in contact with the crustal rocks or the underlying rocks are subjected to great amounts of pressure by overlying rocks. Metamorphism is a process by which already consolidated rocks undergo recrystallisation and reorganisation of materials within original rocks. Mechanical disruption and reorganization of the original minerals within rocks due to breaking and crushing without any appreciable chemical changes is called dynamic metamorphism. The materials of rocks chemically alter and recrystallise due to thermal metamorphism. There are two types of thermal metamorphism — contact metamorphism and regional metamorphism. In contact metamorphism the rocks come in contact with hot intruding magma and lava and the rock materials recrystallise under high temperatures.

6 Quite often new materials form out of magma or lava are added to the rocks. In regional metamorphism, rocks undergo recrystallisation due to deformation caused by tectonic shearing together with high temperature or pressure or both. In the process of metamorphism in some rocks grains or minerals get arranged in layers or lines. Such an arrangement of minerals or grains in metamorphic rocks is called foliation or lineation. Sometimes minerals or materials of different groups are arranged into alternating thin to thick layers appearing in light and dark shades. Such a structure in metamorphic rocks is called banding and rocks displaying banding are called banded rocks. Types of metamorphic rocks depend upon original rocks that were subjected to metamorphism. Metamorphic rocks are classified into two major groups—foliated rocks and non-foliated rocks. Gneissoid, granite, syenite, slate, schist, marble, quartzite etc. are some examples of metamorphic rocks. 1.3.3 Identifying characters of some Metamorphic rocks a) State i) Greenish black/Grey, fine grained, moderate specific gravity. ii) Composed of clay, prominent foliation, gives metallic sound under Hammer blow. b) Phyllite i) Greenish grey/Grey/Green, moderate specific gravity. ii) Composed of chlorite and mica, foliated rock, fine to medium grain size. c) Quartzite i) White/Ash/Grey/Brownish grey, low to medium grained, low to moderate specific gravity. ii) Composed of sand, quartz sharp edge, non foliated. d) Gneiss i) Alternate band of light and dark colored, medium grained, moderate specific gravity. ii) Composed of mica, quartz and feldspar, non foliated. e) Marble i) White/Pink, orangish white, fine to medium grained, low to moderate specific gravity. ii) Composed of lime stone, react with HCl, non foliated. f) Schist i) Silver/White/Black/Green, medium grained, low to moderate specific gravity. ii) Composed of muscovite biotite chlorite, foliated rock, crystalline, quartz, foldspar.

7 Figure 1.4: Different types of sedimentary rocks [https://www.sciencefacts.net/metamorphic- rocks.html] Table 1.3: Keys to identify the Metamorphic rocks Foliation Grain Size Usual Color Other Rock Type foliated fine light very soft; greasy feel Soapstone foliated fine dark soft; strong cleavage Slate nonfoliated fine dark soft; massive structure Argillite foliated fine dark shiny; crinkly foliation Phyllite foliated coarse mixed dark and light crushed and stretched fabric; deformed large crystals Mylonite foliated coarse mixed dark and light wrinkled foliation; often has large crystals Schist foliated coarse mixed banded Gneiss foliated coarse mixed distorted "melted" layers Migmatite

8 foliated coarse dark mostly hornblende Amphibolite nonfoliated fine greenish soft; shiny, mottled surface Serpentinite nonfoliated fine or coarse dark dull and opaque colors, found near intrusions Hornfels nonfoliated coarse red and green dense; garnet and pyroxene Eclogite nonfoliated coarse light soft; calcite or dolomite by the acid test Marble nonfoliated coarse light quartz (no fizzing with acid) Quartzite Igneous or Sedimentary Rocks Metamorphic Rocks Shale — Slate Sandstone — Quartzite Granite — Gneiss Limestone — Marble Coal — Graphite 1.4 Identification of common minerals 1.4.1 Aim To give knowledge to the learners to identify different types of metamorphic rocks along with their distinct characters. 1.4.2 Introduction The earth is composed of various kinds of elements and these elements are in solid form in the outer layer of the earth and in hot and molten form in the interior. About 98 per cent of the total crust of the earth is composed of eight elements like oxygen, silicon, aluminium, iron, calcium, sodium, potassium and magnesium (Table), and the rest is constituted by titanium, hydrogen, phosphorous, manganese, sulphur, carbon, nickel and other elements. Table 1.4: The Major Elements of the Earth's Crust Sl. No. Elements By Weight (%) 1. Oxygen 46.60 2. Silicon 27.72 3. Aluminium 8.13 4. Iron 5.00 5. Calcium 3.63 6. Sodium 2.83 7. Potassium 2.59 8. Magnesium 2.09

9 9. Others 1.41 The elements in the earth's crust are rarely found exclusively but are usually combined with other elements to make various substances. These substances are recognised as minerals. Thus, a mineral is a naturally occurring inorganic substance, having an orderly atomic structure and a definite chemical composition and physical properties. A mineral is composed of two or more elements. But, sometimes single element minerals like sulphur, copper, silver, gold, graphite etc. are found. Through the number of elements making up the lithosphere are limited they are combined in many different ways to make up many varieties of minerals. There are at least 2,000 minerals that have been named and identified in the earth crust; but almost all the commonly occurring ones are related to six major mineral groups that are known as major rock forming minerals. The basic source of all minerals is the hot magma in the interior of the earth. When magma cools, crystals of minerals appear and a systematic series of minerals are formed in sequence to solidify so as to form rocks. Minerals such as coal, petroleum and natural gas are organic substances found in solid, liquid and gaseous forms respectively. 1.4.3 Definition of Minerals: Mineral is an inorganic homogeneous substance usually crystalline with a define chemical composition. Therefore, minerals are natural body without organic particles. Ex. Mica, Talc, Quartz, Feldspar, Gypsum, Hematite, Magnetite, Calcite, Chalcopyrite, Galena, Bauxite. 1.4.4 Physical Characteristics: (i) External crystal form—determined by internal arrangement of the molecules— cubes, octahedrons, hexagonal prisms, etc. (ii) Cleavage—tendency to break in given directions producing relatively plane surfaces—result of internal arrangement of the molecules—may cleave in one or more directions and at any angle to each other. (iii) Fracture—internal molecular arrangement so complex there are no planes of molecules; the crystal wil1 break in an irregular manner not along planes of cleavage. (iv) Lustre—appearance of a material without regard to colour; each mineral has a distinctive lustre like metallic, silky', glossy etc (v) Colour—some minerals have characteristic colour determined by their molecular structure—malachite, azurite, chalcopyrite etc. and some minerals are coloured by impurities. For example, because of impurities quariz may be white, green, red, yellow etc. (vi) Streak—colour of the ground powder of any mineral. It may be of the same colour as the mineral or may differ—malachite is given and gives green streak; fluorite is purple or green but gives a white streak.

10 (vii) Transparency—transparent; light rays pass through so that objects can be seen plainly; translucent—light rays pass through but will get diffused so that objects cannot be seen; opaque—light will not pass at all. (viii) Structure—particular arrangement of the individual crystals; fine, medium or coarse grained; fibrous—seperable, divergent, radiating. (ix) Hardness—relative resistance being scratched; ten minerals are selected to measure the degree of hardness from 1-10. They are: 1. talc; 2 . gypsum; 3. calcite; 4. fluorite; 5. apatite; 6. feldspar; 7. quartz; 8. topaz; 9. corundum; 10. diamond. Compared to this for example, a fingernall is 2.5 and glass or knife blade is 5.5. (x) Specific gravity—the ratio between the weight of a given object and the weight of an equal volume of water; object weighed in air and then weighed in water and divide weight in air by the difference of the two weights. 1.4.5 Some Major Minerals and their Characteristics Feldspar: Silicon and oxygen are common elements in all types of feldspar and sodium, potasium, calcium, aluminium etc. are found in specific feldspar variety. Half of the earth's crust is composed of feldspar. It has light cream to salmon pink colour. It is used in ceramics and glass making. Quartz: It is one of the most important components of sand and granite. It consists of silica. It is a hard mineral virtually insoluble in water. It is white or colourless and used in radio and radar. It is one of the most important components of granite. Pyroxene: Pyroxene consists of calcium, aluminum, magnesium, iron and silica. Pyroxene forms 10 per cent of the earth's crust. It is commonly found in meteorities. It is in green or black colour. Amphibole: Aluminium, calcium, silica, iron, magnesium are the major elements of amphiboles. They form 7 per cent of the earth's crust. It is in green or black colour and is used in asbestos industry. Hornblende is another form of amphiboles. Mica: It comprises of potassium, aluminium, magnesium, iron, silica etc. It forms 4 per cent of the earth's crust. It is commonly found in igneous and metamorphic rocks. It is used in electrical instruments. Olivine: Magnesium, iron and silica are major elements of olivine. It is used in jewellery. It is usually a greenish crystal, often found in basaltic rocks. Besides these main minerals, other minerals like chlorite, calcite, magnetitre, haematite, bauxite and barite are also present in some quantities in the rocks. Metallic Minerals: These minerals contain metal content and can be sub-divided into three types: (i) Precious metals: gold, silver, platinum etc. (ii) Ferrous metals: iron and other metals often mixed with iron to form various kinds of steel. (iii) Non-ferrous metals: include metals like copper, lead, zinc, tin, aluminium etc.

11 Non-Metallic Minerals: These minerals do not contain metal content, Sulphur, phosphates and nitrates are examples of non-metallic minerals. Cement is a mixture of non-metallic minerals. 1.4.6 Identifying characters of Minerals: a) Talc: i) White/Whitish grey/Grey, silky luster, low specific gravity. ii) Less than 2.5, soapy feeling b) Mica: i. Muscovite — i) Colour white, silver, pearly luster, very low specific gravity. ii) Hardness > 2.5, transparent and translucent mineral. ii. Biotite — i) Black coloured, pearly luster, very low specific gravity. ii) Hardness > 2.5, transparent and translucent mineral. c) Gypsum: i) White/Grey colored, sub-pearly luster, low specific gravity. ii) Hardness > 2.5, translucent mineral. d) Quartz: i) White/Greyish white, vitreous luster. ii) Hardness 6, crystalline mineral. e) Feldspar: i. Albite/Plagioclase — i) White/Grey, sub pearly luster, high to moderate specific gravity. ii) Hardness < 5, 2D Clevage. ii. Orthoclase — i) Reddish white/Pink color, sub peurly luster, high to moderate specific gravity. ii) Hardness < 5, 2D (Cleavage f) Hematite: i) Reddish brown (outer surface), Black inner surface, sub metallic luster, very high specific gravity. ii) Hardness 5.5 to 6.5, very low magnetism, gives cherry red streak. g) Magnetite: i) Iron black colored, submetallic to earthy luster, high specific gravity. ii) Hardness 5.5 to 6.5 highly magnetism, gives black streak.

12 h) Calcite: i) White colored, vitreous luster, low to moderate specific gravity. ii) 3D Cleavage, react with HCl. i) Bauxite: i) Creamy/Whitish cream/Grey/Earthy lustre, low to moderate specific gravity. ii) Non crystalline mineral, Pisolitic masses. j) Chalcopyrite: i) Golden yellow/yellow/Green, metallic luster, high specific gravity. ii) Hardness < 3.5 to 4, Greenish black streak, gives smell when HCl is applied. k) Gelena: i. Steel black/Iron black colored, metallic luster, very high specific gravity. ii. Hardness < 5.5, lead grey streak. l) Tourmaline: i. Silver or greenish black coloured, metallic lustre moderate specific gravity. ii. Hardness < 6, prismatic crystalls with rounded shape.

13 Figure 1.5: Different types of minerals'

14 Figure 1.6: Different types of minerals

15 Figure 1.7: Different types of minerals

16 Unit 2: Meteorological parameters 2.1 Temperature 2.1.1 Aim This protocol is to provide guideline and the instruction for monitoring the atmospheric temperature. 2.1.2 Introduction For meteorological purposes, temperature is measured for a number of media. Among them the most common variable measured is the atmospheric temperature (at variable heights). Other variables to be measured are the temperature of the ground, soil, grass minimum and seawater. The thermodynamic temperature (T), with units of kelvin (K), (also defined as "kelvin temperature"), is the basic temperature variable. The kelvin is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. The temperature (t), in degrees Celsius (or "Celsius temperature") is used for most meteorological purposes. A temperature difference of one-degree Celsius (°C) unit is equal to one kelvin (K) unit t/°C = T/K – 273.15 Meteorological requirements for temperature measurements primarily relate to the following: a. The air near the Earth's surface b. The surface of the ground c. The soil at various depths d. The surface levels of the sea and lakes e. The upper air.

17 These measurements are required, either jointly or independently and locally or globally, for input to numerical weather prediction models, for hydrological and agricultural purposes, and as indicators of climatic variability. 2.1.3 Measurement of temperature Measurement of temperature varied on different parameters • Measurement of temperature may be required as continuous records or may be sampled at different time intervals • For climate studies in particular, the temperature measurements are affected by o The state of the surroundings o Vegetation o The presence of buildings and other objects o Ground cover o The condition of and changes in the design of the radiation shield or screen o Other changes in equipment • It is important to note down the circumstances in which the measurements are taken along with the temperature record. This information are known as the metadata. 2.1.4 Equipment The major equipments are used to measure the temperature are: o Thermometers o Liquid-in- glass thermometers o Ordinary thermometers (Mercury-in-glass type thermometer) o Meteorological thermometers o Radiometric thermometers Figure 2.1:Liquid-in-glass thermometer Figure 2.2: Meteorological thermometer Figure 2.3: Radiometric thermometers

18 2.1.5 Thermometer exposure and siting Radiation from the sun, clouds, the ground and other surrounding objects passes through the air without appreciably changing it temperature, but a thermometer exposed freely in the open air can absorb considerable radiation and display the values. 2.1.6 Things to be remember Some important things to be remember during the measurement of the atmosphearic temperature which are o Temperature should be taken in morning, day time and afternoon and make the average. That will be the day temperature. o During taking temperature thermometer should be under some shade to avoid the extra heating of sun. o Measurement should be done in the open air 2.2 Atmospheric pressure 2.2.1 Aim This protocol is to provide guideline and the instruction for monitoring atmospheric pressure. 2.2.2 Introduction The atmospheric pressure on a given surface is the force per unit area exerted by virtue of the weight of the atmosphere above. The pressure is thus equal to the weight of a vertical column of air above a horizontal projection of the surface, extending to the outer limit of the atmosphere. The basic unit for atmospheric pressure measurements is the Pascal (Pa) (or Newton per square meter). The atmospheric pressure is measured by the barometers. Soe barometers are graduated in "millimetres or inches of mercury under standard conditions". Analysed pressure fields are a fundamental requirement of the science of meteorology. 2.2.3 Equipment For meteorological purpous, atmosphearic pressure is generally measured with o electronic barometers o mercury barometers o aneroid barometers or hypsometers Mercury Barometers A barometer is the instrument used to measure atmospheric pressure. Pressure tendency can forecast short term changes in the weather Figure 2.4: Mercury Barometer 19 Aneroid Barometers/ Aneroid Displacement Transducers The aneroid displacement transducers contain a sensor with electrical properties (resistance or capacitance) that changes as the atmospheric pressure changes. Aneroid barometers have lower accuracy than mercury barometers. These are compact and portable and easier to handle and use. Digital Piezoresistive Barometers Today mostly preferred pressure sensor is the piezoresistive sensor. It is cheap, and still delivers a good result. But it has drawbacks, significant power requirements, low output signal, large offset, and temperature dependence. 2.3 Humidity 2.3.1 Aim This protocol is to provide guideline and the instruction for monitoring and atmospheric humidity 2.3.2 Introduction the measurement of atmospheric humidity, and often its continuous recording, is an important requirement in most areas of meteorological activity. The most frequently used quantities in humidity measurements are as follows: Mixing ratio: It is the ratio between the mass of water vapour and the mass of dry air Specific humidity: The ratio between the mass of water vapour and the mass of moist air Figure 2.5: Aneroid Barometer Figure 2.6: Digital Piezoresistive Barometers

20 Relative humidity: The ratio in per cent of the observed vapour pressure to the saturation vapour pressure with respect to water at the same temperature and pressure. 2.3.3 Humidity measurements Humidity measurements at the Earth's surface are required for meteorological analysis and forecasting, for climate studies, and for many special applications in hydrology, agriculture, aeronautical services and environmental studies, in general. They are particularly important because of their relevance to the changes of state of water in the atmosphere. 2.3.4 Equipment The instrument is used for measuring the atmospheric humidity is known as a hygrometer. It measures the moisture content in the atmosphere. There is different type of hygrometer measurement methods. Gravimetric hygrometry This method uses the absorption of water vapour by a desiccant from a known volume of air. The gravimetric hygrometer is used for this purpose. The psychrometric method The measurement of atmospheric humidity is an important requirement in most of the areas of meteorological studies. Psychrometry is defined as the measurement of the moisture content of air. Now a days many humidity measuring devices are available. 2.3.5 Thing to be remember during the measurement Some things must be kept in mind during the measurement of atmospheric humidity o First of all, measurement must be done in the open environment and surrounding should be noted. Presence of water body in surrounding can rise the atmospheric humidity in local scale. o Meter must keep in avoidance of direct sunlight and blowing air to minimize the error 2.4 Wind speed 2.4.1 Aim This protocol is to provide guideline and the instruction for monitoring the surface wind speed. 2.4.2 Introduction Wind velocity is a three-dimentional vector quantity with small scale random fluctuation in space and time. Wind observation and measurement of velocity are required • For weather monitoring and forecasting • For wind load climatology for probability of wind damage Figure 2.7: Hygrometer

21 • For the estimation of wind energy, and as part of the estimation of surface fluxes • For visualise the desperation of the pollutants (gaseous) through the air and its distribution as well as direction. 2.4.3 Methods of measurement and observations • Wind speed should be reported to a resolution of 0.5 meter per second or in knots (0.515 meter per second) to the nearest unit for every 10 min. • Wind direction should be reported in degrees to the nearest 10 O • Surface wind is usually measured by a wind vane and cup or propeller anemometer • Simple hand-held anemometers are also available for this purpose • The standard exposure of wind instruments over a levelled open terrain id 10m above the ground • Two aspects are very important o The sensors should be kept away from local obstructions as much as possible o The local situation should be well documented Figure 2.8: Cup or propeller anemometer Figure 2.9: Hand-held anemometer

22 Unit 3: Air pollution sampling device and Ambient air quality 3.1 Demonstration of the operating principle of High-Volume Sampler 3.1.1 Aim To give knowledge to the learners how the high-volume sampler is being operated and the components of the high-volume sampler. 3.1.2 Introduction High volume samplers are the basic instruments used to monitor Ambient Air Quality. Suspended Particles upto 100 microns have emerged as the most critical among all the criteria air pollutants & is caused by number of sources like: Large, medium & small-scale industries Road dust construction activities, house hold fuel cooking, waste burning, vehicular emissions etc. In order to control the pollution, it is necessary to periodically monitor the air to determine the extent of pollution and to identify the source of emission is designed to meet these needs. That's why, they are in widespread use all over the world to measure air pollution in industrial areas, urban areas, on the shop floor, near monuments and other sensitive areas. The high-volume sampler working on Stokes law for collection of particulates matter and other gaseous materials. 3.1.3 Principle of operation In these samplers, air borne suspended particulates (SPM) are measured by passing air at a high flow rate of 1.1 to 1.7 cubic meters per minute through a high efficiency filter paper which retains the particles. The instrument measures the volume of air sampled, while the amount of particulates collected is determined by measuring the change in weight of the filter paper as a consequence of the sampling. The passage for air reaching the filter is designed to prevent heavier settleable dust particles from reaching the filter (by provision of cyclone) thus measuring the concentration of Suspended particulate matter (SPM) in the atmospheric air. High volume air samplers typically sample more than 1500 cubic metres (m) of air over a 24- hour period, while low volume air samplers draw through only 24m of air, or less. 3.1.4 Components of High-Volume Sampler • Heavy Duty Blower • Orifice flow meter: for measures the flow • Time Totalizer: to measure and record the measure time • Instrument Cabinet

23 • Filter Holder assembly: To hold the filter paper at the right position and ensure maximum suction air pass through the filter paper • Voltage stabilizer: to guards the apparatus from voltage fluctuation • Detachable Gable roof: Allows passage of air and protects filter 3.2 Analysis of sulphur dioxide in ambient air 3.2.1 Aim This protocol is to provide guideline and the instruction for monitoring and analysis of sulphur dioxide (SO 2) in ambient air. 3.2.2 Introduction Sulfur dioxide (SO 2) is a colourless, reactive air pollutant with a strong odor. This gas can be a threat to human health, animal health, and plant life. The main sources of sulfur dioxide emissions are from fossil fuel combustion and natural volcanic activity. Sulfur dioxide irritates the skin and mucous membranes of the eyes, nose, throat, and lungs. High concentrations of SO 2 can cause inflammation and irritation of the respiratory system, especially during heavy physical activity. The resulting symptoms can include pain when taking a deep breath,

24 coughing, throat irritation, and breathing difficulties. High concentrations of SO 2 can affect lung function, worsen asthma attacks, and worsen existing heart disease in sensitive groups. This gas can also react with other chemicals in the air and change to a small particle that can get into the lungs and cause similar health effects. 3.2.3 Standard The national ambient air quality standard for sulphur dioxide is as follows Pollutant Time Weighted Average Concentration [µg/m 3] Industrial, Residential, Rural and other Areas Ecologically Sensitive Area [Notified by Central Government] Sulphur Dioxide (SO 2), Annual * 50 20 24 Hours ** 80 80 * Annual: Arithmetic mean of minimum 104 measurements in a year (twice in a week), at a particular site for 24h at uniform intervals. ** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring. 3.2.4 Methods of Estimation Modified West & Gaeke Method is used to estimate ambient air sulphur dioxide. a) Principal Sulphur dioxide from air is absorbed in a solution of potassium tetrachloromercurate (TCM). A dichlorosulphitomercurate complex, which resists oxidation by the oxygen in the air, is formed. Once formed, this complex is stable to strong oxidants such as ozone and oxides of nitrogen and therefore, the absorber solution may be stored for some time prior to analysis. The complex is made to react with para-rosaniline and formaldehyde to form the intensely coloured pararosaniline methylsulphonic acid. The absorbance of the solution is measured by a spectrophotometer at 560 nm.

25 b) Apparatus and equipment's The following items are required to analysis of sulphur dioxide in ambient air • Analytical balance • Handy air sampler equipped with o Vacuum pump capable to maintain pressure grater than 0.7 atmosphere pressure o Flow controller to control the airflow from 0.2 to 1 L/minute o Impinger, midget glass impinger that contains absorber • Spectrophotometer: Capable of measuring absorbance at 560 nm equipped with 1 cm path length cells • Glass wares: Dark glass were to protect chemicals from sunlight c) Reagents and standers • Absorbing Reagent, Potassium Tetrachloro Mercurate, 0.04 M (TCM): Dissolve 10.86 g mercuric chloride, 0.066 g EDTA and 6.0 g potassium chloride or 4.68 g sodium chloride in water and volume make up to 1 L in a volumetric flask. The pH of this reagent should be approximately 4.0. The absorbing reagent can be used up to six months. Remember this reagent is highly poisonous if spilled on skin, flush off with water immediately. • Sulphamic Acid (0.6%): Dissolve 0.6 g sulphamic acid in 100 ml distilled water. Remember it must be prepared freshly. • 0.2 % Formaldehyde: Dilute 5 mL formaldehyde solution (36-38%) to 1 L with distilled water. Freshly prepare. • Purified Pararosaniline Stock Solution (0.2% Nominal): Dissolve 0.500 gm of specially purified pararosaniline (PRA) in 100 ml of distilled water and keep for 2 days (48 hours). • Pararosaniline Working Solution: 10 ml of stock PRA is taken in a 250 ml volumetric flask. Add 15 ml conc. HCL and make up to volume with distilled water. • Iodine Solution (0.01 N): Place 1.27 g iodine in a 250 ml beaker, add 4 g potassium iodide and 25 ml water. Stir until all is dissolved, then dilute to 1 litre with distilled water. • Starch Indicator Solution: Triturate 0.4 gm soluble starch and 0.002 g mercuric iodide preservative with a little water and add the paste slowly to 200 ml boiling water. Continue boiling until the solution is clear, cool, and transfer to a glass stoppered bottle. • Stock Sodium Thiosulfate Solution (0.01 N): Prepare a stock solution by placing 2.5 g sodium thiosulfate pentahydrate in a beaker, add 0.1 g sodium carbonate and dissolve using boiled and cooled distilled water making the solution up to a final volume of 1 litre. Figure 3.1: Handy air sampler

26 • Standardized Sulphite Solution for Preparation of Working Sulphite-TCM Solution: Dissolve 0.30 g sodium metabisulphite (Na 2 S 2 O 5) or 0.40 g sodium sulphite (Na 2 SO 3) in 500 ml of recently boiled, cooled, distilled water. Sulphite solution is unstable; it is, therefore, important to use water of the highest purity to minimize this instability. This solution contains the equivalent of 320-400 µg/ml of SO 2 • Working Sulphite-TCM Solution: Measure 2 ml of the standard solution into a 100 ml volumetric flask by pipette and bring to mark with 0.04 M TCM. Calculate the concentration of sulphur dioxide in the working solution in micrograms of sulphur dioxide per millilitre. This solution is stable for 30 days if kept in the refrigerator at 5 o C. If not kept at 5 o C, prepare fresh daily. d) Sampling Place 30 ml of absorbing solution in an impinger and sample for four hours at the flow rate of 1 L/min. After sampling measure the volume of sample and transfer to a sample storage bottle. e) Calibration The actual concentration of the sulphite solution is determined by adding excess iodine and back titrating with standard sodium thiosulfate solution. To back-titrate, measure, by pipette, • 50 ml of the 0.01 N iodine solution into each of two 500 ml iodine flasks A and B. To flask A (blank) add 25 ml distilled water and into flask B (sample) measure 25 ml sulphite solution by pipette. Lid up the flasks and keep in dark to react for 5 minutes. • Prepare the working sulphite- tetrachloro Mercurate (TCM) solution at the same time iodine solution is added to the flasks. • By means of a burette containing standardized 0.01 N thiosulfate, titrate each flask in turn to a pale yellow. Then add 5 ml starch solution and continue the titration until the blue colour disappears. f) Procedure Replace any water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber. Mix thoroughly, pipette out 10/20 ml of the collected sample into a 25 ml volumetric flask. • Add 1 ml 0.6% sulphamic acid and allow reacting for 10 minutes to destroy the nitrite resulting from oxides of and make up to 25 ml with distilled water. • Prepare a blank in the same manner using 10 ml of unexposed absorbing reagent. After a 30 min colour development interval and before 60 minutes, measure and record the absorbance of samples and reagent blank at 560 nm. • Use distilled water, not the reagent blank, as the optical reference Preparation of Standards • Measure 0.5 ml, 1.0 ml, 1.5 ml, 2.0 ml, 2.5 ml, 3.0 ml, 3.5 ml and 4.0 ml of working sulphite TCM solution in 25 ml volumetric flask. Figure 3.2: Standard Impinger

27 • Add sufficient TCM solution to each flask to bring the volume to approximately 10 ml. Then add the remaining reagents as described in the procedure for analysis. • A reagent blank with 10 ml absorbing solution is also need to prepare. • Read the absorbance of each standard and reagent blank Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF). Flow Chart for Measurement of Sulphur Dioxide g) Calculation Concentration of sulphate solution Place 30ml of absorbing media in an impinger Connect it to the gas-sampling manifold of gas sampling device (RDS/HVS). Draw air at a sampling ra te of 1L/min for four hours Check the volume of sample at t he end of sampling and record it Transfer the exposed samples in storage bottle and preserve Prepare calibration graph as recommended in method Take 10/20 ml. aliquot of sample in 25 ml. Vol. Flask Take 10/20 ml. of unexposed sample in 25 ml. Vol. Flask (blank) Add 1 ml Sulphamic acid. Keep it 10 minutes Add 2 ml formaldehyde and 2 ml working PRA Make up to mark (25 ml.) with distilled water . Keep it 30 minutes for reaction Set Zero of spectrophotometer with Distilled water Measure absorbance at 560 nm Calculate concentration using calibration graph Calculate concentration of Sulphur dioxide in µg/m3

28 2 / = (1 – 2) × × Where, 1 = Volume of thiosulfate for blank, ml 2 = Volume of thiosulphate for sample, ml = Normality of thiosulphate, 0.01N K= 32000 (Milliequivalent weight SO 2 /µg V= Volume of standard sulphate solution, ml Concentration of Sulphur dioxide (µg/m 3) 2 / 3 = (–) × × × Where, A s = Absorbance of sample A b = Absorbance of reagent blank Cf = Calibration factor V a = Volume of air sampled, m 3 V s = Volume of sample, ml V an = Volume of aliquot taken for analysis, ml

29 3.3 Analysis of Nitrogen dioxide in ambient air 3.3.1 Aim This protocol is to provide guideline and the instruction for monitoring and analysis of Nitrogen dioxide (NO 2) in ambient air. 3.3.2 Introduction Many chemical species of nitrogen oxides (NO x) exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide (NO 2). Nitrogen dioxide is soluble in water, reddish-brown in colour, and a strong oxidant. Nitrogen dioxide is an important atmospheric trace gas, not only because of its health effects but also because a. it absorbs visible solar radiation and contributes to impaired atmospheric visibility b. as an absorber of visible radiation, it could have a potential direct role in global climate change if its concentrations were to become high enough c. it plays a critical role in determining ozone (O 3) concentrations in the troposphere because the photolysis of nitrogen dioxide is the only key initiator of the photochemical formation of ozone, whether in polluted or unpolluted atmospheres. The major source of anthropogenic emissions of nitrogen oxides into the atmosphere is the combustion of fossil fuels in stationary sources (heating, power generation) and in motor vehicles (internal combustion engines). In most ambient situations, nitric oxide is emitted and transformed into nitrogen dioxide in the atmosphere. Oxidation of nitric oxide by atmospheric oxidants such as ozone occurs rapidly, even at the low levels of reactants present in the atmosphere. 3.3.3 Standard The national ambient air quality standard for nitrogen dioxide is as follows Pollutant Time Weighted Average Concentration [µg/m 3] Industrial, Residential, Rural and other Areas Ecologically Sensitive Area [Notified by Central Government] Nitrogen dioxide (NO 2), Annual * 40 30 24 Hours ** 80 80 * Annual: Arithmetic mean of minimum 104 measurements in a year (twice in a week), at a particular site for 24h at uniform intervals. ** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring. 3.3.4 Methods of Estimation Modified Jacob and Hochheiser method is used to estimate ambient air nitrogen dioxide.

30 a) Principal Ambient nitrogen dioxide (NO 2) is collected by bubbling air through a solution of sodium hydroxide and sodium arsenite. The concentration of nitrite ion (NO 2) produced during sampling is determined colorimetrically by reacting the nitrite ion with phosphoric acid, sulfanilamide, and N-(1-naphthyl)-ethylenediamine di-hydrochloride (NEDA) and measuring the absorbance of the highly coloured azo-dye at 540 nm b) Apparatus and equipment's The following items are required to analysis of nitrogen dioxide in ambient air • Analytical balance • Handy air sampler equipped with o Vacuum pump capable to maintain pressure greater than 0.6 atmosphere pressure o Flow controller to control the airflow from 0.2 to 1 L/minute o Impinger, midget glass impinger that contains absorber • Spectrophotometer: Capable of measuring absorbance at 540 nm equipped with 1 cm path length cells • Glass wares: Dark glass were to protect chemicals from sunlight c) Reagents and standers • Absorbing Reagent: 4 g sodium hydroxide dissolved in distilled water and add 1.0 g of sodium arsenite and diluted to 1000 ml with distilled water. • Sulphanilamide Solution: Dissolve 20 g of sulphanilamide in 700 ml of distilled water. Add, with mixing, 50 ml of 85% phosphoric acid and dilute to 1,000 ml. This solution is stable for one month, if refrigerated • N-(1-Naphthyl)-ethylenediamine Di-hydrochloride [NEDA] Solution: Dissolve 0.5 g of NEDA in 500 ml of distilled water. This solution is stable for one month, if refrigerated and protected from light • Hydrogen Peroxide Solution: Dilute 0.2 ml of 30% hydrogen peroxide to 250 ml with distilled water. This solution may be used for one month, if, refrigerated and protected from light • Sodium Nitrite stock solution (1000 µg NO 2 /ml): Dissolve 0.1g NaNO 2 (Assay of minimum 97%) in 100 ml absorbing reagent. • Sodium Nitrite working solution (1 µg NO 2 /ml): Dilute 1 ml stock solution to 1000 ml with absorbing reagent, prepare fresh daily Figure 3.3: Handy air sampler

31 d) Sampling Place 30 ml of absorbing solution in an impinger and sample for four hours at the flow rate of 0.2 to 1 L/min. After sampling measure the volume of sample and transfer to a sample storage bottle. e) Calibration The actual concentration of the sulphite solution is determined by adding excess iodine and back titrating with standard sodium thiosulfate solution. To back-titrate, measure, by pipette, • 50 ml of the 0.01 N iodine solution into each of two 500 ml iodine flasks A and B. To flask A (blank) add 25 ml distilled water and into flask B (sample) measure 25 ml sulphite solution by pipette. Lid up the flasks and keep in dark to react for 5 minutes. • Prepare the working sulphite- tetrachloro Mercurate (TCM) solution at the same time iodine solution is added to the flasks. • By means of a burette containing standardized 0.01 N thiosulfate, titrate each flask in turn to a pale yellow. Then add 5 ml starch solution and continue the titration until the blue colour disappears. f) Procedure Replace any water lost by evaporation during sampling by adding distilled water up to the calibration mark on the absorber, mix thoroughly. • Pipette out 10 ml of the collected sample into a 50 ml volumetric flask. Pipette in 1 ml of hydrogen peroxide solution, 10 ml of sulphanilamide solution, and 1.4 ml of NEDA solution, with thorough mixing after the addition of each reagent and make up to 50 ml with distilled water. • Prepare a blank in the same manner using 10 ml of unexposed absorbing reagent. After a 10 min colour development interval, measure and record the absorbance of samples and reagent blank at 540 nm. • Use distilled water; not the reagent blank, as the optical reference • Samples with an absorbance greater than 1.0 must be re-analyzed after diluting an aliquot of the collected samples with an equal quantity of unexposed absorbing reagent. Preparation of Standards • Measure 1 ml, 2 ml, 4 ml, 6 ml, 8 ml, 10 ml, 12 ml and 15 ml of working nitrate standard solution in 50 ml volumetric flask. • Fill to 20 ml mark with absorbing solution • A reagent blank with 10 ml absorbing solution is also need to prepare. • Then add the other reagents as described in the procedure for analysis • Read the absorbance of each standard and reagent blank Figure 3.4: Standard Impinger

32 Plot a curve absorbance (Y axis) versus concentration (X axis). Draw a line of best fit and determine the slope. The reciprocal of slope gives the calibration factor (CF). Flow Chart for Measurement of Nitrogen Dioxide g) Calculation Concentration of Nitrogen dioxide (μg/m 3) 2 / 3 = (−) × × × × 0.82 Where, A s = Absorbance of sample A b = Absorbance of reagent blank Cf = Calibration factor V a = Volume of air sampled, m 3 Place 30ml of absorbing media in an impinger Connect it to the gas-sampling manifold of gas sampling device (RDS/HVS). Draw air at a sampling ra te of 1L/min for four hours Check the volume of sample at the end of sampling and record it Transfer the exposed samples in storage bottle and preserve Prepare calibration graph as recommended in method Take 10 ml. aliquot of sample in 50 ml. Volumetric Flask Take 10 ml. of unexposed sample in 50 ml. Vol. Flask (blank) Add 1 ml hydrogen peroxide (H 2 O 2), 10 ml sulphanilamide and 1.4 ml NEDA Make up to mark (50 ml) with distilled water . Keep it 10 minutes for reaction Set Zero of spectrophotometer with Distilled water Measure absorbance at 540 nm Calculate concentration using calibration graph Calculate concentration of Nitrogen dioxide in μg/m 3

33 V s = Volume of sample, ml V an = Volume of aliquot taken for analysis, ml 0.82= Sampling efficiency 3.4 Analysis of Particulate matter (PM 10) in ambient air 3.4.1 Aim This protocol is to provide guideline and the instruction for monitoring and analysis of Particulate matter (PM 10) in ambient air. 3.4.2 Introduction Airborne particulate matter represents a complex mixture of organic and inorganic substances. Mass and composition tend to divide into two principal groups: coarse particles mostly larger than 2.5 μm to 10 μm in aerodynamic diameter (PM 10), and fine particles mostly smaller than 2.5 μm in aerodynamic diameter (PM 2.5). The larger particles usually contain earth crust materials and fugitive dust from roads and industries. An idealized distribution of ambient particulate matter is shown in figure (Figure 3.5). Particulate air pollution is a mixture of solid, liquid or solid and liquid particles suspended in the air. These suspended particles vary in size, composition and origin. It is convenient to classify particles by their aerodynamic properties because: a. they govern the transport and removal of particles from the air b. they also govern their deposition within the respiratory system c. they are associated with the chemical composition and sources of particles. These properties are conveniently summarized by the aerodynamic diameter, that is the size of a unit-density sphere with the same aerodynamic characteristics. Particles are sampled and described on the basis of their aerodynamic diameter, usually called simply the particle size.

34 Figure 3.6: Schematic representation of the size distribution of particulate matter in ambient air (USEPA, 1996) 3.4.3 Standard The national ambient air quality standards for Particulate matter (PM 10) is as follows Pollutant Time Weighted Average Concentration [μg/m 3] Industrial, Residential, Rural and other Areas Ecologically Sensitive Area [Notified by Central Government] Particulate Matter (PM 10) Annual * 60 60 24 Hours ** 100 100 * Annual: Arithmetic mean of minimum 104 measurements in a year (twice in a week), at a particular site for 24h at uniform intervals. ** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring. 3.4.4 Methods of Estimation Gravimetric method is used to estimate the concentration of particulate matter in ambient air.

35 a) Principal Air is drawn through a size-selective inlet and through a 20.3 × 25.4 cm (8 × 10 in) filter paper at a flow rate of 1132 L/min. Particles with aerodynamic diameter less than the cut- point of the inlet are collected, by the filter. The mass of these particles is determined by the difference in filter weights prior to and after sampling. The concentration of particulate matter (PM 10) in the designated size range is calculated by dividing the weight gain of the filter paper by the volume of air sampled. b) Apparatus and equipment's The following items are required to analysis of particulate matter (PM 10) in ambient air • Analytical balance • Dryer/ hot air oven • High volume sampler equipped with o Size selective inlet for PM 10 o Automatic volumetric flow control (airflow controlled to 1132 L/min) o Top loading orifice kit c) Reagents and standers A glass fibre filter paper of size 20.3 × 25.4 cm (8×10 in) d) Sampling Open the inlet and secure it according to manufacturer's instructions. Loosen the faceplate wing nuts and remove the faceplate. Filter paper must be dryed in hot air oven and cooled in a decigator. Take the waight of the filter paper and put in to the jacket. Remove the filter from its jacket and centre it on the support screen with the rough side of the filter facing upwards. Replace the faceplate and tighten the wing nuts to secure the rubber gasket against the filter edge. Gently lower the inlet. For automatically flowcontrolled units, record the designated flow rate [1132 L/min] on the data sheet. Record the reading of the elapsed time meter. The specified length of sampling is commonly 8 hours. During this period, hourly reading of flow rate should be taken. After the required time of sampling, record the flow meter reading, take out the filter media from the sampler, and put in a container or envelope. Figure 3.7: High Volume air sampler

36 Figure 3.8: Schematic diagram of high-volume sampler Figure 3.9: PM 10 sampler unit e) Calibration Periodical calibration of the sampler is being done by Orifice Transfer Standard – The PM sampler calibration orifice consists of a 3.175 cm (1.25 in) diameter hole in the end 10 cap of 7.62 cm (3 in) diameter by 20.3 cm (8 in) long hollow metal cylinder. This orifice is mounted tightly to the filter support in place of the inlet during calibration. A small tap on the side of the cylinder is provided to measure the pressure drop across the orifice. A flow rate of 1132 L/min through the orifice typically results in a pressure difference of several inches of water. The relationship between pressure difference and flow rate is established via a calibration curve derived from measurements against a primary standard such as a Roots meter at standard

37 temperature and pressure. Flow resistances that simulate filter resistances are introduced at the end of the calibrator opposite the orifice by a set of perforated circular disks. f) Procedure Inspect the filter for pin holes using a light table. Loose particles should be removed with a soft brush. Apply the filter identification number or a code to the filter if it is not a numbered. Dried in hot air oven within 30-40°C and cooled in an airtight desiccator for 24 hours. Take initial weight of the dried and cooled filter paper (W i) before sampling. Take final weight of the filter paper (W f) Flow Chart for Measurement of PM 10 g) Calculation Concentration of PM 10 (μg/m 3) 10 / 3 = (–) × 10 6 Where, W f = Final weight of filter paper (g) W i = weight of filter paper (g) Check the filter for any physical damages Mark identification number on the filter Condition the filter in conditioning room / desiccator for 24 hours Record initial weight and Place the filter on the sampler Run the sampler for eight hours Record the flow rate on hourly basis Remove the filter from the sampler Keep the exposed filter in a proper container Record the total time of sampling & average flow rate Dry the filter paper and Record final weight Calculate the concentration of PM in μg/m 3

38 10 6 = Conversion of g to μg V = Volume of air sampled, m 3

39 Unit 4: Measurement of Noise level 4.1.1 Aim This protocol aims to be carried out Ambient Noise monitoring on a routine basis or to address public complaints. The objective is to monitor the noise level at a particular site or as described in the complaints. The data generated by the method shall also evaluate with prescribed noise level standards. 4.1.2 Introduction Noise is. typically defined as unwanted sound. Sound which pleases the listeners is music and that which causes pain and annoyance is noise. At the time a sound that is music for some can be noise for others. Machines that have been developed for industrial purposes, for speedy transportation, or household equipment to make life more smoothing by reducing the workload and shaving time most of them produce a sound which becomes noise in different circumstances. It may also be generated from the flashing river ting, rock fall from chutes and funker, air flast etc. From this, we can say that noise is a type of sound with no musical quality a wrong sound in the wrong place and at the wrong time. Noise pollution refers to sounds in the environment that are caused by humans and that threaten the health or welfare of human or animal inhabitants. 4.1.3 Noise Rules and Standards The standards are the statutory values (legally valid) of noise for a specified location and time. Central Government notified the Noise Pollution (Regulation and Control) Rules, 2000 as it is published in the Gazette of India, Extraordinary, Part-II –section 3(ii), vide S.O 123 (E) dated 14.2.2000. In this rule following responsibilities are vested with State Governments, District Magistrate, Police Commissioner, or any other officer, not below the rank of Deputy Superintendent of Police: 1. Enforcement of Noise Pollution control measures and the due compliance of ambient air quality standards in respect of noise. 2. Restriction on the use of Loud Speakers/Public Address system. 3. Restriction on the use of Horns, Sound emitting construction equipment and bursting of Firecrackers. 4. Prohibition of continuance Music Sound or Noise. 5. Authority shall act on the complaint and take action against the violator in accordance with the provisions of the rules. 6. Disallowing sound-producing instruments after 10 p.m to 6 a.m except in closed premises. 7. 7. State Government may permit loudspeakers or public address systems during night hours (between 10.00 p.m. to 12.00 midnight not exceeding 15 days in a year).
40 Table 4.1: Ambient Air Quality Standards in Respect of Noise is notified under Noise Pollution (Regulation and Control) Rules, 2000. Area Code Category of Area/ Zone Limit in dB(A) Leq Day Time Night Time A Industrial Area 75 70 B Commercial Area 65 55 C Residential Area 55 45 D Silence Zone 50 40 Note: • Daytime shall mean from 6 AM to 10 PM • Night time shall mean from 10 PM to 6 AM • A silence Zone is defined as areas up to 100 meters around such premises as hospitals, educational institutes and courts. The Silence Zones are to be declared by a competent authority. • Mixed categories of areas may be declared as one of the four above-mentioned categories by the competent authority. • dB(A) Leq denotes the time-weighted average of the level of sound in decibels on scale A which is relatable to human hearing. • A "decibel" is a unit in which noise is measured. • "A", in dB (A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear. • Leq: It is the energy mean of the noise level over a specific period. 4.1.4 Methods of Estimation 4.1.5 Principal The sound produced from any source is stimuli and it can be measured as sound pressure. The sound pressure range varies from 20μPa- 200 Pa and it can be expressed on a scale based on the log of the ratio of measured sound pressure and a reference standard pressure Sound Level (L), = 10 0 (bel) Were, = Measured quantity of sound pressure or sound power, or sound intensity. 0 = Reference standard quantity of sound pressure, sound power, or sound intensity (20 × 10 - 6 Pa) L= Sound Level in Bels (B) The sound wave energy is converted into an electrical signal through the microphone, then the pre-amplifier boosted it in magnitude. The rectifier converts the AC signals to DC to cause the meddle to display the meter to register the sound pressure level directly in dB. The middle
41 motion is directly controlled by a fast/slow response setting. Sound level meters are designated as small band-held instruments powered by lithium-ion batteries. Leq Leq is the statistical value of sound pressure level that can be equated to any fluctuating noise level. E.g. a sound of 40 dB last for 5 min, for the next 10 min sound is 85 dB and then followed by a sound of 100 dB for the next 5 min, which will compose a fluctuating noise level, which is indicative of producing the same effect over the entire period of 5+10+5= 20 minutes in dB. This value is called Equivalent continuous equal energy level, Leq. Leq = 10∑(10) 10 × = =1 n= number of sound samples, Li=The noise level of any i th sample, ti= time duration of i th sample, tt= total period of the event. Leq is also defined as the constant noise level, which over a given time, expands the same amount of energy, as is expanding by the fluctuating levels over the same time. A sound level meter that measures the sound pressure level with a "flat" response will indicate the strength of low- frequency sound with the same emphasis as higher-frequency sounds. Therefore, the sound meter is equipped with a frequency-weighting filter. The human ear does not respond uniformly to sounds of all frequencies being less efficient to low and high frequencies as compared to medium-range frequencies. To obtain a sound level which covers a wide range of frequencies and conforms approximately to the response of the human ear, a frequency weighting filter is used. The resultant sound level obtained is A weighted sound. Therefore, we measure sound level as Leq dB(A). Figure 4.1:
A graph of the A-, B-, C- and D-weightings across the frequency range 10 Hz – 20 kHz [
https://en.wikipedia.org/wiki/A- weighting#/media/File:Acoustic_weighting_curves_(1).svg]

42 4.1.6 Site selection criteria The site of an area shall be selected based on the land use pattern as prescribed in the legislation e.g. Industrial, Commercial, Residential and Silence Zone. Minimal key points to be maintained: • The station should be located at the ambient level i.e. away from the direct source, away from any vibration and any obstruction. • Categorize the area with a land use pattern. • The microphone must be placed 1.2 -1.5m above the ground level. • In dry conditions with a wind speed of less than 5 m/s. • Isolate the instrument from strong vibration and shock. 4.1.7 Selection of Noise level meter: Type 1 integrating sound level meter with free-field microphone with the accuracy of noise measurement as per IEC 804 (BS 6698) Grade I or IEC 61672-1 (2002-05) Class-I or ANSI type I is to be selected for Noise measurement. 4.1.8 Noise measuring instrument and method: The instrument used to measure and evaluate noise is a sound level meter. This instrument is designed to respond in approximately a similar way as the human ear and to give reproducible measurements of sound pressure level. The basic components of a sound level meter include- • Microphone that converts the sound signal to an equivalent electrical signal, • Amplifiers: Electrical signal produced by the microphone is very small and it required a preamplifier before processing. • weighting network and • display meter reading in dB Figure 4.3: Diagram of Sound Level Meter working mechanism Figure 4.2: Sound Level Meter

43 4.1.9 Calibration: Make sure that the instrument is properly calibrated. Measurements should be accepted as valid only if the calibration level from before and after the noise measurement agrees to be within 1.0 dB. The sound level meter and calibrator will hold a current calibration certificate traceable to national standards. Start the calibrator and put on 1 kHz frequency calibration on two values 94 dB and 114 dB. If the instrument shows more than ± 0.3 dB differences adjust the calibration. Calibration is done O.K. now the instrument is ready for monitoring. 4.1.10 Apparatus and equipment A sound level meter is required for noise measurement 4.1.11 Procedure Controlling the equipment as per the model and manufacturer's instructions. But some basic procedures need to be followed. a) During ambient noise monitoring sound comes from a different direction, so it is important to fit the microphone to the best possible Omni directional characteristics b) First determent the proper measuring range selector. c) According to various measurements, sounds select the time weighting selector to fast a slow. d) Hold the instrument in Range and point the microphone at the measured noise source. The sound level meter will be displayed on the dB unit. e) The noise measurement equipment will be supervised continuously during the monitoring period and notes will be made of the date, time and prevailing weather conditions f) Noise measurements should not be made in fog and rain 4.1.12 Results: Noise can be recorded as: Description of the Location: Date: Noise Level Meter Make Model Serial No. Calibration result of Noise Level Meter Calibration 94 dB at 1000Hz 114 dB at 1000 Hz Initial Final Sampling rate Sl. No. Time duration File No. Sound Parameters (dBA) Leq L 10 L 50 L 90 L min L max 1.

44 2. 3. 4. 5. Average L equivalent dB (A) Monitoring team and signature Unit 5: Plankton collection and counting 5.1.1 Introduction The term plankton was first proposed by Hensen in 1887. The word plankton comes from the Greek word planktos, which means “drifter.” Their name fits, because planktons are un able to swime by their own or fixed any place in the aquatic system. They drift about in the water, allowing tides, currents, and other factors determine where they go. Although they are very small/ microscopic in size but in the aquatic system, they provide a crucial source of food to many small and large aquatic organisms. There are two main types of plankton: phytoplankton, which are plants in nature, and zooplankton, which are animals in nature. Zooplankton and other small marine creatures eat phytoplankton and then become food for fish, crustaceans, and other larger species. Phytoplankton assimilates energy through photosynthesis, the process of using chlorophyll and sunlight to create energy. Like other plants, phytoplankton take in carbon dioxide and release oxygen. Phytoplankton account for about half of the photosynthesis on the planet, making them

45 one of the world's most important producers of oxygen. Phytoplankton rely on nutrients found in their surroundings, such as phosphate, nitrate, and calcium, to thrive. 5.1.2 Collection of Plankton There are three methods of plankton sampling A. Bottle Sampler: Sampling through the bottle sampler is the recommended method to obtain an accurate picture of the quantitative composition of the phytoplankton in the water body. A bottle sampler can obtain the whole size spectrum from the large entities. These are ideal for quantitative plankton collections as required quantities of water can be collected from any desired depth of shallow systems like a lake, the near sea shore water, estuaries and mangroves. Water samples are generally used from vessels, ships or fish trawlers. Figure 5.1:Bottle plankton sampler B. Plankton pumps: Plankton pumps are integrating samplers that pump a continuous stream of water to the surface and the planktons can then be rapidly concentrated by continuous filtration. Because the pumps can collect continuously as the tube is lowered through the water column the samples are integrated from the surface to desired depth. This method has its disadvantages, e.g., breaking up colonies, breaking the body parts of planktons. C. Plankton nets: The easiest and quickest way of obtaining a concentrated sample of phytoplankton is to tow a cone-shaped bolting silk net through the water. The wider end of the net is kept open by a metal ring and this is attached to a tow rope. The narrow end of the net is closed by a plastic bucket or tube. When hauling is done through the water, backpressure builds up at the opening, which prevents some water from flowing through the net. A cone-shaped sleeve allows more effective filtering by reducing the volume of water entering the net. Net with fine meshes size of 5 to 25 μm for phytoplankton and 200 μm for zooplankton are often used. Figure 5.2: Plankton sampling pumps

46 The determination of the volume of water filtered through any plankton net is essential for the estimation of the standing crop. The volume of water traversed by the net is determined as an approximate value by the formula = 2 Where V=volume of the water filtered by the net r = radius at the mouth of the net d= distance through which the net is towed. Figure 5.3:Plankton collection net 5.1.3 Preservation Preservation is the maintenance of the fixed condition for extended periods of time. Specimens after one week fixation are used for preservation after thorough washing with distilled water. Formalin (2.5 – 5.0%) is used in the ratio of 1:9 (sample to preservative). pH should be maintained at 7.0. To preserve the natural color of the plankton, fish and crustaceans may preserve in phenolic antioxidant such as 40% emulsifiable concentrate of butylated hydroxytoluene (BHT) or butylated hydroxyamisole (BHA). 5.1.4 Quantitative estimation Preparation of the sample: - a) Take the concentrated sample. b) Add 10ml of Lugol's Iodine and allow it to stand for at least 24 hrs to ensure c) complete sedimentation (centrifuge if necessary especialy for nanoplankton). d) Remove the supernatant liquid with the help of a pipette. e) Further concentrate the remaining sample upto 10-100ml depending on the number of plankton.

47 5.1.5 Plankton enumeration Planktons are counted through two different and simple methods. a) Drop Count Method: 5.1.5.a.1 Procedure: a) Shake the concentrated sample and put quickly one drop on a clean slide b) with the help of a standard dropper holding it vertically. c) Carefully cover the whole drop with a cover slip of suitable size so that the d) sample does not run out. e) Put the slide under microscope and focus one edge of the cover slip. f) Count the phytoplankton / zooplankton species. g) Shift the slide to the next field. h) In this way observe the whole coverglass and work put planktonic estimation at least for 3-5 drops depending on the density of plankton. 5.1.5.a.2 Observation: Sl. No. Name of the species No. of the organisms/drop Average No. of organisms/ drop 1 2 3 1 2 3 Total 5.1.5.a.3 Calculation: The total number of plankton present in a litre of water sample can be calculated using the following formula: Total number of organisms / L = × × Where, A = Number of organisms / drops, v = Volume of one drop (mL), V = Total volume of the concentrated sample (mL), L = Volume of original sample (L) b) Sedgwick-Rafter Cell: It has been named after the inventor of the cell. The rectangular cavity in the slide (50×20×1 mm) contains exactly 1 mL of liquid sample. This method is better suited for the enumeration of larger planktons like zooplankton. a) Transfer one mL of well mixed plankton sample using graduated pipette into the sedgewick rafter cell. b) Spread evenly in the form of thin layers.

48 c) Focus one edge of the cavity and move the slide horizontally, simultaneously counting the organisms till the other edge. d) Examine this way 3-6 such strips or transects. Figure 5.4: Sedgwick Rafter Cell 5.1.5.b.1 Calculation: The total number of plankton present in a litre of water sample can be calculated using the following formula: Total number of organisms / L = × Where, n = Average no. of plankton present in 1 mL of plankton sample v = Volume of plankton concentrate (mL) and V = Volume of total water filtered (L)

49 Unit 6: Demonstration of vegetation frequency, density, abundance, cover and basal area, dominance, Importance Value Index (IVI) and phytography 6.1 Introduction The collective and continuous growth of plants in space is known as vegetation. A group of several species living together with mutual tolerance and beneficial interactions in a natural area is known as a community. Each community is characterised by its species diversity, growth forms and structure, dominance etc. Details of these aspects are studied by a number of characters a parameters. These are used to express the characteristics of a community. Various characters, that are used to characterise a community are broadly classified as – (i) analytical characters and (ii) synthetic characters. The quantitative characters among analytical characters are – frequency, density, abundance, cover and basal area etc. 6.2 Frequency Frequency indicates the degree of dispersion or spread of individual species with regard to the percentage occurrence. Frequency is expressed as the percentage of quadrats in which a species appears. The formula used is as follows : ( ) = No.of sampling units in which the species occurred Total no.of sampling units studied × 100 If species 'A' occurs in 6 quadrats out of total 10 quadrats studied, the frequency of species 'A' will be 6 10 × 100 = 60% Five frequency classes of plant species have been recognised by Raunkier (1934) Class Frequency percentage A 1-20 B 21-40 C 41-60 D 61-80 E 81-100

50 6.3 Density Density is the numerical strength (number) of individuals in relation to a definite unit space i.e., per unit area. The density of a species is determined by using the formula as given below: Density (D) = Total number of individuals of a species in all sample plots studied Total number of sample plots studied. If there are 7 plants of species 'A' per quadrat of 10m×10m size for 5 plots, density of 'A' will be 7 500 × 1000 = 14 plants per hectre. 6.4 Abundance This is the number of individuals of any species per sampling unit of occurrence. It is calculated as follows: bundance = Total no.of individuals of the species in all the sampling units Total no.of sampling units studied Abundance is categorised into five classes. Class Stands per sq. m. quadrat Rare 1-4 Occasional 5-14 Frequent 15-29 Abundant 30-90 Very abundant 91-100 6.5 Cover and basal area Quantitative values of frequency, density etc. do not provide correct information on the distribution of a species. As different species differ in their growth forms, such values are to be supplemented with other characters like cover and basal area. Cover or herbage cover signifies primarily the area of the ground occupied by the above ground parts of plants, such as leaves, stems as viewed from above. The cover can be measured both as aerial (canopy) cover and as basal cover or basal area. The leaf area index (LAI) is an important device which quantifies the amount of leaf overlap. LAI is a dimensionless quantity which portrays plant canopies. LAI = Total leaf area [m 2] Ground area m 2 Vegetation type Leaf area index Tropical rain forest 10-11 Boreal conifer forest 9-11

51 Deciduous forest 5-8 Grassland 5-8 Tundra 1-2 Semiarid desert 1 A tree's basal area (BA) is measured using the tree's DBH (diameter of the trunk at breast height) in inches by the following formula : BA = π × (DBH 2) 2 144 The factor of 144 is used to convert sq. inches into sq. ft. In simplified form – BA=0.005454×(DBH) 2 sq.ft. The basal area or the area of coverage is used as an index of dominance. The higher the BA or coverage area the greater is dominance. The average BA of one stem multiplied by the density (no. of individuals per unit area) would give the basal cover per unit area. 6.6 Importance value index The importance value index (IVI) measures how dominant a species is in a given forest area. The importance. The IVI of tree species was determined as the sum of relative frequency, relative density and relative dominance. This may be graphically portrayed in the form of phytograph. 6.6.1 Creation of phytograph • A cicle is made and then divided into four equal parts (A, B, C and D) by two radial lines. • Three radii (A, B and C) are divided into 100 scales from centre to circumference. • The fourth radius is divided into 300 scales. • The three radii with 0-100 scales characterise the values of RF on radius A, RD on radius B and relative dominance on radius C. • IVI value is put on radius D in 0-300 scale. • All these points of four radii are joined to get sociological characters and IVI of a species. 6.7 Dominance Dominance is considered as an analytical character. Number of organisms may not give a correct idea of the species. Few trees in a grassland or few grasses in a forest may be of little value. Situation will be different, if we consider area occupied or weight. In dominance cover is included as important. A single tree in grassland may occupy fairly large area and may have

52 Unit 7: Effect of pesticides on opening and closing of stomata of different crops 7.1.1 Introduction Though a common plant function, much remains unknown about stomatal conductance, especially at larger ecosystem scales while its associated processes like photosynthesis and, to a lesser extent, transpiration, are largely well studied. This research gap is surprising considering that sophisticated tools exist to rapidly and accurately measure stomatal conductance in the field. Modern infrared gas analyzers (IRGAs), for instance, used to analyze photosynthesis, are also equipped to measure stomatal conductance. Stomatal conductance (gs) is the diffusion of gas, such as carbon dioxide, water vapor, and oxygen, through the stomata of a plant. It also functions as the measure of stomatal opening in response to environmental conditions. Stomatal conductance occurs specifically through the stomata when they are open; The reverse is known as stomatal resistance. Figure 7.1: Structure of stomatal complex with open and closed stoma. 7.1.2 Understanding Stomata Stomata are found mainly in the epidermis of leaves, and other parts of the above-ground shoot in vascular plants. The stoma is an aperture formed by two guard cells. Connected to the guard cells are subsidiary cells. When the guard cells are flaccid, they close, and when they are turgid, they open, forming the stomata. See Figure 7.1. The shape of guard cells varies based on species. Based on the shape of guard cells and the number and arrangement of subsidiary cells, there are many kinds of stomata, some of which are shown in Figure 7.2. In most plants, stomata are present on both sides of the leaves. In some, they are found only on one side. The density of stomata can also differ based on species. However, environmental factors can also play a role in determining the number of stomata.
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Figure 7.2: Stomatal traits vary between species. The eudicots (A) Arabidopsis thaliana and (B) Phaseolus vulgaris display kidney-shaped guard cells (colored in green). The grasses (C) Oryza sativa and (D) Triticum aestivum show dumbbell-shaped guard cells (solid green) and specialized subsidiary cells (light green gradient). Clear differences in stomatal size and stomatal density can be observed,”
Bertolino et al. 2019. (Image credits: https://www.frontiersin.org/article/10.3389/fpls.2019.00225) 7.1.3 Influences of stomatal conductance Environmental factors can also affect stomatal conductance. External environmental factors influencing stomatal behavior are as follows: 1 . Light is the primary external factor that determines stomatal conductance, as stomata are activated and open during daylight. 2 . Humidity influences stomatal conductance. Low humidity reduces stomatal conductance to preserve water. Stomata will open in high humidity even if the leaf water content is less. 3 . Soil water and nutrient status will also impact stomatal conductance, which will decrease when soil moisture is less. See Figure 3. 4 . Air temperature rises will increase stomatal conductance, independent of plant water status and photosynthesis. While this helps plants cool through evaporation and increases photosynthesis, plants lose more water. 5 . Elevated atmospheric CO 2 concentration decreases stomatal conductance, which can end up reducing photosynthesis. 6 . Salinity stress also reduces stomatal conductance—this is significant as nearly 7% of the global land is saline. 7 . Toxicity of external chemicals also impact on stomatal opening and closing
54 The internal and external factors that control stomatal conductance will also interact, so stomatal response can be complex. 7.1.4 Apparatus • A plant to sample a leaf from • Clear nail varnish (ideally solvent based) • Sellotape • Microscope • Microscope slides • Stage micrometer • Counting device (clicker/ phone app etc.) • Calculator 7.1.5 Method of measurement • Select a leaf from a live plant and cut it off the plant o Geraniums and spider plants make good subjects for this experiment • Place the leaf upside down on a flat surface such as a tile or worktop • Paint clear nail varnish onto the underside of the leaf • Wait for the nail varnish to dry (approx. 5 minutes) • Peel off the layer of varnish using sellotape o Discard the leaf • Place the dried varnish impression on a microscope slide o A coverslip is not required as this isn't a biological sample, just an impression of one o A drop of water is not required either, so long as the sample is laid flat on the slide • Use the usual steps to focus on the sample • Adjust the zoom such that a countable number of stomata are visible in the field of view o Between 15 and 100 is ideal o Even if a stoma is partially visible at the edge, still count it as 1 • Count the stomata in that field of view • Repeat the method after exposure of the toxic chemical (pesticide), and see the opening and closing status of the stomata. • Measure the opening area of the stomata in both cases using the oculometer 7.1.6 Calibration of the Ocular Micrometre This is a simple and precise method for measuring objects seen in the microscope. Ocular micrometres are calibrated by comparing the ocular micrometre scale with a calibrated stage micrometre. A calibration procedure must be completed to determine the calibration factor for each objective and each microscope. following steps are to be followed to calibrate the ocular micrometre: 1 . Insert the ocular micrometre into a 10X eyepiece. The ocular micrometer is divided into ocular divisions(OD). 2 . Place the calibrated stage micrometer slide on the stage and focus on the scale. The stage micrometer has a calibrated scale which is divided into 0.1 millimeters (mm) and 0.01 mm units.

55 3 . Adjust the field so the 0 line of the ocular micrometer (OM) scale is exactly superimposed upon the 0.0 line of the stage micrometer (SM)scale. 4 . Without moving the stage micrometer, locate the point as far to the extreme right as possible where any two lines are exactly superimposed upon each other. 5 . Count the number of divisions (mm) on the stage micrometer between the 0.0 line and the superimposed line to the far right. 6 . Count the number of ocular divisions on the ocular micrometer between the 0 line and the superimposed line to the far right. 7 . Divide the distance determined in step 5 by the number of ocular divisions in step 6 and multiply by 1000 to give the ocular micrometer units in µm. 8 . Repeat steps 3 through 7 for each objective on the microscope. 9 . If at any time the ocular micrometer is moved to a different microscope or a new objective is added to the microscope, the calibration procedure must be completed again. 7.1.7 Result Difference of Percentage of stomatal closing and reducing stomatal opening are infer the affect of toxicant/ xenobiotics on stomatal conductance and diffusion

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ˆlï¸y!ç §%Ë¸y£Ï Ù%_´ !ÓŸª!Óòƒy°Î˚ !lÓ≈yã¸l !Ë¸!_Ü¸ Ù)°ƒyÎ˚l ÓƒÓfliy (Choiced Based Credit System) ¸õ!Ó˚ˆÏÓ¢ !Óòƒy (Environmental Studies) AE-ES-21 ~Ñ¸Ñ¸ÈÈ 1 ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ˆõÔ!úÑ¸ ïyÓ˚íy (Fundamentals of Environment) 7-21 ~Ñ¸Ñ¸ÈÈÈ 2 ≤ÃyÑ‚¸!ì¸Ñ¸ ¢¡ôî ≠ òÓ#Ñ¸Ó˚íˆÏÎyÜƒ ~ÓÇ xòÓ#Ñ¸Ó˚íˆÏÎyÜƒ (Natural Resource:Renewable and Non renewable) 22-40 ~Ñ¸Ñ¸È 3 Óylfl¸ì¸s¸f (Ecosystem) 41-57 ~Ñ¸Ñ¸ 4 ã#Ó˜ÏÓ!â¸eƒ Á ì¸yÓ˚ ¢ÇÓ˚«¸í (Biodiversity and its conservation) 58-70 ~Ñ¸Ñ¸È 5 ¸ô! Ó˚ˆÏÓü î)°Ïí (Environmental Pollution) 71-110 ~Ñ¸Ñ¸È 6 ¸ô!Ó˚ˆÏÓüÜì¸ ¢õ¢ƒyñ ò#!ì¸ ~ÓÇ â¸â≈¸y (Environmental Issues, Policies and Practices) 111-129 ~Ñ¸Ñ¸È 7 ãò¢ÇÖƒy Á ¸ô!Ó˚ˆÏÓü (Human Population and Environment) 130-142

~Ñ¸Ñ¸ÈÈ 1 ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ˆõÔ!úÑ¸ ïyÓ˚íy (Fundamentals of Environment) Ü‡¸ò 1.0 v¸zˆÏjüƒ 1.1 ≤Ãhfl¸yÓòy 1.2 ¸

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ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ÇK¸y [Definition of Environment] 1.3 ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ˆ◊!

í!Ó¶¸yÜ [Types of Environment] 1.4 ˆ¶¸Ôì¸ ¸ô!Ó˚ˆÏÓü ¢¡ôˆÏÑ≈¸ ïyÓ˚íy [Concept of Physical Environment] 1.5 ¸ô!Ó˚ˆÏÓü !ÓîƒyÓ˚ ˆõÔ!úÑ¸ ïyÓ˚íy [Basic Concept of Environmental Studies] 1.6 ¸ô!Ó˚ˆÏÓü !ÓîƒyÓ˚ =Ó˚&c [Importance of Environmental Studies] 1.7 ¸ô!Ó˚ˆÏÓü !ÓîƒyÓ˚ ¸ô!Ó˚!ï [Scope of Environmental Studies] 1.8 ≤ÃyÑ¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ˜Ó!ü‹T [Nature of Physical Environment] 1.9 ≤ÃyÑ¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ v¸z¸ôyîyò [Components of Physical Environment] 1.10 ¸ô!Ó˚ˆÏÓü !ü«¸y [Environmental Education] 1.11 xò%ü#úò# 1.0 v¸zˆÏjüƒ (Introduction) ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ˆÏÓ˚ xy¸õ!l !l¡¨!°!ái¸ !Ó£ÏÏ˚=!° çylˆÏ¸ ¸õyÓ˚ˆÏÓl– ? ¸õ!Ó˚ˆÏÓ¢ Ü¸yˆÏÜ¸ Óˆ Ï°– ? ¸õ!Ó˚ˆÏÓ¢ Ü¸Ï˚ ≤ÃÜ¸yÓ˚ G !Ü¸ !Ü¸– ? ÙylÓç#ÓˆÏl ¸õ!Ó˚ˆÏÓ¢!Óòƒy ¸õyˆÏë¸Ó˚ ≤ÃˆÏÏ˚yçl#ÎˆÏ¸y ¸õ!Ó˚ˆÏÓˆÏ¢Ó˚ !Ó!Ë¸ß˚ ß Ùß ƒy=!°Ó˚ ßÙyôyˆÏlÓ˚ çlƒ xyÙÓ˚y Ü¸# Ü¸# ÓƒÓƒliy @˘Ã•î Ü¸Ó˚Ó– ? ≤ÃyÜ¸!ì¸Ü¸ ¸õ! Ó˚ˆÏÓˆÏ¢Ó˚ ˜Ó!¢‹Tƒ=!° !Ü¸ !Ü¸– ? ≤ÃyÜ¸!ì¸Ü¸ ¸õ!Ó˚ˆÏÓˆÏ¢Ó˚ ˜çÓñ xˆÏçÓ G ¢!_´ í¸z¸õyòyl=!° !Ü¸Ë¸yˆÏÓ ¸õ!Ó˚ˆÏÓ¢ˆÏÜ¸ ≤ÃË¸y! Óï¸ Ü¸ˆÏÓ˚– ? ¸õ!Ó˚ˆÏÓ¢ !¢«¸yÓ˚ í¸zˆÏj¢ƒ–

1.1 ≤Ãhfl¸yÓòy õyò%°Ï ˆÎ ¸ôy!Ó˚ ¸ôy!Ÿª≈Ñ¸ xÓfl¸iyÓ˚ õˆÏïƒ ¸ô¸!lÓ#ˆÏì¸ Ó¢ÓyÇ Ñ¸ˆÏÓ˚ ì¸yˆÏÑ¸£z ¸ô!Ó˚ˆÏÓü ÓˆÏú– ¸ôy!Ó˚ ¸ôy! Ÿª≈Ñ¸ xÓfl¸iy Óú ˆÏì¸ ˆÓyG¸yÎ˚ ≤ÃÑ¸!ì¸Ó˚ ¢õhfl¸ îyòñ ˆÎõòÈÙÙÙÈ ¸ôy£yv¸ ¸ÈÙÈ¸ôÓ≈ì¸ñ òî#ñ ÓòÈÙÈãDúñ Ñ¸#›¸ ¸òì¸Dñ ãúñ õy!›¸ñ Óyì¸y¢ñ ã#Óãls¸ Á õyò%°Ï– ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ~£z v¸z¸ôyîyò=!ú£z õyò%°ÏˆÏÑ¸ ≤ÃÃ¶¸y!Óì¸ Ñ¸ˆÏÓ˚ ~ÓÇ ¸ô!Ó˚ˆÏÓ!Ó‹Tì¸ Ó˚yˆÏÖ– ¸ô!Ó˚ˆÏÓü !Óîƒy ~Ñ¸!›¸ Ó˝õ%Ó# !Ó°ˆÏÏ˚ – Ó˚¢yÎ˚ˆÏòñ ¸ôîyl≈!Óîƒyñ ãÓò!ÓK¸yòñ õ¸!_Ñ¸y!ÓK¸yòñ Ñ¸¸!°ì!Óîƒyñ !â¸!Ñ¸Í¢y! Óîƒyñ ãòfl¸Íyfl¸ìƒñ fl¸Íyfl¸ìƒÑ¸yÓ˚&!Óîƒyñ xy£zòñ ¢õyä!Óîƒyñ £z!ì¸£y¢ñ ¶), ˆÏÜyúñ ¶)¸ì¸_¥ £zì¸ƒy!î Ó˘!Óï !Ó°ÏÏ˚ ~Ó˚ xhs¸Ü≈ì¸– ~Ñ¸ Ñ¸ÌyÎ˚ ¢õhfl¸ ¸ô!Ó˚ˆÏÓü ì¸yÓ˚ ãúñ fl¸ iúñ xhs¸Ó˚#«¸ !òˆÏÏ˚ ~Ñ¸!ìˆÏÑ¸ xyÓ˚ õyò%°Ï xòƒ!ìˆÏÑ¸ÈÙÙÙÈ ~ î%ˆÏÏ˚Ó˚ ÎyÓì¸#Î˚ ! õì¸!fl¸;¸Î˚y ~ÓÇ ì¸Í ¢Óyì¸ ö¸ú◊&!ì¸ ¸ô!Ó˚ˆÏÓü !ÓîƒyÎ˚ xyˆÏúy!â¸ì¸ £ˆÏÏ˚ ÎyˆÏÑ¸– ì¸ˆÏÓ˚ ¸ô!Ó˚ˆÏÓü!ÓK¸yò Á ¸ô!Ó˚ˆÏÓü !Óîƒy Ó˚ õˆÏïƒ ~Ñ¸!›¸ ¸ôyì≈Ñ¸ƒ xyˆÏäÈ– ¸ô!Ó˚ˆÏÓü !ÓK¸yˆÏò Ó#«¸òyÜyˆÏÓ˚ Ó˚ ~Ñ¸›¸y ¶)!õÑ¸y ÌyˆÏÑ¸– ˆÇÖyˆÏò ˜ÓK¸y!òÑ¸ ¸ôÓ˚#«¸yÈÙÈ! òÓ˚#«¸yñ ¸ôî≈ˆÏÓ«¸í Á ì¸Í¢Oyì¸ !¢k¸yhs¸ @˘Ãëí ~Ñ¸!›¸ !ÓˆÏüï°Ï ¶)!õÑ¸y ˆòì˚ – xyÓ˚ ˆ¢£zãõƒ !ÓK¸yˆÏòÓ˚ ~Ñ¸ Óy Î%Ü¸ ÓÎ˚ ~Ñ¸!y ïÑ¸ £ˆÏÏ˚üÓyÎ˚ !Óˆ ÏüºÏ Ó%ƒÍ¸ô!_ ≤ÃˆÏÏ˚yäò– xòƒ!ìˆÏÑ¸ ¸ô!Ó˚ˆÏÓü !Óîƒy ¢Ñ¸ˆÏúÓ˚ äòƒ– ~Ó˚ ~Ñ¸!›¸ Óv¸ !ìÑ¸ £ˆÏFäÈ ¢ˆÏâ¸ì¸ì¸òì¸y (Awareness)– ~£z !ÓîƒyÓ˚ ≤Ãâ¸yÓ˚ Á xÏì¸òì¸Ó˚ v¸zˆÏjüƒ £ˆÏFäÈ !ÓˆÏü°Ï Ñ¸ˆÏÓ˚ äÈye çyiyÓ˚ íˆÏÑ¸ ~ÓÇ çyiyÓ˚ í¶¸yˆÏÓ Ó¸£_Ó˚ õyòÓ ¢¡ôˆÏÑ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢%Ó˚«¸yñ ¢ÇÓ˚«¸í Á ¢%ÓƒÓ£yÓ˚ ¢¡ˆÏì¸ ¢ˆÏâ¸ì¸ò Á xÓ!£ì¸ Ñ¸Ó˚y– Óì¸≈õyòÑ¸yˆÏú– ~£z ú«¸ƒ !òˆÏÏ˚£z ¸ô!Ó˚Ñ¸!"ˆì¸ £ˆÏÏ˚ˆÏäÈ– xÓüƒ xyÓ˚ ~Ñ¸!›¸ v¸zˆÏjüƒ xyˆÏäÈ– ˆòì¸y!ã ¢%¶¸y!ÓˆÏ´ !ÓŸª!Óîƒyú ˆÏÏ˚Ó˚ !ü«¸yl≈# !ü«¸y!ÌˆÏÓ˚ ¸ô!Ó˚ˆÏÓü!ÓîƒyÓ˚ ≤Ãyl!õÑ¸ fl¸ƒ!ü«¸í v¸z¸ôÑ¸Óˆí !£¢yˆÏÓ ~!›¸ ÓƒÓ£*ì¸ £ˆÏÓ– ˆ¢äòƒ£z ~£z xyˆÏúyâ¸òy ¢¡)í≈ ¸ôy‡¸e ´õ !¶¸!_Ñ¸ ~ÓÇ xÓüƒ£z x¢¡)í≈– !ÓŸª!Óîƒyúˆ ÏÏ˚ ¶¸!Ó°ˆÏƒˆÏì¸ ¢¡)í≈ì¸Ó˚ ¢ÇÑ¸ˆÏ" ≤ÃÑ¸yˆÏü xy@˘Ã£#– xÓüƒ ~›¸yÁ !òÿy¸ì¸ ˆÎ ~£z ¢ÇÑ¸ˆÏúòÓ˚ ¸ôÎ≈yˆÏúyâ¸òy !ü«¸yl≈# çyiyÓ˚ íˆÏÑ¸ ¢¡)í≈ì¸Ó˚ Á !Óhfl+ì¸ì¸Ó˚ xyˆÏúyâ¸òyÎ˚ ≤ÃˆÏÓü Ñ¸Ó˚ˆÏì¸ xy@˘Ã£# £ˆ

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ÏÓ– 1.2 ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ÇK¸y (Definition of Environment) ¸ô!Ó˚ˆ

ÏÓü ü∑!›¸Ó˚ v¸zí¸ô!_ Úˆö ¸M¸ÈÛ ü∑ environ ˆÌˆÏÑ¸ñ ÎyÓ˚ xÌ≈ en xˆÌ≈ in xÌ≈yí õˆÏïƒ ~ÓÇ viron xˆÌ≈ circuit xÌ≈yí ¸ô!Ó˚ˆÏÓ‹Tò– xÌ≈yí ¸ô!Ó˚ˆÏÓü ÓúˆÏì¸ ¸ô!Ó˚ˆÏÓ‹TòÑ¸yÓ˚# ¸ôy!Ó˚ ¸ôy!Ÿª≈Ñ¸ xÓfl¸iyˆÏÑ¸ Ó%G¸yÎ˚ – îƒ Ñ¸òÓyîã x:ˆÏö¸yv≈¸ !v¸Ñ¸üòy!Ó˚ˆÏì¸ S1992V ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ÇK¸y !£¢yˆÏÓ Óúy £ˆÏÏ˚ˆÏäÈÈÙÙÙÈ ÚÚ¸ô!Ó˚ˆÏÓü £ú v¸z!qî Á ≤Ãyí# äÙˆÏì¸Ó˚ Á¸ôÓ˚ ≤Ã¶¸yÓ˚ ! Óhfl¸yÓ˚Ñ¸yÓ˚# Ó!£Ó˚ˆÏÏDÓ˚ xÓfl¸iy=!úÓ˚ ¢õ!‹T–ÛÛ ã#ˆÏÓÓ ãß√ñ Ó¸!k¸ Á x!hfl¸c Ó˚«¸yÓ˚ ¢£yÎ˚ˆÑ¸ ˜ãÓñ xˆÏãÓ Á çyÇfl¸¸Ó! ì¸¸Ñ¸ v¸z¸ôyîyò=!ú ¸ôyÓ˚fl¸ô!Ñ¸ !õ!lfl¸;¸Ï˚yÎ˚ ˆÎ ¸ôy!Ó˚ ¸ôy!Ÿª≈Ñ¸ xÓfl¸iy ÜˆÏv¸ ¸ Á˚ˆÏ‡¸ ì¸yˆÏÑ¸ ¸ô!Ó˚ˆÏÓü ÓˆÏú– xyõ≈¢ (Arms) 1994 !Ö É ~ò¶¸yÎ˚ˆÓ˚ò ˆÏõr›¸yú çyˆÏÏ˚™ òyõÑ¸ @˘ÃˆÏs¸i Óˆ ÏúˆÏäÈò ˆÎÈÙÙÙÈ ˜äÓ ¢¡±ÍyˆÏÏ˚Ó˚ ¸ôy!Ó˚ ¸ôy!Ÿª≈Ñ¸ ˜äÓ ~ÓÇ ≤ÃyÑ¸!ì¸ ì¸Ñ¸ xÓfl¸iyˆÏÑ¸ ¸ô!Ó˚ˆÏÓü ÓˆÏú– ¸ô!Ó˚ˆÏÓü !ÓK¸yò# Ó›‰ !Ñ¸ò Á ˆÑ¸úyÓ˚ (Botkin and Keller) 1995 !Ö É ÚÙ~ò¶¸yÎ˚ˆÓ˚ò ˆÏõr›¸yú çyˆÏÏ˚™ÛÛ òyõÑ¸ @˘ÃˆÏs¸i ÓˆÏúˆÏäÈ ˆÎ ã#Óñ v¸z!qî Óy ≤Ãyí# ì¸y ˆÏÎ˚Ó˚ ã#Óòà¸ˆÏe´Ó˚ ˆÎ ˆÑ¸yò ¢õˆÏÏ˚ ˆÎ ¢õhfl¸ ˜äÓ ~ÓÇ xˆÏãÓ Ñ¸yÓ˚í=!ú myÓ˚y ≤Ã¶¸y!Óì¸ £Ïˆñ ˆ¢£z Ñ¸yÓ˚í=!úÓ˚ ¢õ!‹TˆÏÑ¸ ¸ô!Ó˚ˆÏÓü ÓˆÏú– ÈC. C. ParkÈÙ~Ó˚ õˆÏì¸ÈÙÙÙÈ "Environment refers to the sum total of conditions which surround man at a given point in space and time," fl¸iyò Á Ñ¸yˆÏúÓ˚ ˆÑ¸yò ≤ÃÎ_ !Ó®%ˆÏì¸ ˆÎ¢Ó xÓfl¸iy õyò%°ÏˆÏÑ¸ ¸ô!Ó˚ˆÏÓ‹Tò Ñ¸ˆÏÓ˚ ÓˆÏÓ˚yˆÏÏ˚ì¸yˆÏÓ˚ ¢õ!‹TÜ¸ xÓfl¸iyˆÏÑ¸ ¸ô!Ó˚ˆÏÓü ÓˆÏú– 8 ? NSOU ? AE-ES-21

1.3 ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ˆ◊!í!Ó¶¸yÜ (Types of Environment) ≤ÃÑ¸!ì¸Ü¸ì¸ ¸ôyÌ≈Ñ¸ƒ Á ˆõÔ!úÑ¸ Ü‡¸ˆÏòÓ˚ v¸z¸ôÓ˚ !¶¸!_

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Ñ¸ˆÏÓ˚ ¸ô!Ó˚ˆÏÓüˆÏÑ¸ î%!›¸ ≤Ãïyò ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y

ÎyÎ˚ – ÎyÈÙÙÙÈ ≤ÃyÑ¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü (Physical environment) ~ÓÇ ¢yÇfl¸¸Ò!ì¸Ñ¸ Óy õò%°Ïƒ¢‹T ¸ô!Ó˚ˆÏÓü (Cultural or man-made environment) ¸ô¸!lÓ#ˆÏì¸ õyò%°Ï xy¢yÓ˚ xyˆÏÜ ÚÙ¢yÇfl¸¸Ò!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüÛ ÓˆÏú !Ñ¸ä‹È !âÈú òyó ÎyˆÏÑ¸ !âÈúñ ¢ÓÒ£z Ú≤ÃyÑ¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüÛ– ≤ÃyÑ¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü ¢Ó≈e Á ¢Ó¢õˆ õyò%°ˆÏÓ˚ xò%Ñ)¸ú !âÈú òy– ì¸y£z ˆÓ!k¸Ñ¸ ü!_ Á ˜ÓK¸y!òÑ¸ Ñ¸Ì¸ÏÑ¸Ó˚ ¢õ!hfl¸ ≤Ã¶¸!ì¸ˆÏÜˆÏÓ˚ myÓ˚y ≤Ã¶¸y!Óì¸ Á ¢%!ÓïyˆÏì¸ˆ¸ì¸y ≤ÃyÑ¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¸ô!ÓÓ˚≈ì¸ò ¢yïò Ñ¸ˆÏÓ˚ õyò%°Ï ˆÎ ¸ô! Ó˚ˆÏÓü ¢¸!‹T Ñ¸ˆÏÓ˚ˆÏäÈ ì¸yˆÏÑ¸ ¢yÇfl¸¸Ò!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü ÓˆÏú– ¸ô!Ó˚ˆÏÓˆÏüÓ˚ !

78%	**MATCHING BLOCK 4/200**	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó!¶¸ß¨ v¸z¸ôyîyò=!úÓ˚ õˆÏïƒ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡ôÑ≈¸

Á ~ˆÏîÓ˚ ˆ◊!í!Ó¶¸yÜ ¸ôÓ˚ ¸ô,¤¸yÎ˚ äÈˆÏÑ¸Ó˚ xyÑ¸yˆÏÓ˚ ˆîÖyˆÏòy £ˆÏúyÈÙÙÙÈ 1.4 ˆ¶¸Ôì¸ ¸ô!Ó˚ˆÏÓü ¢¡ôˆÏÑ≈¸ ïyÓ˚íy (Concept of Physical Environment) Ú≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüÛ ≤ÃÑ,¸!ì¸Ó˚ ¢,!‹T– ¸ô,!ÌÓ#ˆÏì¸ ã#Ó ãß√yÓyÓ˚ xyˆÏÜ ˆÌˆÏÑ¸£z Ú≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüÛ Ó˚!â¸ì¸ £ˆÏÎ˚ xyˆÏäÈ– ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü Ó˚â¸òyÎ˚ ã#ÓÑ)¸ˆÏúÓ˚ ~õò !Ñ¸ !ÓˆÏŸªÓ˚ ˆ◊¤¸ ã#Ó õyò%ˆÏ°ÏÓ˚Á ˆÑ¸yò ¶)¸!õÑ¸y Óy xÔîyò ˆò£z– õy!›¸ñ ãúñ õÓ˚&¶)¸!õñ ¸ôy£yv¸¸ÈÙÈ¸ôÓ≈ì¸ñ ì¸y¸ôõyeyñ xyo≈ì¸yñ õy!›¸Ó˚ Ü‡¸ò Á ≤ÃÑ,¸!ì¸ñ v¸z!qîñ ≤Ãyí# ¢Ó !Ñ¸ä%È !òˆÏÎ˚£z ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü– ~£z ¸ô!Ó˚ˆÏÓü ˜ì¸!Ó˚ £ˆÏì¸ ≤ÃÑ,¸!ì¸Ó˚ ¢õÎ˚ ˆúˆÏÜˆÏäÈ ˆÑ¸y!›¸ ˆÑ¸y!›¸ ÓäÈÓ˚– î#á≈ ¢õÎ˚ ïˆÏÓ˚ Ö%Ó ï#Ó˚ ≤Ã!e´Î˚yÎ˚ ≤

64%	**MATCHING BLOCK 5/200**	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¸ô!Ó˚Óì≈¸ò £Î˚ – ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆ

ÏÓü ˆÎõò !Ó!¶¸ß¨ v¸z!qî Á ≤Ãyí#ãÜì¸ˆÏÑ¸ ≤Ã¶¸y!Óì¸ Ñ¸ˆÏÓ˚ñ ˆì¸õò£z õyò%ˆÏ°ÏÓ˚ ÎyÓì¸#Î˚ !e´Î˚yÑ¸úyˆÏ¸ôÓ˚ Á¸ôÓ˚Á ≤Ã¶¸yÓ ˆö¸ˆÏú– õyò%ˆÏ°ÏÓ˚ !òÑ¸›¸ ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü î%!›¸ Ñ¸yÓ˚ˆÏí =Ó˚&c¸ô)í≈– (i) ã#Óò ≤ÃˆÏÎ˚yãò#Î˚ üì≈¸ !£¢yˆÏÓ ~ÓÇ (ii) ¢¡ôˆÏîÓ˚ ¶¸y[¸yÓ˚ !£¢yˆÏÓ– NSOU ? AE-ES-21 ? 9 !¢°yü[¸°#Î˚ ¸õ!Ó˚ˆÏÓ¢ ÓyÎ˚%ü[¸°#Î˚ ¸õ!Ó˚ˆÏÓ¢ Óy!Ó˚ü[¸°#Î˚ ¸õ!Ó˚ˆÏÓ¢ Ñ,¸!°Ïñ Ö!òãñ ü!_´ñ Óòã oÓƒ ~ÓÇ !ü"!ÓÑ¸yü ¢Ó !Ñ¸ä%ÈÓ˚£z õ)ú !¶¸!_ £ú ≤ÃÑ,¸!ì¸ – xÌ≈yí ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü £úÈÙÙÙÈ The landscape before man was fashioned on the earth. ¸ô,!ÌÓ#Ó˚ !

39%	**MATCHING BLOCK 6/200**	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó!¶¸ß¨ xM¸ÈˆÏúÓ˚ ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü !Ó!¶¸ß¨ – ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ì¸yÓ˚ì¸õƒ ãúÓyÎ˚%ñ õy!›¸ñ

v¸z!qî Á ≤Ãyí#ãÜˆÏì¸Ó˚ ˜Ó!üˆÏ‹TƒÓ˚ ì¸yÓ˚ì¸õƒ áˆÏ›¸ ~ÓÇ õyò%ˆÏ°ÏÓ˚ !e´Î˚yÈÙÈÑ¸úyˆÏ¸ôÁ ì¸yÓ˚ì¸õƒ ˆîÖy Îy΢ – 1.5 ¸ô!Ó˚ˆÏÓü ! ÓîƒyÓ˚ ˆõÔ!úÑ¸ ïyÓ˚íy (Basic Concepts of Environmental Studies) ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ˆÏD õyò%ˆÏ°ÏÓ˚ !e´Î˚yÈÙÈ≤Ã!ì¸!e´Î˚y !Ó°ÏÎ˚Ñ¸ ¸ôy‡¸£z £ú ¸ô!Ó˚ˆÏÓü!Óîƒy– ¸ô!Ó˚ˆÏÓü !ÓîƒyÎ˚ ˆÎõò ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüñ ¢yõy!ãÑ¸ ¸ô!Ó˚ˆÏÓü Á ¢õ!‹TÜì¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ Ñ¸Ìy Óúy £Î˚ñ ˆì¸õ!ò ~ˆÏîÓ˚ ≤ÃˆÏì¸ƒˆÏÑ¸Ó˚ õˆÏïƒ ˆÎ ¢¡ôÑ≈¸ xyˆÏäÈ ì¸yÁ xyˆÏúyâ¸òy Ñ¸Ó˚y £Î˚ – ¸ô!Ó˚ˆÏÓü â¸â≈¸yÓ˚ õ)ú v¸zˆÏjüƒ£z £ú ¸ô!Ó˚ˆÏÓü ¢¡ôˆÏÑ≈¸ ¢ˆÏâ¸ì¸ò £ÁÎ˚y– xÌ≈yí ¶¸yú¶¸yˆÏÓ ¸ô,!ÌÓ#ˆÏì¸ ˆÓ§ˆÏâ¸ ÌyÑ¸ˆÏì¸ £ˆÏú xÓüƒ£z õyò%°ÏˆÏÑ¸ ¸ô!Ó˚ˆÏÓü ¢¡ôˆÏÑ≈¸ ¢ˆÏâ¸ì¸ò £ˆÏì¸ £ˆÏÓ– ¸ô,!ÌÓ#ˆÏì¸ õyò%°Ï ¢£ ¢õ@˘Ã ã#ÓãÜì¸ ÎyˆÏì¸ fl¸∫y¶¸y!ÓÑ¸¶¸yˆÏÓ Ó¢Óy¢ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ì¸yÓ˚ ãòƒ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ v¸z¸ôyîyò=!úÓ˚ õyòñ ¸ô!Ó˚õyíñ ¢!e´Î˚ì¸y Á ¶¸yÓ˚¢yõƒ Ó˚«¸y Ñ¸Ó˚y ~ÓÇ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢õ¢ƒy=! úÓ˚ fl¸∫Ó˚*¸ô xò%ïyÓò Ñ¸ˆÏÓ˚ ì¸yÓ˚ fl¸iyÎ˚# ¢õyïyˆÏò ÎÌyÎÌ ÓƒÓfl¸iy Ñ¸Ó˚ˆÏì¸ õyò%°ÏˆÏÑ¸ ¸ô!Ó˚ˆÏÓü õòfl¸Ò Ñ¸ˆÏÓ˚ ì%¸úˆÏì¸ ¸ô!Ó˚ˆÏÓü ¸ôyˆÏ‡¸Ó˚ ≤ÃˆÏÎ˚yãò xyˆÏäÈ– xòƒ!îˆÏÑ¸ ≤Ã!ì¸!›¸ õyò%°Ï ˆÌò ì¸yÓ˚ !òã !òã îy!Î˚c ¸ôyúˆÏò Ó ì¸# £Î˚ñ ˆ¢ Óƒy¸ôyˆÏÓ˚ ¢ˆÏâ¸ì¸ò Ñ¸Ó˚ˆÏì¸Á ≤ÃˆÏÎ˚yãò ¸ô!Ó˚ˆÏÓü ¸ôyˆÏ‡¸Ó˚– !Ó!¶¸ß¨ ¶)¸ì¸y!_¥Ñ¸ ¸Ñ¸yˆÏú ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ˆÎxyõ)ú ¸ô!Ó˚Óì≈¸ò £ˆÏÎ˚ˆÏäÈ ì¸y ¢Ó£z !äÈú ≤ÃyÑ,¸!ì¸Ñ¸– xyÓ˚ Óì≈¸õyò Îy ¢yÓ˚y !ÓŸªˆÏÑ¸ ¶¸y!ÓˆÏÎ˚ ì%¸ˆÏúˆÏäÈ ì¸y £ˆÏúy õò%°ÏƒÑ,‹T ¸ô!Ó˚ˆÏÓü ¢ÇÑ¸›¸– ~Ó˚ ˆõyÑ¸y! Óúy Î!î òy Ñ¸Ó˚ˆÏì¸ ¸ôyÓ˚y Îyγ ì¸ˆÏÓ Óì≈¸õyò ¢¶¸ƒì¸y !ò!ÿ£´ £ˆÏÎ˚ ˆÎˆÏì¸ Óyïƒ– ≤Ã!ì¸!òÎ˚ì¸ xyõyˆÏîÓ˚ Ü,£fl¸ìú# Á !ü"äyì¸ Ñ¸!‡¸ò Á ì¸Ó˚ú Óã≈ƒ ¸ôîyÌ≈ñ Óyì¸yˆÏ¢ ÎyòÓy£ò Á !ü" !òÜ≈ì¸ Üƒy¢#Î˚ ¸ôîyˆÏÌ≈Ó˚ õyey!ì¸!Ó˚_´ !òÜ≈õíñ Óƒ¸ôÑ¸ £yˆÏÓ xÓ˚íƒ ˆäÈîò £zì¸ƒy!îÓ˚ ö¸ˆÏú ÓyÎ˚%õ[¸ˆÏú

100%	**MATCHING BLOCK 7/200**	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí ˆÓ˚ˆ

Ïv¸¸ â¸ˆÏúˆÏäÈ– ÎyÓ˚ ö¸ú◊&!ì¸ !£¢yˆÏÓ ¶)¸¸ô,ˆÏ¤¸Ó˚ Á xyÓ£õ[¸ˆÏúÓ˚ v¸z°åì¸yõyey v¸z_ˆÏÓ˚y_Ó˚ Ó,!k¸ ˆ¸ôˆÏÎ˚ â¸ˆÏúˆÏäÈ– ¸ô!Ó˚ˆÏÓü xyã ãã≈!Ó˚ì¸ òyòy ïÓ˚ˆÏòÓ˚ î)°ÏˆÏí SÓyÎ˚%ñ ãúñ ü∑ñ õ,!_Ñ¸yV Á ÁˆÏãyò hfl¸ˆÏÓ˚Ó˚ ïπÇ¢¢yïˆÏò– Sõò%°Ïƒ¢‹TV ~£z î)°ÏˆÏíÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ õyò%°ÏˆÏÑ¸£z Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ¸ô!Ó˚ˆÏÓüˆÏÑ¸ Ó§yâ¸yˆÏì¸ £ˆÏú õyò%ˆÏ°ÏÓ˚ ˙Ñ¸y!hs¸Ñ¸ ≤Ãˆ Ïâ¸‹Ty ~ÓÇ ¢!e´Î˚ ¢£ˆÏˆÏÎy! Üì¸yÓ˚ ≤ÃˆÏÎ˚yãò– ì¸y£z ÷ï%õye !ü!«¸ì¸ ~ÓÇ ¸ô!Ó˚ˆÏÓüõòfl¸Ò õyò%°Ï òÎ˚ñ !ü«¸yÓ˚ ¢Ó≈!Ó°ÏˆÏÎ˚ ~ÓÇ ¢Ó≈hfl¸ˆÏÓ˚ ¸ô!Ó˚ˆÏÓü ¸ôy‡¸ˆÏÑ¸ x¸ô!Ó˚£yÎ≈ Ñ¸ˆÏÓ˚ ì%¸úˆÏì¸ £ˆÏÓñ Îy ¸ô!Ó˚ˆÏÓü ¢Çe´yhs¸ Óì≈¸õyò ¢õ¢ƒy=!úˆÏÑ¸ ¢òy_´ Ñ¸Ó˚ˆÏì¸ Á ì¸yÓ˚ fl¸iyÎ˚# ¢õyïyò Ö%§ˆÏã !òˆÏÎ˚ õyòÓãy!ì¸Ó˚ ≤ÃÑ,¸ì¸ ¢õ,!k¸ áÛ¸yˆÏì¸ ¢y£yÎƒ Ñ¸Ó˚ˆÏÓ– 1.6 ¸ô!Ó˚ˆÏÓü !ÓîƒyÓ˚ =Ó˚&c (Importance of Environmental Studies) ≤Ãyì¸ƒ!£Ñ¸ ã#ÓòˆÏÑ¸ !òÎ˚s¸fí Ñ¸ˆÏÓ˚ ≤ÃÑ,¸!ì¸ ~ÓÇ ì¸yÓ˚ ¸ô!Ó˚ˆÏÓüñ ÷ï%õye xyõÓ˚y òÎ˚ xòƒyòƒ ã#ÓÑ%¸úÁ ≤ÃÑ,¸!ì¸ Á ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ôˆÏîÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú– ¸ô!Ó˚ˆÏÓü!Óîƒyñ ≤ÃÑ,¸!ì¸ õyˆÏÎ˚Ó˚ =Ó˚&cñ Á ì¸yÓ˚ ¢ÇÓ˚«¸í ¢¡∫ˆÏì¸ xÓÜì¸ Ñ¸Ó˚yÎ˚ – !îˆÏòÓ˚ ¸ôÓ˚ !îò ˆÎ¶¸yˆÏÓ ¸ô!Ó˚ˆÏÓü î)°Ïí £ˆÏFäÈñ ãò¢ÇÖƒyÓ˚ Ó,!k¸ £ˆÏFäÈ ì¸yˆÏì¸ ¸ô!Ó˚ˆÏÓü ¢¡ôˆÏÑ≈¸ ¢ˆÏâ¸ì¸òì¸y Ö%Ó£z ãÓ˚&!Ó˚ – ¸ô!Ó˚ˆÏÓü!Óîƒy ˆÎ Ñ¸yÓ˚í=!úÓ˚ ãòƒ =Ó˚&c¸ô)í≈ £ˆÏÎ˚ v¸zˆÏ‡¸ˆÏäÈñ ì¸y £ú ≠ ? !Ó!¶¸ß¨ ¸ô!Ó˚ˆÏÓü ¢¡ô!Ñ≈¸ì¸ ¢õ¢ƒy ˆÎõò !ÓŸªÈÙÈv¸z°åyÎ˚òñ Áãò hfl¸Ó˚ ïπÇ¢ñ x¡‘Ó,!‹Tñ ã#Ó˜ÓÓ!â¸eƒ £…y¢ ~£z ¢õhfl¸ ¢õ¢ƒy xyã xyÓ˚ ˆÑ¸yò ˆîˆÏüÓ˚ õˆÏïƒ ¢#õyÓk¸ òÎ˚ñ ¢yÓ˚y !ÓŸªÓƒy¸ô# ~Ó˚ Ñ¸yÓ˚í ~ÓÇ ≤Ã¶¸yÓ ˆîÖy 10 ? NSOU ? AE-ES-21

ÎyˆÏFäÈ– ~£z ¢õ¢ƒy ¢õyïy˜ÏòÓ˚ ãòƒ xyhs¸ã≈y!ì¸Ñ¸ hfl¸˜ÏÓ˚ ¸ô!Ó˚˜ÏÓü ¢¡ô!Ñ≈¸ì¸ Ķ¸yò ~ÓÇ ¸ô!Ó˚˜ÏÓü ˆâ¸ì¸òyÓ˚ !ÓÑ¸yü á›¸y˜Ïì¸ ¸ô!Ó˚˜ÏÓü !Óîƒy xyÓüƒÑ¸– ? ˆÎ¶¸y˜ÏÓ !î˜ÏòÓ˚ ¸ôÓ˚ !îò ãò¢ÇÖƒyÓ˚ fl¸≥¸#!ì¸ á›¸˜ÏäÈ ì¸yÓ˚ ö¸úfl¸∫Ó˚*¸ô Óã≈ƒ Á î)!°Ïì¸ ¸ôîy˜Ïì≈Ó˚ ¸ô!Ó˚õyí Óyv¸¸˜ÏäÈ– ÷ï% ì¸y£z òÎ˚ñ ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ô˜ÏîÓ˚ xì¸ƒ!ïÑ¸ ÓƒÓ£y˜ÏÓ˚Ó˚ ö¸˜Ïú ì¸yÓ˚ £...y¢Á £˜ÏFäÈ ~ÓÇ î)!°Ïì¸ ¸ôîyÌ≈ ¸ô!Ó˚˜ÏÓ˚˜Ïü ˆö¸úyÓ˚ ö¸˜Ïú ãúñ õy!›¸ ¢Ó!Ñ¸ä%È î)!°Ïì¸ £˜ÏFäÈñ ˆÎõòÈÙÙÙÈ õy!›¸Ó˚ v¸zÓ≈Ó˚ì¸y £...y¢ñ úÓíy_´ì¸y Ó,!k¸ ¢Ó£z ¸ô!Ó˚˜ÏÓü î)°Ï˜ÏíÓ˚ ãòƒ £˜ÏFäÈ– ~£z ¢Ó!Ñ¸ä%È ¢õyïy˜ÏòÓ˚ ãòƒ ¸ô!Ó˚˜ÏÓü !ÓîƒyÓ˚ !Óhfl¸yÓ˚ ãÓ˚&!Ó˚– ? õyòÓ ¢¶¸ƒì¸y ! ÓĶ¸yòñ ≤ÃÎ%!_´Ó˚ ö¸˜Ïú Îì¸ v¸zß¨ì¸ £˜ÏÎ˚˜ÏäÈ ì¸ì¸ ˆÓ!ü ˆÓ!ü ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ v¸z¸ôÓ˚ xì¸ƒyâ¸yÓ˚ ˆÓ˚˜Ïv¸¸˜ÏäÈ– ˜ì¸!Ó˚ Ñ¸Ó˚y £˜ÏÎ˚˜ÏäÈ Óv¸¸ Óv¸¸ £zõyÓ˚ì¸– ˆÑ¸˜Ï›¸ ˆö¸úy £˜ÏFäÈ Óò¶)¸!õ Á ¢Ó%ã ÜyäÈñ ¸ô!Ó˚Ó˚˜Ïì≈¸ Ü˜Ïv¸¸ ˆì¸yúy £˜ÏFäÈ Ñ¸Ç!e´˜Ï›¸Ó˚ ãDú Îy ≤ÃyÑ,¸!ì¸Ñ¸ ¶¸yÓ˚¢yõƒ £...y¢ Ñ¸Ó˚˜ÏäÈ– ? õ˜Ïò Ó˚yÖ˜Ïì¸ £˜ÏÓ ˆ¢ÔÓ˚ãÜíÈÙÈ~Ó˚ õ˜Ïïƒ ~Ñ¸õye ¸ô,!ÌÓ#˜Ïì¸ ≤Ãy˜ÏíÓ˚ ¢M¸ÈyÓ˚ á˜Ï›¸ ˆäÈ– ¢%ì¸Ó˚yÇ Î!î ¢%¸ô!Ó˚Ñ¸!"ì¸ ¶¸y˜ÏÓ v¸zß¨Î˚ò òy Ñ¸Ó˚y £Î˚ ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ô˜ÏîÓ˚ ÓƒÓ£yÓ˚ x!Ñ¸!M¸Èì¸ ¶¸y˜ÏÓ Ñ¸Ó˚y £Î˚ ì¸y£˜Ïú ~£z ≤Ãy˜ÏíÓ˚ xy˜Ïúy ~Ñ¸!îò !ò˜Ï¶¸ Îy˜ÏÓ£z ~ÓÇ xòƒyòƒ @˘Ã˜Ï£Ó˚ õ˜Ïì¸y ¸ô,!ÌÓ# ~Ñ¸!›¸ õ,ì¸ @˘Ã˜Ï£ ¸ô! Ó˚î¸ £˜ÏÓ– ì¸y£z õyòÓ ¢˜Ïâ¸ì¸¸òì¸y Á ¸ô!Ó˚˜ÏÓü˜ÏÑ¸ ¢%fl¸¡ ¢Óú Ó˚yÖyÓ˚ ãòƒ ¸ô!Ó˚˜ÏÓü !ÓîƒyÖ%Ó£z =Ó˚&c¸ô)í≈– 1.7 ¸ô! Ó˚˜ÏÓü !ÓîƒyÓ˚ ¸ô!Ó˚!ï (Scope of Environmental Studies) xyõÓ˚y ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ õ˜Ïïƒ Ó¢Óy¢ Ñ¸!Ó˚ ~ÓÇ ≤ÃÑ,¸!ì¸ õyì¸y ì¸yÓ˚ v¸z¸ôyîyò !î˜ÏÎ˚ xyõy˜ÏîÓ˚ úyúò ¸ôyúò Ñ¸˜ÏÓ˚ò– ì¸y£z ≤ÃÑ,¸!ì¸˜ÏÑ¸ ¢%fl¸¡ Ó˚yÖy xyõy˜ÏîÓ˚ Ñ¸ì≈¸Óƒ– ≤ÃÑ,¸!ì¸ !ò˜ÏãÓ˚ v¸z¸ôyîyò=!úÓ˚ õ˜Ïïƒ ¢%¢yõO¢ƒ Óãyû Ó˚yÖyÓ˚ ˆâ¸‹Ty Ñ¸˜ÏÓ˚ !Ñ¸ls¸ ~Ó˚ Óƒ!ì¸e´õ £ú õyò%°Ïñ õyò%°Ï ì¸yÓ˚ !ò˜ÏãÓ˚ â¸y!£îy ˆõ›¸y˜ÏòyÓ˚ ãòƒ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ v¸z¸ôyîyò˜ÏÑ¸ ò‹T Ñ¸˜ÏÓ˚ â¸˜Ïú˜ÏäÈ– ïπÇ¢ £˜ÏFäÈ ¢Ó%ãñ !òÉ˜ÏŸª°Ï £˜ÏÎ˚ Îy˜ÏFäÈ ¸ô!Ó˚¢%k¸ fl¸∫yî% ã˜ÏúÓ˚ ¶¸y[¸yÓ˚– ~£z ¢Ó!Ñ¸ä%ÈÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ !£¢y˜ÏÓ ¸ô!Ó˚˜ÏÓü!Óîƒy ¸ôy‡¸ƒ !Ó°ÏÎ˚ £ÁÎ˚y Ö%Ó£z ãÓ˚&!Ó˚– ¸ô! Ó˚˜ÏÓü!Óîƒy ¢yïyÓ˚í ¶¸y˜ÏÓ ~Ñ¸!›¸ !õ◊ !Óîƒy Ñ¸yÓ˚í ~!›¸ ~Ñ¸!›¸ òyòy !ÓîƒyÓ˚ ¢Ω¸yÓ˚– Óì≈¸õyò ¸ô!Ó˚˜ÏÓü˜ÏÑ¸ ¢!‡¸Ñ¸ ¶¸y˜ÏÓ ãyò˜Ïì¸ xyõy˜ÏîÓ˚ ¢y£yÎ˚ƒ Ñ¸˜ÏÓ˚ ¸ô!Ó˚˜ÏÓü!Óîƒy– ¸ô!Ó˚˜ÏÓü!ÓîƒyÓ˚ ¢yïyÓ˚í î%!›¸ !ïÑ¸ xy˜ÏäÈñ ~Ñ¸!›¸ ì¸y!_¥Ñ¸ !ïÑ¸ Îy ¸ô! Ó˚˜ÏÓ˚˜ÏüÓ˚ ¢õ¢ƒy=!ú !ò˜ÏÎ˚ xy˜Ïúyâ¸òy Ñ¸˜ÏÓ˚ xyÓ˚ ~Ñ¸!›¸ ÓƒÓ£y!Ó˚Ñ¸ !ïÑ¸ Îy ¢õ¢ƒy=!ú ¢õyïy˜ÏòÓ˚ ãòƒ òyòy ÓƒÓfl¸iy @˘Ã£í Ñ¸˜ÏÓ˚– 1.8 ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ˜Ó!ü‹T (Nature of Physical Environment) (i) ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓü ¢ì¸ì¸ ¸ô!Ó˚Óì≈¸òü#ú É ¸ô,!ÌÓ#Ó˚ ã˜Ïß√Ó˚ ¢õÎ˚ ˆì˜ÏÑ¸ xyã ¸ôÎ≈hs¸ ¸ô,!ÌÓ#Ó˚ ˆ¶¸Ôì¸ Ó˚y¢yÎ˚!òÑ¸ ¸ô!Ó˚Óì≈¸ò á˜Ï›¸ â¸˜Ïú˜ÏäÈ– ¶)¸ÈÙÈx¶¸ƒhs¸Ó˚#í ¶)¸ÈÙÈÜy‡¸!òÑ¸ ü!_´ ¢õ)£ !e´Î˚yü#ú ÌyÑ¸yÎ˚ ¢£òõò Á ¢Ç˜ÏÑ¸yâ¸ò Ó˚˜ÏúÓ˚ ≤Ã¶¸y˜ÏÓ õ£#Öy˜Ïì¸ ¢!M¸Èì¸ ¸ô!úÓ˚y!ü˜Ïì¸ â¸y˜Ïì¸ôÓ˚ ö¸˜Ïú ¢,!‹T £˜ÏÎ˚˜ÏäÈ ¶¸!Dú ¸ôÓ≈ì¸– ¸ô,!ÌÓ#Ó˚ ãß√ú˜Ï@¿ !äÈú òy xyÓ£yÁÎ˚y– !Ó!¶¸ß¨ Üƒy¢ Á ãú#Î˚ Óy˜Ï‹ôÓ˚ xyò%¸ôy!ì¸Ñ¸ £y˜ÏÓ˚ ¸ô!Ó˚Óì≈¸˜ÏòÓ˚ õïƒ !î˜ÏÎ˚ Óì≈¸õyò Óyû˚%õ[¸ú#Î˚ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ¢,!‹T £˜ÏÎ˚˜ÏäÈ– xyÓyÓ˚ Óì≈¸õy˜Ïò @˘Ã#í £yv¸z¢ Üƒy¢=!úÓ˚ õyey!ì¸!Ó˚_´ ¢M¸È˜ÏÎ˚Ó˚ ö¸˜Ïú ¸ô,!ÌÓ#Ó˚ v¸z°åì¸yÓ˚ õyey Ó,!k¸ ˆ¸ô˜ÏÎ˚˜ÏäÈ– xì¸~Ó Óúy Îyñ ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô! Ó˚˜ÏÓü ¢ì¸ì¸£z ¸ô!Ó˚Óì≈¸òü#ú– (ii) ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓü Ñ¸ì¸Ñ¸=!ú !òÎ˚˜ÏõÓ˚ õyïƒ˜Ïõ â¸y!úì¸ £Î˚ É ≤ÃyÑ,¸!ì¸Ñ¸ !òÎ˚õ !fl¸iÓ˚ Á ¢%!ò!î≈‹T– õyò%°Ï ì¸yÓ˚ Ñ¸yãÑ¸˜Ïõ≈Ó˚ õyïƒ˜Ïõ ≤ÃyÑ,¸!ì¸Ñ¸ ≤Ã!e´Î˚y ¢õ)˜Ï£Ó˚ õyey Á ì¸#Ó ì¸yÓ˚ ¸ô!Ó˚Óì≈¸ò á›¸y˜ÏúÁ ≤ÃyÑ,¸! ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ õ%Öƒ NSOU ? AE-ES-21 ? 11 ≤Ã!e´Î˚y¢õ)£ Îy xhs¸ã≈yì¸ Á Ó!£ã≈yì¸ ≤Ã!e´Î˚y¢õ)£ Ñ¸ì¸Ñ¸=!ú ˆõÔ!úÑ¸ ≤ÃyÑ,¸!ì¸Ñ¸ Á Ó˚y¢yÎ˚!òÑ¸ !òÎ˚õ xò%¢y˜ÏÓ˚ â¸˜Ïú– (iii) ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ≤Ã˜Ïì¸ƒÑ¸!›¸ v¸z¸ôyîyò xyhs¸É ¢¡ôÑ≈¸Î%_´ É ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓü Ü‡¸òÑ¸yÓ˚# v¸z¸ôyîyò=!ú xyhs¸É¢ ¡ôÑ≈¸Î%_´ £ÁÎ˚yÎ˚ ~˜ÏíÓ˚ ~Ñ¸!›¸Ó˚ ¸ô!Ó˚Óì≈¸ò á›¸˜Ïú xòƒ!›¸Ó˚ v¸z¸ôÓ˚ ì¸yÓ˚ ≤Ã¶¸yÓ ¸ô˜Ïv¸¸– (iv) ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ≤ÃÓíì¸y £ú ¶¸yÓ˚¢yõƒ xÓfl¸iyÎ˚ v¸z¸ôò#ì¸ £ÁÎ˚y É ¶)¸ÈÙÈxy˜Ïúyv¸¸˜ÏòÓ˚ ö¸˜Ïú ¶)¸!õÓ˚*˜Ï¸ôÓ˚ ˆÎ ¸ô!Ó˚Óì≈¸ò £Î˚ ì¸y˜ÏÑ¸ ¸ô)˜ÏÓ≈Ó˚ xÓfl¸iyÎ˚ !ö¸!Ó˚˜ÏÎ˚ xyòyÓ˚ ãòƒ e´õyÎ˚õyò ≤Ã!e´Î˚y=!ú ¢Ó ¢õÎ˚ !e´Î˚yü#ú Ìy˜ÏÑ¸– ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ¶¸yÓ˚¢yõƒ !Ó!á¯ì¸ £˜Ïú fl¸∫Î˚Ç!e´Î˚ ÓƒÓfl¸iy¸ôòyÓ˚ õïƒ !ì˜ÏÎ˚£z ì¸y ¸ô%òÓ˚yÎ˚ ¶¸yÓ˚¢y˜Ïõƒ v¸z¸ôò#ì¸ £Î˚– (v) ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ˆÑ¸yò ¢ %!ò!î≈‹T ˆ«¸eõyò ˆò£z É ãyÎ˚Üy!Ó˚˜Ïü˜Ï°Ï ì¸y ¢%Ó,£íñ Ó,£íñ õïƒõ ~õò!Ñ¸ ¢%" Óy xò%¸ô!Ó˚˜ÏüÁ £˜Ïì¸ ¸ôy˜ÏÓ˚– 1.9 ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ v¸z¸ôyîyò (Components of Physical Environment) ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓü ˆÎ ˆÎ v¸z¸ôyîyò !î˜ÏÎ˚ Ó˚!â¸ì¸ñ ˆ¢=!ú !ì¸ò ≤ÃÑ¸yÓ˚– 1. x˜ÏãÓ Óy ˆ¶¸Ôì¸ v¸z¸ôyîyò¢õ)£ (Abiotic = non-living components) 2. ˜ãÓ Óy ¢≤Ãyí v¸z¸ôyîyò¢õ)£ (Biotic = living components) 3. ü!_´ v¸z¸ôyîyò (Energy components) !â¸e ≠ ≤

52%	MATCHING BLOCK 8/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ v¸z¸ôyîyò¢õ)£ 12 ? NSOU ? AE-ES-21 ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚

x˜ÏãÓ v¸z¸ôyîyò¢õ)£ !ì¸ò ≤ÃÑ¸yÓ˚– ÎlyÈÙÙÙÈ Ñ¸!‡¸ò (Solid)ñ ì¸Ó˚ú (Liquid) Á Üƒy¢#Î˚ (Gaseous)– (i) Ñ¸!‡¸ò v¸z¸ôyîy˜Ïò Ü!‡¸ì¸ ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚˜ÏÓüñ ÎlyÈÙÙÙÈ ¸ô,!ÌÓ#Ó˚ Ñ¸!‡¸ò xÇü Îy !üúyõ[¸ú (lithosphere) òy˜Ïõ– (ii) ì¸Ó˚ú v¸z¸ôyîy˜Ïò Ü!‡¸ì¸ ≤ÃyÑ,¸! ì¸Ñ¸ ¸ô!Ó˚˜ÏÓüñ ÎlyÈÙÙÙÈ ¸ô,!ÌÓ#Ó˚ ì¸Ó˚ú xÇü Îy Óy!Ó˚õ[¸ú òy˜Ïõ (hydrosphere) ~ÓÇ (iii) Üƒy¢#Î˚ v¸z¸ôyîy˜Ïò Ü!‡¸ì¸ ≤ÃyÑ,¸! ì¸Ñ¸ ¸ô!Ó˚˜ÏÓüñ ÎlyÈÙÙÙÈ ¸ô,!ÌÓ#Ó˚ Üƒy¢#Î˚ xÇü Îy ÓyÎ˚%õ[¸ú òy˜Ïõ (atmosphere) ¸ô!Ó˚!â¸ì¸– (i) !üúyõ[¸ú (Lithosphere) É Ñ¸! ‡¸ò !üúy myÓ˚y Ü!‡¸ì¸ ¸ô,!ÌÓ#Ó˚ Ó!£Ó˚yÓÓ˚í˜ÏÑ¸ !üúyõ[¸ú Ó˚˜Ïú– !Ó!¶¸ß¨ ïÓ˚˜ÏòÓ˚ ü_´ !üúy !î˜ÏÎ˚ ¶)¸cÑ¸ Óy !üúyõ[¸ú Ü!‡¸ì¸– !üúyõ[¸˜ÏúÓ˚ Ü¶¸#Ó˚ì¸y ¢Ó≈e ¢õyò òÎ˚– ¢õ%˜ÏïÓ˚ ì¸ú˜Ïî˜Ïü ~Ó˚ Ü¶¸#Ó˚ì¸y õye 5 !Ñ¸!õ– !Ñ¸ls¸ õ£y˜Ïî˜ÏüÓ˚ xÇ˜Ïü ~Ó˚ Ü¶¸#Ó˚ì¸y ≤ÃyÎ˚ 35 !Ñ¸!õ– !üúyõ[¸˜ÏúÓ˚ ¢Ó˜Ïâ¸˜ÏÎ˚ Á¸ô˜ÏÓ˚Ó˚ xÇü!›¸ !¢!úÑ¸y (Si) Á xƒyú%!õ!òÎ˚yõ (Al) myÓ˚y Ü!‡¸ì¸ £ÁÎ˚yÎ˚ ~˜ÏÑ¸ !¢Î˚yú (SIAL) hfl¸Ó˚ Ó˚˜Ïú– õ£y˜Ïîü=!ú !¢Î˚yú hfl¸Ó˚ myÓ˚y Ü!‡¸ì¸– ~£z hfl¸˜ÏÓ˚ @˘Ãyòy£z›¸ ãyì¸#Î˚ !üúy ˆîÖy ÎyÎ˚– xòƒ! î˜ÏÑ¸ õ£y¢yÜÓ˚=!ú !üúy hfl¸Ó˚ myÓ˚y Ü!‡¸ì¸– ~£z hfl¸˜ÏÓ˚ Óƒy¢Œ›¸ ãyì¸#Î˚ !üúy ˆîÖy ÎyÎ˚– õ£y˜Ïî˜ÏüÓ˚ !üúyÓ˚ áòc Á Áãò õ£y¢yÜ˜ÏÓ˚Ó˚ !üúyÓ˚ ˆì˜ÏÑ¸ Ñ¸õ Ó˚˜Ïú õ£y¢yÜÓ˚=!úÓ˚ Á¸ôÓ˚ õ£y˜Ïîü=!ú ¶¸y¢õyò xÓfl¸iyÎ˚ !ÓÓ˚yã Ñ¸Ó˚˜ÏäÈ– !üúyñ õ‚!_Ñ¸y Á Ö!òã É !üúyõ[¸˜ÏúÓ˚ ¶)¸cÑ¸#Î˚ xÇ˜Ïü v¸z¸ôyîyò Ó˚*˜Ï¸ô Ó˚˜ÏÎ˚˜ÏäÈ !Ó!¶¸ß¨ ≤ÃÑ¸yÓ˚ Ö!òãñ !üúyñ õ‚!_Ñ¸yñ «¸Î˚ãyì¸ Á ¢M¸ÈÎ˚ãyì¸ ¶)¸!õÓ˚*¸ô– ¸ôy£yv¸¸ ¸ôÓ≈˜Ïì¸Ó˚ òƒyÎ˚ Ó,£îyÎ˚ì¸ò ¶)¸!õÓ˚*¸ôñ v¸z!qî Á ≤Ãyí#Ó˚ Óy¢fl¸iyòÓ˚*˜Ï¸ô !Ó!¶¸ß¨ ïÓ˚˜ÏòÓ˚ ˆäÈy›¸ Óv¸¸ ˜Ó!â¸eƒ¸ô)í≈ ¶)¸!õÓ˚*¸ô ≤Ã¶,¸!ì¸– ¢Ó ïÓ˚˜ÏòÓ˚£z ≤ÃyÑ,¸!ì¸Ñ¸ ≤Ã!e´Î˚y ~£z !üúyõ[¸˜ÏúÓ˚ v¸z¸ôÓ˚ !e´Î˚yü#ú £˜ÏúÁ ≤Ãïyòì¸É !üúyõ[¸ú#Î˚ v¸z¸ôyîy˜ÏòÓ˚ ¸ô!Ó˚Óì≈¸ò ¢ÇÜ!‡¸ì¸ £Î˚ î%!›¸ õ)ú ü!_´Ó˚ myÓ˚y– ÎlyÈÙÙÙÈ SÑ¸V x¶¸ƒhs¸Ó˚#í ü!_´ñ ÎyÓ˚ ö¸˜Ïú ¢,!‹T £Î˚ ¶§¸yãñ â%¸ƒ!ì¸ñ ¶)¸!õÑ¸¡ô Á xy˜Ï@¿Î˚!Ü!Ó˚ ~ÓÇ SÖV Ó!£ü≈!_´ñ ÎyÓ˚ ö¸˜Ïú ¶)¸c˜ÏÑ¸Ó˚ v¸z¸ô!Ó˚¶¸y˜ÏÜ xyÓ£!ÓÑ¸yÓ˚ñ ¸ô%!Oì¸fl¸>úòñ òîÈÙÈòî#ñ ÓyÎ˚%≤ÃÓy£ !£õÓy£ñ ¢õ%o ì¸Ó˚D myÓ˚y ¶)¸c˜ÏÑ¸Ó˚ ï#Ó˚ ¸ô! Ó˚Óì≈¸ò á˜Ï›¸ Ìy˜ÏÑ¸– =Ó˚&õ[¸ú !â¸e ≠ !üúyõ[¸ú NSOU ? AE-ES-21 ? 13

!üúyõ[¸ú xyˆÏ@¿Î˚ñ ¸ôyú!úÑ¸ Á Ó˚*¸ôyhs¸!Ó˚ì¸ !üúy myÓ˚y Ü!‡¸ì¸– ~£z !üúy xyÓ£!ÓÑ¸y˚ÏÓ˚Ó˚ ö¸˚Ïú Á õy!›¸ ¢‚!‹TÓ˚ !Ó!¶¸ß¨ ≤Ã!e´Î˚yÎ˚ ~Ñ¸¢õÎ˚ õy!›¸˚Ïì¸ ¸ô!Ó˚î¸ £Î˚ – xÌ≈yÍñ ¶)¸c˚ÏÑ¸Ó˚ Á¸ôÓ˚ !ü!Ìú ˜ãÓ Ó˚y¢yÎ˚!òÑ¸ xyÓÓ˚í˚ÏÑ¸ õy!›¸ Óúy £Î˚ÈÙÙÈ Îy ¸ô!Ó˚ˆÏÓ˚ÏüÓ˚ ¢ã#Ó Á !òã≈#Ó v¸z¸ôyîyò=!úÓ˚ õ˚Ïïƒ ¢Ç˚ÏÎyÜ Ó˚«¸y Ñ¸˚ÏÓ˚ â¸˚Ïú– Ó˚y!üÎ˚yò ˜ÓK¸yò# ¶¸Ñ%¸˚Ïâ¸˚Ï¶¸Ó˚ õ˚Ïì¸ õ‚!_Ñ¸y £ú ~Ñ¸!›¸ Ü!ì¸ü#ú õyïƒõ– Ñ¸yÓ˚í õ‚!_Ñ¸yÓ˚ õ˚Ïïƒ xÓ!fl¸ïì¸ v¸z¸ôyîyò=!úÓ˚ ¸ô!Ó˚Ói≈¸òü#úì¸y õ‚!_Ñ¸yÓ˚ fl¸∫y¶¸y!ÓÑ¸ ï˚Ïõ≈Ó˚Á ¸ô!Ó˚Óì≈¸ò á›¸yÎ˚ – ¶)¸cÑ¸ Ü‡¸òÑ¸yÓ˚# ˆõÔ!úÑ¸ ¸ôîyÌ≈=!úÓ˚ õ˚Ïïƒ x!:˚Ïãòñ !¢!úÑ¸òñ xƒyú%!õ!òÎ˚yõñ ˆúÔ£ñ Ñ¸ƒyú! ¢Î˚yõñ ˆ¢y!v¸Î˚yõñ ¸ô›¸y!¢Î˚yõ Á õƒyÜ˚Ïò!üÎ˚yõ ≤Ãïyò– ~£z xy›¸!›¸ ˆõÔ!úÑ¸ ¸ôîyÌ≈ !î˚ÏÎ˚ ¶)¸c˚ÏÑ¸Ó˚ 98 üì¸yÇü Ü!‡¸ì¸ – !üúyõ[¸ú xyˆÏ@¿Î˚ñ ¸ôyú!úÑ¸ Á Ó˚*¸ôyhs¸!Ó˚ì¸ !üúy myÓ˚y Ü!‡¸ì¸ – xyÓ˚ !üúy ˆì¸y Ö!òã !î˚ÏÎ˚£z ˜ì¸!Ó˚ – !üúyÜ‡¸òÑ¸yÓ˚# ≤Ãïyò Ö!òã îü!›¸ÈÙÙÈ ˆÑ¸yÎ˚y›¸õñ ˆö¸úfl¸≥¸yÓ˚ñ xºñ Ñ¸î≈õ Ö!òãñ ˆÑœ¸yÓ˚y£zv¸ñ £ò≈˚ÏÓœu¸ñ xÜy£z›¸ñ x!ú!¶¸òñ Ñ¸ƒyú¢y£z›¸ñ v¸˚Ïúyõy£z›¸ Á ˆúÔ£ xyÑ¸!Ó˚Ñ¸ – !â¸e ≠ ¶)¸cÑ¸ Ü‡¸òÑ¸yÓ˚# ˆõÔ!úÑ¸ v¸z¸ôyîyò !üúyõ[¸˚ÏúÓ˚ =Ó˚&c É SÑ¸V !üúyõ[¸ú £ú ã#ÓãÜÍ Á v¸z!q˚ÏïÓ˚ xyÓy¢fl¸iúñ SÖV õyò%˚ÏºÏÓ˚ ≤Ã˚ÏÏ˚yão#Î˚ ¢¡ô˚ÏïÓ˚ xyïyÓ˚ Á v¸zÍ¢ SÜV ¶)¸c˚ÏÑ¸Ó˚ ¢˚ÏÓπ≈yFâ¸ hfl¸˚ÏÓ˚ xy˚ÏäÈ õ‚!_Ñ¸y– v¸z!qî Á ≤ÃyÍ#Ñ)¸˚ÏúÓ˚ ≤Ã˚ÏÏ˚yão#

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Î˚ ¢Ó v¸z¸ôÑ¸Ó˚í ¸ôyÁÎ˚y Îy˚ ~£

z õ‚!_Ñ¸y ˆÌ˚ÏÑ¸ – SáV ¶)¸!õÓ˚ ≤ÃÑ¸‚!ì¸ !üúyÓ˚ ˜Ó!ü‹Tƒ myÓ˚y !òï≈y!Ó˚ì¸ £Î˚ – xyÓ˚ ~£z ¶)¸!õÓ˚ ≤ÃÑ¸‚!ì¸£z õyò%˚ÏºÏÓ˚ xÌ≈˜

100% **MATCHING BLOCK 10/200** **SA** MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

Ïò!ì¸Ñ¸ Ñ¸yÎ≈Ñ¸úy¸ô˚ÏÑ¸ Ó˝

úyÇ˚Ïü !òÎ˚s¸fí Ñ¸˚ÏÓ˚ – (ii) Óy!Ó˚õ[¸ú (Hydrosphere) É ¸ô‚!ÌÓ#Ó˚ ¢Ó ïÓ˚˚ÏòÓ˚ ãúÓ˚y!ü˚ÏÑ¸ Óy!Ó˚õ[¸ú Óúy £Î˚ – !üúyõ[¸˚ÏúÓ˚ ˆÎ ¢Ó ò#â%¸ xÇü ãú¸ô)í≈ £˚ÏÎ˚ õ£y¢yÜÓ˚ñ ¢yÜÓ˚ñ òî#ñ £…îñ ÖyúÈÙÈ!Óú ≤Ã¶¸‚!ì¸ ãú¶¸yÜ ¢‚!‹T Ñ¸˚ÏÓ˚˚ÏäÈ ì¸y˚ÏÑ¸ ~Ñ¸¢˚ÏÏD Óy!Ó˚õ[¸ú Óúy £Î˚ ¶)¸¸ô‚˚Ï¤¸Ó˚ ˆõy›¸ xyÎ˚ì¸˚ÏòÓ˚ ≤ÃyÎ˚ 71.4 ¶¸yÜ ã%˚Ïv¸¸ Ó˚˚ÏÎ˚˚ÏäÈ Óy!Ó˚õ[¸ú– ¢yÓ˚y ¸ô‚!Ó# ã%˚Ïv¸¸ Óy!Ó˚õ[¸ú ˆÑ¸y˚ÏòyÈÙÈòyÈÙÈ˚Ñ¸y˚Ïòy Ó˚*˚Ï¸ô !Óîƒõyò Ó˚˚ÏÎ˚˚ÏäÈ£z– ÚÓy!Ó˚ÛÈÙÈÓ˚ !ì¸ò!›¸ Ó˚*¸ôÈÙÙÈ ãúñ ÓÓ˚ö¸ Á ãú#Î˚ Óy‹ô– ÚãúÈÙÈÓ˚*˚Ï¸ô !Óîƒõyòì¸y£z ˆÓ!üÛ– ãú £ú ~Ñ¸!›¸ Óí≈£#òñ Üı£#ò fl¸∫yî£#ò ≤Ãüõ ì¸Ó˚ú ¸ôîyÌ≈ (pH-7)– 14 ? NSOU ? AE-ES-21

¸ô‚!Ó#˚Ïì¸ Óy!Ó˚õ[¸˚ÏúÓ˚ Ó^˘›¸ò SÑ¸V !ÓŸª ¢õ%o (World Ocean) ÈÙÙÈ 97.200 üì¸yÇü SÖV ˆ¶¸ÔõãúÓ˚y!ü Ó˚*˚Ï¸ô ÈÙÙÈ 00.625 üì¸yÇü SÜV òî#ñ £…î £zì¸ƒy!î Ó˚*˚Ï¸ô ÈÙÙÈ 00.024 üì¸yÇü SáV ÓÓ˚ö¸Ó˚*˚Ï¸ô ÈÙÙÈ 02.150 üì¸yÇü SàV ãú#Î˚ Óy‹ôÓ˚*˚Ï¸ô SÓyÎ˚%õ[¸˚ÏúV ÙÙÙÈ 00.001 üì¸yÇü ˆõy›¸ ÈÙÙÈ 100.000 üì¸yÇü ãú ÓyÎ˚%õ[¸ú ˆÌ˚ÏÑ¸ ¸ô‚!Ó#¸ô‚˚Ï¤¸ ~ÓÇ ¸ô‚!Ó# ¸ô‚¤¸ ˆÌ˚ÏÑ¸ ¸ô%íÓ˚yÎ˚ ÓyÎ˚%õ[¸ú xyÓ!Ì≈¸ì¸ £Î˚ – ã˚ÏúÓ˚ ~£z !ÓÓ˚yõ£#ò â¸e´yÑ¸yÓ˚ xyÓì≈¸ò˚ÏÑ¸ ãúâ¸e´ (Hydrological cycle) Ó˚Ïú– ãúâ¸e´ ¢¡ôy!îì¸ £Î˚ !ì¸ò!›¸ ≤Ã!e´Î˚yÓ˚ õyïƒ˚Ïõ– ÎlyÈÙÙÈ Óy‹ô#¶¸Óòñ áò#¶¸Óò Á xïÉ˚Ï«¸¸ôò– ~£z !ì¸ò!›¸ ≤Ã!e´Î˚yÓ˚ ˆÎ ˆÑ¸yò ~Ñ¸!›¸ !Ó!á¯ì¸ £˚Ïú ãúâ¸e´ ¶¸yÓ˚¢yõƒ £yÓ˚yÎ˚ – ¢)Ì≈¸ì¸y˚Ï¸ô ãú¶¸yÜ v¸z_Æ £˚Ïú ã˚Ïú Óy˚Ï‹ô ¸ô!Ó˚î¸ £Î˚ – ˙ Óy‹ô ÓyÎ˚% myÓ˚y ãú¶¸yÜ Á fl¸iú¶¸y˚ÏÜÓ˚ !î˚ÏÑ¸ ¸ô!Ó˚Óy!£ì¸ £Î˚ – xò%Ñ)¸ú ¸ô!Ó˚˚ÏÓ˚Ïü ãú#Î˚Óy‹ô áò#¶)¸ì¸ £˚ÏÎ˚ Ó‚!‹T Óy ì%¸ºy˚ÏÓ˚Ó˚ xyÑ¸y˚ÏÓ˚ fl¸iú¶¸yÜ Á ãú¶¸y˚ÏÜÓ˚ v¸z¸ôÓ˚ ¸ô!ì¸ì¸ £Î˚ – ¶)¸¸ô‚˚Ï¤¸ ˆ¸ôÔ§äÈy˚ÏòyÓ˚ ¸ô)˚ÏÓ≈£z ã˚ÏúÓ˚ !Ñ¸ä%È xÇü Óy˚Ï‹ôÓ˚ xyÑ¸y˚ÏÓ˚ ÓyÎ˚%õ[¸˚Ïú !ö¸˚ÏÓ˚ ÎyÎ˚ – ãúâ¸e´ Ó‚!‹T¸ôy˚Ïì¸Ó˚ ~Ñ¸ xÇü õ‚!_Ñ¸y ˆüyºïí Ñ¸˚ÏÓ˚ ˆ¶¸ÔõãúhflÓ˚ Ü˚Ïv¸¸ ˆì¸y˚Ïú xyÓ˚ !Ñ¸ä%È xÇü x¶¸ƒhs¸Ó˚#í ≤ÃÓy£Ó˚*˚Ï¸ô ¢õ%˚Ïo fl¸iyòyhs¸!Ó˚ì¸ £Î˚ – ¸ô%òÓ˚yÎ˚ ˙ ãú Óy‹ô#¶)¸ì¸ £˚ÏÎ˚ ÓyÎ˚%õ[¸˚Ïú !ö¸˚ÏÓ˚ ÎyÎ˚ – ~£z ¶¸y˚ÏÓ£z ≤ÃÑ¸‚!ì¸˚Ïì¸ ãú â¸e´yÑ¸y˚ÏÓ˚ xyÓ!Ì≈¸ì¸ £Î˚ – ã˚ÏúÓ˚ =Ó˚&c É Óy!Ó˚õ[¸ú ≤ÃyÑ¸‚!ì¸Ñ¸ ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ ¢˚ÏÏD Áì¸˚Ï≤Ãyì¸¶¸y˚ÏÓ ¢¡ô!Ñ≈¸ì¸ – Óy!Ó˚õ[¸ú !Ó!¶¸ß¨ ≤ÃyÑ¸‚!ì¸Ñ¸ ¢¡ô˚ÏïÓ˚ Ó˚¢yÎ˚òyÜyÓ˚ñ õyòÓãy!ì¸Ó˚ Ñ¸y˚ÏäÈ Óy!Ó˚õ[¸˚ÏúÓ˚ =Ó˚&c x¸ô!Ó˚¢#õ– Óy!Ó˚õ[¸˚ÏúÓ˚ =Ó˚&c ò#˚Ïâ¸ xy˚Ïúyâ¸òy Ñ¸Ó˚y £ú– NSOU ? AE-ES-21 ? 15

SÑ¸V ã#Ó˚ÏÍ£ Ü‡¸˚Ïò ãú x¸ô!Ó˚£yÎ≈– ã#Ó˚ÏÍ£ Ü‡¸òÑ¸yÓ˚# v¸z¸ôyîyò=!úÓ˚ õ˚Ïïƒ ã˚ÏúÓ˚ ¸ô!Ó˚õyí£z 70 üì¸yÇü– SÖV ã#Óõ[¸˚Ïú ã˚ÏúÓ˚ ¢õì¸y Ó˚«¸y £Î˚ ãúâ¸˚Ïe´Ó˚ õyïƒ˚Ïõ Îy Óy!Ó˚õ[¸˚ÏúÓ˚

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v¸z¸ô!fl¸i!ì¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú–

SÜV Óy!Ó˚õ[¸ú ã#˚ÏÓÓ˚ ˆ≤Ãy!›¸ò ãyì¸#Î˚ Öy˚ÏïƒÓ˚ ¶¸y[¸yÓ˚ – !Ó!¶¸ß¨ ïÓ˚˚ÏòÓ˚ ¢yõ%!oÑ¸ õyäÈñ !â¸Ç!v¸¸ñ !e´úñ ö¸yí≈ £zì¸ƒy!î ˆÌ˚Ï‹T ¸ô!Ó˚õy˚Ïí ¢õ%˚Ïo ãß√yÎ˚ – SáV Óy!Ó˚õ[¸ú !Ó!¶¸ß¨ Ö!òã oÓƒ Á ãµyúy!ò o˚ÏÓƒÓ˚ ¶¸y[¸yÓ˚ – SàV !â¸Ó˚yâ¸!Ó˚ì¸ Á x! â¸Ó˚yâ¸!Ó˚ì¸ !Óî%ƒÍ ü!_´Ó˚ v¸zÍ¢Á Óy!Ó˚õ[¸ú– Sâ¸V ãúÓyÎ˚% !òÎ˚s¸fí Á ÓyÎ˚%î)ºí ≤Ã!ì¸˚ÏÓ˚yï Ñ¸˚ÏÓ˚ ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ ¶¸yÓ˚¢yõƒ Ó˚«¸yÎ˚ Óy!Ó˚õ[¸˚ÏúÓ˚ ¶)¸!õÑ¸y xÓí≈ò#Î˚ – SäÈV ãú¸ô˚ÏÌ Ó¢%ú˚Ï¶¸ ¸ôíƒoÓƒ ¸ô!Ó˚Ó£í Ñ¸Ó˚y Îy˚Î˚ Ó˚Ïú £…îñ òî#ñ ¢yÜÓ˚ñ õ£y¢yÜÓ˚=!ú˚Ïì¸ x¶¸

83% **MATCHING BLOCK 12/200** **W**

ƒhs¸Ó˚#í Á xyhs¸ã≈y!ì¸Ñ¸ ãú¸ô!Ó˚

Ó£í ÓƒÓfl¸iy Ü˘Ïv¸¸ v¸z˘Ï‡¸ ˘ÏäÈ– SãV Óy!Ó˚õ[¸ú õyò%˘Ï°ÏÓ˚ Ñ¸õ≈ÓÇfl¸iy˘ÏòÓ˚ ~Ñ¸!›¸ ≤Ãiyò ˘Ñ¸w !£¢y˘ÏÓ Ü˘Ïv¸¸ v¸z˘Ï‡¸ ˘ÏäÈ– òy!i¸ü#˘Ïi¸y°åõ[¸ ˘Ïú Ó˝˘ÏúyÑ¸ ¢õ%o ˘Ï˘ÏÑ¸ õÎ¢ƒ xy£Ó˘í Ñ¸ ˘ÏÓ˚ ã#!ÓÑ¸y !òÓ≈y£ Ñ¸ ˘ÏÓ˚ – (iii) ÓyÎ˚%õ[¸ú (Atmosphere) É ÓyÎ˚%õ[¸ú ¸ô¸!ÌÓ#Ó˚ ≤ÃyÑ¸‚!i¸Ñ¸ ¸ô!Ó˚ ˘ÏÓ˘ÏüÓ˚ ~Ñ¸!›¸ xòƒi¸õ ≤Ãiyò v¸z¸ôyîyò ¶)¸¸

88% **MATCHING BLOCK 13/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ô¸¤¸ ˘Ì˘ÏÑ¸ ≤ÃyÎ˚ 10ñ000 !Ñ¸˘Ïúy!õ›¸yÓ˚ ¸ôÎ≈hs¸ !Óhfl+¸i¸ ˘

Î Üƒy¢#Î˚ xyÓÓ˚í ¸ô¸!ÌÓ#˘ÏÑ¸ !á˘ÏÓ˚ Ó˚˘ÏÏ˚˘ÏäÈ i¸y˘ÏÑ¸ ÓÎ˚%õ[¸ú Ó˘Ïú– ÓyÎ˚%õ[¸˘ÏúÓ˚ v¸z¸ôyîyò É ÓyÎ˚%õ[¸ú ≤Ãiyòi¸É !i¸ò!›¸ v¸z¸ôyîy˘Ïò Ü!‡¸i¸ñ ÎlyÈÙÙÙÈ SÑ¸V Üƒy¢#Î˚ v¸z¸ôyîyò SÖV ãú#Î˚ Óy‹ô ~ÓÇ SÜV ˜ãÓ Á x˜ÏãÓ v¸z¸ôyîyò– SÑ¸V Üƒy¢#Î˚ v¸z¸ôyîyò É ÓyÎ˚% £ú !Ó!¶¸ß¨ Üƒy˘Ï¢Ó˚ ¢Ç!õ◊í– !Ó÷k¸ ÓyÎ˚%Ó˚ ≤Ãiyò v¸z¸ôyîyò=!ú £ú òy£z˘Ï›¸Δy˘Ïãòñ x!:˘Ïãòñ Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ ~ÓÇ !Ó!¶¸ß¨ !ò!‹¸Î˚ Üƒy¢ñ ˘Îõò xyÜ≈òñ !£!úÎ˚yõñ ˘äòòñ !e´≤Wzò ≤Ã¶¸!i¸– !ò˘Ïâ¸Ó˚ ¢yÓ˚!í˘Ïi¸ ÓyÎ˚%õ[¸˘ÏúÓ˚ !Ó!¶¸ß¨ v¸z¸ôyîyò=!úÓ˚ ¸ô!Ó˚õyí ˘ïÂÎ˚y £ú– v¸z¸ôyîyò ≤Ãi¸#Ñ¸ ¸ô!Ó˚õyí S% ÷‹Ò ÓyÎ˚%˘Ïi¸V 1. òy£z˘Ï›¸Δy˘Ïãò N 2 78.080 2. x!:˘Ïãò O 2 20.940 3. xyÜ≈ò Ar 0.930 4. Ñ¸yÓ≈ò Èv¸y£zÈÙÈx:y£zv¸ CO 2 0.030 5. !òÎ˚òñ !£!úÎ˚yõñ !e´≤Wzòñ ˘äòò Ne, He, Kr, Xe 0.003 6. ãú#Î˚ Óy‹ô SÖV ãú#Î˚ Óy‹ô É ÓyÎ˚%õ[¸˘ÏúÓ˚ !Ó!¶¸ß¨ Üƒy¢#Î˚ v¸z¸ôyîy˘ÏòÓ˚ ¸ô˘ÏÓ˚£z ãú#Î˚ Óy˘Ï‹ôÓ˚ fl¸iyò– £z£y ÓyÎ˚%õ[¸˘ÏúÓ˚ xi¸ƒhs¸ =Ó˚&c¸ô)í≈ v¸z¸ôyîyòñ v¸z°åi¸yÓ˚ ≤Ã¶¸y˘ÏÓ ¶)¸¸ô¸˘Ï¤¸Ó˚ ãú Óy‹ô#¶)¸i¸ £Î˚ ÓyÎ˚%õ[¸˘Ïú xÓfl¸iyò Ñ¸˘ÏÓ˚ – ÓyÎ˚%õ[¸˘Ïú 16 ? NSOU ? AE-ES-21
ãú#Î˚ Óy˘Ï‹ôÓ˚ v¸z¸ô!fl¸i!i¸Ó˚ ãòƒ£z áò#¶¸Óò ≤Ã!e´Î˚yÓ˚ õyïƒ˘Ïõ ˘õáñ Ó¸!‹Tñ Ñ%¸Î˚yüyñ ì%¸!£ò Á ì%¸°ÏyÓ˚ ¢¸!‹T £Î˚ – v¸zk≈¸yÑ¸y˘Ïü ãú#Î˚ Óy˘Ï‹ôÓ˚ áò#¶¸Ó˘Ïò ¢‹T ú#òi¸y¸ô xyÓ£yÂÎ˚yÓ˚ ¸ô!Ó˚Óí≈¸ò á›¸yÎ˚ – ãú#Î˚ Óy‹ô v¸z°åi¸y˘ÏÑ¸ !òÎ˚s¸fí Ñ¸˘ÏÓ˚ – SÜV ï)!úÑ¸íy É ÓyÎ˚%õ[¸˘ÏúÓ˚ xòƒ ~Ñ¸!›¸ =Ó˚&c¸ô)í≈ v¸z¸ôyîyò £˘Ïúy ï)!úÑ¸íyñ õÓ˚&ô xM¸Èú Á ¢õ%oi¸#˘ÏÓ˚Ó˚ x!i¸ ¢)" ï%˘ÏúyÈÙÈÓy!úñ x!i¸«%¸o Ö!òã úÓíñ !Ó!¶¸ß¨ Ñ¸úÑ¸yÓ˚ÖyòyÓ˚ ˘¸ôyv¸¸y Ñ¸Î˚ úyÓ˚ äÈy£zñ xy˘Ï@¿Î˚ !Ü!Ó˚ £˘Ïi¸ v¸zÍ!«¸Æ äÈy£zñ ¶¸‹ø ≤Ã¶¸!i¸ ï)!úÑ¸íyÓ˚*˘Ï¸ô ÓyÎ˚%õ[¸˘Ïú ˘¶¸˘Ï¢ ˘Óv¸¸yÎ˚ – ~˘ÏiÓ˚ ~Ñ¸˘Ïe xƒ˘ÏÓ˚y¢ú (Aerosol) Ó˘Ïú– ÓyÎ˚%õ[¸˘Ïú ¶¸y¢õyò !Ó!¶¸ß¨ ï)!úÑ¸íy˘ÏÑ¸ xyôÎ˚ Ñ¸˘ÏÓ˚ ãú#Î˚ Óy‹ô áò#¶)¸i¸ £Î˚ Á ˘õáÈÙÈÓ¸!‹T˘Ïi¸ ¸ô!Ó˚íi¸ £Î˚ – ÓyÎ˚%õ[¸˘ÏúÓ˚ !Ó!¶¸ß¨ hfl¸Ó˚ É ÓyÎ˚%õ[¸˘ÏúÓ˚ !Ó!¶¸ß¨ hfl¸Ó˚˘ÏÑ¸ ¢yiyÓ˚íi¸É ì%%ÙÈ¶¸

78% **MATCHING BLOCK 14/200** **SA** Geography-CC-1.1.pdf (D142516024)

y˘ÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ – ÎlyÈÙÙÙÈ SÑ¸V Ó˚y¢yÎ˚!òÑ¸

Ü‡¸ò xò%¢y˘ÏÓ˚ñ SÖV v¸z°åi¸y xò%¢y˘ÏÓ˚ hfl¸Ó˚!ÓòƒƒÇ– ÈU.S.A.Ù~ÈÓ˚ ãyi¸#Î˚ !Óõyò Á õ£yÑ¸yü ¢ÇÈfl¸iy SòyÇyVÓ˚ ¢õ#«¸y xò%Î˚y˚# Ó˚y¢yÎ˚!òÑ¸ Ü‡¸ò xò%¢y˘ÏÓ˚ ÓyÎ˚%õ[¸ú ≤Ãiyòi¸É ï%!›¸ hfl¸˘ÏÓ˚ !Ó¶¸_´ÈÙÙÙÈ S1V ˘£y˘Ïõy!fl¸≥¸Î˚yÓ˚ Óy ¢õõ[¸ú ~ÓÇ S2V ˘£˘Ï›¸˘ÏÓ˚y!fl¸≥¸Î˚yÓ˚ Óy !Ó°Ïõõ[¸ú– S1V ˘£y˘Ïõy!fl¸≥¸Î˚yÓ˚ Óy ¢õõ[¸ú É ¶)¸¸ô¸¤¸ £˘Ïi¸ Á¸ô˘ÏÓ˚Ó˚ !ı˘ÏÑ¸ 90 !Ñ¸!õ ¸ôÎ≈hs¸ xM¸È˘Ïú ÓyÎ˚%õ[¸˘ÏúÓ˚ Ó˚y¢yÎ˚!òÑ¸ Ü‡¸ò ~ÓÇ !Ó!¶¸ß¨ Üƒy˘Ï¢Ó˚ xò%¸ôyi¸ ≤ÃyÎ˚ ~Ñ¸£z Ó˚Ñ¸õ ìy˘ÏÑ¸ñ i¸y£z ~£z hfl¸Ó˚˘ÏÑ¸ Óúy £Î˚ ˘£y˘Ïõy!fl¸≥¸Î˚yÓ˚ Óy ¢õõõ[¸ú– S2V ˘£˘Ï›¸y˘ÏÓ˚y!fl¸≥¸Î˚yÓ˚ Óy !Ó°Ïõõ[¸ú É ˘£y˘Ïõy!fl¸≥¸Î˚yÓ˚ hfl¸˘ÏÓ˚Ó˚ Á¸ô˘ÏÓ˚ ÓyÎ˚%õ[¸˘ÏúÓ˚ |ïπ≈¢#õy xì≈yÍ 10ñ000 !Ñ¸!õ ¸¸ôÎ≈hs¸ xM¸È˘Ïú !Ó!¶¸ß¨ Üƒy˘Ï¢Ó˚ xò%¸ôyi¸ ~ÓÇ !Ó!¶¸ß¨ Üƒy˘Ï¢Ó˚ hfl¸Ó˚=!ú ~Ñ¸£z Ó˚Ñ¸õ ìy˘ÏÑ¸ òyñ i¸y£z ~£z hfl¸Ó˚˘ÏÑ¸ ˘£˘Ï›¸y˘ÏÓ˚y!fl¸≥¸Î˚yÓ˚ Óy !Ó°Ïõõ[¸ú Ó˘Ïú– Ó˚y¢yÎ˚!òÑ¸ Ü‡¸ò xò%¢y˘ÏÓ˚ ~£z hfl¸Ó˚˘ÏÑ¸

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â¸yÓ˚!›¸ v¸z¸ô!Ó¶¸y˘ÏÜ ¶¸yÜ Ñ¸Ó˚y

ÎyÎ˚ – ÎlyÈÙÙÙÈ (
a) £y£z˘Ïv»¸y˘Ïãò hfl¸Ó˚ ÈÙÙÙÈ ÓyÎ˚%õ[¸˘ÏúÓ˚ |ïπ≈¢#õy 10ñ000 !Ñ¸!õ ˘Ì˘ÏÑ¸ ò#˘Ïâ¸ 3ñ500 !Ñ¸!õ ¸ôÎ≈hs¸ xM¸Èú ≤Ãiyòi¸É £y£z˘Ïv»¸y˘Ïãò ¸ôÓ˚õyí% hfl¸Ó˚ myÓ˚y Ü!‡¸i¸ – (b) !£!úÎ˚yõ hfl¸Ó˚ ÈÙÙÙÈ £y£z˘Ïv»¸y˘Ïãò hfl¸Ï˘ÏÓ˚Ó˚ !ò˘Ïâ¸ 3ñ500 !Ñ¸!õ ˘Ì˘ÏÑ¸ 100 !Ñ¸!õ ¸ôÎ≈hs˘¸ xMÈ¸ú ≤Ãiyòi¸É !£!úÎ˚yõ Üƒy¢ myÓ˚y Ü!‡¸i¸ – (c) ¸ôyÓ˚õyí!ÓÑ¸ x!:˘Ïãò hfl¸Ó˚ ÈÙÙÙÈ !£!úÎ˚yõ hfl¸˘ÏÓ˚Ó˚ ! ò˘Ïâ¸ 1ñ000 !Ñ¸!õ ˘Ì˘ÏÑ¸ 200 !Ñ¸!õ ¸ôÎ≈hs¸ xM¸Èú ≤Ãiyòi¸É x!:˘Ïãò myÓ˚y Ü!‡¸i¸ – NSOU ? AE-ES-21 ? 17
(d) xyí!ÓÑ¸ òy£z˘Ï›¸Δy˘Ïãò hfl¸Ó˚ ÈÙÙÙÈ ¸ôyÓ˚õyí!ÓÑ¸ x!:˘Ïãò hfl¸˘ÏÓ˚Ó˚ !‡¸Ñ¸ !ò˘Ïâ¸ 200 !Ñ¸!õ ˘Ì˘ÏÑ¸ ˘£y˘Ïõy!fl¸≥¸Î˚y˘ÏÓ˚Ó˚ ¢#õyòy 90 !Ñ¸!õ ¸ôÎ≈hs¸ xM¸Èú ¸≤Ãiyòi¸É òy£z˘Ï›¸Δy˘Ïãò myÓ˚y Ü!‡¸i¸ – SÖV v¸z°åi¸y xò%¢y˘ÏÓ˚ hfl¸Ó˚!Óòƒy¢ É ÓyÎ˚%õ[¸˘ÏúÓ˚ !Ó!¶¸ß¨ hfl¸˘ÏÓ˚ v¸z°åi¸yÓ˚ i¸yÓ˚i¸õƒ ˘ïÂy Îyˆ – ¶)¸¸ô¸¤¸ ˘Ì˘ÏÑ¸ Î¸i¸£z Á¸ô˘ÏÓ˚ !ı˘ÏÑ¸ ÎyÂÎ˚y Îyˆñ i¸i¸£z ÓyÎ˚%õ[¸˘ÏúÓ˚ v¸z°åi¸y e´õü £…y¢ ˘¸ô˘Ïi¸ ìy˘ÏÑ¸ – v¸z°åi¸y xò%¢y˘ÏÓ˚ ÓyÎ˚%õ[¸ú˘ÏÑ¸ ›¸

79% **MATCHING BLOCK 16/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Δ˘Ï¸ôy!fl¸≥¸Î˚yÓ˚ñ fl¸T…ƒ˘Ï›¸y!fl¸≥¸Î˚yÓ˚ñ ˘õ˘Ï¢y!fl¸≥¸Î˚yÓ˚

ñ

88% **MATCHING BLOCK 17/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÌyˆÏõ≈y!fl˛≥˛Î˚yÓ˚ Óy xyÎ˚ˆÏòy!fl˛≥˛Î˚yÓ˚ñ ~ˆÏ:y!fl˛≥˛Î˚yÓ˚ Á õƒyÜˆÏòˆÏ›˛y!fl˛≥˛Î˚yÓ˚

ñ ÈÙÙÙÈ ~£z äÈÎ˚!›˛ ¶˛yˆÏÜ ¶˛yÜ Ñ˛Ó˚y ÎyÎ˚ – (a) ›˛∆ˆÏ˛ôy!fl˛≥˛Î˚yÓ˚ Óy «%˛∏˛õ[˛ú É ~£z hfl˛Ó˚!›˛ ÓyÎ˚%õ[˛ˆÏúÓ˚ ¢ÓˆÏÌˆÏÑ˛ ! òˆÏâ˛Ó˚ hfl˛Ó˚ – ¶)˛˛ô‚¤˛ ˆÌˆÏÑ˛ 18 !Ñ˛!õ ˛ôÎ≈hs˛ Á˛ôˆÏÓ˚Ó˚ ÓyÎ˚%hfl˛Ó˚ˆÏÑ˛ ›˛∆ˆÏ˛ôy!fl˛≥˛Î˚yÓ˚ ÓˆÏú– ì˛ˆÏÓ !òÓ˚«˛#Î˚ xM˛ÈˆÏú 18 !Ñ˛!õ £ˆÏúÁ ˆõÓ˚& xM˛ÈˆÏú £z£y 89 !Ñ˛!õ ˛ôÎ≈hs˛ !Óhfl+˛ì˛ – ÓyÎ˚%õ[˛ˆÏúÓ˚ !Ó!¶˛ß¨ Üƒy¢#Î˚ v˛z˛ôyîyˆÏòÓ˚ ≤ÃyÎ˚ 76% ~ÓÇ ¢õhfl˛ ≤ÃÑ˛yÓ˚ ãú#Î˚ Óy‹ô Á ï)!úÑ˛íy ~£z hfl˛ˆÏÓ˚£z ˆîÖˆÏì˛ ˛ôyÁÎ˚y ÎyÎ˚ – ˆõáñ Ó‚!‹Tñ ÓL˛ôyì˛ñ G˛v˛¸ñ !ü!üÓ˚ñ Ñ%˛Î˚yüy ¢£ ¢õhfl˛ ≤ÃÑ˛yÓ˚ ≤ÃyÑ˛‚!ì˛Ñ˛ î%ˆÏÎ≈yÜ ~£z hfl˛ˆÏÓ˚£z ˆîÖy ÎyÎ˚ ÓˆÏú ~ˆÏÑ˛ «%˛∏˛õ[˛ú ÓˆÏú– ~£z hfl˛ˆÏÓ˚ ¶)˛˛ô‚¤˛ ˆÌˆÏÑ˛ Á˛ôˆÏÓ˚Ó˚ !íˆÏÑ˛ v˛zFâ˛ì˛y Óyv˛¸yÓ˚ ¢ˆÏD¢ˆÏD ÓyÎ˚%õ[˛ˆÏúÓ˚ ì˛y˛ôõyey £…y¢ ˛ôyÎ˚ – ~£z ì˛y˛ôõyey £…yˆÏ¢Ó˚ £yÓ˚ ¢yïyÓ˚í¶˛yˆÏÓ ≤Ã!ì˛ 100 !õ›˛yÓ˚ v˛zFâ˛ì˛yÎ˚ 0.1 0 ˆ¢!r›˛ˆÏ@˘Ãv˛ Óy ≤Ã!ì˛ 1000 !õ›˛yÓ˚ S1 !Ñ˛!õV v˛zFâ˛ì˛yÎ˚ 6.5 0 ˆ¢!r›˛ˆÏ@˘Ãv˛ – ›˛

70% **MATCHING BLOCK 18/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

∆ˆÏ˛ôy!fl˛≥˛Î˚yÓ˚ Á fl˛T…ƒyˆÏ›˛y!fl˛≥˛Î˚yÓ˚ ~

Ó˚ õïƒÓì≈˛# xM˛Èú ›˛∆ˆÏ˛ôyã òyˆÏõ ˛ô!Ó˚!â˛ì˛ – (b) fl˛T…ƒyˆÏ›˛y!fl˛≥˛Î˚yÓ˚ Óy üyhs˛õ[˛ú É ›˛∆ˆÏ˛ôy˛ôˆÏãÓ˚ Á˛ôˆÏÓ˚ 50 !Ñ˛!õ ˛ôÎ≈hs˛ ÓyÎ˚%hfl˛Ó˚!›˛ fl˛T…ƒyˆÏ›˛y!fl˛≥˛Î˚yÓ˚ òyˆÏõ ˛ô!Ó˚!â˛ì˛ – ~£z ÓyÎ˚%hfl˛ˆÏÓ˚ x!ì˛ ¢)" ï%!úÑ˛íy äÈyv˛¸y ˆÑ˛yòÓ˚ Ñ˛õ ãú#Î˚ Óy‹ô ÌyˆÏÑ˛ òyñ ö˛ˆÏú xyÓ£yÁÎ˚y üyhs˛ ÌyˆÏÑ˛ – ~£zãòƒ ~£z hfl˛Ó˚ˆÏÑ˛ üyhs˛õ[˛ú ÓˆÏú– ÓyÎ˚% ≤ÃÓy!£ì˛ £Î˚ òy ÓˆÏú ~£z hfl˛ˆÏÓ˚Ó˚ õïƒ !î˚ˆÌ˚ ¢yïyÓ˚íì˛É ˆã›˛ !Óõyò=!ú â˛úyâ˛ú Ñ˛ˆÏÓ˚ – ÓyÎ˚%≤ÃÓy£ ÌyˆÏÑ˛ òy ÓˆÏú ˆã›˛!Óõy ˆÏòÓ˚ £z!Óò !òÜ≈ì˛ ˆïßyÎ˚y ˛ô%OyÑ˛yˆÏÓ˚ ¢yîy îyˆÏÜÓ˚ xyÑ˛yˆÏÓ˚ ˆîÖy ÎyÎ˚ – ~£z hfl˛ˆÏÓ˚ v˛zFâ˛ì˛y Óyv˛¸yÓ˚ ¢ˆÏD¢ˆÏD ÓyÎ˚%õ[˛ˆÏúÓ˚ ì˛y˛ôõyey Óyv˛¸ˆÏì˛ ÌyˆÏÑ˛ – ~£z hfl˛ˆÏÓ˚ ÁˆÏãyò Üƒy ˆÏ¢Ó˚ hfl˛Ó˚ ˆÓ!ü ˛ô!Ó˚õyˆÏí ˆîÖy ÎyÎ˚ – fl˛T...

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ƒyˆÏ›˛y!fl˛≥˛Î˚yÓ˚ Á ˆõˆÏ¢y!fl˛≥˛Î˚

yˆÏÓ˚Ó˚ õïƒÓì≈˛# xM˛ÈúˆÏÑ˛ fl˛T…ƒyˆÏ›˛y˛ôã ÓˆÏú– (c) ˆõˆÏ¢y!fl˛≥˛Î˚yÓ˚ É fl˛T…ƒyˆÏ›˛y˛ôˆÏãÓ˚ Á˛ôÓ˚ 80 !Ñ˛!õ ˛ôÎ≈hs˛ ! Óhfl+˛ì˛ ÓyÎ˚%õ[˛úˆÏÑ˛ ˆõˆÏ¢y!fl˛≥˛Î˚yÓ˚ ÓˆÏú– ~£z hfl˛ˆÏÓ˚Á ›˛∆ˆÏ˛ôy!fl˛≥˛Î˚yˆÏÓ˚Ó˚ õˆÏì˛y v˛zFâ˛ì˛y Óyv˛¸yÓ˚ ¢ˆÏD v˛z°åì˛y £…y¢ ˛ôyÎ˚ – õ£yÑ˛yü ˆÌˆÏÑ˛ ˆÎ¢Ó v˛zÕÒy ˛ô‚!ÌÓ#Ó˚ !îˆÏÑ˛ ä%ÈˆÏ›˛ xyˆÏ¢ ˆ¢=!úÓ˚ x!ïÑ˛yÇü ~£z hfl˛ˆÏÓ˚Ó˚ õˆÏïƒ ~ˆÏ¢ ˛ô%ˆÏv˛¸ ÎyÎ˚ – ˆõˆÏ¢y!fl˛≥˛Î˚yˆÏÓ˚Ó˚ Á˛ôˆÏÓ˚ ì˛y˛ôõyey £…y¢ ˛ôyÁÎ˚y ˆÌˆÏõ ÎyÎ˚ – ~£z hfl˛Ó˚ˆÏÑ˛ ˆõˆÏ¢y˛ôã ÓˆÏú– (d)

71% **MATCHING BLOCK 20/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÌyˆÏõ≈y!fl˛≥˛Î˚yÓ˚ Óy xyÎ˚ˆÏòy!fl˛≥˛Î˚yÓ˚ É ˆõˆÏ¢y˛

ôˆÏãÓ˚ Á˛ôˆÏÓ˚ ≤ÃyÎ˚ 500 !Ñ˛!õ ˛ôÎ≈hs˛ !Óhfl+˛ì˛ ÓyÎ˚%hfl˛Ó˚ˆÏÑ˛ ÌyˆÏõ≈y!fl˛≥˛Î˚yÓ˚ Óúy £Î˚ – ~£z xÇˆÏü ÓyÎ˚%õ[˛ˆÏúÓ˚ ì˛y˛ôõyey xì˛ƒhs˛ o&ì˛ £yˆÏÓ˚ Óyv˛¸ˆÏì˛ ÌyˆÏÑ˛ – ~£z xÇˆÏü ÓyÎ˚%hfl˛Ó˚ xì˛ƒhs˛ £yÕÒy– ì˛#Ó ˆ¢ÔÓ˚!Ó!Ñ˛Ó˚ˆÏí Ó˚OòÓ˚!Ÿ¬ Á x!ì˛ ˆÓ=!ò Ó˚!Ÿ¬Ó˚ ¢Çáy ˆÏì˛ ~£z xÇˆÏüÓ˚ ÓyÎ˚% xyÎ˚òÎ%_´ £Î˚ – ì˛y£z ~£z hfl˛Ó˚ˆÏÑ˛ xyÎ˚ˆÏòy!fl˛≥˛Î˚yÓ˚ ÓˆÏú– ¶)˛˛ô‚¤˛ ˆÌˆÏÑ˛ ˛ôy‡˛yˆÏòy ˆÓì˛yÓ˚ ì˛Ó˚D xyÎ˚ˆÏòy!fl˛≥˛Î˚yˆÏÓ˚Ó˚ !Ó!¶˛ß¨ xyˆÏò Óyïy ˆ˛ôˆÏÌ˚ ˛ô%òÓ˚yÎ˚ ¶)˛˛ô‚ˆÏ¤˛ !ö˛ˆÏÓ˚ xyˆÏ¢– ö˛ˆÏú ˛ô‚!ÌˆÏì˛ ˆÓì˛yÓ˚ ¢ÇˆÏÎyÜ Ó˚«˛y Ñ˛Ó˚y ¢Ω˛Ó £Î˚ – ~£z hfl˛ˆÏÓ˚ !Ó!¶˛ß¨ ì˛!v˛¸ì˛y£ì˛ xí%Ó˚ ˆâ˛Ô¡∫Ñ˛ !ÓˆÏ«˛ˆÏ˛ôÓ˚ ö˛ˆÏú xí%=!ú ˆ≤Ãy›˛ò Á £zˆÏúÑ˛›˛∆ˆÏòÓ˚ ¢Çfl˛ôˆÏü≈ v˛zˆÏ_!ãì˛ £ˆÏÎ˚ ˛ôˆÏv˛¸ ~ÓÇ ¢%ˆÏõÓ˚& Á Ñ%˛ˆÏõÓ˚& xM˛ÈˆÏú ~Ñ˛≤ÃÑ˛yÓ˚ v˛zlµú xyˆÏúyÑ˛ !ÓFä%ÈÓ˚í ˆîÖy ÎyÎ˚ñ ~ˆÏÑ˛ ˆõÓ˚&ˆÏãƒy!ì˛ ÓˆÏú– ¢%ˆÏõÓ˚& xM˛ÈˆÏúÓ˚ ˆõÓ˚&ˆÏãƒy!ì˛ˆÏÑ˛ ¢%ˆÏõÓ˚&≤Ã¶˛y Óy xyˆÏÓ˚yÓ˚y ˆÓy!Ó˚Î˚y!ú¢ ~ÓÇ Ñ%˛ˆÏõÓ˚& xM˛ÈˆÏúÓ˚ ˆõÓ˚&ˆÏãƒy!ì˛ˆÏÑ˛ Ñ%˛ˆÏõÓ˚&≤Ã¶˛y Óy xyˆÏÓ˚yÓ˚y xfl˛T…y!ú¢ ÓˆÏú– 18 ? NSOU ? AE-ES-21

(e) ~ˆÏ:y!fl˛≥˛Î˚yÓ˚ É ÌyˆÏõ≈y!fl˛≥˛Î˚yˆÏÓ˚Ó˚ Á˛ôˆÏÓ˚ ≤ÃyÎ˚ 750 !Ñ˛!õ ˛ôÎ≈hs˛ ˆÎ ÓyÎ˚%hfl˛Ó˚ xyˆÏäÈ ì˛yˆÏÑ˛ ~ˆÏ:y!fl˛≥˛Î˚yÓ˚ ÓˆÏú– ~£z hfl˛ˆÏÓ˚Á v˛zFâ˛ì˛y Óyv˛¸yÓ˚ ¢ˆÏD¢ˆÏD ÓyÎ˚%õ[˛ˆÏúÓ˚ ì˛y˛ôõyey ï#ˆÏÓ˚ ï#ˆÏÓ˚ Ó‚!k˛ ˛ôyÎ˚ – ~£z hfl˛ˆÏÓ˚ !£!úÎ˚yõ Á £y£zˆÏv»˛yˆÏãò Üƒy ˆÏ¢Ó˚Ó˚ ≤Ãyïyòƒ ˆîÖy ÎyÎ˚ – (f) õƒyÜˆÏòˆÏ›˛y!fl˛≥˛Î˚yÓ˚ É ~ˆÏ:y!fl˛≥˛Î˚yˆÏÓ˚Ó˚ Á˛ôˆÏÓ˚ ÓyÎ˚%õ[˛ˆÏúÓ˚ ˆü°Ï ¢#õy ˛ôÎ≈hs˛ ÓyÎ˚%hfl˛Ó˚ˆÏÑ˛ õƒyÜˆÏòˆÏ›˛y!fl˛≥˛Î˚yÓ˚ ÓˆÏú– ~£z hfl˛ˆÏÓ˚ ÓyÎ˚%õ[˛úˆÏÑ˛ ˆÓ‹Tò Ñ˛ˆÏÓ˚ ~Ñ˛!›˛ ˆ≤Ãy›˛ò Á £zˆÏúÑ˛›˛∆ˆÏòÓ˚ ˆâ˛Ô¡∫Ñ˛#Î˚ ˆ«˛ˆÏeÓ˚ ¢˛!‹T £Î˚ – ~£z hfl˛Ó˚ ¢¡ôˆÏÑ˛≈˛ !ÓˆÏü°Ï !Ñ˛ä%È ãyòy ÎyÎ˚ òy– ÓyÎ˚%õ[˛ˆÏúÓ˚ =Ó˚&c É ˛ô‚!ÌˆÏì˛ ÓyÎ˚%õ[˛ˆÏúÓ˚ =Ó˚&c x˛ô!Ó˚¢#õ– ÓyÎ˚%õ[˛ˆÏúÓ˚ ãòƒ£z ˛ô‚!ÌˆÏì˛ ˛≤ÃyˆÏíÓ˚ x!hfl˛c ú«˛ Ñ˛Ó˚y ÎyÎ˚ – ãúñ Óyì˛y¢ ≤Ã¶‚˛!ì˛Ó˚ v˛zÍ¢ £ú ÓyÎ˚%õ[˛ú– ≤Ãyí#ãÜÍˆÏÑ˛ x!:ˆÏãò Á v˛z!qîãÜÍˆÏÑ˛ Ñ˛yÓ≈òÈÙÙÙÈ NSOU ? AE-ES-21 ? 19

v¸y£zÈÙÈx:y£zv¸ ¢Ó˚ÓÓ˚y£ Ñ¸ˆÏÓ˚ Óyÿ˚%õ[¸ú– Óyÿ˚%õ[¸ú ¸ô¸!ÌÓ#ˆÏì¸ ì¸y¸ôõyeyÓ˚ ¶¸yÓ˚¢yõƒ Ó˚«¸y Ñ¸ˆÏÓ˚ – ï)!úÑ¸íy Óyÿ˚%õ[¸ˆÏúÓ˚ ì¸y¸ô ˆüy°Ï˚Ïíñ äú#Î˚ Óy˜Ï‹ôÓ˚ áò#¶¸ÓˆÏò ¢y£yÎƒ Ñ¸ˆÏÓ˚ – äú#Î˚ Óy˜Ï‹ô ˜õáñ Ó,!‹Tñ ì%¸°ÏyÓ˚¸ôyì¸ Á Ñ%¸Î˚yüyÓ˚ ¢,!‹T Ñ¸ˆÏÓ˚ – (iv) ˜äÓõ[¸ú (Biosphere) É ¸ ¸¶)¸ÈÙÈ¸ô¸ˆÏ¤¸ xÓfl¸iyòÑ¸yÓ˚# ¢Ñ¸ú ¢ã#Ó v¸z¸ôyîyò ˜äÓõ[¸ˆÏúÓ˚ xhs¸¶%≈¸_´ – ˆÎ ˆÑ¸yò ¢ã#Ó v¸z¸ôyîyòñ ì¸y xyí%Ó#«¸!òÑ¸ ã#Ó£z ˆ£yÑ¸ Óy ¢y˜ÏúyÑ¸ ¢Ç˜ÏŸ°ÏÑ¸yÓ˚# ¢Ó%ã v¸z!qî Óy ã#ÓˆÏ◊¤¸ õyò%°Ï îy£z ˆ£yÑ¸ òy ˆÑ¸òñ ˆÑ¸v¸z£z ¸ô!Ó˚ˆÏÓˆÏüÓ˚ õˆÏïƒ ~Ñ¸yÑ¸# ˆÓ§ˆÏâ¸ ìyÑ¸ˆÏì¸ ¸ôyˆÏÓ˚ òy– ¢Ñ¸ˆÏú£z ˆÑ¸yò òy ˆÑ¸yò ¶¸yˆÏÓ ~ˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ v¸z¸ôÓ˚ ≤Ãì¸ƒ«¸ Óy ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ !ò¶≈¸Ó˚ü#ú £ˆÏì¸ £Î˚ – !ÓhflÓ¸y!Ó˚ì¸ ¶¸yˆÏÓ Óúy îyÎ˚ñ ¢Ó%ã v¸z!qî ¢)Î≈yˆÏúyˆÏÑ¸Ó˚ v¸z¸ô!fl¸i!ì¸ˆÏì¸ õy!›¸ ˆÌˆÏÑ¸ äú Á Ö!òã v¸z¸ôyîyò ¢Ç@˜Ã£ Ñ¸ˆÏÓ˚ x!:ˆÏãò ~ÓÇ

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üÑ≈¸Ó˚y äyì¸#Î˚ Öyîƒ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ îy ≤Ãyí#Ñ%¸ú Öyîƒ !£¢yˆÏÓ @˜Ã£í Ñ¸ˆÏÓ˚ ~

ÓÇ v¸zÍ¸ôß¨ x!:ˆÏãò Ÿª¢ˆÏò Ñ¸yˆÏã úyÜyÎ˚ñ ¸ô!Ó˚Ó˚ˆÏì≈¸ Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zv¸ ˆÎyÜyò ˆÎ˚ˆÎ˚ îy v¸z!qîÑ%¸ú ¢y˜ÏúyÑ¸¢ÇˆÏŸ°ÏÓ˚ Ñ¸yˆÏã úyÜyÎ˚ – xyÓyÓ˚ xí%ã#ÓÓ˚y õ¸ì¸ v¸z!q˜ÏîÓ˚ Á ≤Ãyí#Ó˚ ˆÎ£yˆÏü°Ï Öyîƒ !£¢yˆÏÓ @˜Ã£í Ñ¸ˆÏÓ˚ ~ÓÇ ì¸y ˆ¶¸ˆÏD ≤ÃˆÏÏ˚yò#Î˚ òyòy v¸z¸ôyîyˆÏÑ¸ S˜ÎòÈÙÈÙÈ òy£zˆÏ›¸∆yˆÏòñ ¸ô›¸y!üÎ˚yõñ ö¸¢ö¸Ó˚yˆÏ¢ñ Ñ¸ƒyú!¢Î˚yõ äyì¸#Î˚ ˆõÔúV õy!›¸Ó˚ õˆÏïƒ !ö¸!Ó˚ˆÏÏ˚ ˆîÎ˚ îy v¸z!q˜ÏîÓ˚ Ó,!k¸ˆÏì¸ Ñ¸yˆÏã úyˆÏÜ– 1.10 ¸ô!Ó˚ˆÏÓü !ü«¸y (Environmental Education) õyò%°Ï ≤ÃÑ¸,!ì¸Ó˚ ˆ◊¤¸ã#Ó ˆÎ !òˆÏãÓ˚ â¸y!£îy xò%ÎyÎ˚# ¸ô!Ó˚ˆÏÓˆÏüÓ˚ v¸z¸ôyîyò=!úˆÏÑ¸ ÎyÓ¢yîƒ ¶¸yˆÏÓ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ ~ÓÇ ¸ô!Ó˚ˆÏÓü ÑˆÏÑ¸ Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– ~£z ¸ô!Ó˚ˆÏÓü ¢ˆÏâ¸ì¸ì¸òì¸y xyõyˆÏîÓ˚ îy!Ó˚ˆÏc Óy Ñ¸ì≈¸Óƒ– ~£z Ñ¸yÓ˚ˆÏí£z Ú¸ô! ÓˆÏÏüÛ Á Ú!ü«¸yÛ ~£z ì%!›¸ ü˜ÏΣÓ˚ ¢õßÍˆÏ áˆÏì¸ £ˆÏÎ˚ˆÏäÈ Ú¸ô!Ó˚ˆÏÓü !ü«¸yÛ (Environmental Education)– ¢yÏyÓ˚í ¶¸yˆÏÓ Óúy £Î˚ 1948 ¢yˆÏú ¸ôƒy!Ó˚ˆÏ¢ xò%!¤¸ì¸ xyhs¸ÉÓ˚y‹T…#Î˚ ≤ÃÑ¸,!ì¸ Á ≤ÃyÑ¸,!ì¸Ñ¸ ¢¡ôˆÏîÓ˚ ¢ÇÓ˚«¸í ¢Çfl¸iyÓ˚ (INCW–International Union for Conservation of Water) ¢ˆÏ¡øúˆÏò ≤ÃÌõ ~£z ¸ô!Ó˚ˆÏÓü !ü«¸yÓ˚ Ñ¸ìy ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – ¸ô!Ó˚ˆÏÓü !ü«¸yÓ˚ õ%ÖƒÓ v¸z˜ÏüüƒÏ=!ú £úÈÙÈÙÈ S1V äò¢yiyÓ˚ˆÏíÓ˚ õˆÏïƒ ¸ô!Ó˚ˆÏÓü ¢¡ô!Ñ≈¸ì¸ ¢õ¢ƒy ~ÓÇ ¢ˆÏâ¸ì¸òì¸y Ó,!k¸ Ñ¸Ó˚y– S2V ¸ô!Ó˚ˆÏÓü ¢¡∫ˆÏì¸ òyòy x!¶¸K¸ì¸y xã≈ò Ñ¸Ó˚y ~ÓÇ ¸ô!Ó˚ˆÏÓüˆÏÑ¸ Á ì¸yÓ˚ ¢¡!ì¸ òyòy ¢õ¢ƒy ¶¸yˆÏúy Ñ¸ˆÏÓ˚ ˆÓyG¸y– S3V äòÜˆÏíÓ˚ õˆÏïƒ ~Ñ¸!›¸ ¸ô!Ó˚ˆÏÓü ¢£yò%¶)!ì¸Ó˚ î¸!‹T¶¸!D ˜ì¸!Ó˚ Ñ¸Ó˚y– S4V ¸ô!Ó˚ˆÏÓüˆÏÑ¸ ¢õ¢ƒy Ö%§ˆÏã ˆÓÓ˚ Ñ¸Ó˚y ~ÓÇ ì¸yÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ Ö%§ˆÏã ˆÓÓ˚ Ñ¸Ó˚y– S5V äò¢yiyÓ˚íˆÏÑ¸ ¸ô!Ó˚ˆÏÓü ¢¡ô!Ñ≈¸ì¸ òyòy !e´Î˚yÑ¸úy¸ô xÇü@˜Ã£í Ñ¸Ó˚yˆÏòy– 1.11 xò%ü#úò# ¢! ‡¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚& ≠ S1V ì¸y¸ôõyeyñ xy˜Ïúyñ Óyì¸y¸y¢ñ õy!›¸ £zì¸ƒy!îÈÙÈÙÈ (i) ˜äÓ v¸z¸ôyîyò (ii) x˜ÏäÓ v¸z¸ôyîyò (iii) ã#ˆÏÓÓ˚ x≤ÃˆÏÏ˚yã#ò (iv) ¸ô¸!ÌÓ#Ó˚ v¸zˆÏÕˆÏÎÜƒ v¸z¸ôyîyò òÎ˚ – S2V ¶)¸cˆÏÑ¸ ¢ÓˆÏìˆÏÑ¸ ˆÓ!ü ˆÑ¸yò ˆõÔú ¸ôyÁÎ˚y Îyÿ˚/(i) ! ¢!úÑ¸ò (ii) xƒyú%!õòÎ˚yõ (iii) x!:ˆÏãò (iv) ˆúÕ£ 20 ? NSOU ? AE-ES-21
S3V ¶)¸¸ô¸ˆÏ¤¸ ãˆÏúÓ˚ ¸ô!Ó˚õyí ÈÙÈÙÈ% (i) 30 (ii) 71 (iii) 75 (iv) 90 S4V Óyÿ˚% õ[¸ˆÏú òy£zˆÏ›¸∆yˆÏãˆÏòÓ˚ ¸ô!Ó˚õyíÈÙÈÙÈ (i) 70.28% (ii) 80% (iii) 78.08% (iv) 77.08% S5V ≤Ã!ì¸ 1000 !

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õ›¸yÓ˚ v¸zFâ¸ì¸y Ó,!k¸Ó˚ ¢yˆÏì ¢yˆÏì ì¸y¸ôõyey £...

y¢ ¸ôyÿ˚ÈÙÈÙÈ (i) 6 0 C (ii) 6.4 0 C (iii) 6.5 0 C (iv) 1 0 C S6V ¢yiyÓ˚í¸ ˆã›¸ !Óõyò=!ú â¸úyâ¸ú Ñ¸ˆÏÓ˚ ÈÙÈÙÈ (i) ›¸∆ˆÏ¸ôy¸ôã (ii) ›¸

68% MATCHING BLOCK 23/200 SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

∆ˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ (iv) ˆõˆÏ¢y¸

ôã S7V fl¸T…

87% MATCHING BLOCK 24/200 SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ Á ˆõˆÏ¢y!fl¸≥¸Î˚

yˆÏÓ˚Ó˚ õïƒÓ≈¸# xM¸ÈúˆÏÑ¸ ÓˆÏúÈÙÈÙÈ (i) ›¸∆ˆÏ¸ôy¸ôã (ii) ›¸∆ˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T…ƒyˆÏ›¸y¸ôã (iv) ˆõˆÏ¢y¸ôã S8V xyˆÏÓ˚yÓ˚y ˆÓy!Ó˚ˆÎ˚!ú¢ ˆÑ¸yìÿ˚ ˆïÓ˚ˆÏì¸ ¸ôyÁÎ˚y îyÎ˚ ÈÙÈÙÈ (i) Ñ%¸ˆÏëÓ˚& (ii) ¢%ˆÏëÓ˚& (iii) î%!›¸ˆÏì¸£z (iv) ˆÑ¸yò!›¸ òy S9V Óyÿ˚%õ[¸ˆÏú ¢ÓˆÏìˆÏÑ¸ ˆÓ!ü ¸ô!Ó˚õyí Üƒy¢#Î˚ v¸z¸ôyîyò ˆÑ¸yò hfl¸ˆÏÓ˚ xÓ!fl¸ì¸ ÈÙÈÙÈ (i) ›¸∆ˆÏ¸ôy¸ôã (ii) ›¸

54% MATCHING BLOCK 27/200 SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

∆ˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ (iv) ÌyÓ˚ˆÏõy!fl¸≥¸Î˚yÓ˚

S10V ˆÑ¸yò hfl¸ˆÏÓ˚ Óyÿ˚% xyÎ˚ˆÏò î%_´ÈÙÈÙÈ (i) ›¸∆ˆÏ¸ôy¸ôã (ii) ›¸

54% **MATCHING BLOCK 28/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

∆ˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T...ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ (iv) ÌyÓ˚ˆÏõy!fl¸≥¸Î˚yÓ˚

x!ì¸ ¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ¸ô!Óˆ˚ÏÓü Óúˆìì¸ !Ñ¸ ˆÓyˆÏG¸ò/ S2V ˜ãÓ v¸z¸ôyîyò Ñ¸yˆÏÑ¸ ÓˆÏú/ v¸zîy£Ó˚í !îò– S3V ! ¢Î˚yú Ñ¸yˆÏÑ¸ ÓˆÏú/ S4V «%¸∏¸ õ[¸ú Ñ¸yˆÏÑ¸ ÓˆÏú/ S5V Áãò Üƒy¢ ˆÑ¸yò hfl¸ˆÏÓ˚ ¢ÓˆÏìˆÏÑ¸ ˆÓ!ü ¸ôyÁÎ˚y ÎyÎ˚/ ¢Ç!«¸Æ v¸z_Ó˚ ! ¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ¸ô!Óˆ˚ÏÓü !ÓîƒyÓ˚ =Ó˚&c Óí≈òy Ñ¸Ó˚&ò– S2V ¸ô!Óˆ˚ÏÓˆÏüÓ˚ v¸z¸ôyîyò=!ú !Ñ¸ !Ñ¸/ S3V ãˆÏúÓ˚ =Ó˚&c ¢¡

100% **MATCHING BLOCK 25/200** **W**

ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S4V

ã#Ó õ[¸ú Ñ¸yˆÏÑ¸ ÓˆÏú/ S5V ¸ô!Óˆ˚ÏÓü !ü«¸yÓ˚ õ%Öƒ v¸zˆÏjüƒÈÙÈ=!ú !úÖ%ò– S6V v¸z°åì¸yÓ˚ v¸z¸ôÓ˚ !¶¸!_ Ñ¸ˆÏÓ˚ ÓyÎ˚%õ[¸úˆÏÑ¸ Ñ¸Î˚!›¸ hfl¸ˆÏÓ˚ ¶¸yÜ Ñ¸Ó˚y £ˆÏÎ˚ˆÏäÈ Á !Ñ¸ !Ñ¸/ v¸z_Ó˚ ¢ÇˆÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (ii) x˜ÏãÓ v¸z¸ôyîyò S2V (iii) x!:ˆÏãò S3V (ii) 71% S4V (iii) 78.08% S5V (iii) 6.5 0 C S6V (iii) fi›¸∆ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ S7V (iii) fi›¸∆ƒyˆÏ›¸y¸ôã S8V (ii) ¢%ˆÏõÓ˚& S9V (ii) ›¸∆ˆÏö¸y!fl¸≥¸Î˚yÓ˚ S10V (iv) ÌyˆÏõ≈y!fl¸≥¸Î˚yÓ˚ NSOU ? AE-ES-21 ? 21
~Ñ¸Ñ¸È 2 ≤ÃyÑ¸¸!ì¸Ñ¸ ¢¡ôî ≠ òÓ#Ñ¸Ó˚íˆÏÎyÜƒ ~ÓÇ xòÓ#Ñ¸Ó˚íˆÏÎyÜƒ (Natural Resource : Renewable and Non renewable) Ü‡¸ò 2.0 v¸zˆÏjüƒ 2.1 ≤Ãhfl¸ÏyÓòy 2.2 ≤ÃÑ¸yÓ˚ˆÏ¶¸î (Types of resource) 2.3 Óò¢¡ôî (Forest Resource) 2.3.1 ¶¸yÓ˚ˆÏì¸Ó˚ xÓfl¸iyò 2.32. Óò¶)¸!õÓ˚ v¸z¸ôÑ¸y!Ó˚ì¸y (Importance of Forest) 2.3.3xÓ˚íƒ !òïò Á ãòãy!ì¸Ó˚ v¸z¸ôÓ˚ ì¸yÓ˚ ≤Ã¶¸yÓ (Deforestation and effects of deforestation on Tribal people) 2.3.4 ˆÎÔÌ Óò ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Joint Forest Management) 2.4 Ö!òã¢¡ôî (Mineral Resources) 2.4.1 Öòò ¸ôk¸!ì¸ 2.4.2 ¶¸yÓ˚ˆÏì¸Ó˚ Ö!òã ¢¡ôî (Minaral resources in India) 2.4.3 ¸ô!Óˆ˚ÏÓü Á ¢õyˆÏãÓ˚ v¸z¸ôÓ˚ Öòò Ñ¸yˆÏÎ≈Ó˚ ≤Ã¶¸yÓ (Environmental and social impacts of mining) 2.5 ¶)¸!õ¢¡ôî (Land Resources) 2.51 ¶)¸!õ Á ¶)¸!õ ¢¡ôˆÏîÓ˚ =Ó˚&c (Importance of Land and Land Resources) 2.5.2 ¶)¸!õÓ˚ xÓ«¸Î˚ Á ¶)¸!õ î)°Ïí (Land Degradation and Land Pollution) 2.5.3 ¶)¸!õ xÓ«¸ˆÏÎ˚Ó˚ Ñ¸yÓ˚í 2.5.4 ¶)¸!õ ïπ¢ (Landslide) 2.5.5 õ,!_Ñ¸y «¸Î˚ (Land erosion) 2.6 ãú¢¡ôî (Water Resource)
2.6.1 ¶)¸¸ô,ˆÏ¤¸Ó˚ ãˆÏúÓ˚ Ó^˘›¸ò (Distribution of water on Earth) 2.6.2 ¶)¸¸ô,ˆÏ¤¸Ó˚ Á ¶)¸ÜˆÏ¶≈¸Ó˚ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ Á x¸ôÓƒÓ£yÓ˚ (Use and over-utilization of surface and groundwater) 2.6.3 ãˆÏúÓ˚ x¸ôÓƒÓ£yÓ˚ 2.6.4 ãú ¢ÇÑ¸›¸ !òÓyÓ˚í (Minimise water crisis) 2.6.5 ¶¸yÓ˚ˆÏì¸Ó˚ ãú ¢¡ôˆÏîÓ˚ ÓƒÓfl¸iy¸ôòy (Water resource management in India) 2.7 ïyÓ˚íˆÏÎyÜƒ v¸zß¨Î˚ˆÏòÓ˚ ïyÓ˚íy (Concept of Sustainable development) 2.7.1 ò#!ì¸ !òˆÏî≈!üÑ¸y (Guidelines) 2.8 xò%ü#úò# 2.0 v¸zˆÏjüƒ ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ˆÏÓ˚ xy¸õ!l !l¡¨!°!áï¸ !Ó£ÏÎ˚=!° çylˆÏï¸ ¸õyÓ˚ˆÏÓl– ? §¡õò Ü¸yˆÏÜ¸ ÓˆÏ°ñ •z•y Ü¸Î˚≤ÃÜ¸yÓ˚ G !Ü¸ !Ü¸– ? Ë¸yÓ˚ˆÏï¸Ó˚ !Ó!Ë¸ß¨ xÇˆÏ¢ Ólç §¡õˆÏòÓ˚ xÓfliyl G í¸z¸õˆÏÎyà#ï¸y– ? xÓ˚îƒ !lôˆÏlÓ˚ Ü¸yÓ˚î G Ê¸°yÊ¸°– ? á!lç §¡õˆÏòÓ˚ §ÇK¸y– ? ! Ü¸ !Ü¸ ¸õk¸!ï¸ˆÏï¸ áll Ü¸yÎ≈ §¡õß¨•Î˚– ? Ë)¸!Ù G Ë)¸!Ù §¡õˆÏòÓ˚ =Ó˚&cñ Ë)¸!Ù ò)£Ïîñ Ë)¸!Ù ôÁ§ G Ë)¸!Ù xÓ«¸ˆÏÎ˚Ó˚ ≤ÃyÜ¸¸!ï¸Ü¸ G Ùl%£Ïƒò‚T Ü¸yÓ˚î– ? Ù¸!_Ü¸y «¸ˆÏÎ˚Ó˚ Ùl%£Ïƒ§„‚T G ≤ÃyÜ¸¸!ï¸Ü¸ Ü¸yÓ˚î ~ÓÇ ï¸y !lÓyÓ˚ˆÏîÓ˚ í¸z¸õyÎ˚– ? ç° §¡õˆÏòÓ˚ ≤ÃˆÏÎ˚yçl#Î˚ï¸y G fli°Ë¸yˆÏàÓ˚ ç°Ó^˝ê¸l– ? Ë)¸àË≈¸fli çˆÏ°Ó˚ ÓƒÓ•yÓ˚ñ x¸õÓƒÓ•yÓ˚ G ç°§ÇÜ¸ê¸ !lÓyÓ˚ˆÏîÓ˚ í¸z¸õyÎ˚=!°– 2.1 ≤Ãhfl¸ÏyÓòy ˆÎ ¢õhfl¸ v¸z¸ôÑ¸Ó˚í Îy Ó˚*¸ôyhs¸!Ó˚ì¸ Óy ~õò¶¸yˆÏÓ ¸ô!Ó˚Ó!ì≈¸ì¸ £ˆÏì¸ ¸ôyˆÏÓ˚ ˆÎ ~!›¸ xyˆÏÓ˚y õ)úƒÓyò ~ÓÇ îÓ˚Ñ¸y!Ó˚ £ˆÏÎ˚ Áˆ‡¸ Óy õyò%ˆÏ°ÏÓ˚ ˜îò!®ò ã#ÓˆÏò ˆÎ ¢õhfl¸ Ólfl¸ ÓƒÓ£*ì¸ £Î˚ ì¸yˆÏÑ¸£z ¢¡ôî (Resource) Óúy £Î˚– ¸ô,!ÌÓ#Ó˚ ! Ñ¸ä%È !Ñ¸ä%È Ólfl¸ !òˆÏã ˆÌˆÏÑ¸£z ¢¡ôî ì¸yˆÏîÓ˚ ≤ÃyÑ¸¸!ì¸Ñ¸ ¢¡ôî (Natural Resource) Óúy £Î˚ñ ˆÎõòÈÙÙÈ ãúñ Óyì¸y¢ñ õy!›¸ñ Ö! òãñ ã#ÓÑ)¸ú £zì¸ƒy!î– õyò%°Ï ì¸yÓ˚ xì¸ƒyï%!òÑ¸ !ÓK¸yò ~ÓÇ Îs¸f¸ôy!ì¸ myÓ˚y xyˆÏÓ˚y NSOU ? AE-ES-21 ? 23
ˆÓ!ü ÓƒÓ£yÓ˚ ˆÎyÜƒ Á xyˆÏÓ˚y !Ó!¶¸ß¨ ¢¡ôˆÏî ¸ô!Ó˚Óì≈¸ò á›¸yˆÏFäÈ ˆÎõòÈÙÙÈ ü!_´ ¢¡ôî– Óì≈¸õyò Î%ˆÏÜ fl¸∫yfl¸iƒÓyòñ !ü!«¸ì¸ñ ˆõïy¸ô)í≈ Á ¢Ó≈¸ô!Ó˚ ü‚Cúy¸ôÓ˚yÎ˚í òyÜ!ÓˆÑ¸ ˆÎ ˆÑ¸yò ˆîˆÏüÓ˚ õ)úƒÓyò ¢¡ôî xÌ≈yÍ õyòÓ ¢¡ôî ÓˆÏú !â¸!£´ì¸ Ñ¸Ó˚y £Î˚– ~£z xïƒyˆÏÎ˚ !Ó!¶¸ß¨ ïÓ˚ˆÏòÓ˚ ¢¡ôˆÏîÓ˚ õ)úì¸ òÓ#Ñ¸Ó˚í ˆÎyÜƒ Á xòÓ#Ñ¸Ó˚í ˆÎyÜƒ ¢¡ôˆÏîÓ˚ ÓƒÓ£yÓ˚ñ x¸ôÓƒÓ£yÓ˚ ~ÓÇ ì¸yˆÏîÓ˚ ¢ÇÓ˚«¸í¸
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yˆÏúyÑ¸¢Çˆ‘Ïº (Photosynthesis) ≤Ã!e´Î˚yÓ˚ õyïƒˆÏõ v¸z!qî Óyì¸yˆÏ¢Ó˚ CO 2 ˆÑ¸ ˆüyºí Ñ¸ˆÏÓ˚ ~ÓÇ ¸ô!Ó˚Ó˚ˆÏì≈¸ O 2 Óyì¸yˆÏ¢ äÈyˆÏv¸¸ – Ñ¸yÓ≈ò ¢M¸ÈÎ˚ (Carbon sequestration) ¸ôk¸!ì¸ˆÏì¸ ÜyäÈ¸ôyúyÓ˚ xyÎ˚ì¸ò Ó¸!k¸ ¸ôyÎ˚ ~ÓÇ ¢yˆÏÏ ¢yˆÏÏ Óyì¸yˆÏ¢Ó˚ Ñ¸yÓ≈ˆÏòÓ˚ ¸ô!Ó˚õyí Ñ¸õÎ˚ – ~Ó˚ ö¸ˆÏú !@ˆÃò £yv¸z¢ Üƒy¢ (Greenhouse Gas)ÙÈ~Ó˚ ¸ô!Ó˚õyí £…y¢ ¸ôyÎ˚ ~ÓÇ ö¸úfl¸ÎÓ˚*¸ô ! ÓŸª v¸zºåyÎ˚ˆÏòÓ˚ (Global warming) ≤Ã¶¸yÓ £…y¢ ¸ôyÎ˚ – ≤Ã!ì¸ÓäÈÓ˚ ≤ÃyÎ˚ 2.0 !Ó!úÎ˚ò ›¸ò Ñ¸yÓ≈ò ˆÏÑ¸ Óò¶)¸!õ ˆüyºí Ñ¸ˆÏÓ˚ – S2V Óò¶)¸!õÓ˚ v¸z!qˆÏïÓ˚ !üÑ¸ˆÏv¸¸Ó˚ ¢Çú@¿ õy!›¸ˆÏì¸ v¸z¸ô!fl¸ìì¸ ¸ô!Ó˚ì¸ƒ_´ !£v¸z!õÑ¸ xƒy!¢v¸ ~ÓÇ Fluric xƒy!¢v¸ Óyì¸yˆÏ¢Ó˚ ≤ÃyÎ˚ 3 !õ!úÎ˚ò ›¸ò Ñ¸yÓ≈ò ˆüyºí Ñ¸ˆÏÓ˚ Ó˚yÖˆÏì¸ ¸ôyˆÏÓ˚ – S3V ÜyˆÏäÈÓ˚ !üÑ¸v¸¸ õy!›¸ˆÏÑ¸ Ö%Ó xyˆÏÎfi›¸¸ô¸ˆÏ‹T ïˆÏÓ˚ Ó˚yˆÏÜ ~ÓÇ ÜyˆÏäÈÓ˚ üyÖyÈÙÈ≤ÃüyÖy Ó¸!‹TÓ˚ âúˆÏÑ¸ ¢Ó˚y¢!Ó˚ õy!›¸ˆÏÑ¸ xyáy¸ xyòˆÏì¸ ˆÏîˆÏÎ˚ òy ö¸ˆÏú ¶)¸!õ«¸Î˚ ˆÓ˚yí £Î˚ – S4V ÜyäÈ ¸ôyì¸yÓ˚ ˆfi›¸yõy›¸yÓ˚ õyïƒˆÏõ õy!›¸Ó˚ âúˆÏÑ¸ Óyì¸yˆÏ¢Ó˚ õˆÏïƒ Óy‹Ñ¸ÑyˆÏÓ˚ !òÜ≈õò Ñ¸ˆÏÓ˚ ì¸yÓ˚ ö¸ˆÏú Óò¶)¸!õÓ˚ Á¸ôÓ˚ ˆõˆÏáÓ˚ ¢¸!‹T £Î˚ – Îy ¸ôÓ˚ Óì≈¸#Ñ¸yˆÏú ü#ì¸!ú¶)¸ì¸ £ˆÏÏ Ó¸!‹TÓ˚ ¢¸!‹T Ñ¸ˆÏÓ˚ – ¢%ì¸Ó˚yÇ Óúy ÎyÎ˚ Óò¶)¸!õ Ó¸!k¸ õyˆÏò Ó¸!‹T¸ôyì¸ Ó¸!k¸ – S5V ÜyˆÏäÈÓ˚ !üÑ¸v¸¸ ~ÓÇ Ñ¸y[¸ Ó¸!‹T¸ôyˆÏì¸Ó˚ âúˆÏÑ¸ ¢Ó˚y¢!Ó˚ ÓˆÏÏ ˆÎˆÏì¸ ˆîˆÏÎ˚ òy ì¸yÓ˚ ö¸ˆÏú õy!›¸Ó˚ ! òˆÏâ¸Ó˚ âühfl¸ˆÏÓ˚Ó˚ Ó¸!k¸ ˆÏì¸Á Óò¶)¸!õÓ˚ ¶)¸!õÑ¸y xyˆÏäÈ– S6V Óò¶)¸!õ Óyì¸yˆÏ¢Ó˚ ï)!úÑ¸íyñ !ÓºÎ_´ Üƒy¢ ˆÎõò SOx, NOx ˆüyºí Ñ¸ˆÏÓ˚ ~ÓÇ !Ñ¸ä%È !Ñ¸ä%È ÜyäÈ ˆÎòò !òõñ £zv¸zÑ¸ƒy!úô›¸yü Óyì¸yˆÏ¢Ó˚ ã#Óyí% ïπÇ¢ Ñ¸ˆÏÓ˚ – ì¸y£z Óò¶)¸!õˆÏÑ¸ ≤ÃÑ¸“!ì¸Ó˚ ö%¸¢ö%¸¢ Óúy £Î˚ – S7V ü)∑ºí ≤Ã!ì¸ˆÏÓ˚yˆÏï Óò¶)¸!õÓ˚ ¶)¸!õÑ¸y ¸ôyì¸y !ì¸%_´ Óò¶)¸!õÓ˚ ¶)¸!õÑ¸y xyˆÏäÈ– S8V Óò¶)¸!õ Ó˚ú ã#Óyls¸Ó˚ Óy¢fl¸iyò ≤ÃyÎ˚ fl¸iú¶¸yˆÏÜÓ˚ 70% ã#Óyls¸ Óò¶)¸!õˆÏì¸ ˆïÓ˚ˆÏì¸ ¸ôyÁÎ˚y Ïyî˚ñ ì¸y£z Óò¶)¸!õ ã#Ó ˜Ó!â¸ˆÏefÓ˚ xyïyÓ˚ ! £¢yˆÏÓ ïÓ˚y £Î˚ – S9V Óòã¢¡ôî õyò%ˆÏºÓ˚ â¸y!£îy ~ÓÇ Ó˚&!ãÓ˚ Á¸ôÓ˚ ≤Ã¶¸yÓ !Óhfl¸yÓ˚ Ñ¸ˆÏÓ˚ – Ñ¸y¤¸¢¡ôîñ òyòy ö¸úã)úñ È˚ºïñ ö%¸ú £zì¸ƒy!î ¢¡ôî xy!ïÓ¢#Ó˚ Óò¶)¸!õ ˆÌˆÏÑ¸ xy£Ó˚í Ñ¸ˆÏÓ˚ !òˆÏãˆÏïÓ˚ ˆ¸ô›¸ â¸yúyˆÏòyÓ˚ äÈyó ~ÓÇ ã#!ÓÑ¸y !òÓ≈y£ Ñ¸ˆÏÓ˚ Îy ˆÏÑ¸ – NSOU ? AE-ES-21 ? 25

2.3.3 xÓ˚íƒ !òïò Á ãòãy!ì¸Ó˚ v¸z¸ôÓ˚ ì¸yÓ˚ ≤Ã¶¸yÓ (Deforestation and effects of deforestation on Tribal people) õyòÓ ¢¶¸ƒì¸y Îì¸ xyï%!òÑ¸ ˆÌˆÏÑ¸ xyï%!òÑ¸ì¸Ó˚ £ˆÏÎ˚ ˆÏäÈ ~ÓÇ ãòãy!ì¸Ó˚ !Óhfl¸yÓ˚ á ˆÏ›¸ ˆÏäÈ ì¸ì¸ ÓòyM¸Èú ïπÇ¢ £ˆÏÎ˚ ˆÏäÈñ ÓòyM¸Èú ïπÇˆÏ¢Ó˚ ≤Ãïyò Ñ¸yÓ˚í =!ú £úÈÙÙÙÈ S1V !Ó!¶¸ß¨ ïÓ˚ˆÏòÓ˚ v¸zß¨Î˚òõ)úÑ¸ !e´Î˚yÑ¸úy¸ô ˆÎõòÈÙÙÙÈ Ó˚yhfl¸yñ ˆÓ˚ú úy£zòñ Óv¸¸ Óv¸¸ ãúyïyÓ˚ ~ÓÇ Ñ¸yÓ˚Öyòy !òõ≈yí Ñ¸yˆÏÎ≈Ó˚ ãòƒ Óò¶)¸!õ Ñ¸y›¸y £ˆÏFäÈ– S2V ãµyúy!òÓ˚ Ñ¸yˆÏãÓ˚ ãòƒ @˘Ãyõƒ ãòãy!ì¸ ÜyäÈ¸ôyúy ˆÑ¸ˆÏ›¸ ˆòÎ˚ – S3V ãò¢ÇÖƒyÓ˚ Ó‚!k¸Ó˚ ãòƒ ì¸yˆÏîÓ˚ ÖyˆÏîƒÓ˚ ˆÎyÜyò !îˆÏì¸ òì%¸ò v¸zÓ≈Ó˚ ã!õÓ˚ ãòƒ Óò¶)¸!õˆÏÑ¸ ! òÉˆÏü°Ï Ñ¸Ó˚y £ˆÏFäÈ– S4V x!ì¸!Ó˚_´ ¸ô÷â¸yÓ˚í Óò¶)¸!õÓ˚ £…yˆÏ¢Ó˚ ~Ñ¸!›¸ Ñ¸yÓ˚í– S5V Óòã oÓƒy!î ˆÎõòñ xy¢ÓyÓ ¸ôˆÏeÓ˚ ãòƒ Ñ¸y‡¸ñ Ñ¸yÜã !üˆÏ“Ó˚ ãòƒ Ñ§¸yâ¸yõyú £zì¸ƒy!îÓ˚ ãòƒ Óò¶)¸!õ !Óò‹T £ˆÏFäÈ– S8V ≤ÃyÑ¸¸!ì¸Ñ¸ Ñ¸yÓ˚í ˆÎõòÈÙÙÙÈ îyÓyòúñ x@¿%Í¸ôyì¸ £zì¸ƒy!îÓ˚ ãòƒÁ Óò¶)¸!õ !Óò‹T £Î˚ – ö¸úyö¸ú ≠ xÓ˚ˆÏíƒÓ˚ Óylfl¸ì¸ ˆÏs¸fÓ˚ ¢yˆÏÌ xÓ˚ˆÏíƒÓ˚ xy!îÓy¢# Óy ÓòÓy¢# õyò%°ÏˆÏîÓ˚ ã#ÓòÎyey ÁˆÏì¸y≤Ãì¸ ¶¸yˆÏÓ ã!v¸¸ì¸ xˆÏòÑ¸›¸y !õˆÏÌyã#!ÓˆÏîÓ˚ òƒyÎ˚ – ÓòyM¸Èú ò‹T £ÁÎ˚yÓ˚ ö¸ˆÏú xy!îÓy¢# õyò% °ÏˆÏîÓ˚ ã#ÓòÎyeyÓ˚ Á¸ôÓ˚ !Ó!¶¸ß¨ ≤Ã¶¸yÓ ¸ôˆÏv¸¸ˆÏäÈñ ˆ¢=!ú £úÈÙÙÙÈ S1V ÓòyM¸Èú xy!îÓy¢#ˆÏîÓ˚ ïõ≈#Î˚ Á ¢yÇfl¸‚Ò!ì¸Ñ¸ ¸ô#‡¸fl¸iyò ö¸ˆÏú Óò ïπÇ¢ £ÓyÓ˚ ãòƒ ì¸yˆÏîÓ˚ ¢yõy!ãÑ¸ Á ¢yÇfl¸‚Ò!ì¸Ñ¸ xyâ¸Ó˚í!Ó!ï !Ó!á¯ì¸ £Î˚ – S2V ÓòyM¸Èú ò‹T £ÁÎ˚yÎ˚ ì¸yˆÏîÓ˚ Óy¢fl¸iyò fl¸iyòyhs¸!Ó˚ì¸ £Î˚ – S3V ÓòyM¸Èú ò‹T £ÓyÓ˚ ö¸ˆÏú ì¸yˆÏîÓ˚ ã#!ÓÑ¸yÓ˚ õ)ú v¸zÍ¢ !Óò‹T £Î˚ ~ÓÇ ¸ôyüy¸ôy!ü ì¸yˆÏîÓ˚ õyò!¢Ñ¸ Á üyÓ˚#!Ó˚Ñ¸ fl¸∫yfl¸iƒ !Óò‹T £Î˚ – S4V Ó˚&!ã Ó˚&!›¸Ó˚ ãòƒ ì¸yÓ˚y òyòyò x¢yõy!ãÑ¸ !e´Î˚yÑ¸úyˆÏ¸ôÓ˚ ¢yˆÏÌ Î%_´ £Î˚ – S5V ÓòyM¸Èú !Óò‹T £ÓyÓ˚ ö¸ˆÏú ¸ô‚!Ó#Ó˚ xˆÏòÑ¸ ãyÎ˚Üyˆì¸ !Ó!¶¸ß¨ ≤Ãyâ¸#ò ãòãy!ì¸ !Óú%Æ £ˆÏÎ˚ ˆÜˆÏäÈ– 2.3.4 ˆÎÔÌ Óò ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Joint Forest Management) ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¶¸yÓ˚¢yõƒ Ó˚«¸y Ñ¸Ó˚yÓ˚ ãòƒ ~ÓÇ Óò¶)¸!õ ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ òyòy ïÓ˚ˆ

ÏíÓ˚ ¸

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ô!Ó˚Ñ¸“òy @˘Ã£í Ñ¸Ó˚y £ˆÏÎ˚ ˆÏäÈ ì¸yˆÏîÓ˚ õˆÏíƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £

ú ˆÎÔÌ Óò ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy– ~!›¸ ~Ñ¸!›¸ fl¸iyò#Î˚ ãòÜí ~ÓÇ ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ ÓòîÆˆÏÓ˚Ó˚ ˆÎÔÌ ¢£ˆÏÎyˆÏÜ Óò ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Joint Forest Management)– ~!›¸ ≤ÃÌõ ≤ÃˆÏâ¸‹Tyõ)úÑ¸ ¶¸yˆÏÓ 1971ÈÙÈ72 ¢yˆÏú ¸ô!ÿ¸õÓˆÏDÓ˚ ˆõ!îò#¸ô%Ó˚ ˆãúyÓ˚ xyv¸¸yÓy!v¸¸ ãDˆÏú â¸yú% Ñ¸Ó˚y £Î˚ – ˆ¢£z ¢õÎ˚ ÓòîÆˆÏÓ˚Ó˚ xy!ïÑ¸y!Ó˚Ñ¸ !äÈˆÏúò 26 ? NSOU ? AE-ES-21 v¸É x!ãì¸ Ñ%¸õyÓ˚ ÓƒyòyãÅ#– ≤ÃÌõyÓƒfl¸iyÎ˚ xyv¸¸yÓy!v¸¸ˆì¸ 11!›¸ @˘ÃyˆÏõÓ˚ 3670 ãò ¢î¢ƒˆÏÑ¸ !òˆÏÎ˚ ~£z ˆÎÔÌ Ñ¸õ≈¢)â¸# â¸yú% Ñ¸Ó˚y £Î˚ – ¸ôÓ˚Ói≈¸#Ñ¸yˆÏú 1989ÈÙÈ1990ÈÙÈ~ ¸ô!ÿ¸õÓD ¢Ó˚Ñ¸yÓ˚ JFM ˆÑ¸ xò%ˆÏõyîò ˆîÎ˚ ~ÓÇ ~›¸yÁ ãyòyÎ˚ ˆÎ Óò≤Ã!ì¸Ó˚«¸y ¢!õ!ì¸Ó˚ ¢î¢ƒÓ˚y ˆõy›¸ Ñ¸y¤¸ãyì¸ oˆÏÓƒÓ˚ !Óe´ˆÏÎ˚Ó˚ 25% ¶¸yÜ ¸ôyˆÏÓ ~ÓÇ ì¸yÓ˚y Ñ¸y¤¸ Óƒì¸#ì¸ xòƒyòƒ oÓƒy!îÁ Óò ˆÌˆÏÑ¸ ¢Ç@˘Ã£ Ñ¸Ó˚ˆì¸ ¸ôyÓ˚ˆÏÓ– ¸ôÓ˚Ói≈¸#Ñ¸yˆÏú ¸ô!ÿ¸õÓˆÏD xyˆÏÓ˚y xˆÏòÑ¸ Óò≤Ã!ì¸Ó˚«¸y ¢!õ!ì¸ Ü!‡¸ì¸ £Î˚ñ ~Ó˚ ¸ôÓ˚Ói≈¸#Ñ¸yˆÏú xòƒyòƒ Ó˚yãƒ ~ÓÇ ¶¸yÓ˚ì¸ ¢Ó˚Ñ¸yÓ˚ ~£z ˆÎÔÌ Óò¸ô!Ó˚â¸yúò ÓƒÓfl¸iyÎ˚ xò%≤Ãy!îì¸ £ˆÏÎ˚ òyòy ãyÎ˚Üy Î˚ ~Ó˚ ≤ÃˆÏÎ˚yÜ Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– 2.4 Ö!òã ¢¡ôî (Mineral Resources) ≤ÃyÑ¸¸!ì¸Ñ¸¶¸yˆÏÓ Ó˝ú«¸ ÓäÈÓ˚ ïˆÏÓ˚ ¶)¸¸ô‚ˆÏ¤¸ Ö! òˆÏãÓ˚ ¢‚!‹T £ˆÏÎ˚ ÌyˆÏÑ¸ – ~Ó˚ ~Ñ¸!›¸ !ò!î≈‹T Ó˚y¢yÎ˚!òÑ¸ ˜Ó!ü‹Tƒ xyˆÏäÈ– xyÑ¸!Ó˚Ñ¸ £ú ~Ñ¸!›¸ Ö!òã Óy xˆÏòÑ¸ Ö!òˆÏãÓ˚ ¢õ!‹T ÎyÓ˚ ˆÌˆÏÑ¸ ≤ÃˆÏÎ˚yã#Î˚ ¸ôîyÌ≈ !ò‹Òyüò Ñ¸Ó˚y ~ÓÇ !Ó!¶¸ß¨ Ñ¸yˆÏã úyÜyˆÏòy ¢Ω¸Óñ ˆÎõòÈÙÙÙÈ ïyì%¸ñ ˆúy£yñ !òˆÏÑ¸úñ ì¸yõy ! ãB¸ ≤Ã¶¸¸!ì¸ !ü“ˆÏ«¸ ˆÏe ÓƒÓ£*ì¸ x!ì¸ ≤ÃˆÏÎ˚yãò#Î˚ Ñ§¸yâ¸yõyú ~äÈyv¸¸y Ñ¸Î˚úyñ ˆ¸ôˆÏ›¸ ∆y!úÎ˚yõñ ˆ¢yòyñ !£ˆÏÓ˚ £zì¸ƒy!îÁ Ö!òã ¢ ¡ôˆÏîÓ˚ v¸zîy£Ó˚í– Ö!òã xyÑ¸!Ó˚Ñ¸ ˆÏÑ¸ õy!›¸Ó˚ Ü¶¸#Ó˚ ˆÌˆÏÑ¸ Öòò Ñ¸ˆÏÓ˚ Óy£zˆÏÓ˚ ~ˆÏò Ñ¸yˆÏã úyÜyˆÏòy £Î˚ – ~£z Öòò Ñ¸yÎ≈ ¢yïyÓ˚íì¸ â¸yÓ˚!›¸ ïyˆÏ¸ô £ˆÏÎ˚ ÌyˆÏÑ¸ÈÙÙÙÈ ??≤Ã¢ˆÏ¸ôÑ¸!›¸Ç (prospecting) ≠ Ö!òˆÏãÓ˚ ¢ı¸yò Ñ¸Ó˚y– ??xˆÏß∫°Ïí (Exploration) ≠ Ö!òˆÏãÓ˚ xÓfl¸iyòñ xyÑ¸yÓ˚ñ xyÎ˚ì¸ò ~ÓÇ xÌ≈˜ÏòÓ!ì¸Ñ¸ õ)úƒ ¸ô!Ó˚õy¸ô Ñ¸Ó˚y– ??v¸zß¨Î˚ò (Development) ≠ òyòy !òõ≈yí Ñ¸yã Á ¸ô!Ó˚Ñ¸y‡¸yˆÏõy ˜ì¸!Ó˚ Ñ¸Ó˚y ÎyˆÏì¸ õy!›¸Ó˚ !òˆÏâ¸ ãõy Ö!òã ˆÓÓ˚ Ñ¸ˆÏÓ˚ xyòy ÎyÎ˚ – ??ˆüy°Ïí (Exploitation) ≠ Ö! òÓ˚ õïƒ ˆÌˆÏÑ¸ Ö!òã ˆÓÓ˚ Ñ¸ˆÏÓ˚ xyòy– 2.4.1 Öòò ¸ôk¸!ì¸ ¢yïyÓ˚í¶¸yˆÏÓ 2 ïÓ˚ˆÏòÓ˚ Öòò Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ÈÙÙÙÈ S1V ¸ô‚¤¸ì¸ú Öòò (Surface Mining) ≠ ~!›¸ Ói≈¸õyˆÏò Ó˝ú ≤Ãâ¸!úì¸ Öòò ¸ôk¸!ì¸ – ¶)¸¸ô‚ˆÏ¤¸Ó˚ ÜyäÈ¸ôyúyñ õy!›¸ ~ÓÇ ≤ÃyÌ!õÑ¸ !üúy hfl¸Ó˚ˆÏÑ¸ Ö%§ˆÏv¸¸ ˆö¸úy £Î˚ ~ÓÇ ì¸yÓ˚ ¸ôÓ˚ Ö!òˆÏãÓ˚ hfl¸Ó˚!›¸ Ö%§ˆÏv¸¸ Óy£zˆÏÓ˚ !òˆÏÎ˚ xy¢y £Î˚ – v¸zîy£Ó˚íÈÙÙÙÈ Open pit mining, Strip mining £zì¸ƒy!î– S2V ¶)¸Ü¶≈¸fl¸i Öòò (Underground Mining) ≠ ¢%v¸¸D Ö%§ˆÏv¸¸ õy!›¸Ó˚ Ü¶¸#ˆÏÓ˚ ˆ¸ôÔ§ˆÏäÈ ì¸yÓ˚ ˆÌˆÏÑ¸ Ö!òˆÏãÓ˚ hfl¸Ó˚!›¸ˆÏÑ¸ Óy£zˆÏÓ˚ xyòy £Î˚ – ¶)¸¸ô‚ˆÏ¤¸Ó˚ v¸z¸ô!Ó˚ì¸ú x«¸ì¸ ÌyˆÏÑ¸ ~ÓÇ ÖòˆÏòÓ˚ ¸ôÓ˚ ö§¸yÑ¸y ãyÎ˚Üy!›¸ Óy!ú mÓ˚y ¶¸!ì≈¸ Ñ¸ˆÏÓ˚ ˆîÁÎ˚y £Î˚ – Drift mining, Slop mining ~£z ¸ôk¸!ì¸Ó˚ v¸zîy£Ó˚í– 2.4.2 ¶¸yÓ˚ˆì¸Ó˚ Ö!òã ¢¡ôî (Minaral resources in India) ¶¸yÓ˚ì¸ ≤ÃyÑ¸¸!ì¸Ñ¸ Ö!òã ¢¡ôˆÏîÓ˚ ¶¸y[¸yÓ˚ ~ÓÇ Ö!òˆÏãÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚£z ¶¸yÓ˚ì¸ xyã ì¸yÓ˚ fl¸iyò !ÓˆÏŸª Á¸ôˆÏÓ˚Ó˚ !îˆÏÑ¸ @˘Ã£í Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– ≤ÃyÎ˚ 87 ïÓ˚ˆÏòÓ˚ Ö!òã ¢¡ôî ¶¸yÓ˚ì¸ v¸zÍ¸ôyîò Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ – NSOU ? AE-ES-21 ? 27

¶¸yÓ˚ˆÏì¸Ó˚ v¸z˙ÏÕ'Ö˙ÏÏyÜƒ Ö!òã ~ÓÇ ì¸y˙ÏîÓ˚ v¸zí¸ôß¨ fl¸iúÈÙÙÙÈ e´!õÑ¸ ¢ÇÖƒy Ö!òã fl¸iyò 1 xƒyú%!õ!òÎ˚yõ ˆÑ¸Ó˚yúy 2 ~¢ˆÏÓfi›¸¢ Ñ¸í≈y›¸Ñ¸ñ Ó˚yãfl¸iyò 3 Ó:y£z›¸ G¸yv¸¸Ö[¸ñ õ£yÓ˚y‹T...ñ â¸[¸#Üv¸¸ 4 Ñ¸Î˚úy ¸ô!ÿ¸õÓD SÓ˚y!òÜOVñ G¸yv¸¸Ö[¸ SG¸y!Ó˚Î˚yñ ˆÓyÑ¸y˙ÏÓ˚yV 5 £#˙ÏÓ˚ õïƒ≤Ã˙Ïìü S¸ôyß¨yV 6 ˆ¢yòy Ñ¸í≈y›¸Ñ¸ S˙Ñ¸yúyÓ˚V 7 ˆe´y!õÎ˚yõ Á!v¸¸üy S¢%!Ñ¸®yV 8 Ö! òã ˆì¸ú xy¢yõ 2.4.3 ¸ô!Ó˚ˆÏÓü Á ¢õy˙ÏãÓ˚ v¸z¸ôÓ˚ Öòò Ñ¸y˙Ïî≈Ó˚ ≤Ã¶¸yÓ (Environmental and social impacts of mining) S1V ¸ô! Ó˚ˆÏÓ˙ÏüÓ˚ v¸z¸ôÓ˚ ≤Ã¶¸yÓ ≠ Öòò Ñ¸yî≈ ¸ô!Ó˚ˆÏÓ˙ÏüÓ˚ v¸z¸ôÓ˚ Óƒy¸ôÑ¸ £y˙ÏÓ˚ ≤Ã¶¸yÓ ˆö¸ˆÏú ly˙ÏÑ¸ñ ˆÎõòÈÙÙÙÈ ? ˆ¢yòyñ !¢¢yñ ì¸yõyñ !ãB¸ñ Ó˚ˆ&ˆÏ¸òyñ ˆúy£y ¢yïyÓ˚í ¢yúö¸£zv¸ Î%_´ ¸ôyÌÓ˚ ˆÌˆÏÑ¸ ¸ôyÁÎ˚y Ìyλ – ¢%ì¸Ó˚yÇ Öòò Ñ¸y˙ÏãÓ˚ ¸ôÓ˚ xyÑ¸!Ó˚Ñ¸ ¢Ç@˘Ã£ £˙ÏÎ˚ ˆÜˆÏú ¸ôyÌ˙ÏÓ˚Ó˚ ˆÎ !Óüyú ¸ôy£yv¸¸ ¢¸!‹T £Î˚ ì¸yÓ˚ ˆÌˆÏÑ¸ Ó°Ï≈yÓ˚ ¢õÎ˚ ¸ôyÌ˙ÏÓ˚ lyÑ¸y «¸!ì¸Ñ¸Ó˚ ¸ôîyÌ≈ ã˙ÏúÓ˚ ¢y˙Ïì !õˆÏü !Ü˙ÏÎ˚ xƒy!¢v¸ ãyì¸#Î˚ ì¸Ó˚ú Óã≈ƒ ¸ôîy˙Ïì≈Ó˚ ¢¸!‹T Ñ¸ˆÏÓ˚ – v¸zˆÏÕ'Öƒ !Ó°Ï˚ ~£z ˆÎ xƒy!¢v¸ ãyì¸#Î˚ Óã≈ƒ xy˙Ï¢ ¸ôy˙Ïü lyÑ¸y ¸ôîy˙Ïì≈Ó˚ õ˙ÏîƒÓ˚ ì)!°Ïì¸ ˆõÔú ˆÎõòÈÙÙÙÈ ì¸yõyñ !¢¢yñ Ñ¸ƒv¸!õÎ˚yõ ¸ôyÓ˚î £zì¸ƒy!ì˚ˆÏÑ¸ oÓ#¶)¸ì¸ Ñ¸ˆÏÓ˚ ~ÓÇ ì¸y ¸ôÓ˚ Óì≈¸# Ñ¸y˙Ïú ˆ¶¸Ôõ ãú hfl¸Ó˚ˆÏÑ¸ ì)!°Ïì¸ Ñ¸ˆÏÓ˚ ly˙ÏÑ¸ – ? lfl¸¸ôyÑ¸!ì¸ Öòò Ñ¸yî≈ãyì¸ Óã≈ƒ ¸ôîyÌ≈ ˆÌˆÏÑ¸ Ó°Ï≈yÑ¸y˙Ïú xÓ!ü‹T !Ó!¶¸ß˙ ¶¸y!Ó˚ iyì%¸ ˆe´y!õÎ˚yõ xƒyú%!õ!òÎ˚yõ Ñ¸ƒv¸!õÎ˚yõ £zì¸ƒy!î ¸ôyŸª≈Óì≈¸# ã˙Ïú â¸ˆÏú xy˙Ï¢ ~ÓÇ ì) °Ïí á›¸yÎ˚ – ? ~äÈyv¸¸y Öòò Ñ¸yã Ñ¸Ó˚ˆÏì¸ x!ì¸!Ó˚_´ õyeyÎ˚ ¶)¸!õ«¸Î˚ £˙ÏÎ˚ ly˙ÏÑ¸ ly ¸ôyŸª≈Óì≈¸# òì# Óy ãúyüÎ˚˙ÏÑ¸ «¸!ì¸@˘Ãhfl¸ Ñ¸ˆÏÓ˚ ly˙ÏÑ¸ – Open cast miningÙÈ~Ó˚ ˆ«¸ˆÏe õy!›¸ˆÏì¸ x˙ÏòÑ¸ Ü¶¸#Ó˚ Üˆ˙Ïì≈¸Ó˚ ¢¸!‹T £Î˚ ~ÓÇ ì¸yÓ˚ ãòƒ ≤Ã!ì¸!òÎ˚ˆì¸ ãúˆÏÑ¸ ÓyÑ¸z˙ÏÓ˚ ¸ôyˆÏ¡ôÓ˚ ¢y£yÎƒ ˆö¸úy £Î˚ ñ ö¸úfl¸ÍÓ˚*¸ô õy!›¸Ó˚ !òˆÏâ¸Ó˚ ãú hfl¸Ó˚ £...y¢ ¸ôyÎ˚ – 28 ? NSOU ? AE-ES-21 ? Öòò Ñ¸y˙ÏãÓ˚ ãòƒ ~ÓÇ ì¸yÓ˚ ¸ô!Ó˚Ó£˙ÏòÓ˚ ãòƒ ›¸òÈÙÈ›¸ò ï%ˆÏúyñ õy!›¸ Óyì¸y˙Ï¢ ˆõ˙Ïü ~ÓÇ ÓyÎ˚%ì)°Ïí Ñ¸ˆÏÓ˚ – ? Öòò Ñ¸y˙ÏãÓ˚ ãòƒ !Óüyú ~úyÑ¸y ã%ˆÏv¸¸ Óò¶)¸!õ Á ¶)¸ô¸ ˆÏ¤¸Ó˚ õy!›¸ˆÏÑ¸ ¢!ÓÓ˚ˆÏÎ˚ ˆîÁÎ˚y £Î˚ ö¸úfl¸ÍÓ˚*¸ô ã#Ó ˜Ó!â¸ˆÏe ƒÓ˚ £...y¢ á˙Ï›¸ – ? v¸zí¸ôß¨ ¸ôyÌÓ˚ñ õy!›¸Ó˚ hfl(¸ô xy˙Ïü¸ôy˙ÏüÓ˚ â¸y°Ïˆ ÏÏyÜƒ ã!õ˙ÏÑ¸ «¸!ì¸@˘Ãhfl¸ Ñ¸ˆÏÓ˚ Á õy!›¸Ó˚ ≤ÃÑ¸!ì¸Ó˚ ¸ô! Ó˚Óì≈¸ò á›¸yÎ˚ – S2V ¢õy˙ÏãÓ˚ Á¸ôÓ˚ ≤Ã¶¸yÓ ≠ ? Ñ¸Ö˙Ïòy Ñ¸Ö˙Ïòy fl¸iyò#Î˚ Óy!¢®y˙ÏîÓ˚ ¢¡ô)í≈¶¸y˙ÏÓ xòƒe ¢!Ó˚ˆÏÎ˚ !òˆÏÎ˚ ÌyÁÎ˚y £Î˚ – ~Ó˚ ö¸ˆÏú ì¸y˙ÏîÓ˚ ã#ÓòÌyey Á ¶)¸!õ ¢ÓÓ˚z ò‹T £Î˚ – ? Öòò Ñ¸y˙ÏãÓ˚ ãòƒ Óy£z˙ÏÓ˚ ˆÌˆÏÑ¸ x˙ÏòÑ¸ ◊!õÑ¸ xy˙Ï¢ ~ÓÇ xy˙Ïü¸ôy˙Ïü Ó¢!ì¸ Üˆ ÏÌv¸¸ ˆì¸y˙Ïú Ìy ¸ô)ˆÏÓ≈Ó˚ fl¸iyò#Î˚ õyò%˙Ïãò˙ÏîÓ˚ fl¸Íy¶¸y!ÓÑ¸ ã#ÓòÌyey Á ¢Çfl¸Ò!ì¸ˆÏÑ¸ ≤Ã¶¸y!Óì¸ Ñ¸ˆÏÓ˚ – ? ¸ô!Ó˚ˆÏÓüñ ˆ¶¸Ôõúñ ÓyÎ˚%ñ Öyîƒ ì)°Ïî≈Ó˚ ö¸ˆÏú fl¸iyò#Î˚ xy!îÓy¢#ˆÏîÓ˚ üyÓ˚#!Ó˚Ñ¸ xÓò!ì¸ á›¸y ~ÓÇ !¢!úÑ¸ !¢¢ñ xy¢ˆÏÓ¢ˆÏ›¸y!¢¢ñ Ñ¸ƒ™y˙ÏÓ˚Ó˚ õì¸ ã!›¸ú ˆÓ˚y˙ÏÜÓ˚ ¢¸!‹T £Î˚ – ? ~äÈyv¸¸y ã#ÓÑ¸y Á õyò%ˆ°ÏÓ˚ xì≈˜Ïò!ì¸Ñ¸ v¸zß¨!ì¸Ó˚ ãòƒ Öòò Ñ¸yã ¢yƒyÎƒ Ñ¸ˆÏÓ˚ – 2.5 ¶)¸!õ ¢¡ôî (Land Resources) ¸ô!Ó˚ˆÏÓ˙ÏüÓ˚ v¸z¸ôyîyò=!úÓ˚ õˆÏïƒ xòƒfi¸õ £ú ¶)¸!õ– xyÓ˚ ¶)¸!õ x!ì¸ õ)úƒÓyò ¢¡ôî Ó˚ˆÏú xì¸#ˆÏì¸ Ó˚yãyÎ˚ Ó˚yãyÎ˚ Î%k¸ ˆú˙ÏÜ˙ÏäÈ– ÷ì% ì¸y£z òÎ˚ ñ Óì≈¸õyˆÏò £y!õ!ò Ó˚yãyÎ˚ Ó˚yãyÎ˚ Î%k¸ ˆú˙ÏÜ˙ÏäÈ– ÷ì% ì¸y£z òÎ˚ ñ Óì≈¸õyˆÏò £y!õ!ò Ó˚yãyÎ˚ Ó˚yãyÎ˚ Î%k¸ ˆú˙ÏÜ˙ÏäÈ Ó˚ ¸ôy!Ó˚Óy˙ÏÓ˚Ó˚ ˆÌ ¸ô!Ó˚Ó£ Ó˚ˆÏÎ˚ˆÏäÈ ¸ôyˆÏÑ¸Ó˚ ˆîÁÎ˚y £Î˚ – 2.5.1 ¶)¸!õ Á ¶)¸!õ ¢¡ôˆÏîÓ˚ =Ó˚&c (Importance of Land and Land Resources) ¸ô¸!ÌÓ#Ó˚ 29% fl¸iú¶¸yÜ Îy v¸zßâ%¸ñ ˆÑ¸yÌyÁ !üúyhfl¸Ó˚ xyÓyÓ˚ ˆÑ¸yÌyÁ õy!›¸Ó˚ xyhfl¸Ó˚í myÓ˚y ë¸yÑ¸y– ~£z fl¸iú¶¸y˙ÏÜÓ˚ õy!›¸ñ âúñ Ö!òãñ v¸z!qî Á ã#Óãls¸ˆÏÑ¸ õyò%°Ï !òˆÏãÓ˚ ≤ÃÏ˙ÏÎ˚ãò ˆõ›¸y˙Ïì¸ ¢¡ôî !£¢y˙ÏÓ˚ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ – ~Ó˚ !¶¸!_ˆÏì¸ xì≈˜Ïò!ì¸Ñ¸ v¸zß¨!ì¸ NSOU ? AE-ES-21 ? 29 õyò%°Ï Ñ¸!°ÏÑ¸yî≈ Á Öyîƒ v¸zí¸ôyò Ñ¸Ó˚ˆÏäÈ– Óy¢fl¸iyˆÏòÓ˚ ãòƒ üÉÓ˚ @˘Ãyõ ˜ì¸!Ó˚ Ñ¸Ó˚ˆÏäÈñ ~äÈyv¸¸y !ü"yM¸ÈúÁ Üˆv¸¸ ì%¸ú˙ÏäÈ– ¶)¸!õ ~Ñ¸!›¸ xòÓ#Ñ¸Ó˚í ˆÎyÜƒ ¢¡ôî £ˆÏúÁ ¢!‡¸Ñ¸¶¸yˆÏÓ ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏú ì¸y˙ÏÑ¸ òÓ#Ñ¸Ó˚í ˆÎyÜƒ ¢¡ôˆÏì¸ ¸ô!Ó˚Ó!ì≈¸ì¸ Ñ¸Ó˚y ¢Ω¸Ó– 2.5.2 ¶)¸!õÓ˚ xÓ«¸Î˚ Á ¶)¸!õ ì)°Ïí (Land Degradation and Land Pollution) ãò¢ÇÖƒy Ó¸!k¸Ó˚ ¢yˆÏ ¢yˆÏ â¸y!£îyÁ xˆÏòÑ¸ ˆÓ˚ˆÏv¸¸ˆÏäÈ ö¸ˆÏú v¸zß¨ì¸ Ñ¸¸!°ÏÑ¸y˙Ïî≈Ó˚ õyÿƒ˙ÏõÓ˚ ˆÎyÜyòñ !ü"Á v¸zß¨ì¸ òÜÓ˚ ¸ô!Ó˚Ñ¸ˆ"òyÓ˚ Ó¸!k¸ á˙Ï›¸ˆÏäÈ ÎyÓ˚ ¢yˆÏÎ˚ ¶)¸!õÓ˚ xÓ«¸Î˚ Á ì)°Ïí ¢õyò%¸ôyˆÏì¸ Ó¸!k¸ ˆ¸ô˙ÏÎ˚ˆÏäÈ– ~ÓyˆÏÓ˚ ÓyÓ˚ Ó¸!k¸ ˆ¸ô˙ÏÎ˚ˆÏäÈ ÓyÓ˚ Ó¸!k¸ ˆ¸ô˙ÏÎ˚ˆÏäÈ ãy£y˙ÏÓ˚ Ó¸!k¸ ˆ¸ô˙ÏÎ˚ˆÏäÈ ¶)¸!õÓ˚ xÓ«¸Î˚ Á ì)°Ïí ¢õyò%¸ôyˆÏì¸ Ó¸!k¸ ˆ¸ô˙ÏÎ˚ˆÏäÈ ÓyÓ˚ Ó¸!k¸ ˆ¸ô˙ÏÎ˚ˆÏäÈ xÓ«¸Î˚ Á ¶)¸!õ ì)°Ïí Ñ¸yÓ˚í– 2.5.3 ¶)¸!õ xÓ«¸˙ÏÎ˚Ó˚ Ñ¸yÓ˚í ¶)¸!õ xÓ«¸˙ÏÎ˚Ó˚ Ñ¸yÓ˚í=!úú £úÈÙÙÙÈ ≤ÃyÑ¸!ì¸Ñ¸ Ñ¸yÓ˚í ≠ ?? ¸ôyÓ≈ì¸ƒ xM¸È˙Ïú ¶)¸!õÓ˚ ïπˆÏ¢Ó˚ Ñ¸yÓ˚ˆÏí ¶)¸!õÓ˚ xÓòõ á˙Ï›¸ – ??ÓòƒyÓ˚ ¢õÎ˚ ¢yõ!Î˚Ñ¸¶¸y˙ÏÓ ¶)¸!õÓ˚ ÓƒÓ£yÓ˚ ˆÎyÜfi¸y £...y¢ ¸ôyÎ˚ – ??ÓòƒyÓ˚ ¢õÎ˚ v¸z¸ôÑ)¸úÓ˚ì≈¸# xM¸È˙Ïú ¢yõ!Ñ¸ ˆòyòy Óy!ú ë%¸ˆÏÑ¸ ¶)¸!õÓ˚ úÓ˚y_ˆì¸y Ó!k¸ Ñ¸ˆÏÓ˚ – õò%°Ïƒ ¢‹T Ñ¸yÓ˚í ≠ ??x!ì¸!Ó˚_´ â¸y°ÏˆÏÓy˙Ï¢Ó˚ õyïƒˆÏõ ¶)¸!õÓ˚ v¸zÓ≈Ó˚ì¸y £...y¢ ¸ôyÎ˚ – ??x!òÎ˚!s¸fi¸ ¸ô÷â¸yÓ˚ˆÏîÓ˚ ö¸ˆÏú ¶)¸!õÓ˚ ÓƒÓ£yÓ˚ ˆÎyÜfi¸y £...y¢ ¸ôyÎ˚ – ??Ö!ò xM¸È˙Ïú Öòò ¢‹T ¶¸! Ó°Ïƒˆì¸Ó˚ ãòƒ ≤Ãã%¸Ó˚ ÓƒÓ£yÓ˚ ãòƒ ‹T £Î˚ – ??ìÉÓ˚ ÓyM¸È˙Ïú xyÓy≈òy ¢M¸È˙ÏÎ˚Ó˚ ö¸ˆÏú ≤Ãâ%¸Ó˚ ¸ô!Ó˚ ÓyÓ˚ ã!õ xÓƒÓ£yÎ≈ £˙ÏÎ˚ Á!‡¸ – 2.5.4 ¶)¸!õ ïπ¢ (Landslide) ˆÑ¸yò ¶)¸¶¸y˙ÏÜÓ˚ !Óhfl+¸ì¸ xÇü ≤ÃyÑ¸!ì¸Ñ¸ Óy õyò%°ÏÓ˚ !e´Î˚yÓ˚ ≤Ã¶¸y˙ÏÓ £‡¸yí !Óâ%¸fi¸ £˙ÏÎ˚ !òˆÏâ¸ ˆò˙Ïõ xy¢y˙ÏÑ¸ ¶)¸!õïπ¢ Ó˚ˆÏú– ¢yïyÓ˚íì¸ ¸ôy£y!v¸¸ xM¸È˙Ïú Ó°Ï≈yÑ¸y˙Ïú Öyv¸¸y ë¸yú Î%_´ xÇü=!úˆÏì¸ ~£z ïÓ˚ˆÏòÓ˚ á›¸òy ˆîÁÎ˚y Ìyλ – 30 ? NSOU ? AE-ES-21 Ñ¸yÓ˚í ≠ ≤ÃyÑ¸!ì¸Ñ¸ Ñ¸yÓ˚í=!ú £úÈÙÙÙÈ S1V ¶)¸!õÑ¸¸ô S2V x!ìÑ¸ Ó¸!‹T¸ôyì¸ S3V ì¸#Ó Öyv¸¸y ë¸y˙Ïú â%¸!ì¸ ÌyÑ¸ˆÏú S4V ¶)¸! õÓ˚ Ü‡¸ò S5V xhs¸Ó≈ì≈¸# ã˙ÏúÓ˚ ≤ÃÓy£ ÌyÑ¸ˆÏú ¶)¸!õïπ¢ £˙ÏÎ˚ ly˙ÏÑ¸ – õò%°Ïƒ ¢‹T Ñ¸yÓ˚í ≠ ??¸

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ô!Ó˚Ó£ò ÓƒÓfl¸iy v¸zß¨ì¸ Ñ¸Ó˚

yÓ˚ ì¸y!ÜˆÏî Ó˚yhfl¸yñ ˆÓ˚úúy£zò ˜ì¸!Ó˚ Ñ¸Ó˚y £ˆÏFäÈ ¸ôyÓ≈ì¸ƒ xM¸Ȉϊ– ??v¸ƒyõ !òõ≈yí ??ÓòyM¸Èú ò‹T ??Ó,£Í xRy!úÑ¸yñ ˆ£yˆÏ›¸ú £zì¸ƒy!î ¸ôy£yˆÏv¸¸Ó˚ ë¸yú ˜ì¸!Ó˚Ó˚ õyïƒˆÏõ ¶)¸!õïπˆÏ¢Ó˚ ≤ÃˆÏÑ¸y¸ô Ó,!k¸ Ñ¸ˆÏÓ˚ˆÏäÈ– ≤Ã¶¸yÓ ≠ ~Ó˚ ≤Ã¶¸yˆÏÓ ≤Ãyí£y!ò £Î˚ ~õò!Ñ¸ Óv¸¸ !Ó¸ôî≈ˆÏÎ˚ Á ˆv¸ˆÏÑ¸ xyòˆÏì¸ ¸ôyˆÏÓ˚ñ Óò¶)¸!õ ò‹T £ΙñãÃ#Ó˜ÏÓ!â¸eƒ ïπÇ¢ £Î˚ – Ó˚yhfl¸y áy›¸ñ !òõ≈yí ò‹T £ˆÏΙ ΙyΙ˚ – 2.5.5 õ,!_Ñ¸y «¸Î˚ (Land erosion) òî#ñ ÓyΙ˚% ≤Ã¶¸yÓñ Ó,!‹TÓ˚ ãú Á ¢õ%o ì¸Ó˚D ≤Ã¶¸¸!ì¸ ≤ÃyÑ¸¸!ì¸Ñ¸ Ñ¸yÓ˚ˆÏíÓ˚ ≤Ã¶¸yˆÏÓ ≤Ã!ì¸!òΙ˚ì¸ õ,!_Ñ¸y «¸Î˚ £ˆÏΙ˚ â¸ˆÏúˆÏäÈ– õyò%ˆÏºÏÓ˚ !e´Î˚yÑ¸úyˆÏ¸ôÓ˚ myÓ˚y ì¸y xyˆÏÓ˚y Ó,!k¸ ¸ôyˆÏFäÈñ ö¸úfl¸ÍÓ˚*¸ô Ñ¸!ºÏ ã!õÓ˚ ¸ô!Ó˚õyí £…y¢ ¸ôyˆÏFäÈñ v¸zÍ¸ôyîò Óƒy£ì¸ £ˆÏFäÈ– ??¸ôy£yˆÏv¸¸Ó˚ ïyˆÏ¸ô â¸yºÏ Ñ¸Ó˚yÓ˚ äòƒ Á ÜÓy!î ¸ô÷ â¸yÓ˚ˆÏíÓ˚ äòƒ ¶)¸!õ«¸Î˚ £Î˚ – ??Óò¶)¸!õ Á õy!›¸Ó˚ Á¸ôˆÏÓ˚Ó˚ ¢Ó%ã £…y¢ Ñ¸Ó˚yÓ˚ ö¸ˆÏú õy!›¸ xyúÜy £ˆÏΙ ΙyΙ˚ ~ÓÇ ì¸yÓ˚ «¸Î˚ £Î˚ – ??Ö!ò xMȸˆÏú Öòò Ñ¸yˆÏãÓ˚ äòƒ õ,!_Ñ¸yÓ˚ ΈÏì‹T «¸Î˚ £Î˚ – õ,!_Ñ¸yÓ˚ «¸Î˚ !òΈs¸fˆÏíÓ˚ v¸z¸ôyΙ˚ É ??¸ôy£y!v¸¸ xMȸˆÏú ë¸yú% äyΙ˚Üyˆì¸ Óò¶)¸!õÓ˚ ¢,!‹T Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ??v¸z¸õÑ)¸ˆÏú ¸ôyv¸¸ Óy ¸ôyìÓ˚ myÓ˚y v¸z¸õÑ)¸ú xMÈ¸ú ˆë¸ˆÏÑ¸ !ΈÏì¸ £ˆÏÓ ΙyˆÏì¸ «¸Î˚ òy £Î˚ – ??¸ôy£yˆÏv¸¸Ó˚ ë¸yˆÏú â¸yˆÏºÏÓ˚ äòƒ v¸z¸ôÎ%_´ ë¸yú ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ ì¸ˆÏÓ£z â¸yºÏ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ??õÓ˚&¶)¸!õÓ˚ â¸y!Ó˚!îˆÏÑ¸ G¸yÁ ÜyˆÏäÈÓ˚ õì¸ Üyäȃy!Üˆ Ïî ÓúΙ˚ Óò¶)¸!õ !òõ≈yí Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– 2.6 ãú ¢¡ôî (Water Resource) ãú ãÃ#ÓÑ%¸ˆÏúÓ˚ Ñ¸yˆÏäÈ xì¸ƒyÓüƒÑ¸ ¢¡ôîñ ãú äÈyv¸¸y ãÃ#Óò x¢Ω¸Ó– xyõÓ˚y ÖyÓyÓ˚ äÈyv¸¸y 30 !îò ¸ôÎ≈hs˘¸ ˆÓ§ˆÏâ¸ ÌyѸˆÏì¸ ¸ôy!Ó˚ !Ѹls˘¸ ãú äÈyv¸¸y õye Ѹ ˆÏΙѸ !ò£z ˆÓ§ˆÏâ¸ ÌyѸy ¢Ω¸Ó– xyõyˆÏîÓ˚ üÓ˚#ˆÏÓ˚ ãˆÏúÓ˚ ¸ô!Ó˚õyí 1% Ѹõˆ Ïú xyõÓ˚y ˆì¸‹TyÓ˚ xò%¶¸Ó £Î˚ !Ѹls˘¸ 10% Ѹõˆ Ïú õ,ì%¸ƒ ¸ôÎ≈hs˘¸ £ˆÏì¸ ¸ôyˆÏÓ˚ – NSOU ? AE-ES-21 ? 31 õyò%ˆÏºÏÓ˚ ˜ìò!®ò Ѹyˆ Ïã ãˆ ÏúÓ˚ =Ó˚&c x¸ô!Ó˚¢#õ– fl¸¨yòñ ˆüÓˆÏâ¸Ó˚ Ѹyˆ Ïãñ Óyß¨yñ Ü,£fl¸i!ú ¸ô!Ó˚‹ÒyÓ˚ ¸ô! Ó˚FäÈß¨ì¸yÓ˚ Ѹ yÓ˚ˆ Ïí ≤Ãâ%¸Ó˚ ¸ô!Ó˚õyˆÏí ãú ÓƒÓ£yÓ˚ £ˆÏΙ˚ ÌyˆÏÑ¸ – ãÃ#ÓòÎy¸ôò äÈyv¸¸yÁ õyòÓ ¢¶¸ƒì¸yÓ˚ ¢yˆÏì ãˆ ÏúÓ˚ =Ó˚&c x¸ô!Ó˚¢#õ– õyòÓ ¢¶¸ƒì¸yÓ˚ xì¸#ì¸ á§y›¸ˆÏú ãyòy ΙyΙ˚ ¢¶¸ƒì¸yÓ˚ ¢¸!‹T £ˆÏΙ˚!äÈú òî#ˆÏÑ¸ ˆÑ¸w Ñ¸ˆÏÓ˚ ~äÈyv¸¸y Ѹ¸! ºÏѸyÎ≈ Á !ü“ˆÏ«¸ˆÏe ≤Ãâ%¸Ó˚ ¸ô!Ó˚õyˆÏí ãˆ ÏúÓ˚ ≤ÃˆÏΙ˚yãò £ˆÏΙ˚ ÌyˆÏÑ¸ – ~£z ≤ÃˆÏΙ˚yãˆÏòÓ˚ ˆÎyÜyò !î˚ˆÏì¸ ¶)¸Üˆ Ï¶≈¸Ó˚ ãú ¶¸y[¸yˆÏÓ˚Ó˚ ÓƒÓ£yÓ˚ Óyv¸¸ˆÏäÈ– ö¸ˆÏú ¶)¸Ü¶≈¸fl¸i ãˆ ÏúÓ˚ ¶¸y[¸yÓ˚ e´õü ¢ÇÑ%¸!â¸ì¸ £ˆÏFäÈñ Óyv¸¸ˆÏäÈ ãú ¢ÇÑ¸›¸ – ãú ¢ ¡ôˆÏîÓ˚ £…yˆÏ¢Ó˚ Ѹ yÓ˚ˆ Ïí xyã ÓyhfΙ%¸ì¸ˆÏs¸fÓ˚ ãÃ#Ó˜ÏÓ!â¸eƒ ¸ôÎ≈hs˘¸ ¢ÇÑ¸ˆÏ›¸Ó˚ õ%ˆÏÖ– 2.6.1 ¶)¸¸ô,ˆÏ¤¸Ó˚ ãˆÏúÓ˚ Ó^˘›¸ò (Distribution of water on Earth) ¸ô,!ÏÓ#Ó˚ 71 ¶¸yÜ ãú Á 29 ¶¸yÜ fl¸iú ì¸y£z xy¸ôyì¸ ì¸!‹TˆÏì¸ ãˆÏúÓ˚ ¶¸y[¸yÓ˚ x¸ô!Ó˚¢#õ £ˆÏúÁñ xyã !ÓˆÏŸªÓ˚ Ó˝ ˆîü ãú ¢ÇÑ¸ˆÏ›¸ ¶%¸ÜˆÏäÈ– ì¸yÓ˚ ≤Ãïyò Ѹ yÓ˚ˆí £ú ¸ô,!ÏÓ#ˆÏì¸ ˆõy›¸ ãˆ ÏúÓ˚ 97 üì¸yÇü ãú ¢õ%ˆÏo xÓfl¸iyò Ѹ Ó˚ˆÏäÈ Îy xy¢ˆ Ïú xƒÓ£yΈ≈ ˆòyòy ãú xyÓ˚ Óy!Ѹ 3 üì¸yÇü ãú Îy fl¸iú ¶¸yˆÏÜ xyˆÏäÈ ì¸y fl¸Íyî% ãˆ ÏúÓ˚ õˆÏïƒ ¸ôˆÏv¸¸ – ~£z 3% ãú ¢!MÈ¸ì¸ xyˆÏäÈñ ¶)¸¸ô,ˆÏ¤¸Ó˚ ãúñ ¶)¸ÈÙÈx¶¸ƒhs˘¸ ˆÏÓ˚Ó˚ ãúñ ˆõÓ˚& ≤ÃˆÏüü Á ¸ôy£yˆÏv¸¸ ÓÓ˚ö¸ !£¢yˆÏÓ– ¶)¸ÈÙÈ¶¸yˆÏÜ ãˆÏúÓ˚ 2% ãú ÓÓ˚ö¸ !£¢yˆÏÓ ¢!MÈ¸ì¸ xyˆÏäÈ !£õÓy£ ~ÓÇ ¸ôy£yˆÏv¸¸ñ xyÓ˚ Óy!Ѹ 1% ãú Îy xy¢ˆÏú xyõÓ˚y ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ ¸ôy!Ó˚ ì¸yÓ˚ òî# òyúyñ ãúyüΈ Á ˆ¶¸Ôõ ãú hfl¸ÏˆÏÓ˚ ¢!MÈ¸ì¸ xyˆÏäÈ– fl¸iú ¶¸yˆÏÜÓ˚ ~£z 1% ãúÓ˚y!üˆÏѸ 100 ¶¸yˆÏÜ ¶¸yÜ Ѹ Ó˚ˆÏú 96.6% ˆ¶¸Ôõ ãúñ 1.4% ãúyüˆÏΙ˚Ó˚ ãúñ ˆòyòy £…î Á Öy!v¸¸ 1.4% ~ÓÇ ã#Î˚ Óy‹ô Á òî# òyúy 0.8%– Ѹ yÓ˚ í ≠ ¶)¸!õ«¸Î˚ ~Ѹ¸!›¸ Ö%Ó fl¸Íy¶¸y!ÓÑ¸ á›¸òyÈÙÙÈ fl¸iú¶¸yˆÏÜÓ˚ ãúÓr›¸ò SÓÓ˚ö¸ äÈyv¸¸yV xÓfl¸iyò ãˆ ÏúÓ˚ ¸ô!Ó˚õyí S%V ˆ¶¸Ôõ ãúhfl¸Ó˚ SxÜ¶¸#Ó˚V 48.3 ˆ¶¸Ôõ ãúhfl¸Ó˚ SÜ¶¸#Ó˚V 48.3 ¸ô%Ñ%¸Ó˚ñ ãúyüΈ 1.4 ˆòyòy ãˆÏúÓ˚ Ö§y!v¸¸ Á £…î 1.2 õ,!_Ѹ yÓ˚ ã#Î˚ Óy‹ô 0.7 òî# òyúy Á xòƒyòƒ 0.1 ¢%ì¸Ó˚yÇ v¸z¸ô!Ó˚v¸z_´ ãú Ór›¸ò myÓ˚y ˆÓyG¸y ÎyˆÏFäÈ ˆõy›¸ ÓƒÓ£yΈ≈ ãˆÏúÓ˚ ˆÓ!üÓ˚ ¶¸yÜ›¸y£z ˆ¶¸Ôõ hfl¸ˆÏÓ˚ ¢!M¸Èì¸ – !Ѹls¸ ì¸y xy£Ó˚í Ѹ Ó˚y Ѹ‹T¢yïƒ ì¸yäÈyv¸¸y ˆ¶¸Ôõ ãú ¢%ˆÏ¸ôΈ ãˆÏúÓ˚ ¢ˆÏÓ≈yíÑ¸‹T ¶¸y[¸yÓ˚ – ΈÏFäÈ ÓƒÓ£yÓ˚ ~£z õ)úƒÓò ¢¡ôˆÏîÓ˚ £…y¢ á›¸yˆÏFäÈ– ì¸y£z ≤ÃˆÏΙ˚yãò !ÓÑ¸“ ¶¸yÓòyÓ˚ Îy xyÜyõ#!ˆÏòÓ˚ ãú ¢ÇÑ¸›¸ î)Ó˚ Ѹ Ó˚ˆÏÓ– 32 ? NSOU ? AE-ES-21 2.6.2 ¶)¸¸ô,ˆÏ¤¸Ó˚ Á ¶)¸Üˆ Ï¶≈¸Ó˚ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ Á x¸ôÓƒÓ£yÓ˚ (Use and over-utilization of surface and groundwater) ˜ìò!®ò ¢õhfl¸ !e´Î˚yÑ¸úyˆÏ¸ôÓ˚ äòƒ ãˆÏúÓ˚ ≤ÃˆÏΙ˚yãò#ˆì¸y x¸ô!Ó˚¢#õ– fl¸¨yòñ ÖyÁΈyÈÙÈîyÁΈy Á Ü,£fl¸iú#Ó˚ Ѹ yˆÏãÓ˚ äòƒ ãˆÏúÓ˚ ≤ÃˆÏΙ˚yãò xˆÏòÑ¸ – Ü,£fl¸iyú#Ó˚ Ѹ yˆ Ïã õyÌy !¸ôä%È ãˆÏúÓ˚ ¸ô!Ó˚õyí 70ÈÙÈ130 !ú›¸yÓ˚ ÈÙÈ~Ó˚ õì¸ – ~äÈyv¸¸y Ѹ¸!ºÏѸyãñ ! ü“Ó˚ ˆ«¸ˆÏe ¸≤ÃˆÏΙ˚yãò#Î˚ ãˆÏúÓ˚ ¸ô!Ó˚õyí xˆÏòÑ¸ ˆÓ!ü– ì¸¸ì¸#Î˚ !ÓˆÏŸªÓ˚ xÌ≈yí v¸zß¨Î˚òü#ú ˆîü=!úÓ˚ ˆ«¸ˆÏe Ѹ¸!ºÏѸyˆÏÎ≈ ÓƒÓ£*ì¸ ãˆÏúÓ˚ ¸ô!Ó˚õyí ≤ÃyΙ˚ 70%– ÷ì% v¸zß¨Î˚òü#ú ˆîü=!ú£z òÎ˚ v¸zß¨ì¸ ˆîü=!úÓ˚ ˆ«¸ˆÏeÁ Ѹ¸!ºÏѸ ì¸ ÓƒÓ£*ì¸ ãˆÏúÓ˚ ¸ô! Ó˚õyí ˆÓ!ü ì¸ ˆÏÓ !ü“ˆÏ«¸ˆÏeÁ ~Ó˚ ¸ô!Ó˚õyí ì%¸úòyõ)úÑ¸¶¸yˆÏÓ ˆÓ!ü– ¢¶¸ƒì¸yÓ˚ ≤Ãyâ¸#òÑ¸yˆÏú ãˆÏúÓ˚ ≤ÃˆÏΙ˚yãò !äÈú x“ !Ѹls¸ Óì≈¸õyˆÏò v¸zß¨ì¸ ãÃ#ÓòÎyeyÓ˚ ì¸y!Üˆ Ïî @˘Ãyõ Á ü£ˆÏÓ˚ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ ˆÓˆÏv¸¸ˆÏäÈ– ~£z ãˆÏúÓ˚ â¸y!£îy ˆõ›¸yˆÏì¸ ˆ¶¸Ôõ ãˆÏúÓ˚ ÓƒÓ£yˆÏÓ˚Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#úì¸y ˆÓˆÏv¸¸ˆÏäÈ e´õü– !Ó÷k¸ Á ¸ôyòˆÏÎyÜƒ ~£z ˆ¶¸Ôõ ãúˆÏÑ¸ Ü,£fl¸iyú#ñ ˆ¢ˆÏâ¸ ~ÓÇ !ü“ˆÏ«¸ˆÏe ÓƒÓ£yÓ˚ Ѹ Ó˚y !Ó÷k¸ ãˆÏúÓ˚ x¸ôâ¸ÎΈ äÈyv¸¸y xòƒ !ѸâÈ%È òy– ¢ÓˆÏ«¸ˆÏe ãú ¢Çˆ«¸Ïíñ ãˆÏúÓ˚ ¶¸ˆÏÜ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ¢Óòy¢ ˆ ÏÓ˚ã !Ñ¸ÓÑ¸ ÓƒÓ£yÓ˚ Ѹ Ó˚y !£¢yˆÏÓ ÓÓ˚ö¸ !£¢yˆÏÓ ÓƒÓ£yÓ˚ !ÓòƒyˆÏ¢Ó˚ ÓƒÓ£yÓ˚ Ѹ Ó˚y ¢ÇÑ¸›¸ – ¢ì¸Ó˚ ÓƒÓ£yÓ˚ ¢ÇÑ¸›¸ – ¢ì¸Ó˚ ¢ã£*ì¸ ÓƒÓ£yÓ˚ ¸ô!Ó˚õyí Ѹ ˆÏÓ˚ ÓyÓ˚ ˆÓÓ˚ !ü“ ÓƒÓ£yÓ˚ ¢!ì¸ÓyÓ˚ ¢ÇÑ¸›¸ ˆ¢õ¸ÓƒÓ£y ì¸ ¢ì¸Ó˚ !ü“ ÓƒÓ£yÓ˚ ¢ÇÑ¸›¸ ˆÓ!ü ¢ ˆÓ!ü Óyv¸¸ˆÏäÈ– ¢¶¸ƒì¸yÓ˚ ˜ì¸!Ó˚ Ѹ Ó˚y ¢Óòy¢– ÖyÓyÓ˚ ¸ôyˆÏò£ ¸ô!Ó˚õyí 1% ãú Ѹ Ó˚ˆÏÓ ¸ôyò£ xˆÏÓ˚ ÓƒÓ£yÓ˚ ¢¶¸ƒì¸yÓ˚ ¸ô!Ó˚õyí– ¢!Ó˚ì¸ ÓƒÓ£yÓ˚ ãˆÏúÓ˚ ¢ÇÑ¸›¸ x¸ôÓƒÓ£yÓ˚ ÓƒÓ£yÓ˚ £ˆÏΙ˚ äÈyv¸¸y!Ѹ ÓƒÓ£yÓ˚ !ÓòƒyˆÏ¢Ó˚ (%) !Ó˚ü ãˆÏúÓ˚ ¶¸yÓ˚ˆÏì¸ ãˆÏúÓ˚ Óƒ˚ (%) ãˆÏúÓ˚ Óƒ˚ (%) Óƒ˚ (%) Ѹ¸!ºÏѸyã 70 30 82 70 !ü“ 22 59 10 15 Ü,£fl¸iyú# 8 11 8 5 2.6.3 ãˆÏúÓ˚ x¸ôÓƒÓ£yÓ˚ ≠ !îˆÏòÓ˚ ÷Ó˚&ˆÏì¸ á%õ ¶¸yèy ˆÌˆÏÑ¸ Ó˚yˆÏì¸ á%õyˆÏì¸ ÎyÁΈy ¸ôÎ≈hs¸ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ £Î˚ ¢ÓˆÏ«¸ˆÏe– ≤Ãì¸ƒ£ xyõyˆÏîÓ˚ ãÃ#ÓòÎyeyÓ˚ ì¸y!Üˆ Ïî 70ÈÙÈ130 !ú›¸yÓ˚ ãú õyÌy !¸ôä%È ≤ÃˆÏΙ˚yãò– ì¸ˆÏÓ ~Ó˚ ¸ô!Ó˚õyí fl¸iyò !ÓˆÏüˆÏºÏ ¸ô!Ó˚Ó!≈ì¸ £ˆÏΙ˚ ÌyˆÏÑ¸ – Óì≈¸õyˆÏò xì¸ƒy!ïÑ¸ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ñ î)ºÏíñ ãú ¢ÇÑ¸ˆÏ›¸Ó˚ ¢¡ø%Ö#ò Ѹ ˆÏÓ˚ˆÏäÈ– 2019 ¢yˆÏú @˘Ã#‹øÑ¸yˆÏú ˆâ¸ß¨y£z ¢£ ˆÓü Ѹ ˆÏΙѸ !›¸ v¸zß¨ì¸ ü£Ó˚ ¶¸Î˚yÓ£ ãú ¢ÇÑ¸ˆÏ›¸Ó˚ ¢¡ø%Ö#ò £ˆÏΙ˚ ˆÏäÈ– xyÜyõ# !îˆÏò ~Ó˚ ¶¸Î˚yÓ£ì¸y Ñ¸õˆÏÓ òy ÓÓ˚Ç Óyv¸¸ˆÏÓ– ì¸y£z ≤ÃˆÏΙ˚yãò ãˆÏúÓ˚ x¸ôÓƒÓ£yÓ˚ Ñ¸!õˆÏΙ˚ ãú¢ÇÑ¸›¸ î)Ó˚ Ñ¸Ó˚y– NSOU ? 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ãú x¸ôÓƒÓ£yˆÏÓ˚Ó˚ õyïƒõ=!ú £úÈÙÙÙÈ ??Ñ¸!°ÏÑ¸yˆÏÎ≈ x!ì¸!Ó˚_´ !Ó÷k¸ ˆ¶¸Ôõ ãˆÏúÓ˚ ÓƒÓ£yÓ˚– ??÷‹Ò xM¸ÈˆÏú xyo≈ Ñ¸! °ÏÓ˚ ≤ÃÓì≈¸ò– ??ü£Ó˚yM¸ÈˆÏú ˆ¸ôÒÓ˚¢¶¸y myÓ˚y x!ì¸!Ó˚_´ ãú ¢Ó˚ÓÓ˚y£ ~ÓÇ ãú ¢Ó˚ÓÓ˚y£ Ñ¸Ó˚yÓ˚ Ñ¸ú ˆÌˆÏÑ¸ õyey!ì¸! Ó˚_´ ¸ô!Ó˚õyˆÏí ãú ¸ôˆÏv¸¸ ÌyÁÎ˚y– ??Óy!v¸¸ áÓ˚ñ äyõyÑ¸y¸ôv¸¸ñ Üy!v¸¸ ≤Ã¶¸!ì¸ ¸ô!Ó˚‹ÒyÓ˚ Ñ¸Ó˚yÓ˚ Ñ¸yÓ˚ˆÏí ≤Ãâ%¸Ó˚ ¸ô! Ó˚õyˆÏí ãú ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – ??!ü"yM¸ÈˆÏú ÓƒÓ£*ì¸ ãú ¸ô%òÉ ÓƒÓ£yÓ˚ òy Ñ¸Ó˚y ~ÓÇ î)!°Ïì¸ ãúÈ òî#ÈÙÈòyúyˆÏì¸ ˆö¸ˆÏú ì¸y î)!°Ïì¸ Ñ¸Ó˚y– ??ì¸y¸ô !ÓÎ%ƒÍ ˆÑ¸w=!úˆÏì¸ ≤Ãâ%¸Ó˚ ¸ô!Ó˚õyˆÏí ãˆÏúÓ˚ ≤ÃˆÏÏ˚yãò £Î˚ ~ÓÇ ì¸yˆÏì¸ ¸ô%òÉ ¸ô!Ó˚ˆÏüy!ïì¸ ãú ÓƒÓ£yÓ˚ òy Ñ¸ˆÏÓ˚ òî# Á ˆ¶¸Ôõ ãú ÎˆÏÏFäÈ ¸ô!Ó˚õyˆÏí !ò‹Òyüò Ñ¸Ó˚yÓ˚ ö¸ˆÏú ãú hfl¸ˆÏÓ˚Ó˚ £…y¢ á›¸ˆÏäÈ– ??xyo≈ xM¸ÈˆÏú ¶)¸¸ô¸ˆÏ¤¸Ó˚ ãˆÏúÓ˚ ¢%!Óïy ÌyÑ¸ˆÏúÁ Ñ¸!°ÏÑ¸yˆÏÎ≈ ˆ¶¸Ôõ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ – 2.6.4 ãú ¢ÇÑ¸›¸ !òÓyÓ˚í (Minimise water crisis) ! òi¨!ú!Öì¸ ¸ôk¸!ì¸=!ú xÓúiÍò Ñ¸ˆÏÓ˚ ãú ¢ÇÑ¸›¸ !òÓyÓ˚í Ñ¸Ó˚y ¢Ω¸ÓÈÙÙÙÈ ? äòÜíˆÏÑ¸ ãˆÏúÓ˚ ÓƒÓ£yÓ˚ Á x¸ôÓƒÓ£yÓ˚ ¢ ¡ôˆÏÑ≈¸ K¸yò îyò Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ~ÓÇ ¢ˆÏâ¸ì¸ò Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ??ãú ¢Ó˚ÓÓ˚y£ Ñ¸Ó˚yÓ˚ Ñ¸ú=!úˆÏì¸ fl¸ÍÎ˚Ç!e´Î˚ ›¸ƒy¸ô ÓƒÓ£yÓ˚ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – ??≤Ã!ì¸!›¸ Óy!v¸¸ˆÏì¸ ÓƒÓ£*ì¸ ãúˆÏÑ¸ ¸ô%òÉ ÓƒÓ£yÍ≈ Ñ¸Ó˚yÓ˚ ÓƒÓfl¸iy Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ?? Ñ¸!°ÏÑ¸yˆÏÎ≈ ˆÎ ¢õhfl¸ ü¢ƒ â¸yˆÏ°Ï ˆÓ!ü ãú úyˆÏÜ ì¸yÓ˚ äyÎ˚ÜyÎ˚ fl¸Í" ãú úyˆÏÜ ˆ¢£zÓ˚Ñ¸õ ü¢ƒ ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ??Drip ãúˆÏ¢â¸ Á !fl¸±B¸úyÓ˚ ¸ôk¸!ì¸ˆÏì¸ â¸y°Ï Ñ¸Ó˚ˆÏú fl¸Í" ãˆÏú ˆÓ!ü ö¸¢ú £Î˚ – ??!üˆÏ" v¸zß¨ì¸ ≤ÃÎ%!_´ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ≤ÃˆÏÏ˚yãò ÌyˆÏì¸ Ñ¸õ ãú úyˆÏÜ– ??!â¸Ó˚yâ¸!Ó˚ì¸ ¸ôk¸!ì¸ˆÏì¸ ¸ô%Ñ%¸Ó˚ Á Öyú Öòò Ñ¸Ó˚yÓ˚ õyïƒˆÏõ Ó¸!‹TÓ˚ ãú ¢ÇÓ˚«¸í– ??Óy!v¸¸Ó˚ äÈyˆÏî Ó¸!‹TÓ˚ ãú ¢Ç@ˇÃ£ Ñ¸ˆÏÓ˚ ì¸y Ñ¸yˆÏã úyÜy ˆÏòy £Î˚ – ??ÎˆÏÏFäÈ Ü¶¸#Ó˚ òúÑ)¸ ¸ô Öòò Á ÎˆÏÏFäÈ ãú ¢Ç@ˇÃˆÏ£Ó˚ ˆ«¸ˆÏe î¸ë¸¸ ¸ôîˆÏ«¸¸ô @ˇÃ£í Ñ¸Ó˚y îÓ˚Ñ¸yÓ˚ – ??ãˆÏúÓ˚ îyõ ¢!‡¸Ñ¸ ¶¸yˆÏÓ ÓˆÏyÓy v¸z!â¸ì¸ Ìyˆì¸ xÎy x¸ôÓƒÓ£yÓ˚ òy £Î˚ – 2.6.5 ¶¸yÓ˚ˆÏì¸Ó˚ ãú ¢¡ôˆÏÏÓ˚ ÓƒÓfl¸iy¸ôòy (Water resource management in India) 1956 ¢yˆÏú ¶¸yÓ˚ˆÏì¸ ãú ¢¡ôî ÓƒÓfl¸iy¸ôòyˆÏÑ¸ õyÌyÎ˚ ˆÓ˚ˆÏÖ ! Ó˚¶≈¸yÓ˚ ˆÓyv≈¸ xƒyQ ˜ì¸!Ó˚ £Î˚ (River Board Act, 1956)– òî# xÓÓy!£Ñ¸yÎ˚ ãú¢¡ôˆÏÏÓ˚ Ó^ˇ›¸òñ ÓƒÓfl¸iy¸ôòy Á ¸ô!Ó˚Ñ¸"òyÓ˚ v¸zˆÏj ˆÏüƒ ~!›¸ ˜ì¸!Ó˚ Ñ¸Ó˚y £Î˚ – òî# 34 ? NSOU ? AE-ES-21
xÓÓy!£Ñ¸y ¸ôyŸª≈Óì≈¸# Ó˚yãƒ=!úÓ˚ õˆÏïƒ ˙Ñ¸ƒ òy ÌyÑ¸yÎ˚ñ Ó·¸¸ô%e ˆÓyv≈¸ñ òõ≈îy !òÎ˚s¸ fíÆÓ˚ñ îyˆÏõyîÓ˚ ¶¸ƒy!ú Ñ¸ˆÏ¸ô≈yˆÏÓ˚üòñ ì%¸D¶¸oy ˆÓyv≈¸ Ü‡¸ò Ñ¸Ó˚y £Î˚ v¸z_´ òî#=!úÓ˚ xÓÓy!£Ñ¸yÓ˚ ãˆÏúÓ˚ Ó^ˇ›¸òñ ¸ô!Ó˚Ñ¸"òy Á ÓƒÓfl¸iy¸ôòyÓ˚ ì¸y!ÜˆÏî– ¶¸yÓ˚ˆÏì¸Ó˚ ¶)Ü¶≈¸fl¸i ãˆÏúÓ˚ ¸ô!Ó˚õyí Á xÓfl¸iy äyòyÓ˚ äòƒ 1997 ¢yˆÏúÓ˚ ã%úy£z õyˆÏ¢ ˆÑ¸w#Î˚ ¶)Ü¶≈¸fl¸i ãú íÆÓ˚ (Central Ground Water Authority) ¸ô!Ó˚ˆÏÓü ¢ÇÓ˚«¸í xy£zòñ S1986V xï#ˆÏò Ü‡¸ò Ñ¸Ó˚y £Î˚ – Ó˚yãƒ=!úÓ˚ õˆÏïƒ äyì¸#Î˚ ãú òî#!ì¸ Á ¢õ#«¸y Ñ¸Ó˚yÓ˚ äòƒ 'National Water Council' Ü‡¸ò Ñ¸Ó˚y £Î˚ – ~£z ¸ô!Ó˚°ÏˆÏîÓ˚ ì¸_¥yÓïyˆÏò 2012 ¢yˆÏú äyì¸#Î˚ ãú òî#!ì¸Ó˚ Ö¢v¸¸y ˜ì¸!Ó˚ Ñ¸Ó˚y £Î˚ ÌyÓ˚ õ%Öƒ !Ó°ÏÎ˚ £ú ÚÚãú ~Ñ¸!›¸ ¢ÇÑ¸›¸y¸ôß¨ ¢¡ôî ~ÓÇ ã#Óò Á Óylfl¸ì¸ˆÏìs¸fÓ˚ äòƒ xyÓüƒÑ¸ÛÛ– ãú¢¡ôî õs¸fˆÏÑ¸Ó˚ xï#ˆÏò ÌyÑ¸y !Ó!¶¸ß¨ ¢Çfl¸iy=!ú v¸zˆÏÖ'Ö Ñ¸Ó˚y £úÈÙÙÙÈ ≤Ãïyò x!ö¸ˆÏ¢Ó˚ xhs¸¶%≈¸_´ ≠ ? ˆÑ¸w#Î˚ ãú Ñ¸!õüò (Central Water Commission, CWC) ? ˆÑ¸w#Î˚ õy!›¸ ~ÓÇ Ö!òã Ü˚ˆÏÓ°Ïíy ˆÑ¸w (Central Soil and Material Research Station, CSMRS) ¢£yÎ˚Ñ¸ x!ö¸¢ ≠ ??ÜDy Óòƒy !òÎ˚s¸fÑ¸ Ñ¸!õüò (Ganga Flood Control Commission, GFCC) ??ö¸yÓ˚yE¸y Óƒy˚ˆÏÓ˚ã ≤ÃÑ¸" (Farakka Barrage Project; FBP) ??ˆÑ¸w#Î˚ ãú Á ü!_´ Ü˚ˆÏÓ°Ïíy ˆÑ¸w (Central Water & Power Research Station; CWPRS) ??Îõ%òy òî# ˆÓyv≈¸ (Yamuna River Board, YRB) ~äÈyv¸¸y ≠ ??NPCC (National Projects Construction Corporation Limited) ??NIH (National Institute of Hydrology) ??Brahmaputra Board ??Tunghabhadra Board ÈÙÙÙÈ£zì¸ƒy!í ~Ó˚ xhs¸Ü≈ì¸ 2.7 ïyÓ˚íˆÏÏyÜƒ v¸zß¨Î˚ˆÏòÓ˚ ïyÓ˚íy (Concept of Sustainable development) xyhs¸ã≈y!ì¸Ñ¸ hfl¸ˆÏÓ˚ ¸ô!Ó˚ˆÏÓü ¢Çe´yhs¸ ¶¸yÓòy!â¸hs¸yÓ˚ ≤ÃÌõ ¢ö¸ú v¸zˆÏÏƒÜ ÷Ó˚& £Î˚ 1972 ¢yˆÏú– ~£z ÓäÈÓ˚ ¢%£zˆÏv¸ˆÏòÓ˚ Ó˚yãïy®# fi›¸Ñ¸ˆÏ£yˆÏõ Ó˚y‹T…¢ÇˆÏáÓ˚ õyòÓ ¸ô!Ó˚ˆÏÓü (Human Environment) ü#°Ï≈Ñ¸ ¢ˆÏøú ˆò ¸ô!Ó˚ˆÏÓü Á v¸zß¨Î˚ˆÏò õˆÏïƒ !ò!Óv¸¸ ¢¡ôÑ≈¸ Üˆv¸¸ ˆì¸yúyÓ˚ úˆÏ«¸ƒ !ÓˆÏŸªÓ˚ ¢Ó ˆÏüˆÏÑ¸ xy£¥yò Ñ¸Ó˚y £Î˚ – ~ˆÏì¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ õ)ú ¢õ¢ƒy=!ú ~ÓÇ î)°Ïí ¢¡ô!Ñ≈¸ì¸ !ÓhflÎ˚!Ó˚ì¸ xyˆÏúyâ¸òy £Î˚ñ ~ÓÇ ¸ô!Ó˚ˆÏÓü Á v¸zß¨Î˚ò ¢¡ôˆÏÑ≈¸ 109!›¸ !¢k¸yhs¸ ˆòÁÎ˚y £Î˚ – ~Ó˚ ¸ôÓ˚ 1980 ¢yˆÏú ≤ÃÑ¸!ì¸ Á ≤ÃyÑ¸!ì¸Ñ¸ ¢¡ôˆÏÏÓ˚ ¢ÇÓ˚«¸ˆÏí xyhs¸ã≈y!ì¸Ñ¸ ¢Çá (International Union for NSOU ? AE-ES-21 ? 35
the conservation of Nature and Natural Resources) ïyÓ˚íˆÏÏyÜƒ Óy !fl¸i!ì¸ü#ú v¸zß¨Î˚ˆÏòÓ˚ ïyÓ˚íy!›¸Ó˚ v¸z¸ôÓ˚ =Ó˚&c ˆîÎ˚ – ~Ó˚ Á Ñ¸ˆÏÏÓˆ Ñ¸ÓäÈÓ˚ ¸ôÓ˚ 1987 ¢yˆÏú Ó˚y‹T…¸ô%ˆÏOÓ˚ v¸zˆÏïƒˆÏÜ fl¸iy!¸ôì¸ £Î˚ ¸ô!Ó˚ˆÏÓü Á v¸zß¨Î˚ò ¢Çe´yhs¸ !ÓŸª Ñ¸!õüò (World commission on the Environment and development)– ~£z Ñ¸!õüˆÏòÓ˚ ¢¶¸y¸ô!ì¸ !äÈˆÏúò òÓ˚ˆÏÁˆÏÎ˚Ó˚ ≤ÃïyòõsÓ¸f# Ó yr›¸úƒyu¸ (Brundland) ~ÓÇ ì¸yÓ˚ òyõ xò%¢yˆÏÓ˚ ~£z Ñ¸!õüò Ó yr›¸úƒyu¸ Ñ¸!õüò òyˆÏõ ¸ô!Ó˚!â¸ì¸– ~£z Ñ¸!õüò ÚÚxyõyˆÏîÓ˚ ¢yïyÓ˚í ¶¸!Ó°ÏƒÍÛÛ Óy "Our Common Future" ü#°Ï≈Ñ¸ ≤Ã!ì¸ˆÏÓîò î#á≈fl¸iyÎ˚# v¸zß¨Î˚ˆÏòÓ˚ î%!›¸ õ)ú !Ó°
ÏÎ˚

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ÏÎ˚Ó˚ v¸z¸ôÓ˚ =Ó˚&c xyˆÏÓ˚y¸ô Ñ¸ˆÏÓ˚

ÈÙÙÙÈ (i) ¸ô!Ó˚ˆÏÓü Óy Óylfl¸ì¸s¸fˆÏÑ¸ x«%¸] Ó˚yÖy ~ÓÇ (ii) ¸ô!Ó˚ˆÏÓˆÏüÓ˚ =íÜì¸ õyò x¸ô!Ó˚Ó!ì≈¸ì¸ ˆÓ˚ˆÏÖ õyò%ˆÏºÏÓ˚ ã#ÓòìyÓ˚ˆÏíÓ˚ õyò v¸zß¨Î˚ˆÏò Îbü#ú £ÁÎ˚y– ~£z î%!›¸ !Óº¨ÏÎ˚ˆÏÑ¸ õyÌyÎ˚ ˆÓ˚ˆÏÖ Ó yr›¸úƒyu¸ Ñ¸!õüò !fl¸i!ì¸ü#ú v¸zß¨Î˚ˆÏòÓ˚ ¢ÓˆÏâ¸ˆÏÎ˚ ãò!≤ÃÎ˚ ¢ÇK¸y ˆîòÈÙÙÙÈ !fl¸i!ì¸ü#ú v¸zß¨Î˚ò £ú Óì≈¸õyˆÏòÓ˚ ¢õhfl¸ ≤ÃˆÏÎ˚yãò=!úˆÏÑ¸ ~õò¶¸yˆÏÓ ˆõ›¸yˆÏòy Îyˆ Ïì¸ ¶¸! Óº Ïƒí ≤ÃãˆÏß√Ó˚ â¸y!£îy=!ú ˆõ›¸yˆÏòyÓ˚ «¸õì¸y ò‹T òy £Î˚ (Sustainable development is the development that meets the needs and aspirations of the present without compromising the ability of future generation to meet their own needs)– !fl¸i!ì¸ü#ú v¸zß¨Î˚ˆÏòÓ˚ ¢¡ôˆÏÑ≈¸ Ó yr›¸úƒyˆÏu¸Ó˚ ~£z Ó_´Óƒ ¸ôÓ˚Óì≈¸#Ñ¸yˆÏú ≤Ãâ%¸Ó˚ !Óì¸ˆÏÑ≈¸Ó˚ ãß√ !îˆÏúÁ ~£z Ó_´Óƒ xì¸ƒhs¸ =Ó˚&c¸ô)í≈– ¸ôˆÏÓ˚ xÓüƒ 1991ˆì¸ IUCN Report ÚˆÑ¸Î˚y!Ó˚Ç ö¸Ó˚ !î xyÌ≈Û (Carino for the Earth) ~ÓÇ 1992ÈÙÈÓ˚ ¢!¡ø!úì¸ Ó˚y‹T…¸ô%ˆÏOÓ˚ Ó¢%ı¸Ó˚y ¢ˆÏ¡øúˆÏòÓ˚ Ú~ˆÏãu¸y 21ÛÈÙÈÁ (Agenda 21 of Earth Summit) v¸zß¨Î˚ò ¢¡∫ˆÏı¸ ~Ñ¸£z Ñ¸Ìy ÓˆÏú– xÌ≈yí !fl¸i!ì¸ü#ú v¸zß¨Î˚ò £úÈÙÙÙÈ ??(1) Îy !›¸!Ñ¸ˆÏÎ˚ Ó˚yÖy ÎyÎ˚ Ñ¸ˆÏÎ˚Ñ¸ ≤Ããß√ ïˆÏÓ˚ ??(2) ÎyÓ˚ ~Ñ¸!›¸ ¢Ó≈yD#ò î¸!‹T¶¸!D xyˆÏäÈ– ??(3) Îy Óì≈¸õyˆÏòÓ˚ ãòƒ £ˆÏúÁ ¶¸!ÓºÏƒˆÏì¸Ó˚ ˆÑ¸yˆÏòy «¸!ì¸ Ñ¸ˆÏÓ˚ òy– ??(4) Îy !ÓˆÏüºÏ Ñ¸ˆÏÓ˚ ¸ô¸!ÌÓ#Ó˚ ÜÓ˚#Ó õyò%ˆÏºÏÓ˚ â¸y!£îy ¸ô)Ó˚ˆÏíÓ˚ !îˆÏÑ¸ ˆÓ!ü òãÓ˚ Ó˚yˆÏÖ– ??(5) ¢yÇfl¸ˆÒ!ì¸Ñ¸ Á ã#Ó˜ÏÓ!â¸eƒ Ó˚«¸yÓ˚ v¸z¸ôÑ¸Ó˚ˆÏíÓ˚ ÎyÎ ÓƒÓ£yÓ˚ ¢%!ò!ÿ¸ì¸ Ñ¸ˆÏÓ˚– 2.7.1 ò#!ì¸ !òˆÏî≈!üÑ¸y (Guidelines) !fl¸i!ì¸ü#ú v¸zß¨Î˚ò ¢¡ôˆÏÑ≈¸ xyõÓ˚y ˆÎ ïyÓ˚íy ˆ¸ôˆÏÎ˚!äÈñ ì¸yˆÏì¸ ~›¸y fl¸ô‹T ˆÎ ãò¢yïyÓ˚ˆÏíÓ˚ ¢!e´Î˚ ¢õÌ≈ò Á ¢£ˆÏÎy!Üì¸y äÈyv¸¸y ~£z ïÓ˚ˆÏòÓ˚ v¸zß¨Î˚ò ¢Ω¸Ó òÎ˚ – ~ˆÏ«¸ˆÏe ≤Ãïyò ò#!ì¸ !òˆÏî≈! üÑ¸y=!ú £úÈÙÙÙÈ [1] v¸zß¨Î˚òõ)úÑ¸ ˆÎÈÙÈˆÑ¸yˆÏòy Ñ¸yˆÏã !¢k¸yhs¸ @˘Ã£ˆÏíÓ˚ ¢õÎ˚ ãò¢yïyÓ˚íˆÏÑ¸ xÇü#îyÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– [2] !ÓˆÏŸªÓ˚ !Ó!¶¸ß¨ xM¸ÈˆÏú !¶¸ß¨ !¶¸ß¨ xyÌ≈ÙÈ¢yõy!ãÑ¸ õì¸Óyî Á Ó˚#!ì¸ò#!ì¸ ≤Ãâ¸!úì¸ xyˆÏäÈ– ¢%ì¸Ó˚yÇ ¸ô!ÓˆÏÓü ¢¡ôˆÏÑÓ˚ ¢!‡¸Ñ¸ ÓƒÓ£yÓ˚ Á ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ xÌ≈˜Ïò!ì¸Ñ¸ Á ¢yõy!ãÑ¸ ˆÜy¤¸#=!úÓ˚ õˆÏïƒ ¸ôyÓ˚fl¸ô!ÓˆÑ¸ ˆÓyG¸y¸ôv¸¸y ≤ÃˆÏÎ˚yãò– [3] !fl¸i!ì¸ü#ú v¸zß¨Î˚ˆÏòÓ˚ ãòƒ ¢¡ôˆÏîÓ˚ ¢ÇÓ˚«¸í ≤ÃˆÏÎ˚yãò– ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ ≤ÃˆÏÎ˚yãòÈÙÙÙÈ ??[a] ¢¡ôˆÏîÓ˚ v¸zÍ¸ôyîò Á ÓƒÓfl¸iyÓ˚ !òÎ˚s¸fí ??[b] ˆÑ¸yˆÏòy !ÓˆÏüºÏ ¢¡ôî ˆ¢£z¢

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Ó Ñ¸yˆÏã ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓñ ˆÎ¢Ó Ñ¸			

yˆÏãÓ˚ ¸ôˆÏ«¸ v¸z¸ôˆÏÎyÜ# ~ÓÇ xyÓ˚ ˆÑ¸yˆÏòy ¢¡ôî ¸ô!Ó˚Óì≈¸ !£¢yˆÏÓ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ÎyˆÏÓ òy– Ö!òã ˆì¸ú v¸z_y¸ô ¢¸!‹TÓ˚ Ñ¸yˆÏã Á !Óî%ƒÍ v¸zÍ¸ôyîˆÏò ÓƒÓ£*ì¸ 36 ? NSOU ? AE-ES-21 £ˆÏì¸ ¸ôyˆÏÓ˚– !Ñ¸ls¸ v¸z_y¸ô ¢¸!‹T Ñ¸Î˚úyñ Ñ¸y‡¸ Óy ≤ÃyÑ¸¸!ì¸Ñ¸ ÜƒyˆÏ¢Ó˚ myÓ˚yÁ £ˆÏì¸ ¸ôyˆÏÓ˚– !Óî%ƒÍñ Ñ¸Î˚úy ¸ô%!v¸¸ˆÏÎ˚ xÌÓy ãú≤ÃÓy£ ˆÌˆÏÑ¸Á v¸zÍ¸ôy!îì¸ £ˆÏì¸ ¸ôyˆÏÓ˚– Ö!òã ˆì¸ú ¸ô!Ó˚ˆÏüyïò Ñ¸ˆÏÓ˚ ˆÎ ˆ¸ôˆÏ›¸∆yú Óy ÜƒyˆÏ¢y!úò ¸ôyÁÎ˚y ÎyÎ˚ ì¸y ˆõy›¸Ó˚Üy!v¸¸ Á !Óõyòˆ Ï¸ôyì¸ â¸yúyˆÏòyÓ˚ ãòƒ ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – !Ñ¸ls¸ ˆõy›¸Ó˚Üy!v¸¸ Á !Óõyòˆ Ï¸ôyì¸ â¸yúyˆÏòyÓ˚ Ñ¸yã Ñ¸Î˚úyñ Ñ¸y‡¸ñ ≤ÃyÑ¸¸!ì¸Ñ¸ Üƒy¢ Óy ãú!Óî%ƒˆÏì¸Ó˚ myÓ˚y ¢Ω¸Ó òÎ˚ – ¢%ì¸Ó˚yÇ ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ Ö!òã ˆì¸ú v¸z_y¸ô ¢¸!‹T Óy ! Óî%ƒÍ v¸zÍ¸ôyîˆÏòÓ˚ ãòƒ ÓƒÓ£yÓ˚ òy Ñ¸ˆÏÓ˚ ˆõy›¸Ó˚Üy!v¸¸ Á !Óõyòˆ Ï¸ôyì¸ â¸yúyˆÏòyÓ˚ ãòƒ ~ÓÇ xyÓ˚Á ˆÎ¢Ó Ñ¸yã ˆì¸ú äÈyv¸¸y xyÓ˚ xòƒ ˆÑ¸yˆÏòy !ã!òˆÏ¢Ó˚ myÓ˚y ¢Ω¸Ó òÎ˚ ˆ¢£z¢Ó Ñ¸yˆÏãÓ˚ ãòƒ ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ??[c] ≤ÃyÑ¸¸!ì¸Ñ¸ ¢¡ôî=! úÓ˚ õˆÏïƒ Ñ¸Î˚úyñ ≤ÃyÑ¸¸!ì¸Ñ¸ Üƒy¢ñ Ö!òã ˆì¸ˆÏúÓ˚ õˆÏì¸y ˆÎ=!ú ¢!M¸Èì¸ Óy Ü!FäÈì¸ ¢¡ôî ˆ¢=!úÓ˚ ¸ô!Ó˚Óˆ Ïì≈¸ ÎÌy¢Ω¸Ó ãú≤ÃÓy£ñ ¢)Î≈!Ñ¸Ó˚íñ ÓyÎ˚%≤ÃÓy£ Á Óò¶)¸!õÓ˚ õˆÏì¸y ¸ô%ò¶≈¸Ó ¢¡ôî ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ ü!_´ v¸zÍ¸ôyîˆÏòÓ˚ Ñ¸yˆÏã Ñ¸Î˚úyñ ˆì¸ú Á ≤ÃyÑ¸¸!ì¸Ñ¸ Üƒy¢Ó˚ ÖÓ˚â¸ ÎÌy¢Ω¸Ó Ñ¸!õˆÏÎ˚ ãúˆÏfl¸Àyˆ Ïì¸ñ ¢)Î≈!Ñ¸Ó˚íñ ÓyÎ˚%≤ÃÓy£ Á xòƒyòƒ x!â¸Ó˚yâ¸!Ó˚ì¸ ü!_´Ó˚ ÓƒÓ£yÓ˚ Óyv¸¸yˆÏì¸ £ˆÏÓ– ??[d] ¢¡ôˆÏîÓ˚ v¸zÍ¸ôyîò !ÓK¸yò¢¡øì¸¶¸yˆÏÓ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ~õò¶¸yˆÏÓ v¸zÍ¸ôyîò Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ÎyˆÏì¸ ˆÑ¸yˆÏòy x¸ôâ¸Î˚ òy áˆÏ›¸ ~ÓÇ ¢

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ÓˆÏâ¸ˆÏÎ˚ Ñ¸õ ÖÓ˚ˆÏâ¸ ¢ÓˆÏâ¸ˆÏÎ˚ ˆÓ!ü			

v¸zÍ¸ôyìò Ñ¸Ó˚y Îyΰ – ??[e] ˆÑ¸yˆÏòy !ã!òˆÏ¢Ó˚ v¸zÍ¸ôyìò ÷ï% ≤ÃyÑ¸,¸!ì¸Ñ¸ ¢¡ô˜ÏîÓ˚ Á¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚ òy– ~Ñ¸!›¸ !Óˆ˜Ïü°Ï xò%¸ôyˆÏì¸ ≤ÃyÑ¸,¸!ì¸Ñ¸ ¢¡ôîñ ◊õ Á õ)úïˆÏòÓ˚ ¢õßÎˆÏÎ˚Ó˚ myÓ˚y£z v¸zÍ¸ôyìò ¢Ç¤á!›¸ì¸ £Î˚ – ~£z Ñ¸yÓ˚ˆÏí ¢¡ô˜ ¢ÇÓ˚«¸í Ñ¸Ó˚ˆÏì¸ £ˆÏú ÷ï% ≤ÃyÑ¸,¸!ì¸Ñ¸ ¢¡ô˜ !òˆÏÎ˚ !ÓˆÏÓâ¸òy Ñ¸Ó˚ˆÏú â¸ú˜ÏÓ òyñ ◊õ õ)úïò ≤Ã¶¸,¸!ì¸ xòƒyòƒ v¸z¸ôyìyò=!ú !òˆÏÎ˚ Á !ÓˆÏÓâ¸òy Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– Óƒy¸ôÑ¸ Ñ¸,¸!°Ï¸ôk¸!ì¸ˆÏì¸ Ñ¸¸õ ã!õˆÏì¸ ˆÓ!ü õ)úïò Á ˆÓ!ü ◊!õÑ¸ !òˆÏÎ˚yÜ Ñ¸ˆÏÓ˚ ˆ¢£z ~Ñ¸£z ¸ô!Ó˚õyí ö¸¢ú ö¸úy˜Ïòy Îyΰ – xì≈yí ≤ÃyÑ¸,¸!ì¸Ñ¸ ¢¡ô˜ÏîÓ˚ xò%¸ôyì¸ Ñ¸!õˆÏÎ˚ ~ÓÇ v¸zÍ¸ôyìˆÏòÓ˚ xòƒyòƒ v¸z¸ôyìy˜ÏòÓ˚ xò%¸ôyì¸ Óy!v¸¸ˆÏÎ˚ xyõÓ˚y ~Ñ¸£z ¸ô!Ó˚õyí !ã!ò¢ v¸zÍ¸ôyìò Ñ¸Ó˚ˆÏì¸ ¸ôy!Ó˚ – ~£z¶¸yˆÏÓ ≤ÃyÑ¸,¸!ì¸Ñ¸ ¢¡ô˜ÏîÓ˚ ¢ÇÓ˚«¸í £ˆÏì¸ ¸ôyˆÏÓ˚ – ??[f] Ü!FäÈì¸ ¢¡ô˜ÏîÓ˚ õ˜ÏìƒÑ¸ì¸=!ú ¢¡ô˜ ≤ÃÑ¸,¸!ì¸ ˆÎ˚ˆÏÑ¸ xy£Óˆ˜ÏíÓ˚ ¸ôÓ˚ ÓyÓ˚ÓyÓ˚ ÓƒÓ£yÓ˚ Ñ¸Ó˚y (Recyling) Îyΰ – ˆÎõò xyÑ¸!ÓˆÑ¸ ˆúy£y Ü!FäÈì¸ Óy ¢!M¸Èì¸ ¢¡ôìó ~Ñ¸›¸y !ò!î≈T ¸ô!Óˆõy˜Ïí ¸ô¸!ÌÓ#ˆÏì¸ ¢!M¸Èì¸ xyˆÏäÈ ~ÓÇ Ö!ò ˆÎ˚ˆÏÑ¸ v¸zˆÏ_yúˆÏòÓ˚ ¢ˆÏD ¢ˆÏD ~Ó˚ ¸ô!Ó˚ˆõyí fl¸iyΰ#¶¸yˆÏÓ Ñ¸ˆÏõ ÎyˆÏFäÈ– !Ñ¸ls¸ñ ˆúy£y Á £zfl¸ôyˆÏì¸Ó˚ ˜ì¸!Ó˚ !ã!ò¢ ÓƒÓ£yˆÏÓ˚Ó˚ xò%¸ô˜ÏyÜ# £ˆÏÎ˚ ˆÜˆÏú ˆ¢=!ú Ü!ú˜ÏÎ˚ xyÓyÓ˚ òì%¸ò ÓƒÓ£yÎ≈ !ã!ò¢ ˜ì¸!Ó˚ Ñ¸Ó˚y Îyΰ – ??[g] ¸ô¸!ÌÓ#ˆÏì¸ ¢¡ô˜ÏîÓ˚ ¢Ó≈y!ìÑ¸ x¸ôâ¸Î˚ á˜Ï›¸ Î%ˆÏk¸Ó˚ ö¸ˆÏú– xyï%! òÑ¸ ¢Ó≈ydÑ¸ õ£yÎ%k¸ x¸ô!Óˆ˜Ïõ˜Ï ¢¡ô˜ÏîÓ˚ ïπÇ¢yìò Ñ¸ˆÏÓ˚ – ~Ó˚ ¢ˆÏD Óì≈¸õyˆÏò Î%_´ £ˆÏÎ˚ ˆÏäÈ ¢s¸fy¢Óyî– !ÓŸªã%ˆÏv¸¸ ¢s¸fy¢Óyî# Ñ¸yÌ≈Ñ¸úy¸ô ¢¡ô˜ÏîÓ˚ ïπÇ¢ ¢yìò Ñ¸Ó˚ˆÏäÈ– Î%k¸ Á ¢s¸fy¢Óyî# Ñ¸yÌ≈Ñ¸úy¸ô Óì¸ ~ÓÇ ¸ô¸!ÌÓ#ˆÏì¸ !â¸Ó˚ˆfl¸iyΰ# üy!hs¸ ≤Ã!ì¸!¤¸ì¸ òy £ˆÏú ¢¡ô˜ ¢ÇÓ˚«¸ˆÏíÓ˚ ˆÑ¸yˆÏòy ÓƒÓfl¸iy£z ¸ô%ˆÏÓ˚y¸ô%!Ó˚ ö¸ú≤Ã¢) £ˆÏÓ òy– ??[h] ¢¡ô˜ ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ ¢¡ô˜ v¸zÍ¸ôyìò Á ÓƒÓ£yˆÏÓ˚Ó˚ ˆ«¸ˆÏe Óƒ!_´fl¸ˆlyì≈ Á ¢ö!‹T fl¸ˆ¸lyˆÏì≈Ó˚ õ˜ÏìƒÑ¸ õ)ú m®µ Ó˚ˆÏÎ˚ ˆÏäÈ ì¸y î)Ó˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ~Ó˚ ãòƒ ¢¡ô˜ ¢ÇÓ˚«¸í ¢¡ô˜ÏÑ≈¸ ãòÜˆÏíÓ˚ ˆâ¸ì¸òy Ó!k¸ ~ÓÇ ˆÎ¢Ó ¢¡ô˜ÏîÓ˚ ¢ÇÓ˚«¸í ãÓ˚ˆ&Ó˚# ˆ¢=!úÓ˚ Á¸ôÓ˚ ¢õyã Ó˚yˆÏ‹T…Ó˚ ˆÑ¸yˆÏòy òy ˆÑ¸yˆÏòyÓ˚ Ñ¸õ !òÎ˚ˆ¸fí ≤ÃˆÏÎ˚yãò– ãy@˘Ãì¸ ãòõyòy¢ Á Ñ¸ÚfyÍ¸ì¸# Ó˚y‹T…£z ¢õ!‹Tfl¸ˆlyˆÏì≈Ó˚ ¢Ó≈≤ÃyòyÓ˚ Ó˚«¸Ñ¸ – [4] Ó¢%ı¸Ó˚yÓ˚ ÓƒÓ«¸õì¸y xò%Îyΰ# v¸zß¨Î˚ò ≠ ¸ô!Óˆ˜ÏÓü Á ÓylÍ¸ì¸ˆÏs¸fÓ˚ [Ecosystem] ÓƒÓ«¸õì¸yÓ˚ ~Ñ¸!›¸ !ò!î≈T ¢#õy xyˆÏäÈ– ˆ¢£z ¢#õy x!ì¸e´õ Ñ¸Ó˚ˆÏú ¸ô!ÓˆÏÓü î)!°Ïì¸ £Î˚ Á Óylfl¸ì¸s¸f !Ó¸ô≈Ì≈ £ˆÏÎ˚ ¸ôˆÏv¸¸– ¢Ó xM¸ÈˆÏúÓ˚ Óylfl¸ì¸ˆÏs¸fÓ˚ ÓƒÓ«¸õì¸y ¢õyò òÎ˚ – ˆÑ¸yˆÏòy xM¸ÈˆÏúÓ˚ Óylfl¸ì¸ˆÏs¸fÓ˚ ÓƒÓ«¸õì¸y xò%Îyΰ# ˆ¢£z xM¸ÈˆÏúÓ˚ ãò¢ÇÖƒy Á NSOU ? AE-ES-21 ? 37

ã#ÓòÎy¸ôò ≤Ãíyú#Ó˚ ¢yõÓ¢ƒ !ÓÏyò Ñ¸Ó˚y ≤ÃˆÎ˚yãò– ì¸ˆÏÓ£z v¸zß¨Î˚ò !fl¸i!ì¸ü#ú £ˆÏÓ– ~Ó˚ ãòƒ !Óˆü°Ï ¸ôî≈ˆÏ«¸íñ ≤ÃÎ%!_´ Á Ñ¸õ≈¸ôs¸iy ≤ÃˆÎ˚yÜ Ñ¸Ó˚y îÓ˚Ñ¸yÓ˚ – [5] ¸ô!Óˆ˜ÏÓˆÏüÓ˚ =ïÜì¸ õyò Óãyΰ ˆÓ˚ˆÏÖ v¸zß¨Î˚ò ≠ v¸zß¨Î˚ˆÏòÓ˚ ˆÎ¢Ó ¸ôs¸iy Á ¸ôk¸!ì¸ ¸ô!Óˆ˜ÏÓüÓ˚ =ïÜì¸ õyˆÏòÓ˚ £…y¢ á›y¸yÎ˚ˆ ñ Óylfl¸ì¸ˆÏs¸fÓ˚ ¸ô%òÓ˚&Í¸ôyìò «¸õì¸y «%¸] Ñ¸ˆÏÓ˚ ˆ¢=!ú Óyì¸!ìˆÏì¸ £ˆÏÓ– !fl¸i!! ì¸ü#ú v¸zß¨Î˚ˆÏòÓ˚ ãòƒ ¸ô!Óˆ˜ÏÓüÓ˚ =ïÜì¸ õyò Óãyΰ Ó˚yÖy îÓ˚Ñ¸yÓ˚ – Ñ¸yÓ˚í ¸ô!Óˆ˜ÏÓüÓ˚ =ïÜì¸ õyò Óãyΰ ÌyÑ¸ˆÏúÓ£z Óylfl¸ì¸ˆÏs¸fÓ˚ ¸ô%òÓ˚&Í¸ôyìò «¸õì¸y x«%¸] Ìy˜ÏÑ¸ – [6] x¢yõƒ î)Ó˚#Ñ¸Ó˚í ≠ ¸ô¸!ÌÓ#ˆÏì¸ x˝ Ñ¸ˆÏÎ˚Ñ¸!›¸ ˆîü ïò#– ˆÓü#Ó˚ ¶¸yÜ ˆü î!Ó˚o ~Ñ¸!›¸ ˆî˜ÏüÓ˚ õ˜ÏìƒÁ xM¸ÈˆÏúÈÜÈxM¸ÈˆÏú ˜Ó°Ïõƒ Ó˚ˆÏÎ˚ˆÏäÈ– ¸ôyOyˆÏÓÓ˚ ï%¸úòyÎ˚ !Ó£yÓ˚ Óy Á!v¸¸üy xˆÏòÑ¸ !¸ô!äÈˆÏÎ˚ xyˆÏäÈ– ~Ñ¸!›¸ xM¸ÈˆÏúÓ˚ õ˜ÏìƒÁ ïò# î!Óˆ˜Ïo !ÓÓ˚y›¸ ˜Ó°Ïõƒ ˆîy Îyΰ – ~£z ¢Ó≈Óƒy¸ô# x¢yõƒ òyòy¶¸yˆÏÓ ¢¡ô˜ÏîÓ˚ x¸ôâ¸Î˚ˆ ñ Óylfl¸ˆÏì¸s¸fÓ˚ xÓ«¸Î˚ ~ÓÇ ¸ô!Óˆ˜ÏÓüÓ˚ !òÌyÓ˚&í «¸!ì¸ Ñ¸Ó˚ˆÏäÈ– !fl¸i!ì¸ü#ú v¸zß¨Î˚ˆÏòÓ˚ ãòƒ ˆî˜ÏüÈÜÈˆî˜Ïüñ xM¸ÈˆÏúÈÜÈxM¸ÈˆÏúñ õyò%ˆÏ°ÏÈÜÈõyò%ˆÏ°Ï ˜Ó°Ïõƒ î)Ó˚ Ñ¸ˆÏÓ˚ ¢yõƒ!ãÑ¸ Óƒyΰ Á ¢yõƒ ≤Ã!ì¸!¤¸y Ñ¸Ó˚y îÓ˚Ñ¸yÓ˚ – [7] î)°Ïí !òÎ˚s¸fí ≠ ¸ô!Óˆ˜ÏÓü î)!°Ïì¸ £ˆÏú ¢¡ô˜ÏîÓ˚ ïπÇ¢¢yìò á˜Ï›¸ñ Óylfl¸ì¸s¸f !Ó¸ô≈Ì≈ £ˆÎ˚ ñ v¸z!qî Á ≤Ãyí#Ó˚ x!hfl¸c ¢ÇÑ¸›¸y¸ôß¨ £Î˚ – ˆü°Ï ¸ôÌ≈hs¸ ÷ï% ˆÎ˚ v¸zß¨Î˚ò Óƒy£ì¸ £Î˚ ì¸y£z òÎ˚ˆ ñ õyò%ˆÏ°ÏÓ˚ x!hfl¸cÁ !Ó¸ôß¨ £ˆÏÎ˚ ¸ôˆÏv¸¸– ì¸y£z î)°Ïí !òÎ˚s¸fí

äÈyv¸¸y !fl¸i!ì¸ü#ú v¸zß¨Î˚ò ¢Ω¸Ó òÎ˚ – [8]

ãò¢ÇÖƒy !òÎ˚s¸fí ≠ Óì≈¸õyˆÏò !ÓŸªÓ˚ ãò¢ÇÖƒy 600 ˆÑ¸y!›¸Ó˚ Á ˆÓ!ü– xyÜyõ# 50 ÓäÈˆÏÓ˚ ~£z ãò¢ÇÖƒy Ó¸!k¸ ˆ¸ôˆÎ˚ £ˆÏÓ 650 ˆÑ¸y!›¸Ó˚ Á ˆÓ!ü– ˆúyÑ¸¢ÇÖƒy ~£z £yˆÏÓ˚ Óyv¸¸ˆÏì¸ ÌyÑ¸ˆÏú Óyîƒ Á xòƒyòƒ !ã!òˆÏ¢Ó˚ â¸y!£îy xfl¸fl¸ˆfly¶¸y!ÓÑ¸¶¸yˆÏÓ Ó¸!k¸ ¸ôyˆÏÓ ~ÓÇ ¸ô!Óˆ˜ÏÓüÓ˚ Á¸ôÓ˚ !òÎ˚yÓ˚&í â¸y¸ô ¸ôv¸¸ˆÏÓ– Óì≈¸õyò Á ¶¸!Ó°ƒˆÏì¸Ó˚ ¢¡ô˜ÏîÓ˚ ˆÎyÜyò x«%¸] Ó˚yÖˆÏì¸ £ˆÏú v¸zß¨Î˚ò ¢%fl¸iyΰ# Ñ¸Ó˚ˆÏì¸ £ˆÏúñ ãßÓ£yÓ˚ !òÎ˚s¸fí x¸ô!Ó˚£yÎ≈– 2.8 xò%üÏ#úò# ¢!‡¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚ˆ&ò ≠ S1V ~ˆÏîÓ˚ õ˜ÏìƒÑ¸ ˆÑ¸yò!›¸ xòÓ#Ñ¸Ó˚í ˆÎyÜƒ ¢¡ô˜ òÎ˚ˆÈÙÙÙÈ (i) Ñ¸Î˚ˆúy (ii) ˆúy£y (iii) Óò¶)!õ (iv) Ö!òã ˆì¸ú S2V MoEFCC ~Ó˚ ¸ô%ˆÏÓ˚y òyõ !Ñ¸ÈÙÙÙÈ (i) Ministry of Environment Forest and Climate Control (ii) Ministry of Environment Forest and Climate Change (iii) Ministry of Environment For Climate Control (iv) Ministry of Environment For Climate Change S3V Ö!òã v¸zÍ¸ôß¨ fl¸iú a b c d (a) ˆ¢yòy (i) Ó˚yò#ÜÓ (1) iv i iii ii 38 ? NSOU ? AE-ES-21

(b) Ñ¸Î˚ˆúy (ii) ¢%!Ñ¸®y (2) iii i ii iv (c) ˆe´y!ôΰyõ (iii) ˆÑ¸yúyÓ˚ (3) i iv ii iii (d) Ö!òã ˆì¸ú (iv) !v¸ÜÓÎ˚ (4) ii iii iv i S4V ¸ô¸!ÌÓ#Ó˚ ˆõy›¸ ãú¶¸yˆÏÜÓ˚ ãú ¢õ%ˆÏò v¸z¸ô!fl¸ì¸ (i) 50% (ii) 75% (iii) 97% (iv) 82% S5V ˆÑ¸yò ˆ«¸ˆÏe ¢ˆÏÓ≈yFã¸ ãú ÓƒÓ£*ì¸ £Î˚ˆÈÙÙÙÈ (i) !ü˝ (ii) Ü, £fl¸iy!ú (iii) Ñ¸,¸!°ÏÑ¸yã (iv) ˆ£yˆÏ›¸ú S6V ¶¸yÓ˚ˆÏì¸Ó˚ ¢Ó≈¢Ó¸£Í òî# xÓÓy!£Ñ¸y ˆÑ¸yò!›¸ˆÈÙÙÙÈ (i) !¢ı%¸ (ii) ˆÜyîyÓÓ˚# (iii) ÜDy (iv) Ñ¸yˆÏÓÓ˚# S7V ~Ñ¸ ãò õyò%ˆÏ°ÏÓ˚ ≤Ãì¸ƒ£ Üˆ˜Ïv¸¸ Ñ¸ì¸ !ú›¸yÓ˚ ãú ≤ÃˆÎ˚yãòÈÙÙÙÈ (i) 299ÈÜÈ250 (ii) 100ÈÜÈ150 (iii) 70ÈÜÈ130 (iv) 50ÈÜÈ110 S8V 2019 ¢yˆÏú ãú ¢ÇÑ¸ˆ›¸ xye´yhs¸ üÉÓ˚ £úÈÙÙÙÈ (i) Ñ¸úÑ¸yì¸y (ii) ˆâ¸ß¨y£z (iii) xy¢yõ (iv) Ñ¸í≈y›¸Ñ¸ S9V ˆÑ¸yò!›¸ ≤ÃyÑ¸,¸!ì¸Ñ¸ Óòãyì¸ ¢¡ô˜ òÎ˚ˆÈÙÙÙÈ (i) ãµyúyò! Ñ¸y‡¸ (ii) õï% (iii) Ë°!ï ÜyäÈ (iv) ì¸¢Ó˚ S10V ~Ó˚ 2017 ¢yˆÏúÓ˚ ì¸Ìƒ xò%Îyΰ# ¶¸yÓ˚ˆÏì¸Ó˚ ˆõy›¸ ¶)¶¸yˆÏÜÓ˚ ______ % Óò¶)!õ myÓ˚y xyÓ¸ì¸ÈÙÙÙÈ (i) 21% (ii) 21.53%¸ (iii) 23.78% (iv) 42% x!ì¸ ¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃÙ¿ ≠ S1V xòÓ#Ñ¸Ó˚í ˆÎyÜƒ ¢¡ô˜ Ñ¸yˆÏÑ¸ ÓˆÏú⁄2!›¸ v¸zîy£Ó˚í îò– S2V Ñ¸yÓ≈ò ¢M¸ÈÎ˚ Ñ¸yˆÏÑ¸ ÓˆÏú⁄ S3V xÓ˚ˆÏíƒ !òïò Ñ¸yˆÏÑ¸ ÓˆÏú⁄ S4V ¸ô¸¤¸ì¸ˆÏú Öòò ¸ôk¸!ì¸ Óú˜Ïì¸ !Ñ¸ ˆÓyˆÏG¸ò⁄ S5V õ¸!_Ñ¸y «¸Î˚ Ñ¸yˆÏÑ¸ ÓˆÏú⁄ S6V ˆ¶¸Ôõ ãú £… yˆÏ¢Ó˚ õ%Óƒ Ñ¸yÓ˚í =!ú !Ñ¸ !Ñ¸⁄ NSOU ? AE-ES-21 ? 39

¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃÙ¿ ≠ S1V ≤ÃyÑ¸,¸!ì¸Ñ¸ ¢¡ô˜ Ñ¸Î˚ ≤ÃÑ¸yÓ˚⁄ v¸zîy£Ó˚í ¢£ ÓƒyÖƒy Ñ¸Ó˚&ò– S2V Óò¶)!õ xyõyˆÏîÓ˚ ! Ñ¸¶¸yˆÏÓ v¸z¸ôÑ¸yÓ˚ Ñ¸ˆÏÓ˚⁄ S3V ˆÎÒì¸ Óò ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy Óú˜Ïì¸ !Ñ¸ ˆÓyˆÏG¸ò– S4V ¸ô!Óˆ˜ÏÓüÓ˚ Á¸ôÓ˚ Öòò Ñ¸yˆÏäÈÓ˚ ≤Ã¶¸yÓ=!ú !úÖ%ò– S5V ¶)!õ xÓ«¸ˆÏÎ˚Ó˚ Ñ¸yÓ˚í=!ú ÓƒyÖƒy Ñ¸Ó˚&ò– S6V ¶¸yÓ˚ˆÏì¸ ãú ¢ÇÑ¸›¸ !òÓyÓ˚ˆÏíÓ˚ v¸z¸ôyΰ=!

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ú xy ˆÏúyâ¸òy Ñ¸Ó˚&ò– v¸z_Ó˚ ¢

Ç ˆÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (iii) Óò¶)¸!õ S2V (ii) Ministry of Environment Forest and Climate Change S3V S2V iii i ii iv S4V (iii) 97% S5V (iii) Ñ,¸!°ÏÑ¸yã S6V (iii) ÜDy S7V (iii) 70 ÈÙÈ 130 S8V (ii) ˆâ¸ß¨y£z S9V (iv) ì¸¢Ó˚ S10V (ii) 21.53% 40 ? NSOU ? AE-ES-21 ~Ñ¸Ñ¸ È3 Óylfl¸ì¸s¸f (Ecosystem) Ü‡¸ò 3.0 v¸z ˆÏjüƒ 3.1 ≤Ãhfl¸yÓòy 3.2 Óylfl¸ì¸ ˆÏs¸fÓ˚ ¢ÇK¸y (Definition of Ecosystem) 3.3 ¸Óylfl¸ì¸ ˆÏs¸fÓ˚ ˜Ó!ü‹Tƒ (Characteristics of Ecosystem) 3.4 Óylfl¸ì¸ ˆÏs¸fÓ˚ ≤ÃÑ¸yÓ˚ ˆÏ¶¸î (Types of Ecosystem) 3.4.1 Óò¶)¸!õÓ˚ Óylfl¸ì¸s¸f (Forest ecosystem) 3.4.2 ì¸¸í¶)¸!õÓ˚ Óylfl¸ì¸s¸f (Grassland ecosystem) 3.4.3 ¢yõ%!oÑ¸ Óylfl¸ì¸s¸f (Marine ecosystem) 3.5 Óy ˆÏÎ˚yõ (Biome) 3.6 Óylfl¸ì¸ ˆÏs¸fÓ˚ v¸z¸ôyîyò (Componets of Ecosystem) 3.6.1 Ñ¸yÎ≈!¶¸!_Ñ¸ v¸z¸ôyîyò 3.6.2 ¢yÇÜ‡¸!òÑ¸ v¸z¸ôyîyò 3.7 ›¸∆!¸ôÑ¸ ˆú ˆÏ¶¸úñ Öyîƒü,Cúñ Öyîƒ ãyúÑ¸ Á Öyîƒ !¸ôÓ˚y!õv¸ (Trophic level, Food chain, Food web and Food Pyramid) 3.8 Óylfl¸ ˆÏì¸s¸fÓ˚ v¸zÍ¸ôyîòü#úì¸y (Productivity of Ecosystem) 3.9 Óylfl¸ì¸ ˆÏs¸f ü!_´ ≤ÃÓy£ (Energy flow in Ecosystem) 3.9.1 ì¸y¸ô Ü!ì¸!ÓîƒyÓ˚ ¢)emÎ˚ 3.9.2 ü!_´≤ÃÓy ˆÏ£Ó˚ ¸ôÎ≈yÎ˚ 3.9.3 ü!_´≤ÃÓy ˆÏ£Ó˚ õ ˆÏv¸ú 3.9.4 ü!_´≤ÃÓy ˆÏ£Ó˚ ˜Ó!ü‹Tƒ 3.10 ¸ô%!‹T â¸e´ (Nutrient Cycle) 3.10.1 ¢ÇK¸y 3.10.2 !Ó!¶¸ß¨ ¸ô%!‹T â¸e´ 3.10.2.1 Ñ¸yÓ≈ò â¸e´ 3.10.2.2 òy£z ˆÏ›¸∆y ˆÏãò â¸e´ 3.11 xò%ü#úò#

3.0 v¸z ˆÏjüƒ ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ ˆÏÓ˚ xy¸õ!l !!¡¨!°!áï¸ !Ó£ÏÎ˚=!° çylˆÏï¸ ¸õyÓ˚ ˆÏÓl– ? Óy›ï¸ ˆÏsfÓ˚ ßÇK¸yñ ˜Ó!¢‹Tƒ G ≤ÃÜ¸yÓ˚ ˆÏË¸ò– ? Óy›ï¸ ˆÏsfÓ˚ í¸z¸õyòyl– ? ê¸∆!¸õÜ¸ ˆ°ˆÏË¸°ñ áyòƒ¢,C°ñ áyòƒ çy°Ü¸ G áyòƒ !¸õÓ˚y!Ùí¸– ? Óy›ï¸ ˆÏsf ¢!_´ ≤ÃÓy•– ? ¸õ%!‹Tã¸e´ Ü¸y ˆÏÜ¸ Ó ˆÏ° G !Ó!Ë¸ß¨ ≤ÃÜ¸yÓ˚ ¸õ%!‹Tã¸e´ – 3.1 ≤Ãhfl¸yÓòy ã#Ó Á ì¸yÓ˚ ¸ô!Ó˚ ˆÏÓ ˆÏüÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ xyhs¸É¢¡ôÑ≈¸ â¸â≈¸yÓ˚ !Ó°ÏÎ˚ ˆÏÑ¸ Óylfl¸!ÓîƒyÓy ecology Ó ˆÏú– ãyõ≈yò !ÓK¸yò# ˆ£ ˆÏÑ¸ú (Haeckel) 1866 !Ö fi›¸y ˆÏ∑ ¢Ó≈≤ÃÌõ Oekologie S@˘Ã#Ñ¸ 'Oikos' xÌ≈ Óy¢fl¸iyò ~ÓÇ 'Logos' xÌ≈ K¸yòV ü∑!›¸ ≤Ã ˆÏÎ˚yÜ Ñ¸ ˆÏÓ˚ò– ~£z Oekologie ˆÌ ˆÏÑ¸£z ecology ü∑!›¸Ó˚ v¸zÍ¸ô!_– Óylfl¸!ÓîƒyÓ˚ ¢yïyÓ˚í ¢ÇK¸y !£¢y ˆÏÓ Óúy ÎyÎ˚ ÚÚˆÎ ≤ÃyÑ,¸!ì¸Ñ¸ !ÓK¸yò Óy !Óîƒ ã# ˆÏÓÓ˚ ¢ ˆÏD ˆ¶¸Ôì¸ Á ¢ã#Ó ¸

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ô!Ó˚ ˆÏÓ ˆÏüÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ !e´Î˚

y ~ÓÇ ~£z !e´Î˚yÓ˚

ö¸ ˆÏú v¸zq$ì¸ ˆÓß ˆÏâ¸ ÌyÑ¸yÓ˚ v¸z¸ôyîyò Á ü!_´ ¢¡ô ˆÏÑ≈¸ !ÓK¸yò¢¡øì¸ ïyÓ˚íyÓ˚ ¢,!‹T Ñ¸ ˆÏÓ˚ ì¸y ˆÏÑ¸ Ó ˆÏú Óylfl¸!ÓîƒyÛÛ– Óylfl¸!ÓîƒyÓ˚ ˆõÔú Ñ¸yÎ≈Ñ¸Ó˚# ~Ñ¸Ñ¸ ˆÏÑ¸ Óylfl¸ì¸s¸f Ó ˆÏú– ˆÑ¸y ˆÏòy ~Ñ¸≤ÃÑ¸yÓ˚ ã#Ó ˆÏÑ¸ ¸ô!Ó˚ ˆÏÓ‹TòÑ¸yÓ˚# ~ÓÇ ì¸yÓ˚ ¢ ˆÏD ¢¡ôÑ≈¸ Ó˚«¸yÑ¸yÓ˚# ¢ã#Ó Á !òã≈#Ó Ólfl¸¢õ)£ ˆÏÑ¸ ã#Ó!›¸Ó˚ ¸ô!Ó˚ ˆÏÓü Ó ˆÏú– ~Ñ¸!›¸ ã# ˆÏÓÓ˚ ¢ ˆÏD ì¸yÓ˚ ¸ô!Ó˚ ˆÏÓ ˆÏüÓ˚ ≤Ã!ì¸!òÌ˚ì¸£z ˆÑ¸y ˆÏòy òy ˆÑ¸y ˆÏòy xyîyò≤Ãîy ˆÏòÓ˚ ¢¡ôÑ≈¸ ¸ô!Ó˚ú!«¸ì¸ £Î˚ – ~£z¶¸y ˆÏÓ xyîyò≤Ãîy ˆÏòÓ˚ myÓ˚y ˆÑ¸y ˆÏòy ~Ñ¸!›¸ xM¸È ˆÏú Ó¢Óy¢Ñ¸yÓ˚# ¢Ñ¸ú ã#Ó ¢¡±îyÎ˚ £z ¸ôÓ˚fl¸ô ˆÏÓ˚Ó˚ v¸z¸ôÓ˚ ≤Ãì¸ƒ«¸ Óy ¸ô ˆÏÓ˚y«¸¶¸y ˆÏÓ !ò¶≈¸Ó˚ü#ú £ ˆÏÎ˚ ¸ô ˆÏv¸¸ ~ÓÇ ~£

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ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸yÓ˚ !¶¸!_ ˆÏì¸£

z Ó¢Óy ˆÏ¢Ó˚ v¸z¸ô ˆÏÎyÜ# ˆÎ ¢%ü,Cú ÓƒÓfl¸iy!›¸ Ü ˆÏv¸¸ Á ˆÏ‡¸ ì¸y ˆÏÑ¸£z Óylfl¸ì¸s¸f Ó ˆÏú– Ólfl¸ì¸¸ô ˆÏ«¸ ¸ô,!ÌÓ#Ó˚ Óy ˆÏÎ˚y!fl¸≥¸Î˚yÓ˚ Ó˚¨¢ÇÖƒÑ¸ Óylfl¸ì¸ ˆÏs¸fÓ˚£z ¢õ!‹Tõye– ¢%ì¸Ó˚yÇ Óúy ˆÎ ˆÏì¸ ¸ôy ˆÏÓ˚ Óylfl¸ì¸s¸f £ú !ò!î≈‹T ¢õ ˆÏÎ˚ ~Ñ¸!›¸ !ò!î≈‹T fl¸iy ˆÏò !Óhfl+¸ì¸ ~õò ~Ñ¸ õ%_´ ÓƒÓfl¸iy Îy ˆÏì¸ !Ó!¶¸ß¨ ¢ã#Ó Á ãv¸¸¸

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v¸z¸ôyîyò ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ !e´Î˚yÈÙÈ≤Ã!ì¸!e´Î˚yÓ˚ õyïƒ ˆÏõ ¢%

ü,Cú¶¸y ˆÏÓ˚ ˆÓß ˆÏâ¸ Ìy ˆÏÑ¸– Óylfl¸ì¸s¸f ≤ÃyÑ,¸!ì¸Ñ¸ S ˆÎõòÈÙÙÙÈ ¸ô%Ñ%¸Ó˚ñ òî#ñ xÓ˚íƒ £zì¸ƒy!îV Óy Ñ,¸!eõ S ˆÎõòÈÙÙÙÈ õyäñ áÓ˚ñ Óßyïñ ÓyÜyòñ ü£Ó˚ £zì¸ƒy!îV ~£z î%£z ≤ÃÑ¸yÓ˚ £ ˆÏì¸ ¸ôy ˆÏÓ˚ – 3.2 Óylfl¸ì¸ ˆÏs¸fÓ˚ ¢ÇK¸y (Definition of Ecosystem) 1935 ! Ö fi›¸y ˆÏ∑ Óylfl¸!Óî ~. !ã. ›¸ƒy™!ú (A. G. Tansley) Óylfl¸ì¸s¸f Óy eco-system ü∑!›¸ ≤ÃÌõ â¸Î˚ò Ñ¸ ˆÏÓ˚ò– !ì¸!ò 'eco' ü∑!›¸ ˆÏÑ¸ ¸ô!Ó˚ ˆÏÓü x ˆÏÌ≈ ÓƒÓ£yÓ˚ Ñ¸ ˆÏÓ˚ò– !ÓK¸yò# Á ˆÏÎ˚ Óﬁ›¸yÓ˚ (Webster) 'System' ü∑!›¸Ó˚ ÓƒyÖƒy ≤Ãîyò Ñ¸ ˆÏÓ˚ò– ìß¸yÓ˚ õ ˆÏì¸ñ ¸ô%O#Ñ,¸ì¸ Óylfl¸¢õ)ˆÏ£Ó˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ xyhs¸É!e´Î˚yÓ˚ ö¸ ˆÏú ¢Ç ˆÏÎyÜ ¢y!ïì¸ £Î˚ – Óylfl¸!Óî Áv¸yõ (Odum, 1971) Óylfl¸! ÓîƒyÓ˚ !ò¡¨Ó˚*¸ô ˜ÓK¸y!òÑ¸ ¢ÇK¸y ≤Ãîyò Ñ¸ ˆÏÓ˚òÈÙÙÙÈ 42 ? NSOU ? AE-ES-21

ÚÚˆÎ !ÓˆÏü°Ï ¸ôk¸!ì¸ ˆÏì¸ ˆÑ¸yˆÏòy Ó¢!ì¸fl¸iyˆÏò xÓ!fl¸iì¸ ã#ÓˆÏÜy¤¸#=!ú ~ˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ ¢ˆÏD ~ÓÇ Á£z Ó¢!ì¸ xM¸ÈˆÏúÓ˚ x˜ÏãÓ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ˆÏD !õÌ!fl¸;¸Î˚y Ñ¸ˆÏÓ˚ ~Ñ¸!›¸ ¢%!fl¸iì¸ ì¸s¸f Ü‡¸ò Ñ¸ˆÏÓ˚ñ ˆ¢£z ¢%!fl¸iì¸ ì¸s¸f Ü‡¸ˆÏòÓ˚ !e´Î˚y ¸ôk¸!ì¸ˆÏÑ¸ Óylfl¸ì¸s¸f ÓˆÏú–ÛÛ 3.3 Óylfl¸ì¸ˆÏs¸fÓ˚ ˜Ó!ü‹Tƒ (Characteristics of Ecosystem) !ÓK¸yò# !fl¸øÌ (Smith) 1974 !Ö fi›¸yˆÏ∑ Óylfl¸ì¸ˆÏs¸fÓ˚ !òi¨!ú!Öì¸ ˜Ó!ü‹Tƒ¢õ)ˆÏ£Ó˚ v¸zˆÏÕ'Ö Ñ¸ˆÏÓ˚òÈÙÙÙÈ 1. Óylfl¸ì¸s¸f £ú Óylfl¸!ÓîƒyÓ˚ õ)ú Ñ¸yÎ≈Ñ¸Ó˚# ~Ñ¸Ñ¸– Óylfl¸ì¸ˆÏs¸fÓ˚ õˆÏïƒ !îˆÏÎ˚£z ¸ô%!‹TÓ˚ â¸e´ xyÓ!ì≈¸ì¸ £Î˚ – 2. Óylfl¸ì¸s¸f ¸ô!Ó˚ˆÏÓˆÏüÓ˚ !Ó!¶¸ß¨ ˜ãÓ ~ÓÇ x˜ÏãÓ v¸z¸ôyîyò !òˆÏÎ˚ Ü!‡¸ì¸– 3. Óylfl¸ì¸ˆÏs¸fÓ˚ õˆÏïƒ !îˆÏÎ˚£z ü!_´Ó˚ ≤ÃÓy£ ¢Çá!›¸ì¸ £Î˚ – ~£z ≤ÃÓy£ ÓãyÎ˚ Ó˚yÖyÓ˚ ãòƒ v¸z¸ôyîyò¢õ)ˆÏ£Ó˚

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õˆÏïƒ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡ôÑ≈¸ ÜˆÏv¸¸ ÁˆÏ‡¸– 4. Óylfl¸ì¸ˆ

ˆÏs¸fÓ˚ õˆÏïƒ !îˆÏÎ˚ ü!_´Ó˚ ≤ÃÓ£ò õyey v¸zÍ¸ôyîÑ¸ ¢‚‹T ü!_´Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú– 5. ü!_´ ¸ô!Ó˚Ó£ˆÏòÓ˚ ¢õÎ˚ ≤Ã!ì¸!›¸ ›¸∆! ¸ôÑ¸ hfl¸ˆÏÓ˚ ü!_´Ó˚ ¸ô!Ó˚õyí £…y¢ ¸ôyÎ˚ ~ÓÇ ~£z ˜Ó!ü‹Tƒ£z ≤Ã!ì¸!›¸ hfl¸ˆÏÓ˚ ã#Ó¶¸Ó˚ !òï≈yÓ˚í Ñ¸ˆÏÓ˚ – 6. ≤ÃyÌ!õÑ¸ ›¸∆! ¸ôÑ¸ hfl¸Ó˚ ˆÌˆÏÑ¸ v¸zFâ¸ì¸Ó˚ ›¸∆! ¸ôÑ¸ hfl¸ˆÏÓ˚ xˆÏ¸ô«¸yÑ,¸ì¸ ã!›¸ú ì¸s¸f ¸ô!Ó˚ú!«¸ì¸ £Î˚ ~ÓÇ ≤Ã!ì¸!›¸ hfl¸ˆÏÓ˚ !fl¸i!ì¸ü!_´Ó˚ ¸ô! Ó˚õyí £…y¢ ¸ôyÎ˚ – 7. ˆÑ¸yˆÏòy ~Ñ¸!›¸ Óylfl¸ì¸ˆÏs¸f !ò!î≈‹T ≤Ãäy!ì¸Ó˚ ¸ô¸ô%ˆÏúüò ~Ñ¸!›¸ !ò!î≈‹T ¢#õy ¸ôÎ≈hs¸ Ó‚!k¸ ¸ôyÎ˚ ~ÓÇ ì¸yÓ˚ ¸ôÓ˚ !fl¸iì¸yÓfl¸iyÎ˚ xyˆÏ¢ ~ÓÇ !Ó!¶¸ß¨ ≤ÃyÑ‚¸!ì¸Ñ¸ Ñ¸yÓ˚ˆÏí £…y¢≤ÃyÆ £Î˚ – 3.4 Óylfl¸ì¸ˆÏs¸fÓ˚ ≤ÃÑ¸yÓ˚ˆÏ¶¸î (Types of Ecosystem) ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ã#Ó ~ÓÇ ãv¸¸ v¸z¸ôyîyò ¢õ)ˆÏ£Ó˚ xyhs¸É!e´Î˚yÓ˚ ö¸ˆÏú ~Ñ¸!›¸ Óylfl¸ì¸s¸f ÜˆÏv¸¸ ÁˆÏ‡¸– ¸ô! Ó˚ˆÏÓˆÏü !Ó!¶¸ß¨ ïÓ˚ˆÏïÓ˚ Óylfl¸ì¸s¸f ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚ – v¸zîy£Ó˚ífl¸∫Ó˚*¸ôÈÙÙÙÈ Óò¶)¸!õñ ì¸¸í¶)¸!õñ õÓ˚&¶)¸!õñ ãúy¶)¸!õñ S¸ô%Ñ%¸Ó˚ñ òî#ñ Ó‚£Í ãúyüÎ˚V ~ÓÇ ¢yõ%!oÑ¸ Óylfl¸ì¸s¸f ~ˆÏîÓ˚ õˆÏïƒ Ñ¸ˆÏÎ˚Ñ¸!›¸ !

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òˆÏ¡¨ ¢ÇˆÏ«¸ˆÏ¸ô xyˆÏúyâ¸òy Ñ¸Ó˚y £ú– 3.4.1

Óò¶)¸!õÓ˚ Óylfl¸ì¸s¸f (Forest ecosystem) ¸ô¸!ÌÓ#Ó˚ ¢õ@˘Ã ¶)¸ÈÙÈ¶¸yˆÏÜÓ˚ 40% ãyÎ˚Üy ã%ˆÏv¸¸ xyˆÏäÈ Óò¶)¸!õ ~ÓÇ ¸ô!Ó˚õyí õ)ú ¶)¸ÈÙÈ¶¸yˆÏÜÓ˚ ~ˆÏÑ¸Ó˚ ¸ô§yâ¸ xÇü– Óò¶)¸!õÓ˚ Óylfl¸ì¸ˆÏs¸fÓ˚ õ%Öƒ v¸z¸ôyîyò=!ú £úÈÙÙÙÈ ??x˜Ïã!ÓÑ¸ v¸z¸ôyîyò ≠ õy!›¸Ó˚ x˜Ïã!ÓÑ¸ v¸z¸ôyîyˆÏòÓ˚ ¢yˆÏÌ ¢yˆÏÌ õ¸ì¸ ¸ôîyÌ≈ñ ˆÎõò õ¸ì¸ ≤Ãîyò ÜyˆÏäÈÓ˚ ¸ôyì¸yñ üyÖyÈÙÈ≤ÃüyÖyÓ˚ xÇüyÓˆÏü°Ï ¸ôˆÏâ¸ õy!›¸Ó˚ v¸zÓ≈Ó˚ì¸y Ó‚!k¸ Ñ¸ˆÏÓ˚ – NSOU ? AE-ES-21 ? 43
??˜ã!ÓÑ¸ v¸z¸ôyîyò ≠ Óò¶)¸!õˆÏì¸ v¸z¸ô!fl¸iì¸ ã#ˆÏÓÓ˚ õˆÏïƒ Öyîƒ ü‚Cú !òˆÏ¡¨y_´ ¶¸yˆÏÓ ÓãyÎ˚ ÌyˆÏÑ¸– v¸zÍ¸ôyîÑ¸ ≠ Óò¶)¸!õÓ˚ Óylfl¸ì¸ˆÏs¸fÓ˚ ≤Ãîyò v¸zÍ¸ôyîÑ¸ !£¢yˆÏÓ ÜyäÈˆÏÑ¸£z ïÓ˚y £Î˚ ì¸ˆÏÓ =Õ√ãyì¸#Î˚ v¸z!qîÁ ¸ôyÁÎ˚y ÎyÎ˚ – ~£z Ñ¸yÓ˚ˆÏí Óò¶)¸!õˆÏì¸ ¢ÓˆÏÌˆÏÑ¸ ˆÓ!ü ã#Ó˜ÏÓ!â¸eƒ ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚ – üyúñ ˆ¢=òñ £zv¸zÑ¸ƒy!ú¸ô›¸yü ≤Ã¶¸,!ì¸ ÜyäÈ õ)úì¸ Óò¶)¸!õˆÏì¸ ãß√yÎ˚ – ~äÈyv¸¸y ¸ôy£y!v¸¸ xM¸ÈˆÏú ¸ôy£zòñ ã%!ò≤Ãy¢ñ !¢v¸yÓ˚ £zì¸ƒy!î ÜyäÈ ˆîÖˆÏì¸ ¸ôyÁÎ˚y ÎyÎ˚ – ÖyîÑ¸ ≠ S1V ≤ÃÌõ ˆ◊í#Ó˚ ÖyîÑ¸ ≠ üyÑ¸y£yÓ˚# ≤Ãyí# ÎyÓ˚y ÜyˆÏäÈÓ˚ ¸ôyì¸y ˆÖˆÏÎ˚ ˆÓ§ˆÏâ¸ ÌyˆÏÑ¸ ˆÎõòÈÙÙÙÈ !¸ô•¸ôˆÏv¸¸ñ õyÑ¸v¸¸¢yñ !Ó›¸úñ !úö¸£¸ôyÓ˚ £zì¸ƒy!î ˆäÈy›¸ ≤Ãyí# ~ÓÇ £y!ì¸ñ ò#úÜy£zñ £!Ó˚íñ Ñ¸y‡¸!Óv¸¸y!úñ Óyî%v¸¸ñ õˆÏDy¢ £zì¸ƒy!î ˆîÖˆÏì¸ ¸ôyÁÎ˚y ÎyÎ˚ – S2V !mì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸ ≠ õÇüy¢# ≤Ãyí#ñ ˆÎõò ¢y¸ôñ ¸ôy!Öñ !›¸Ñ¸!›¸!Ññ ˆüÎ˚yú £zì¸ƒy!î S3V ì¸,ì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸ ≠ ¢ˆÏÓ≈yFâ¸ hfl¸ˆÏÓ˚Ó˚ ÖyîÑ¸ SõyÇüy¢#V !£¢yˆÏÓ Óyáñ !¢Ç£ñ £zì¸ƒy!î ÎyÓ˚y !mì¸#Î˚ ˆ◊í#Ó˚ Á ≤ÃÌõ ˆ◊í#Ó˚ v¸z¶¸Î˚ˆÏîÓ˚ Öyîƒ !£¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚– !ÓˆÏÎ˚yãÑ¸ ≠ ~£z Óylfl¸ì¸ˆÏs¸f Ó˝ïÓ˚ˆÏòÓ˚ xyí%Ó#«¸!òÑ¸ ã#Ó ¸ôyÁÎ˚y ÎyÎ˚ ˆÎõò äÈeyÑ¸ Sxƒyfl¸ôyÓ˚!ãúy¢ñ ¸ô! úˆÏ¸ôyÓ˚y¢ £zì¸ƒy!îVñ Óƒy˚ÏQy!Ó˚Î˚y SÓƒy!¢úy¢ñ Ñœ¸!fl¸T…!v¸Î˚yõñ !¢v¸zˆÏv¸yˆÏõyòy¢ £zì¸ƒy!îV ÎyÓ˚y õ¸ì¸ ˜ãÓ¸ôîyÌ≈ˆÏÑ¸ õy!›¸Ó˚ v¸z¸ôyîyˆÏò ¸ô!Ó˚íì¸ Ñ¸ˆÏÓ˚ – òy!ì¸ü#ˆÏì¸y°å xM¸ÈˆÏúÓ˚ Óò¶)¸!õˆÏì¸ !ÓˆÏÎ˚yãˆÏòÓ˚ õyey xˆÏòÑ¸ ˆÓ!ü– 3.4.2 ì¸¸í¶)¸!õÓ˚ Óylfl¸ì¸s¸f (Grassland ecosystem) ¸ô¸!ÌÓ#Ó˚ ¢õ@˘Ã ¶)¸ÈÙÈ¶¸yˆÏÜÓ˚ ˆõy›¸yõy!›¸ 19% £ú ì¸¸í¶)¸!õ– ì¸¸í¶)¸!õ Óylfl¸ì¸ˆÏs¸fÓ˚ ≤Ãîyò v¸z¸ôyîyò ¢õ)£ ≠ ? x˜ÏãÓ v¸z¸ôyîyò ≠ !Ó!¶¸ß¨ ˆõÔú ˆÎõòÈÙÙÙÈ C, H, O, N, P, S £zì¸ƒy!î õy!›¸ ~ÓÇ Óyì¸yˆÏ¢ xÓ!fl¸iì¸ Îy òy£zˆÏ›¸∆›¸ñ ö¸¢ˆÏö¸›¸ ~ÓÇ ¢yúˆÏö¸›¸ ≤Ãîyò Ñ¸ˆÏÓ˚ñ ¢yˆÏÌ òyòy ˆ›¸∆¢ÈÙÈ~!úˆÏõr›¸Á v¸z¸ô!fl¸iì¸ ÌyˆÏÑ¸– ??˜ãÓ v¸z¸ôyîyò ≠ v¸zÍ¸ôyîÑ¸ ≠ ö¸y£zˆÏ›¸y≤'yB¸›¸ò äÈyv¸¸y ¢Ó%ã ˜üÓyú Á òyòy ãúã v¸z!qî ˆÎõò Ñ¸â%¸!Ó˚ ¸ôyòyñ üyú%Ñ¸ñ ¸ôpñ ¸ôyì¸yG§¸y!G¸ñ £y£z!v»¸úyñ ÷ü!òñ ¶¸ƒy!ú!¢ˆÏò!Ó˚Î˚y £zì¸ƒy!î õ%Öƒ v¸zÍ¸ôyîÑ¸ !£¢yˆÏÓ xÓfl¸iyò Ñ¸ˆÏÓ˚ – ÖyîÑ¸ ≠ ≤ÃyÌ!õÑ¸ ÖyîÑ¸ ≠ ¸ô%Ñ%¸ˆÏÓ˚Ó˚ õ%Öƒ ≤ÃyÌ!õÑ¸ ÖyîˆÏÑ¸Ó˚ õˆÏïƒ ã%≤'yB¸›¸òñ ˆäÈy›¸õyäÈñ üyÑ¸y£yÓ˚# Óv¸¸õyäÈ ˆÎõòÈÙÙÙÈ Ó˚&£zñ ¸Ñ¸yì¸úy £zì¸ƒy!î– ~äÈyv¸¸y !Ñ¸ä%È ≤Ãyí# xyˆÏäÈ ÎyÓ˚y ãˆÏúÓ˚ ~Ñ¸îõ !òˆÏâ¸Ó˚ hfl¸ˆÏÓ˚ ÌyˆÏÑ¸ñ ≤ÃyÎ˚ õy!›¸Ó˚ Ñ¸yäÈyÑ¸y!äÈ ~Ó˚y õ)úì¸ õÓ˚y ¸ôâ¸y ÖyÓyÓ˚ ˆÖˆÏì¸ ¸ôäÈ® Ñ¸ˆÏÓ˚ – ~ˆÏîÓ˚ ˆÓòÌ¢‰ ÓˆÏú– v¸zîy£Ó˚ífl¸∫Ó˚*¸ôÈÙÙÙÈ üyõ%Ñ¸ñ !G¸ò%Ñ¸ñ õy=Ó˚ñ !üÇ! Ü ãyì¸#Î˚ õyäÈ– !mì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸ ≠ ˆäÈy›¸ ˆ¸ôyÑ¸yõyÑ¸v¸¸ñ ã%≤'yB¸›¸òˆÏîÓ˚ ÖyÎ˚ ~ÓÇ !Ñ¸ä%È ˆäÈy›¸ õyäÈ xyˆÏäÈ ÎyÓ˚yÁ ≤'yB¸›¸òˆÏîÓ˚ ÖyÎ˚ñ ì¸yˆÏîÓ˚ !mì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸ ÓˆÏú– ì¸,ì¸#Î˚ ˆ◊!íÓ˚ ÖyîÑ¸ ≠ Ó‚£Í õyÇ¢yü# õyäÈÓ˚yñ ˆÎõòÈÙÙÙÈ ˆÓyÎ˚yúõyäÈñ ~Ó˚y ˆäÈy›¸ õyäÈˆÏîÓ˚ !òˆÏãÓ˚ Öyîƒ !£¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸– 44 ? NSOU ? AE-ES-21

!ÓˆÏÎ˚yãÑ¸ ≠ ~˜ÏîÓ˚ «%¸o ÖyîÑ¸Á Óúy £˜ÏÎ˚ ìy˜ÏÑ¸– ¸ô%Ñ%¸˜ÏÓ˚Ó˚ Óylfl¸ì¸˜Ïs¸f ≤Ãâ%¸Ó˚ ¸ô!Ó˚õy˜Ïí !Ó˜ÏÎ˚yã˜ÏÑ¸Ó˚ ¢Ω¸yÓ˚ ¸ôyÁÎ˚y ÎyÎ˚– ì¸yÓ˚ ≤Ãïyò Ñ¸yÓ˚í ¸ô%Ñ%¸˜ÏÓ˚Ó˚ õ˜Ïïƒ ˜ã!ÓÑ¸ Óã≈ƒ¸ôîyÌ≈ x˜ÏòÑ¸ ˆÓ!ü ¸ô!Ó˚õy˜Ïí xy˜Ï¢– ~äÈyv¸¸y !Ó!¶¸ß¨ ≤Ãyí# Á v¸z!q˜ÏîÓ˚ õ¸ì¸ ˆî£yÓ˜Ïü°ÏÁ ìy˜ÏÑ¸– !Ó!¶¸ß¨ Óƒy˜ÏQy!Ó˚Î˚yÓ˚ ¢y˜ÏÌ òyòy ïÓ˚˜ÏòÓ˚ äÈeyÑ¸ ¸ôyÁÎ˚y ÎyÎ˚ñ ˆÎõòÈÙÙÈ Ñœ¸ƒy˜Ïv¸y˜Ïfl¸ôy!Ó˚Î˚yõñ Ó˚!£˜Ïãy¸ôy¢ ≤Ã¶,¸!ì¸ ¸ô%Ñ%¸˜ÏÓ˚Ó˚ Ñ¸yîy Óy ¸ôßyÑ¸ÈÙÈ~Ó˚ õ˜Ïïƒ !Ó˜ÏÎ˚yãÑ¸ !£¢y˜ÏÓ xÓfl¸iyò Ñ¸˜ÏÓ˚– 3.4.3 ¢yõ%!oÑ¸ Óylfl¸ì¸s¸f (Marine ecosystem) ¸ô,!ÌÓ#Ó˚ ˆõy›¸ ãú¶¸y˜ÏÜÓ˚ 97% ¢õ%o– fl¸∫yî% ã˜ÏúÓ˚ Óylfl¸ì¸˜Ïs¸fÓ˚ ì%¸úòyÎ˚ ¢yõ%!oÑ¸ Óylfl¸ì¸s¸f x˜ÏòÑ¸ !fl¸i!ì¸ü#úñ ì¸yÓ˚ xòƒì¸õ Ñ¸yÓ˚í xyÓ˚ !Ñ¸ä%ÈÈ£z òy ¢õ%˜ÏoÓ˚ úÓíy_´ ãú ~ÓÇ xòƒyòƒ ˆ¶¸Ôì¸ÈÙÙÈv¸z¸ôyîyò ˆÎõò ì¸y¸ôõyeyñ oÓ#¶)¸ì¸ x!:˜Ïãò ~ÓÇ xy˜Ïúy Ö%Ó Ñ¸õ ¸ô!Ó˚Ói≈¸ò £Î˚– ˜ã!ÓÑ¸ v¸z¸ôyîyò ≠ ¢yõ%!oÑ¸ Óylfl¸ì¸˜Ïs¸fÓ˚ ˜ã!ÓÑ¸ v¸z¸ôyîyò ¢õ)£ £ú– v¸zÍ¸ôyîÑ¸ ≠ ~£z Óylfl¸ì¸˜Ïs¸fÓ˚ v¸zÍ¸ôyîÑ¸ ˆ◊í#Ó˚ õ˜Ïïƒ v¸z˜ÏÕ'Ö˜ÏÏyÜƒ ö¸y£z˜Ï›¸y ≤'ƒyB¸›¸òñ v¸yÎ˚y›¸õ ~ÓÇ !Ñ¸ä%È xyò!Ó«¸!íÑ¸ ˜üÓyú¢õ)£– ~äÈyv¸¸yÁ ¢yõ%!oÑ¸ xyÜyäÈyñ Óyîy!õ Á úyú ˜üÓyú– ~£z v¸zÍ¸ôyîÑ¸ ¢õ%˜ÏoÓ˚ !Ó!¶¸ß¨ Ü¶¸#Ó˚ì¸yÎ˚ !Ó¶¸_´ ìy˜ÏÑ¸– ÖyîÑ¸ ≠ üyÑ¸y£yÓ˚# ÎyÓ˚y ¢Ó˚y¢!Ó˚ v¸zÍ¸ôyîÑ¸˜ÏÑ¸ xy£yÓ˚ !£¢y˜ÏÓ @˘Ã£í Ñ¸˜ÏÓ˚– ˆÎõòÈÙÙÈ ã%ÈÙÈ≤'ƒyB¸›¸òñ üyõ%Ñ¸ £zì¸ƒy!î– !mì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸ ≠ ÎyÓ˚y v¸z¸ô!Ó˚v¸z_´ ≤ÃyÌ!õÑ¸ ÖyîÑ¸˜ÏÑ¸ Öyîƒ !£¢y˜ÏÓ @˘Ã£í Ñ¸˜ÏÓ˚ñ ˆÎõòÈÙÙÈ õyäÈ S˜£!Ó˚Ó˚Çñ ¢y!v≈¸òñ õÑ¸˜ÏÓ˚ú £zì¸ƒy!îV– ì¸,¸ì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸ ≠ õyÇüy¢# õyäÈ ÎyÓ˚y !mì¸#Î˚ ˆ◊í#Ó˚ ÖyîÑ¸˜ÏîÓ˚ ÖyÎ˚ñ ˆÎõòÈÙÙÈ Ñ¸v≈¸ £y!úÓ%›¸ ~Ó˚y£z Öyîƒ ü¸C˜ÏúÓ˚ ¢˜ÏÓ≈yFâ¸ fl¸iyò x!ïÑ¸yÓ˚#– ! Ó˜ÏÎ˚yãÑ¸ ≠ xyò%Ó#«¸!íÑ¸ ã#Ó ÎyÓ˚y õ,ì¸ ˜ã!ÓÑ¸ Ólfl¸Ó˚ ¸ôâ¸˜ÏòÓ˚ Ñ¸y˜Ïã xÇü@˘Ã£í Ñ¸˜ÏÓ˚ ì¸y˜ÏîÓ˚ !Ó˜ÏÎ˚yãÑ¸ Ó˜Ïú– ¢yïyÓ˚îì¸ ¢yõ%!oÑ¸ Óylfl¸ì¸˜Ïs¸f Óƒy˜ÏQ!Ó˚Î˚ !Ó˜ÏÎ˚yãÑ¸ !£¢y˜ÏÓ õ%Öƒ ¶)¸!õÑ¸y ¸ôyúò Ñ¸˜ÏÓ˚– 3.5 Óy˜ÏÎ˚yõ (Biome) ˆÑ¸yò ! ò!î≈‹T ˆ¶¸Ô˜ÏÜy!úÑ¸ xM¸È˜ÏúÓ˚ Óylfl¸ì¸˜Ïs¸fÓ˚ ¢õ!‹T˜ÏÑ¸ Óy˜ÏÎ˚yõ Ó˜Ïú– ãúÓyÎ˚%Ó˚ ≤ÃÑ,¸!ì¸ ~Ñ¸!›¸ !ò!î≈‹T Óy˜ÏÎ˚y˜Ïõ Ó¢Óy¢Ñ¸yÓ˚# v¸z!qî Á ≤Ãyí# ˆÜy¤¸#Ó˚ ≤Ããy!ì¸ ~ÓÇ ˜Ó!ü‹Tƒ !òï≈yÓ˚í Ñ¸˜ÏÓ˚– xÓfl¸iy˜ÏòÓ˚ !¶¸!_˜Ïì¸ Óy˜ÏÎ˚yõ˜ÏÑ¸ õ%Öƒ

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î%£z ¶¸y˜ÏÜ ¶¸yÜ Ñ¸Ó˚y £Î˚ÈÙÙÈ

fl¸iúã Óy˜ÏÎ˚yõ (Terrestrial Biome) Á ãúã Óy˜ÏÎ˚yõ (Aqatic Biome)– fl¸iúã Óy˜ÏÎ˚y˜ÏõÓ˚ ˆ◊í#˜Ï¶¸îÈÙÙÈ ¢Ó˚úÓÜ≈#Î˚ Óò¶)¸!õ (Coniferous Forest)ó ¸ôí≈˜Ïõyâ¸# Óò¶)¸!õ (Deciduous Forest)ó ì¸,í¶)¸!õ (Grassland)ó ¢y¶¸yòy (Savana)ó !£õyúÎ˚ ~ÓÇ õÓ˚&¶)¸! õÓ˚ Óy˜ÏÎ˚yõ (Desert Biome)– ãúã Óy˜ÏÎ˚yõ !ì¸ò≤ÃÑ¸yÓ˚ÈÙÙÈ fl¸∫yî% ã˜ÏúÓ˚ (Freshwater biome)ñ {°ÏÍ úÓíy_´ S˜¶¸!v¸¸ÈÙÈxM¸ÈúV (Estuarine Biome) ~ÓÇ ¢yõ%!oÑ¸ Óy˜ÏÎ˚yõ (Marine Biome)– 3.6 Óylfl¸ì¸˜Ïs¸fÓ˚ v¸z¸ôyîyò (Componets of Ecosystem)

65% **MATCHING BLOCK 46/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Óylfl¸ì¸˜Ïs¸fÓ˚ Ñ¸yÎ≈Ñ¸y!Ó˚ì¸yÓ˚ v¸z¸ôÓ˚ !¶¸!_ Ñ¸˜ÏÓ˚ !

ÓK¸yò# Áv¸yõ (1966) Óylfl¸ì¸˜Ïs¸fÓ˚ v¸z¸ôyîyò¢õ)£˜ÏÑ¸ ≤Ãïyò î%£z¶¸y˜ÏÜ ¶¸yÜ Ñ¸˜ÏÓ˚ò– ~Ó˚y Îlye´˜ÏõÈÙÙÈ NSOU ? AE-ES-21 ? 45
1– Ñ¸yÎ≈!¶¸!_Ñ¸ v¸z¸ôyîyò 2– ¢yÇÜ‡¸!òÑ¸ v¸z¸ôyîyò xyÓyÓ˚ Ü‡¸òÜì¸¶¸y˜ÏÓ Óylfl¸ì¸˜Ïs¸fÓ˚ v¸z¸ôyîyò¢õ)£˜ÏÑ¸ !ò¡¨!ú!Öì¸ v¸z¸ôy˜ÏÎ˚ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ÈÙÙÈ Óylfl¸ì¸˜Ïs¸fÓ˚ v¸z¸ôyîyò !òã#≈Ó

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v¸z¸ôyîyò ¢ã#Ó v¸z¸ôyîyò x˜ÏãÓ v¸z¸ôyîyò ˜ãÓ v¸z¸ôyîyò ˆ¶¸Ôì¸ v¸z¸ôyîyò

v¸zÍ¸ôyîÑ¸ ÖyîÑ¸ !Ó˜ÏÎ˚yãÑ ¸ ≤ÃÌõ ˆ◊í#Ó˚ !mì¸#Î˚ ˆ◊í#Ó˚ ¢˜ÏÓ≈yFâ¸ ˆ◊í#Ó˚ ÖyîÑ¸ ÖyîÑ¸ ÖyîÑ¸ 3.6.1 Ñ¸yÎ≈!¶¸!_Ñ¸ v¸z¸ôyîyò fl¸∫˜Ï¶¸yã# v¸z¸ôyîyò ≠ ˆÎ¢Ñ¸ú ã#Ó !ò˜Ïã˜ÏîÓ˚ Öyîƒ !ò˜ÏãÓ˚y£z v¸zÍ¸ôß¨ Ñ¸Ó˚˜Ïì¸ ¸ôy˜ÏÓ˚ ì¸y˜ÏîÓ˚ fl¸∫˜Ï¶¸yã# v¸z¸ôyîyò Ó˜Ïú– Ñ¸˜ÏÎ˚Ñ¸!›¸ ≤Ãyí# S˜ÎõòÈÙÙÈ £zv¸z!@'òyV äÈyv¸¸y ˆÑœ¸y˜ÏÓ˚y!ö¸ú Î%_´ ¢Ñ¸ú v¸z!q˜ÏîÓ˚ £z ~£z «¸õì¸y Óì≈¸õyò– ˆÑœ¸y˜ÏÓ˚y!ö¸ú ÓyÎ˚% ˆÌ˜ÏÑ¸

61% **MATCHING BLOCK 48/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zx:y£zv¸ (CO 2) @˘Ã£í Ñ¸˜ÏÓ˚ ~ÓÇ ¢)Î≈y˜ÏúyÑ¸

Á õ)ú˜ÏÓ˚yõ myÓ˚y ˆüy!°Ïì¸ ã˜ÏúÓ˚ ¢y£y˜ÏÏƒ ¢y˜ÏúyÑ¸¢Ç˜ÏŸ'°Ï ≤Ã!e´Î˚yÎ˚ ã!›¸ú üÑ≈¸Ó˚y Öyîƒ ˜ì¸!Ó˚ Ñ¸˜ÏÓ˚– 6CO 2 + 12H 2 O = C 6 H 12 O 6 + 6O 2 + 6H 2 O + ì¸y¸ôü!_´– @'%˜ÏÑ¸yã (C 6 H 12 O 6) äÈyv¸¸yÁ ˆ≤Ãy!›¸òñ xƒyõy£z˜Ïòy xƒy!¢v¸ £zì¸ƒy!î ≤Ã˜ÏÎ˚yãò#Î˚ v¸z¸ôyîyò¢õ)£Á ¢Ç˜ÏŸ'!°Ïì¸ £Î˚– xÌ≈yÍñ ¸ô,!ÌÓ#Ó˚ ¢Ñ¸ú v¸z!qî£z Óylfl¸ì¸˜Ïs¸fÓ˚ v¸zÍ¸ôyîÑ¸– ¸ôÓ˚˜Ï¶¸yã# v¸z¸ôyîyò ≠ ˆÎ ¢Ñ¸ú ã#Ó !ò˜ÏãÓ˚ Öyîƒ !ò˜ÏãÓ˚y ˜ì¸!Ó˚ Ñ¸Ó˚˜Ïì¸ ¸ôy˜ÏÓ˚ òyñ ¸ôÓ˚ls¸ Öy˜ÏîƒÓ˚ ãòƒ x˜ÏòƒÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú ì¸y˜ÏîÓ˚ ¸ôÓ˚˜Ï¶¸yã# Ó˜Ïú– !Ñ¸ä%È ˆÑœ¸y˜ÏÓ˚y!ö¸ú !Ó£#ò v¸z!qî ~ÓÇ ¢Ñ¸ú ≤Ãyí# ≤Ãì¸ƒ«¸ Óy ¸ô˜ÏÓ˚y«¸¶¸y˜ÏÓ v¸zÍ¸ôyî˜ÏÑ¸Ó˚ v¸z¸ôÓ˚ Öy˜ÏîƒÓ˚ ãòƒ !ò¶≈¸Ó˚ü#ú– 3.6.2 ¢yÇÜ‡¸!òÑ¸ v¸z¸ôyîyò !òã≈#Ó v¸z¸ôyîyò ≠ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ¢Ñ¸ú ãv¸¸ v¸z¸ôyîyò ~Ó˚ xhs¸Ü≈ì¸– ~£z v¸z¸ôyîyò¢õ)£˜

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ÏÑ˛ !ò¡¨!ú!Öì˛ ¶˛yˆÏÜ ¶˛yÜ Ñ˛Ó˚y Îyΰ

ÈÙÙÙÈ (i) x˜ÏãÓ v˛z˛ôyîyò ≠ ãúñ õy!›˛ñ !Ó!¶˛ß¨ Ö!òã úÓíñ Üƒy¢#ΰ ˛ôîyÌ≈ Óylfl˛ì˛ˆÏs˛fÓ˚ x˜ÏãÓ v˛z˛ôyîyò– ¢Ó%ã v˛z!qî Öyîƒ ≤Ãlfl˛!ì˛ˆÏì˛ ~£z ¢Ñ˛ú v˛z˛ôyîyò¢õ)£ˆÏÑ˛ ÓƒÓ£yÓ˚ Ñ˛ˆÏÓ˚– (iii) ˜ãÓ v˛z˛ôyîyò ≠ õ,ì˛ v˛z!qî Óy ≤Ãyí#Ó˚ ˆîˆÏ£Ó˚ !Ó!¶˛ß¨ Ó˚Ñ˛õ ˜ãÓÓlfl˛Ó˚ ˛ôâ˛ˆÏòÓ˚ ö˛ˆÏú v˛zq$ì˛ ˛ôîyÌ≈¢õ)£ñ ˆÎõòÈÙÙÙÈ ˆ≤Ãy!›˛òñ ö˛ƒy›˛ñ £zv˛z!Ó˚ˆÎ˚yñ Ñ˛yˆÏÓ≈y£y£zˆÏv»˛›˛ £zì˛ƒy!î ˛ô!Ó˚ˆÏÓˆÏüÓ˚ ˜ãÓ v˛z˛ôyîyˆÏòÓ˚ xhs˛Ü≈ì˛– (iii) ˆ¶˛Ôì˛ v˛z˛ôyîyò ≠ ˆ¢ÔÓ˚ü!_´ñ ì˛y˛ôõyeyñ ÓyΈ%≤ÃÓy£ñ xyˆÏúyñ xyo≈ì˛y £zì˛ƒy!î ˛ô!Ó˚ˆÏÓˆÏüÓ˚ ˆ¶˛Ôì˛ v˛z˛ôyîyò– ˆÎ ˆÑ˛yˆÏòy Óylfl˛ì˛ˆÏs˛fÓ˚ ≤ÃˆÏÏ˚yãò#ΰ ü!_´Ó˚ ~Ñ˛õye v˛zÍ¢ ¢)Î≈yˆÏúyÑ˛– 46 ? NSOU ? AE-ES-21

¢yˆÏúyÑ˛¢ÇˆÏŸ’ˆÏ°Ï ãv˛¸ v˛z˛ôyîyò ã#!Óì˛ v˛z˛ôyîyò ÖyîÑ˛ ˛ôÓ˚ˆÏ¶˛yã# ¢ã#Ó v˛z˛ôyîyò ≠ Óylfl˛ì˛ˆÏs˛fÓ˚ ¢Ñ˛ú ã#Ó£z ~£z v˛z˛ôyîyˆÏòÓ˚ xhs˛Ü≈ì˛– ~£z v˛z˛ôyîyò¢õ)£ˆ

88% **MATCHING BLOCK 50/200** **SA** Geography-CC-1.1.pdf (D142516024)

ÏÑ˛ !ò¡¨!ú!Öì˛ ¶˛yˆÏÜ ¶˛yÜ Ñ˛Ó˚y ÎyΰÈÙÙÙÈ v˛

zÍ˛ôyîÑ˛ ≠ ˆÎ ¢Ñ˛ú ˆÑœ˛yˆÏÓ˚y!ö˛úÎ%_´ ã#Ó ¢yˆÏúyÑ˛¢ÇˆÏŸ’ˆÏ°Ï ≤Ã!e´Î˚yΰ ì˛yÓ˚ !òˆÏãÓ˚ ˆîˆÏ£ üÑ≈˛Ó˚y ãyì˛#ΰ Öyîƒ ≤Ãlfl˛ì˛ Ñ˛Ó˚ˆÏì˛ ˛ôyˆÏÓ˚ ì˛yˆÏîÓ˚ v˛zÍ˛ôyîÑ˛ ÓˆÏú– ˆÎõòÈÙÙÙÈ ˆÑœ˛yˆÏÓ˚y!ö˛úÎ%_´ ¢Ó%ã v˛z!qî– ¢Ñ˛ú ≤Ãyí#£z ã#ÓòïyÓ˚ˆÏíÓ˚ ãòƒ ≤Ãì˛ƒ«˛ Óy ˛ôˆÏÓ˚y«˛¶˛yˆÏÓ

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v˛zÍ˛ôyîˆÏÑ˛Ó˚ v˛z˛ôÓ˚ !ò¶≈˛Ó˚ü#ú–

ÖyîÑ˛ ≠ ˆÎ ¢Ñ˛ú ã#Ó ¢yˆÏúyÑ˛¢ÇˆÏŸ’ˆÏ°Ï x«˛õ ~ÓÇ ÖyˆÏîƒÓ˚ ãòƒ ≤Ãì˛ƒ«˛ Óy ˛ôˆÏÓ˚y«˛¶˛yˆÏÓ

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v˛zÍ˛ôyîˆÏÑ˛Ó˚ v˛z˛ôÓ˚ !ò¶≈˛Ó˚ü#ú

ì˛yˆÏîÓ˚ ÖyîÑ˛ ÓˆÏú– ≤Ãïyòì˛ !ì˛ò ˆ◊í#Ó˚ ÖyîÑ˛ Óylfl˛ì˛ˆÏs˛f ˛ô!Ó˚ú!«˛ì˛ £Î˚ – SÑ˛V ≤ÃÌõ ˆ◊í#Ó˚ ÖyîÑ˛ ≠ ˆÎ ¢Ñ˛ú ≤Ãyí# ì˛yˆÏîÓ˚ ã#Óò ïyÓ˚ˆÏíÓ˚ ãòƒ ¢Ó˚y¢!Ó˚

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v˛zÍ˛ôyîˆÏÑ˛Ó˚ v˛z˛ôÓ˚ !ò¶≈˛Ó˚ü#ú

ì˛yˆÏîÓ˚ ≤ÃÌõ ˆ◊í#Ó˚ ÖyîÑ˛ ÓˆÏú– ˆÎõòÈÙÙÙÈ üyõ%Ñ˛ñ ì˛‚íˆÏ¶˛yã# õyäÈñ ˆÜyÓ˚&ñ äÈyÜúñ £!Ó˚í £zì˛ƒy!î– SÖV !mì˛#ΰ ˆ◊í#Ó˚ ÖyîÑ˛ ≠ ˆÎ ¢Ñ˛ú ≤Ãyí# ÖyˆÏîƒÓ˚ ãòƒ ≤ÃÌõ ˆ◊í#Ó˚ ÖyîˆÏÑ˛Ó˚ v˛z˛ôÓ˚ !ò¶≈˛Ó˚ü#ú ì˛yˆÏîÓ˚ ˆÜÔí ÖyîÑ˛ Óy !mì˛#ΰ ˆ◊í#Ó˚ ÖyîÑ˛ ÓˆÏú– ˆÎõòÈÙÙÙÈ ˆòÑ˛ˆÏv˛¸ñ !Ó!¶˛ß¨ ˛ôì˛D¶)Ñ˛ ˛ôy!Ö £zì˛ƒy!î– SÜV ¢ˆÏÓ≈yFâ˛ ˆ◊í#Ó˚ ÖyîÑ˛ ≠ ˆÎ ¢Ñ˛ú ≤Ãyí# ì˛yˆÏîÓ˚ ÖyˆÏîƒÓ˚ ãòƒ ≤ÃÌõ Óy !mì˛#ΰ ˆ◊í#Ó˚ ÖyîˆÏÑ˛Ó˚ v˛z˛ôÓ˚ !ò¶≈˛Ó˚ü#ú ì˛yˆÏîÓ˚ ¢ˆÏÓ≈yFâ˛ ˆ◊í#Ó˚ ÖyîÑ˛ ÓˆÏú– ˆÎõòÈÙÙÙÈ Óyáñ !¢Ç£ñ õyò%°Ï £zì˛ƒy!î– !ÓˆÏÏ˚yãÑ˛ ≠ ˆÎ ¢Ñ˛ú xí%ã#Ó õ,ì˛ v˛zÍ˛ôyîÑ˛ ~ÓÇ ÖyîˆÏÑ˛Ó˚ ˆî£ˆÏüˆ°ÏˆÏÑ˛ !ÓˆÏÏ˚y!ãì˛ Ñ˛ˆÏÓ˚ Óylfl˛ì˛ˆÏs˛f v˛zÍ˛ôyîˆÏÑ˛Ó˚ ˛ô%òÉÓƒÓ£yˆÏÓ˚ÏyÜƒ ˜ãÓ Ólfl˛ˆ

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Ïì˛ Ó˚*˛ôyhs˛!Ó˚ì˛ Ñ˛ˆÏÓ˚ ì˛yˆÏîÓ˚ !

ÓˆÏÏ˚yãÑ˛ ÓˆÏú– ˆÎõòÈÙÙÙÈ !Ó!¶˛ß¨ ÓƒyÑ˛ˆÏ›˛!Ó˚Î˚y Á äÈeyÑ˛– Óylfl˛ì˛s˛f Óy £zˆÏÑ˛y!¢ˆÏfi›˛ˆÏõÓ˚ !

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Ó!¶˛ß¨ v˛z˛ôyîyò=!úÓ˚ õˆÏïƒ ˛ôyÓ˚fl˛ô!Ó˚Ñ˛ ¢¡ôÑ≈˛ !

òˆÏâ˛ äÈˆÏÑ˛Ó˚ ¢y£yˆÏÎƒ ˆîÖyˆÏòy £ˆÏúyÈÙÙÙÈ NSOU ? AE-ES-21 ? 47

3.7 ›˛∆!˛ôÑ˛ ˆúˆÏ¶˛úñ Öyîƒü‚Cúñ Öyîƒ ãyúÑ˛ Á Öyîƒ !˛ôÓ˚y!õv˛ (Trophic level, Food chain, Food web and Food Pyramid)

90%	MATCHING BLOCK 56/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

v¸z!qî Á ≤Ãyí#Ó ̊ ¸ôyÓ ̊fl¸ô!Ó ̊Ñ¸ ¢¡

ô ̂ÏÑ≈¸Ó ̊ Ñ¸Ìy
ãyò ̂Ì¸ £ ̂Ïú ¸ô%!‹T hfl¸Ó ̊ñ Öyîƒü‚Cúñ Öyîƒ ãyúÑ¸ñ Öyîƒ !¸ôÓ ̊y!õv¸ Á £z ̂ÏÑ¸y!¢ ̂Ïfi› ̧ ̂ÏõÓ ̊ ü!_ ́≤ÃÓy£ ≤Ã¶¸¸!ì¸ ¢¡∫ ̂Ì¸ ! Ó ̂Ïü°Ï¶¸y ̂ÏÓ Κ¸yò xy£Ó ̊í Ñ¸Ó ̊y ≤Ã ̂Ïî ̈yãò– ›¸∆!¸ôÑ¸ hfl¸Ó ̊ ≠ £z ̂ÏÑ¸y!¢ ̂Ïfi› ̧ ̂ÏõÓ ̊ xhs¸Ü≈ì¸ ̂Ñ¸y ̂Ïòy ¢î¢ƒ ã#Ó Öyîƒü‚C ̂ÏúÓ ̊ ̂Î Öyîƒhfl¸ ̂ÏÓ ̊ xÓfl¸iyò Ñ¸ ̂ÏÓ ̊ ̂¢£z Öyîƒhfl¸Ó ̊ ̂ÏÑ¸ Á£z Öyîƒü‚C ̂ÏúÓ ̊ Ú¢ÇÓ ̊!«¸ì¸ ì¸úÛ Óy Ú›¸∆!¸ôÑ¸ ̂ú ̂Ï¶¸úÛ Óy Ú¸ô%!‹T hfl¸Ó ̊Û Ó ̂Ïú– ~Ñ¸!›¸ Öyîƒü‚C ̂Ïú î%£z Óy ì¸ ̂Ì¸y!ïÑ¸ ›¸∆!¸ôÑ¸ ̂ú ̂Ï¶¸ú ÌyÑ¸ ̂Ì¸ ¸ôy ̂ÏÓ ̊ – v¸zí¸ôyîÑ¸ S¢Ó%ã v¸z!qîV Öyîƒü‚C ̂ÏúÓ ̊ ¢)â¸ôy Ñ¸ ̂ÏÓ ̊ñ ì¸y£z ~£z hfl¸Ó ̊ ̂ÏÑ¸ ÚÚ≤Ãìõ ›¸∆!¸ôÑ¸ ̂ú ̂Ï¶¸úÛÛ Óúy £Î ̈ – Öyîƒü‚Cú ≠ Öyîƒ Öyî ̂ÏÑ¸Ó ̊ ¢ ¡ô ̂ÏÑ≈¸Ó ̊ Á¸ôÓ ̊ !¶¸!_ Ñ¸ ̂ÏÓ ̊ !ò!î≈‹T ≤Ãíyú# ̂Ì¸ Öyîƒü!_ ́ v¸zí¸ôyî ̂ÏÑ¸Ó ̊ Ñ¸yäÈ ̂Ì ̂ÏÑ¸ e ́õ¸ôî≈y ̂Ïî ̈ xyÓ ̊Á v¸zß ̈ì¸ ã#Ó ̂ÏÜy¤¸#Ó ̊ õ ̂Ïîƒ ≤ÃÓy!£ì¸ £Î ̈ – ü!_ ́ ≤ÃÓy ̂Ï£Ó ̊ ~£z e ́!õÑ¸ ¸ôî≈yÎ ̈ ̂ÏÑ¸ Öyî‚üCú Ó ̂Ïú– !ÓΚ¸yò# Áv¸y ̂ÏõÓ ̊ õ ̂Ì¸ñ ÚÚv¸zí¸ôyîÑ¸ Ñ¸ì¸≈Ñ¸ xyÓk¸ ü!_ ́ ¸ôÓ ̊ ¸ôÓ ̊ !Ó!¶¸ß ̈ Öyîƒhfl¸ ̂ÏÓ ̊Ó ̊ õïƒ !î ̂Ïî ̈ ≤ÃÓy!£ì¸ £Î ̈ ¢ ̂ÏÓ≈yFâ¸ Öyîƒhfl¸ ̂ÏÓ ̊ ̂¸ôÓ§äÈy ̂ÏòyÓ ̊ ü‚Cú ̂ÏÑ¸ Öyîƒü‚Cú Ó ̂Ïú–ÛÛ v¸zîyÊÓ ̊í ífl¸∫Ó ̊*¸ôñ ~Ñ¸!›¸ !õ!‹T ã ̂ÏúÓ ̊ Öyîƒü‚C ̂ÏúÓ ̊ õyïƒ ̂Ïõ ü!_ ́≤ÃÓy£ ò# ̂Ïâ¸ ̂ÏÚy ̂Ïòy £ú– Sv¸zí¸ôyîÑ¸V S≤Ãìõ ̂◊í#Ó ̊ ÖyîÑ¸V S!mì¸#Î ̈ ̂◊í#Ó ̊ ÖyîÑ¸V Sì¸ì¸#Î ̈ ̂◊í#Ó ̊ ÖyîÑ¸V Sâì¸%¸Ì≈ ̂◊í#Ó ̊ ÖyîÑ¸V v¸z!qîñ ̃üÓyú ¸ôì¸D Óƒyà õyäÈ õyò%°Ï Sö¸y£z ̂Ì›¸∆y≤'ƒyB¸›¸òV Óylfl¸ì¸ ̂Ïs¸f ¢yiyÓ ̊î¸ !òì ̈!ú!Öì¸ !ì¸ò ≤ÃÑ¸yÓ ̊ Öyîƒü‚Cú ̂ÏÜy Ìyî ̊ – ̂ÏõòÈÙÙÙÈ S1V !úÑ¸yÓ ̊# Öyîƒü‚Cú (Predator food chain) ≠ ~£z ü‚Cú v¸zí¸ôyîÑ¸ ̂Ì ̂ÏÑ¸ ÷Ó ̊& £Î ̈ ~ÓÇ ~Ó ̊ ¸ôÓ ̊Ói≈¸# ¸ôî≈yÎ ̈=!ú ̂Ì¸ ã# ̂ÏÓÓ ̊ xyÑ¸yÓ ̊ e ́õü Óyv¸¸ ̂Ì¸ Ìy ̂ÏÑ¸ ~ÓÇ ~Ñ¸£z ¢ ̂ÏD ì¸y ̂ÏìÓ ̊ ¢ÇÖƒyÁ £…y¢ ¸ôyÎ ̈ – v¸zîy£Ó ̊í ≠ÈÙÙÙÈ v¸z!qî Ñ¸#›¸¸ôì¸D Óƒyà Óyã¸ôy!Ö S2V ¸ôÓ ̊ã#Ó# Öyîƒü‚Cú (Parasitic food chain)≠ ~£z ü‚Cú Ó¸£Í ã#Ó ̂Ì ̂ÏÑ¸ xyÓ ̊Ω¸ £ ̂ÏÎ ̈ e ́õ¸ôî≈y ̂ÏÎ ̈ «%¸o ¸ôÓ ̊ã#Ó# ̂Ì¸ ̂ü°Ï £Î ̈ – v¸zîy£Ó ̊í ≠ÈÈÙÙÙÈ õyò%°Ï Ñ¸¸!õ xyîƒ≤Ãyí# S3V õ¸ì¸ã#Ó# Öyîƒü‚Cú (Saprophytic food chain) ≠ ~£z ü‚Cú õ¸ì¸ã#Ó# ̂Ì ̂ÏÑ¸ xyÓ ̊Ω¸ £ ̂Ïî ̈ ÓƒyÑ¸ ̂Ï›¸!Ó ̊ ̂Î ̈y ̂Ì¸ ̂ü°Ï £Î ̈ – v¸zîy£Ó ̊í ≠ÈÙÙÙÈ õ¸ì¸ v¸z!qî äÈeyÑ¸ ÓƒyÑ¸ ̂Ï›¸! Ó ̊ ̂Î ̈y 48 ? NSOU ? AE-ES-21
Öyîƒ ãyúÑ¸ ≠ Óylfl¸ì¸ ̂Ïs¸fÓ ̊ ü!_ ́ Á Ólfl¸ x¢ÇÖƒ xyhs¸É¢¡ôÑ≈¸ ̂Î%_ ́ Öyîƒü‚C ̂ÏúÓ ̊ õ ̂Ïîƒ !î ̂Ïî ̈ ≤ÃÓy!£ì¸ £Î ̈ – ~£z¶¸y ̂ÏÓ ̊ ¢ÇÎ%_ ́ Öyîƒü‚Cú=!ú ̂ÏÑ¸ Öyîƒ ãyúÑ¸ Ó ̂Ïú– !ò ̂Ï¡ ̈ ̂≤Ã£z!Ó ̊ ì¸ í¶)¸!õÓ ̊ ~Ñ¸!›¸ Öyîƒ ãyúÑ¸ !â¸e¢£ ̂ÏÜy ̂Ïòy £ú– Öyîƒ !¸ôÓ ̊y!õv¸ ≠ ~Ñ¸!›¸ !ò!î≈‹T Óylfl¸ì¸ ̂Ïs¸fÓ ̊ !Ó!¶¸ß ̈ ¸ô%!‹Tì¸ ̂Ïs¸fÓ ̊ ¢yõ!@ ̆ÃÑ¸ Ü‡ò ̂ÏÑ¸ xò%e ́!õÑ¸ ¶¸y ̂ÏÓ ̊ ¢yãy ̂Ïú ̂Î !¸ôÓ ̊y!õv¸ Óy !üÖÓ ̊ Ü!‡ì¸ £Î ̈ ì¸y ̂ÏÑ¸ Öyîƒ !¸ôÓ ̊y!õv¸ Ó ̂Ïú– !Ó !›¸ü £z ̂ÏÑ¸y!ú!ãfi› ̧ â¸yú≈¢ ~ú›¸ò (1972) ¢Ó≈≤Ãìõ ~£z !¸ôÓ ̊y!õv¸ ¢¡ô ̂ÏÑ≈¸ ïyÓ ̊íy ̂ÏîÎ ̈– S1V ¢ÇÖƒy ¸!¸ôÓ ̊y!õv¸ S2V ü!_ ́Ó ̊ !¸ôÓ ̊y!õv¸ S3V ã#Ó¶¸Ó ̊ !¸ôÓ ̊y!õv¸ S1V ¢ÇÖƒy !¸ôÓ ̊y!õv¸ ≠ v¸zí¸ôyîÑ¸ ̂Ì ̂ÏÑ¸ ÷Ó ̊& Ñ¸ ̂ÏÓ ̊ ¢ ̂ÏÓ≈yFâ¸ ¸ôî≈y ̂ÏÎ ̈Ó ̊ ÖyîÑ¸ ¸ôî≈hs¸ ã# ̂ÏÓÓ ̊ ¢ÇÖƒy e ́õü Ñ¸õ ̂Ì¸ ÌyÑ¸ ~Ó ̊* ̂Ï¸ô ¢‹T !¸ôÓ ̊y!õv¸ ̂ÏÑ¸ ¢ÇÖƒy ! ¸ôÓ ̊y!õv¸ Ó ̂Ïú– ò# ̂Ïâ¸ ~Ñ¸!›¸ ¢ÇÖƒyÓ ̊ !¸ôÓ ̊y!õv¸ ̂ÏÜy ̂Ïòy £úÈÙÙÙÈ ~Öy ̂Ïò v¸zyÎ ̈›y¸yõñ !v¸ ̂Ïòyõœ¸ƒy ̂Ïã ̂Ïú›‰¸¢ Á ö¸y£z ̂Ì›¸y≤'ƒyB¸›¸ ̂ÏòÓ ̊ ¢ÇÖƒy x ̂ÏòÑ¸ ̂Ó!ü Sv¸zí¸ôyîÑ¸V– ≤Ãìõ ̂◊í#Ó ̊ ÖyîÑ¸ ̂Ïõòñ e ́y¢‰¸ ̂Ì›¸!¢Î ̈yòÈÙÈ~Ó ̊ ¢ÇÖƒy v¸zí¸ôyî ̂ÏÑ¸Ó ̊ ¢ÇÖƒy ̂Ì ̂ÏÑ¸ Ñ¸õ– xyÓyÓ ̊ !mì¸#Î ̈ ̂◊í#Ó ̊ Öyî ̂ÏÑ¸Ó ̊ S!ì¸!õV ¢ÇÖƒy ¢Ó ̊ ̂Ïî ̂ÏÑ¸ Ñ¸õ– NSOU ? AE-ES-21 ? 49
S2V ü!_ ́Ó ̊ !¸ôÓ ̊y!õv¸ ≠ ~Ñ¸!›¸ Öyîƒü‚C ̂ÏúÓ ̊ ≤Ã!ì¸!›¸ Öyîƒhfl¸ ̂ÏÓ ̊ Sv¸zí¸ôyîÑ¸ ̂Ì ̂ÏÑ¸ ¢ ̂ÏÓ≈yFâ¸ ̂◊í#Ó ̊ ÖyîÑ¸ ¸ôî≈hs¸V ¢!M¸Èì¸ ü!_ ́Ó ̊ ¸ô!Ó ̊ õyí e ́õyß∫ ̂Ïî ̈ £…y¢ ̂ ¸ô ̂Ïî ̈ ̂Î !¸ôÓ ̊y!õv¸ ¢¸!‹T Ñ¸ ̂ÏÓ ̊ ì¸y ̂ÏÑ¸ ü!_ ́Ó ̊ !¸ôÓ ̊y!õv¸ Ó ̂Ïú– ~Ñ¸!›¸ ü!_ ́Ó ̊ ! ¸ôÓ ̊y!õ ̂Ïv¸Ó ̊ !â¸e ̂ÏÜy ̂Ïòy £úÈÙÙÙÈ S3V ã#Ó¶¸Ó ̊ !¸ôÓ ̊y!õv¸ ≠ ~Ñ¸!›¸ Öyîƒü‚C ̂ÏúÓ ̊ ≤Ã ̂Ì¸ ̂Ï ƒÑ¸ hfl¸ ̂ÏÓ ̊Ó ̊ ¢ã#Ó Ólfl¸Ó ̊ ÷‹Ó Áãò ̂ÏÑ¸ ã#Ó¶¸Ó ̊ Ó ̂Ïú– ̂ÏÜy Ìy ̂ v¸zí¸ôyî ̂ÏÑ¸Ó ̊ ã#Ó¶¸Ó ̊ ̂Ì ̂ÏÑ¸ ≤ÃÑ¸Ó ̊ hfl¸ ̂ÏÓ ̊Ó ̊ Öyî ̂ÏÑ¸Ó ̊ ã#Ó¶¸Ó ̊ Ñ¸õ £Î ̈ñ xyÓyÓ ̊ ≤ÃÑ¸Ó ̊ ̂Ì ̂ÏÑ¸ !mì¸#Î ̈ hfl¸Ó ̊ ̂Ì ̂ÏÑ¸ ì¸ì¸#Î ̈ hfl¸ ̂ÏÓ ̊ ã#Ó¶¸Ó ̊ e ́õyß∫ ̂Ïî ̈ Ñ¸õ ̂Ì¸ ÌyÑ¸ – ~£z¶¸y ̂ÏÓ ̊ ¢‹T !¸ôÓ ̊y! õv¸ ̂ÏÑ¸ ã#Ó¶¸ ̂ÏÓ ̊Ó ̊ !¸ôÓ ̊y!õv¸ Ó ̂Ïú– ¸ôÓ ̊ã#Ó# ̂ÏîÓ ̊ ̂«¸ ̂Ïe ã#Ó¶¸Ó ̊ !¸ôÓ ̊y!õv¸ !Ó¸ôÓ ̊#ì¸ õ%Ö# £ ̂Ïî ̈ Ìy ̂ÏÑ¸ – !ò ̂Ï¡ ̈ ã#Ó¶¸ ̂ÏÓ ̊Ó ̊ !¸ôÓ ̊y!õv¸ ̂ÏÜy ̂Ïòy £ú– 3.8

68%	MATCHING BLOCK 57/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Óylfl¸ì¸ ̂Ïs¸fÓ ̊ v¸zí¸ôyîòü#úì¸y (Productivity of Ecosystem) Óylfl¸ì¸ ̂Ïs¸fÓ ̊ ≤

Ãìõ ›¸∆!¸ôÑ¸ hfl¸Ó ̊!›¸ v¸zí¸ôyîÑ¸ Óy ¢Ó%ã v¸z!qî– ¢Ó%ã v¸z!qî ¢)Î≈y ̂Ïúy ̂ÏÑ¸Ó ̊ v¸z¸ô!fl¸i!ì¸ ̂Ì¸ ~ÓÇ ¸ôefl¸i ̂Ñœ¸y ̂ÏÓ ̊y! ö¸ ̂ÏúÓ ̊ ¢y£y ̂Ïîƒ Óyî ̈%!fl¸ii¸ x!: ̂Ïãò Á ã ̂ÏúÓ ̊ ¸ôyÓ ̊fl¸ô!Ó ̊Ñ¸ !Ó!e ̂Î ̈y ̂ üÑ≈¸Ó ̊y Öyîƒ v¸zí¸ôyîò Ñ¸ ̂ÏÓ ̊ – ö¸ ̂Ïú Óúy ̂Ì ̂Ì¸ ¸ôy ̂ÏÓ ̊ ¢)Ì≈ Ó ̊!Ÿ¬ ü!_ ́ !£¢y ̂ÏÓ ã#!Óì¸ Ñ¸úy ̂ xy_#¶)¸ì¸ £Î ̈ Óy üÑ≈¸Ó ̊y Öy ̂Ïîƒ õ ̂Ïîƒ !fl¸ii¸ £Î ̈ – ̂Ì ̂Ï£%¸ v¸z!qî üÑ≈¸Ó ̊y Ü‡ ̂ÏòÓ ̊ õyïƒ ̂Ïõ ¢Ñ¸ú ü!_ ́ Ó ̊y¢yÎ ̈!òÑ¸ ü!_ ́ !£¢y ̂ÏÓ ̊ ¢!M¸Èì¸ Ñ¸ ̂ÏÓ ̊ ö¸ ̂Ïú v¸zí¸ôß ̈ üÑ≈¸Ó ̊yÓ ̊ ¸ô!Ó ̊õyí äÈyòy ¸ôÓ ̊ã#Ó# ≤Ãyí# õyÇ¢yü# ≤Ãyí# ≤ÃÃy!òÑ¸ ÖyîÑ¸ v¸zí¸ôyîÑ¸ 50 ? NSOU ? AE-ES-21
ÌyÑ¸ ̂Ïú Ñ¸# ¸ô!Ó ̊õyí ü!_ ́Ó ̊ xy_#Ñ¸Ó ̊í £ ̂Ïî ̈ ̂ÏäÈ ì¸y ãyòy ¢Ω¸Ó– ~ ̂ÏÑ¸ £z ¢yõ!@ ̆ÃÑ¸ ≤ÃÃy!òÑ¸ v¸zí¸ôyîò Óy Gross Primary Productivity Ó ̂Ïú– ~£z v¸zí¸ôy!îì¸ ü!_ ́Ó ̊ Ó ̋úÇü v¸z!q ̂ÏîÓ ̊ Ÿª¢ ̂Ïò ÓƒÎ£*ì¸ £Î ̈ ¢%ì¸Ó ̊y¢Ç ¸ô ̂ÏÓ ̊y«¸¶¸y ̂ÏÓ v¸z!q ̂ÏîÓ ̊ ¢Ñ¸ú ̃ãÓ ¸ôîy ̂Ïì≈Ó ̊ ¸ô!Ó ̊õy ̂Ïí ¢ ̂ÏD ¢ ̂ÏD ã#Ó¶¸ ̂ÏÓ ̊Ó ̊ (Biomass) Áãò ¸ôyÁÎ ̈y Ìyî ̊ – xyÓyÓ ̊ ≤ÃÑ¸¸ì¸ v¸zí¸ôyîò Óy Net Production £ú ã#Ó¶¸Ó ̊ Á Ÿª¢ ̂Ïò ÓƒÓ£*ì¸ ü!_ ́Ó ̊ !Ó ̂Ïî ̈yÜö¸ú– Üy!í!ì¸Ñ¸ ¶¸y°Ïyî ̊ Pg - R = Pn ; ̂ÏÜy ̂Ïò Pg = ¢yõ!@ ̆ÃÑ¸ v¸zí¸ôyîòñ Óy Pg = Pn + R ; Pn = ≤ÃÑ¸¸ì¸ v¸zí¸ôyîò R = Ÿª¢ ̂Ïò !ò!õ_ ü!_ ́Ó ̊ Óƒ ̂Î ̈ – xì≈yíñ !ò!î≈‹T ¢õ ̂Ï ̈Î ̈ !fl¸i!ì¸ ü!_ ́Ó ̊ Ó¸!k¸ ̂ÏÑ¸£z ≤ÃÑ¸¸ì¸ v¸zí¸ôyîò ~ÓÇ ̂ÎÈÙ ̂Ñ¸y ̂Ïòy ¢õ ̂Ï ̈Î ̈Ó ̊ ¢yõ!@ ̆ÃÑ¸ ü!_ ́Ó ̊ v¸zí¸ôyîò ̂ÏÑ¸ ã#Ó¶¸Ó ̊ Ó ̂Ïú– ~£z Üy!í!ì¸Ñ¸ ¢)ï ̂Ïe Pg = R £Î ̈ ì¸ ̂ÏÓ ü!_ ́Ó ̊ £y ̂ÏÓ ̊Ó ̊ ì¸yÓ ̊ì¸ ̂õƒ £Î ̈ òy– xyÓyÓ ̊ Pg < R £ ̂Ïú ã#Ó¶¸Ó ̊ £…y¢ ¸ôyÎ ̈ – ~Ñ¸£z¶¸y ̂ÏÓ Pg > R £ ̂Ïú ã#Ó¶¸ ̂ÏÓ ̊Ó ̊ Áãò Ó¸!k¸ ¸ôyÎ ̈ – 3.9 Óylfl¸ì¸ ̂Ïs¸f ü!_ ́ ≤ÃÓy£ (Energy flow in Ecosystem) ~Ñ¸!›¸ Óylfl¸ì¸ ̂Ïs¸f v¸z¸ô!fl¸ii¸ ¢ã#Ó ~ÓÇ !òã≈#Ó v¸z¸ôyîy ̂ÏòÓ ̊ õ ̂Ïîƒ xyhs¸É¢¡ôÑ≈¸ Óí≈òy– ¢Ñ¸ú ¢ã#Ó Ólfl¸ ̂¢ÔÓ ̊!_ ́ ̂ÏÑ¸ Ñ¸y ̂Ïã úyÜyÎ ̈ – v¸z!qî ¢y ̂ÏúyÑ¸¢Ç ̂ÏŸ°Ï ¸ôók¸!ì¸ ̂Ì¸ ̂¢ÔÓ ̊

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ü!_´ˆÏÑ¸ Ó˚y¢yÎ˚!òÑ¸ ü!_´ˆÌ¸ Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ ~

ÓÇ !Ó¸ôyÑ¸#Î˚ Ñ¸y˚Ïî≈ ~£z Ó˚y¢yÎ˚!òÑ¸ ü!_´ Îy!s¸fÑ¸ xÌÓy ì¸y¸ô ü!_´ˆÌ¸ Ó˚*¸ôyhs¸!Ó˚ì¸ £Î˚ – xyÓyÓ˚ ~Ñ¸£z Óylfl¸ì¸ˆÏs¸f Óì≈¸õyò Öyîƒ ~ÓÇ ÖyîÑ¸ ¸ôÓ˚fl¸ôˆÏÓ˚Ó˚ ¢ˆÏD Öyîƒü¸Cú ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – v¸zí¸ôyîÑ¸ ¢¸‹T ü!_´ Öyîƒü¸CˆÏúÓ˚ õyïƒˆÏõ !ò¡¨ì¸õ Öyîƒhfl¸Ó˚ v¸zFâ¸ì¸Ó˚ Öyîƒhfl¸ˆÏÓ˚Ó˚ !îˆÏÑ¸ ≤ÃÓy!£ì¸ £Î˚ – ö¸ˆÏú ü!_´≤ÃÓyˆÏ£Ó˚ ¢ÇK¸y !£¢yˆÏÓ xyõÓ˚y Óú˜Ì¸ ¸ôy!Ó˚ñ ÚÚü!_´Ó˚ xÓfl¸iyhs¸Ó˚ Á Öyîƒü¸CˆÏúÓ˚ !Ó!¶¸ß¨ ›¸∆!¸ôÑ¸ hfl¸ˆÏÓ˚Ó˚ ã#ˆÏÓÓ˚ õˆÏïƒ !îˆÏÎ˚ ~Ñ¸ ïyÓ˚yÓy!£Ñ¸ ¸ô!Ó˚â¸yúòˆÏÑ¸ ü!_´≤ÃÓy£ Ó˚ˆÏú–ÛÛ Óylfl¸ì¸ˆÏs¸fÓ˚ ü!_´Ó˚ ≤ÃÓ£ò ¢¡ôˆÏÑ≈¸ ¢õƒÑ¸ xò%ïyÓò Ñ¸Ó˚ˆÌ¸ £ˆÏú ì¸y¸ôÜ!ì¸!Óîƒ yÓ˚ ≤Ãìõ Á !mì¸#Î˚ ¢)e ¢¡ˆÌ¸ !Ó˚ˆÏü°¶¸yˆÏÓ K¸yò lyÑ¸y ≤ÃˆÏÏˆyãò– 3.9.1 ì¸y¸ô Ü!ì¸!Óîƒyó˚ ¢)emÎ˚ ≤Ãìõ ¢)e ≠ ü!_´Ó˚ ¢¸!‹T Óy !Óòyü £Î˚ òy– ÷ï%õye ~Ñ¸ xÓfl¸iy ˆÌˆÏÑ¸ xòƒ xÓfl¸iyÎ˚ ü!_´Ó˚ ¸ô!Ó˚Óì≈¸ò á˜Ì¸ – !mì¸#Î˚ ¢)e ≠ ÎÖò ü!_´Ó˚ fl¸iyòyhs¸Ó˚ Óy xÓfl¸iyhs¸Ó˚ á˜Ì¸ ì¸Öò ü!_´Ó˚ !Ñ¸ä%È xÇü ~õò xÓfl¸iyÎ˚ ˆ¸ôÔ§äËyÎ˚ ˆÎ~!›¸ ¸ôÓ˚Óì≈¸# ¸ôÎ≈yˆÏÎ˚ ≤ÃÓy!£ì¸ £ˆÌ¸ ¸ôyˆÏÓ˚ òy– ~Ñ¸!›¸ Óylfl¸ì¸ˆÏs¸f ˆ¢ÔÓ˚ü!_´ˆÌˆÏÑ¸ v¸z!qˆÏîÓ˚ ˆÎˆÏ£

100% **MATCHING BLOCK 59/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó˚y¢yÎ˚!òÑ¸ ü!_´ˆÌ¸ Ó˚*¸ôyhs¸!Ó˚ì¸ £

ÁÎ˚yì¸y¸ô Ü!ì¸!Óîƒyó˚ ≤Ãìõ ¢)eˆÏÑ¸ xò%¢Ó˚í Ñ¸ˆÏÓ˚ – xyÓyÓ˚ !Ó!¶¸ß¨ ÖyîÑ¸ hfl¸ˆÏÓ˚ Ó˚*¸ôyhs¸!Ó˚ì¸ £ÁÎ˚yÓ˚ ¢õÎ˚ ˆÎ ü!_´ £...y¢ ¸ôyÎ˚ˆñ ì¸y ì¸y¸ô Ü!ì¸!ÓîƒyÓ˚ !mì¸#Î˚ ¢)ˆÏeÓ˚ ¢y£yˆÏÏƒ Óƒyƒy Ñ¸Ó˚y Îy˚ – 3.9.2 ü!_´≤ÃÓyˆÏ£Ó˚ ¸ôî≈yÎ˚ Óylfl¸ì¸ˆÏs¸f Ó˚*¸ôyhs¸!Ó˚ì¸ ˆ¢ÔÓ˚ü!_´ v¸zí¸ôyîÑ¸ ˆÌˆÏÑ¸ !ì¸ò!›¸ ¸ôî≈yˆÏÎ˚ ÖyîˆÏÑ¸Ó˚ ˆîˆÏ£ fl¸iyòyhs¸!Ó˚ì¸ £Î˚ – ˆÎõòÈÙÙÈ NSOU ? AE-ES-21 ? 51

(i) ü!_´ xã≈ò ≠ Óylfl¸ì¸ˆÏs¸f ü!_´Ó˚ õ)ú v¸zÍ¢ £ú ¢)Î≈yˆÏúyÑ¸ – ¢Ó%ã v¸z!qî ¢

80% **MATCHING BLOCK 60/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

yˆÏúyÑ¸¢Çˆ¶Ÿ°Ï ≤Ã!eˆÎ˚yÎ˚ ˆ¢ÔÓ˚ü!_´ @˘Ã£í Ñ¸ˆÏÓ˚

ì¸

89% **MATCHING BLOCK 61/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

yˆÏÑ¸ Ó˚y¢yÎ˚!òÑ¸ ü!_´ˆÌ¸ Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ – ~£

z ü!_´ v¸zí¸ôß¨ Öyˆ˚ÏƒÓ˚ õˆÏïƒ !fl¸i!ì¸ü!_´Ó˚*ˆÏ¸ô xyÓk¸ lyˆÏÑ¸ – ˆ¢ãòƒ ~£z ¸ôî≈yÎ˚ˆÏÑ¸ ü!_´ xã≈ò ¸ôî≈yÎ˚ Óˆ˚Ïú– ¢)î≈ ˆÌˆÏÑ¸ xy¸ô! ì¸ì¸ ˆ¢ÔÓ˚ü!_´Ó˚ õye 0.2 üì¸yÇü v¸zí¸ôyîÑ¸ ¢yˆÏúyÑ¸¢Çˆ¶Ÿ°Ï ≤Ã!eˆÎ˚yÎ˚ ¢Çˆ¶Ÿ'!°Ì¸ ÖyˆÏîƒ xyÓk¸ Ñ¸Ó˚ˆÌ¸ ¸ôyˆÏÓ˚ – (ii) ü!_´Ó˚ ÓƒÓ£yÓ˚ ≠ v¸zí¸ôyîˆÏÑ¸Ó˚ ¢Çˆ¶Ÿ'!°Ì¸ ÖyˆÏîƒ ˆÎ ¸ô!Ó˚õyí ü!_´ xyÓk¸ £Î˚ ì¸yÓ˚ !Ñ¸ä%È xÇü ì¸yÓ˚y !òˆÏãÓ˚ üyÓ˚#Ó˚Ó¸_#Î˚ Ñ¸yˆÏã ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ – !Ñ¸ä%È xÇü x¸ôyâ¸ƒ Á ˆÓ˚â¸ò ¸ôîyÌ≈Ó˚*ˆÏ¸ô ¸ô!Ó˚ˆÏÓˆÏü ¸ô!Ó˚ì¸ƒ_´ £Î˚ – xÓ!ü‹TyÇüñ ≤Ãyí#

90% **MATCHING BLOCK 62/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó˚y ≤Ãì¸ƒ«¸ Óy ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ @˘Ã£

í Ñ¸ˆÏÓ˚ Öyîƒfl¸ì¸ !fl¸i!ì¸ ü!_´ˆÏÑ¸ Ÿª¢ò ≤Ã!eˆÎ˚yÓ˚ ¢y£yˆÏƒ Ü!ì¸ü!_´ˆÌ¸ Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ ~ÓÇ !Ó!¶¸ß¨ ˜ãÓ!òÑ¸ Ñ¸yã=!ú ¢¡ôß¨ Ñ¸ˆÏÓ˚ – (iii) ü!_´ fl¸iyòyhs¸Ñ¸Ó˚í ≠ v¸zí¸ôyîÑ¸ ˆÌˆÏÑ¸ ü!_´ ≤Ãìõ ˆ◊í#Ó˚ ÖyîˆÏÑ¸Ó˚ ~ÓÇ ¸ôî≈yÎ˚ˆe !òÑ¸ !mì¸#Î˚ ˆ◊í#Ó˚ Á ì¸ì¸#Î˚ ˆ◊í#Ó˚ ÖyîˆÏÑ¸Ó˚ ˆîˆÏ£ ≤ÃÓy!£ì¸ Óy fl¸iyòyhs¸!Ó˚ì¸ £Î˚ – ¢ˆÏÓ≈y¸ô!Ó˚ !Ó˚ˆÏÎ˚yãÑ¸ õ¸ì¸ ÖyîÑ¸ ¢õ)£ˆÏÑ¸ !Ó!Ÿ'‹T Ñ¸ˆÏÓ˚ ¸ô%òÓ˚yÎ˚ ¸ô!Ó˚ˆÏÓˆÏü !òˆÏÓ˚ ˆÌ!ˆ ˆî˚ – 3.9.3 ü!_´≤ÃÓyˆÏ£Ó˚ õˆÏv¸ú v¸z¸ôˆÏÓ˚Ó˚ !â¸ˆÏe !ì¸ò!›¸ Óy: S1, 2 ~ÓÇ 3V !ì¸ò!›¸ ¸ôî≈yÎ˚ˆe ´!òÑ¸ Öyîƒhfl¸Ó˚ˆÌˆÏÑ¸ !òˆÏì≈ü Ñ¸ˆÏÓ˚ ~ÓÇ ¸ôyÉz¸ô úyÉzò!›¸ ü!_´ ≤ÃÓ£ˆÏòÓ˚ Öyîƒhfl¸ˆÏÓ˚ ≤ÃˆÏÓü ~ÓÇ Öyîƒhfl¸Ó˚ ˆÌˆÏÑ¸ !ò‹;õíˆÌ≈ü Ñ¸ˆÏÓ˚ – ≤ÃÌ!›¸ Öyîƒhfl¸ˆÏÓ˚Ó˚ ã#Ó¢õ)£ ì¸yÓ˚ ¸ô)Ó≈Ó˚ì≈¸# Öyîƒhfl¸Ó˚ ˆÌˆÏÑ¸ ü!_´ @˘Ã£í Ñ¸ˆÏÓ˚ ~ÓÇ ~£z Ü£#ì¸ ü!_´Ó˚ ˆÓ!üÓ˚ ¶¸yÜ£z üyÓ˚#Ó˚Ó¸_#Î˚ Ñ¸yˆÏã ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ – ˆÓü !Ñ¸ä%È ¸ô!Ó˚õyí ü!_´ xÓƒÓ£*ì¸ lyˆÏÑ¸ ~ÓÇ Óy! Ñ¸ ¸ô!Ó˚õyí !òã ˆÎ˚£ xy_#Ñ¸Ó˚í £Î˚ – xì≈yÍñ ü!_´Ó˚ xhs¸õ%≈Ö# Á Ó!£õ≈%Ö# ≤ÃÓ£ˆÏò ü!_´Ó˚ ¸ô!Ó˚õyí £...y¢ ¸ôyÎ˚ˆñ Îy ì¸y¸ôÜ!ì¸!ÓîƒyÓ˚ !mì¸#Î˚ ¢)eˆÏÑ¸ ¢õ≈Ìò Ñ¸ˆÏÓ˚ – v¸z¸ô!Ó˚!Ñ¸B¸ì¸ õˆÏv¸ú xò%¢yˆÏÓ˚ 3000 !Ñ¸ˆÏúy Ñ¸ƒyˆÏúy!Ó˚ ˆ¢ÔÓ˚ü!_´ ¢Ó%ã v¸z!qˆÏîÓ˚ v¸z¸ôˆÏÓ˚ xy¸ô!ì¸ì¸ £Î˚ !Ñ¸ls¸ ¢Ó%ã v¸z!qî õye 1500 !Ñ¸ˆÏúy Ñ¸ƒyˆÏúy!Ó˚ ü!_´ ˆüyˆÏ°í Ñ¸ˆÏÓ˚ñ ÎyÓ˚ õˆÏïƒ õye 1.5 !Ñ¸ˆÏúy Ñ¸ƒyˆÏúy!Ó˚ ≤ÃÌõ ˆ◊íÓ˚ ÖyîˆÏÑ¸ ¸ô!Ó˚ˆÏÓ!ü≈ì¸ £Î˚ – ¢%ì¸Ó˚yÇ ≤ÃÃÑ¸ì¸ v¸zí¸ôyîò 1.5 !Ñ¸ˆÏúy Ñ¸ƒyˆÏúy!Ó˚ ~ÓÇ ˆüy°Ï Öyîƒhfl¸ˆÏÓ˚ ¢yõ!@˘ÃÑ¸ ü!_´ ì¸yÓ˚ õye 10%– xì≈yÍ ≤ÃÌ!›¸ Öyîƒhfl¸ˆÏÓ˚ ü!_´Ó˚ ¸ô!Ó˚õyí ¸ôî≈yÎ˚ˆe !òÑ¸¶¸yˆÏÓ £...y¢ ¸ôyÎ˚ – 52 ? NSOU ? AE-ES-21

3.9.4 ü!_´≤ÃÓyˆÏ£Ó˚ ˜Ó!ü‹Tƒ ~Ñ¸!›¸ Óylfl¸ì¸ ˆÏs¸f ü!_´Ó˚ ≤ÃÓ£ˆÏòÓ˚ ˜Ó!ü‹Tƒ=!ú !ò¡¨Ó˚*¸ôÈÙÙÈ ??Óylfl¸ì¸ ˆÏs¸fÓ˚ ¢õ@˘Ã ü!_´Ó˚ v¸zÍ¢ £ú ˆ¢ÔÓ˚ü!_´– ??ü!_´≤ÃÓy£ ì¸y¸ôÜ!ì¸!ÓîƒyÓ˚ ≤ÃÌõ Á !mì¸#Î˚ ¢)eˆÏÑ¸ ˆõˆÏò â¸ˆÏú– ??Óylfl¸ì¸ ˆÏs¸f ü!_´Ó˚ ≤ÃÓy£ ¢Ó≈îy£z ~Ñ¸õ%Ö#– v¸zÍ¸ôyîÑ¸ ˆÌˆÏÑ¸ ¢ˆÏÓ≈yFâ¸ ˆ◊!íÓ˚ ÖyîÑ¸ ¸ôÎ≈hs¸ ≤Ã!ì¸!›¸ Öyîƒhfl¸ˆÏÓ˚ ü!_´Ó˚ ¸ô!Ó˚õyí e´õü £…y¢ ¸ôyÎ˚ – 3.10 ¸ô%!‹T â¸e´ (Nutrient Cycle) ¸ôîyˆÏÌ≈Ó˚ ¢ÇÓ˚«¸í ¢)e xò%ÎyÎ˚# ˆÑ¸yˆÏòy ¸ôîyÌ≈ˆÏÑ¸£z ¢‚!‹T Óy ïπÇ¢ Ñ¸Ó˚y ÎyÎ˚ òy– fl¸∫y¶¸y! ÓÑ¸¶¸yˆÏÓ£z ≤ÃÑ‚¸!ì¸fl¸i Ñ¸yÓ≈ò ~ÓÇ òy£zˆÏ›¸∆yˆÏãò ¢õˆÏÎ˚Ó˚ ¢ˆÏD ¢ˆÏD !Ó!¶¸ß¨ÓyÓ˚ ÓƒÓ£*ì¸ £Î˚ – Ó!£ÉãÜì¸ ˆÌˆÏÑ¸ !Óüyú ¸ô!Ó˚õyí ¸ôîyÌ≈ Ñ¸ÖòÉz ¸ô‚!ÌÓ#Ó˚ x¶¸ƒhs¸ˆÏÓ˚ ≤ÃˆÏÓü Ñ¸ˆÏÓ˚ òyñ Óy ¸ô‚!ÌÓ# ˆÌˆÏÑ¸ Á£z ¸ôîyÌ≈ Ó!£ÉãÜˆÏì¸ Üõò

61% **MATCHING BLOCK 63/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸ˆÏÓ˚ òy– Ñ¸yÓ≈òñ òy£zˆÏ›¸∆yˆÏãòñ x!:ˆÏãòñ ö¸¢ö¸Ó˚y¢

ñ ¢yúö¸yÓ˚ ≤Ã¶‚¸!ì¸ ˆ≤ÃyˆÏ›¸y≤'yãˆÏõÓ˚ !Ó!¶¸ß¨ v¸zˆÏÕ'ÖˆÏÎyÜƒ ˆõÔ!úÑ¸ v¸z¸ôyîyò– ~£z v¸z¸ôyîyò¢õ)£ ¢Ó≈îy£z â¸e´yÑ¸yˆÏÓ˚ ≤ÃÑ‚¸!ì¸fl¸i !Ó!¶¸ß¨ ¸ôîyˆÏÌ≈Ó˚ õïƒ !îˆÏÎ˚ xyÓ!ì≈¸ì¸ £Î˚ – 3.10.1 ¢ÇK¸y ˆ≤ÃyˆÏ›¸y≤'yãˆÏõÓ˚ ≤Ãïyòì¸õ Ó˚y¢yÎ˚!òÑ¸ v¸z¸ôyîyò¢õ)£ ã#Óõ[¸ˆÏú !ò!î≈‹T ˜Ó!ü‹TƒÎ%_´ ¸ôˆÏÌ ¸ô!Ó˚ˆÏÓü ˆÌˆÏÑ¸ ã#ˆÏÓ ~ÓÇ ã#Ó ˆÌˆÏÑ¸ ¸ô!Ó˚ˆÏÓ˚ˆÏü â¸e´yÑ¸yˆÏÓ˚ xyÓ!ì≈¸ì¸ £Î˚ – !Ó!¶¸ß¨ Ó˚y¢yÎ˚!òÑ¸ v¸z¸ôyîyˆÏòÓ˚ ~£z â¸e´=!úˆÏÑ¸ ã#ÓÈÙÈ¶)¸ÈÙÈÓ˚y¢yÎ˚!òÑ¸ â¸e´ (Bio-geochemical cycle) ÓˆÏú– ã#ˆÏÓÓ˚ ~£z ¢Ñ¸ú v¸z¸ôyîyò ~ÓÇ ˆÎÔˆÏÜÓ˚ â¸e´ˆÏÑ¸ ¸ô%!‹Tâ¸e´Á (Nutrient cycle) ÓˆÏú– 3.10.2 !Ó!¶¸ß¨ ¸ô%!‹T â¸e´ ≤ÃÑ‚¸!ì¸Ó˚ Ó˚y¢yÎ˚!òÑ¸ â¸e´=!úÓ˚ õˆÏïƒ Ñ¸yÓ≈ò â¸e´ñ òy£zˆÏ›¸∆yˆ

85% **MATCHING BLOCK 64/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÏãòÏ â¸e´ñ x!:ˆÏãò â¸e´ñ ö¸¢ö¸Ó˚y¢ â¸e´ñ ¢yúö¸yÓ˚ â¸e´ !

100% **MATCHING BLOCK 65/200** **W**

ÓˆÏü°Ï¶¸yˆÏÓ v¸zˆÏÕ'ÖˆÏÎyÜƒ– !

67% **MATCHING BLOCK 66/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

òˆÏ¡¨ Ñ¸yÓ≈ò â¸e´ ~ÓÇ òy£zˆÏ›¸∆yˆÏãò â¸e´ xyˆÏúyâ¸òy Ñ¸Ó˚

y £ú– 3.10.2.1 Ñ¸yÓ≈ò â¸e´ !Ó!¶¸ß¨ Ó˚y¢yÎ˚!òÑ¸ ¸ô%!‹T â¸ˆÏe´Ó˚ õˆÏïƒ Ñ¸yÓ≈ò â¸e´£z ¢Ó≈y!ïÑ¸ ¢Ó˚ú– v¸z!qˆÏîÓ˚ ¢yˆÏúyÑ¸¢ÇˆÏŸ'ˆÏ°ÏÓ˚ ≤Ãïyòì¸õ v¸z¸ôyîyò £ú Ñ¸yÓ≈ò– ≤ÃÑ‚¸!ì¸Ó˚ Ñ¸yÓ≈ˆÏòÓ˚ Ó˝úyÇü£z ¢õ%ˆÏo Óy£zÈÙÈÑ¸yÓ≈ˆÏò›¸ !£¢yˆÏÓ ¢!M¸Èì¸ ÌyÑ¸ˆÏúÁ ~£z Ñ¸yÓ≈ˆÏòÓ˚ ¶¸y[¸yÓ˚£z ÓyÎ˚%Ó˚ Ñ¸yÓ≈ˆÏòÓ˚ ¸ô!Ó˚õyí !òÎ˚s¸fí Ñ¸ˆÏÓ˚ – ¢ˆÏÓ≈y¸ô!Ó˚ Ñ¸yÓ≈ò â¸e´!›¸ ã#Ó Á ÓyÎ˚%!fl¸ìi¸ Ñ¸yÓ≈ˆÏòÓ˚ õˆÏïƒ£z xyÓ!ì≈¸ì¸ £Î˚ – ~Ñ¸!›¸ Óylfl¸ì¸ˆÏs¸f

84% **MATCHING BLOCK 67/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈òñ Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zv¸ Ó˚*ˆÏ¸ô

v¸zÍ¸ôyîÑ¸ S¢Ó%ã v¸z!qîV myÓ˚y ˆüy!°Ïì¸ £Î˚ – xì¸É¸ôÓ˚ v¸zÍ¸ôyîÑ¸ ˆÌˆÏÑ¸ ≤ÃÌõ hfl¸ˆÏÓ˚Ó˚ ÖyîÑ¸ñ ≤ÃÌõ hfl¸ˆÏÓ˚Ó˚ ÖyîÑ¸ ˆÌˆÏÑ¸ !mì¸#Î˚ hfl¸ˆÏÓ˚Ó˚ ÖyîÑ¸ ~ÓÇ ˆ¢Öyò ˆÌˆÏÑ¸ ¢ˆÏÓ≈yFâ¸ hfl¸ˆÏÓ˚Ó˚ ÖyîˆÏÑ¸Ó˚ õˆÏïƒ ¢M¸Èy!Ó˚ì¸ £Î˚ – ¢Ó˚ˆÏüˆÏ°Ï ~£z ¢Ñ¸ú ÖyîÑ¸ !ÓˆÏÎ˚yãÑ¸ myÓ˚y !ÓˆÏÎ˚y!ãì¸ £ˆÏÎ˚ Ñ¸yÓ≈òÓ˚*ˆÏ¸ô ¸ô%òÓ˚yÎ˚ ÓyÎ˚%ˆÏì¸ !ö¸ˆÏÓ˚ ÌyÎ˚ – xÌ≈yÍñ ÓyÎ˚%!fl¸ìi¸ Ñ¸yÓ≈òÈÙÙÙv¸zÍ¸ôyîÑ¸ÈÙÙÙ ÈÖyîÑ¸ÈÙÙÙÈ!ÓˆÏÎ˚yãÑ¸ÈÙÙÙÈÓyÎ˚% ~£z¶¸yˆÏÓ â¸e´!›¸ ¢¡ôß¨ £Î˚ – NSOU ? AE-ES-21 ? 53 v¸zÍ¸ôyîÑ¸ äÈyv¸¸yÁ ¢õ%ˆÏoÓ˚ ãúñ ≤Ãhfl¸Ó˚Ö[¸ñ â%¸òy¸ôyÌÓ˚ñ !üúy ≤Ã¶‚¸!ì¸ ÓyÎ˚%Ó˚ Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zv¸ ˆüy°Ïí Ñ¸ˆÏÓ˚ !Ó!¶¸ß¨ ïyì¸Ó Ñ¸yÓ≈ˆÏò›¸ Ü‡¸ò Ñ¸ˆÏÓ˚ – ~ äÈyv¸¸yÁ Ñ¸Î˚úy Á ˆ¸ôˆÏ›¸∆y!úÎ˚yõ ãyì¸ oˆÏÓƒÓ˚ î£ò Á ¶)¸Ü¶≈¸fl¸i Ñ¸ˆÏÎ˚Ñ¸ ≤ÃÑ¸yÓ˚ ã#Óyí%Ó˚ üyÓ˚#Ó˚Ó˚_#Î˚ !e´Î˚yÓ˚

ö¸ˆÏú ÓyÎ˚%õ[¸ˆÏú

90% **MATCHING BLOCK 68/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí Ó‚!k¸ ¸

ôyÎ˚ –
xyˆÏ@¿Î˚!Ü!Ó˚ Á v¸z°à ≤Ãfl¸ÀÓí ˆÌˆÏÑ¸À

54% **MATCHING BLOCK 69/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zx:y£zv¸ !òÜ≈ì¸ £Î˚ – Ñ¸yÓ≈ò v¸y£zx:y£zˆÏv¸Ó˚

ãúã ¸ôÎ≈yÎ˚ xïÉ˚Ï«¸¸ô ¸ôk¸!ì¸ ˆÏì¸ ¢¡ôß¨ £Î˚ – Ñ¸yÓ≈ò v¸y£zx:y£zv¸ ãˆÏúÓ˚ ¢ˆÏD !Ó!e´Î˚yÎ˚ Ñ¸yÓ≈!òÑ¸ xƒy!¢v¸ (H 2 CO 3) v¸zí¸ôß¨ Ñ¸ˆÏÓ˚ – !Ó!e´Î˚y!›¸ ¢Ó≈îy !Ó¸ôÓ˚#ì¸õ%Ö# £ÁÎ˚yÓ˚ ãòƒ Ñ¸yÓ≈!òÑ¸ xƒy!¢v¸ Á£z !Ó¸ôÓ˚#ì¸õ%Ö# !Ó!e´Î˚yÎ˚ H + ~ÓÇ CH 3 - xyÎ˚ˆÏò ˆ¶¸ˆÏà ÌyÎ˚ – !Ó!e´Î˚yÓ˚ ¢õ#Ñ¸Ó˚í!›¸ !òj¨Ó˚*¸ôÈÙÙÙÈ CO 2 + H 2 O ? H 2 CO 3 ? H + + HCO 3 – SÑ¸yÓ≈! òÑ¸ xƒy!¢v¸V HCO 3 – ? 2H + + CO 3 – SÓy£zÑ¸yÓ≈ˆÏò›¸V SÑ¸yÓ≈ˆÏò›¸V !òˆÏ¡¨Ó˚ !â¸ˆÏe ~Ñ¸!›¸ Óylfl¸ì¸ˆÏs¸fÓ˚ Ñ¸yÓ≈ò â¸e´ ˆîÖyˆÏòy £úÈÙÙÙÈ !â¸e ≠ ≤ÃÑ¸¸!ì¸ˆÏì¸ Ñ¸yÓ≈ò â¸e´ 3.10.2.2 òy£zˆÏ›¸Δyˆ Ïãò â¸e´ ã#ÓˆÏîˆÏ£Ó˚ xòƒì¸õ ≤Ãïyò ¢ÇÜ‡¸Ñ¸ Ólfl¸!›¸ £ú ˆ≤Ãy!›¸ò– ~£z ˆ≤Ãy!›¸ò £y£zˆÏv»¸yˆÏãòñ òy£zˆÏ›¸ΔyˆÏãòñ x!:ˆÏãò ~ÓÇ Ñ¸yÓ≈ò á!›¸ì¸ ¸ôîyÌ≈– Ñ¸yˆÏã£z Óúy ˆÎˆÏì¸ ¸ôyˆÏÓ˚ òy£zˆÏ›¸ΔyˆÏãò ã#ÓˆÏîˆÏ£Ó˚ xòƒì¸õ ≤Ãïyò v¸z¸ôîyò– ÓyÎ˚%õ[¸ˆÏú üì¸Ñ¸Ó˚y 78 ¶¸yÜ òy£zˆÏ›¸ΔyˆÏãò ÌyÑ¸y ¢ˆÏ_¥Á v¸z!qî ì¸y ≤Ãì¸ƒ«¸¶¸yˆÏÓ @˘Ã£í Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ òy– v¸z!qîÓ˚y õy!›¸ˆÏì¸ xÓ!fl¸ïì¸ñ oˆÏÓƒ

83% **MATCHING BLOCK 70/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

òy£zˆÏ›¸Δ›¸ ˆÌˆÏÑ¸ òy£zˆÏ›¸ΔyˆÏãò @˘Ã£í Ñ¸ˆÏÓ˚ ˆ≤

Ãy!›¸ˆÏò Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ xlÓy !ü¡Jãyì¸#Î˚ Ñ¸ˆÏÎ˚Ñ¸!›¸ v¸z!qî ì¸yˆÏíÓ˚ õ)ˆÏú xÓ!fl¸ïì¸ Ñ¸ì¸=!ú !õˆÏlyã#Ó# ÓƒyÑ¸ˆÏ›¸! Ó˚ˆÏÎ˚yÓ˚ ¢y£yˆÏÎƒ ≤Ãì¸ƒ«¸¶¸yˆÏÓ òy£zˆÏ›¸ΔyˆÏãòˆÏÑ¸ õ¸!_Ñ¸y!fl¸ïì¸ Ñ¸ˆÏÓ˚ – 54 ? NSOU ? AE-ES-21 ≤ÃÑ¸¸!ì¸fl¸i òy£zˆÏ›¸ΔyˆÏãò ¸ôyÓ˚õyìÓÑ¸ xÓfl¸iyÎ˚ xƒyˆÏõy!òÎ˚yÎ˚ xyÓk¸ £Î˚ – xì¸É¸ôÓ˚ ~£z xƒyˆÏõy!òÎ˚y ~ÓÇ òy£zˆÏ›¸Δ›¸ Ó¸!‹TÓ˚ ãˆÏúÓ˚ õyìƒˆÏõ õy!›¸ˆÏì¸ ˆòˆÏõ xyˆÏ¢ ~ÓÇ ˆ¢ÖyˆÏò !õ!◊ì¸ £Î˚ – ~£z !õ!◊ì¸ xƒyˆÏõy!òÎ˚y v¸zFâ¸ ˆ◊!íÓ˚ v¸z!qî myÓ˚y xƒyˆÏõy!òÎ˚y xyÎ˚ò (NH 4 -) !£¢yˆÏÓ ˆüy!ºì¸ £ˆÏì¸ ¸ôyˆÏÓ˚ – xòƒ ¸ôk¸!ì¸ˆÏì¸ !Ñ¸ä%È ÓƒyÑ¸ˆÏ›¸!ÓˆÎ˚yñ äÈeyÑ¸ ~ÓÇ ò#úy¶¸ ¢Ó%ã ˜üÓyú ÓyÎ˚%!fl¸ïì¸ òy£zˆÏ›¸Δyãòˆ ÏÑ¸ !òÉ¢y!Ó˚ì¸ Ñ¸ˆÏÓ˚ ~ÓÇ £y£zˆÏv»¸yˆÏãˆÏòÓ˚ ¢ˆÏD ~Ó˚ !Ó!e´Î˚yÎ˚ xƒyˆÏõy!òÎ˚y v¸zí¸ôß¨ £Î˚ – õ¸!_Ñ¸y!fl¸ïì¸ xƒyˆÏõy!òÎ˚y ãú Á Ñ¸ˆÏÎˆÑ¸!›¸ Ó˚y¢yÎ˚!òÑ¸ ¸ôîyˆÏÌ≈Ó˚ ¢Çfl¸ôˆÏü≈ ~ˆÏú xƒyˆÏõy!òÎ˚y á!›¸ì¸ úÓˆÏí ¸ô!ÓÓ˚ïì¸ £Î˚ Óy ~£z xƒyˆÏõy!òÎ˚y õ¸!_Ñ¸yÎ˚ xÓ!fl¸ïì¸ Ñ¸ˆÏÎˆÑ¸!›¸ ÓƒyÑ¸ˆÏ›¸!ÓˆÎ˚yÓ˚ SòyÎ˚£

58% **MATCHING BLOCK 71/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

zˆÏ›¸ΔyˆÏ¢yˆÏõyòy¢V ≤Ã¶¸yˆÏÓ ãy!Ó˚ £ˆÏÎ˚ òy£zˆÏ›¸ΔˆÏ›¸ ¸ô!Ó˚ì¸ £Î˚ – òy£zˆ

Ï›¸Δy ˆÏ¢yˆÏõyòy¢ 2NH 3 + 3O 2 → 2NO 2 + 2H 2 O + 2H + Sòy£z›¸Δy£z›¸V xì¸É¸ôÓ˚ ~£z òy£z›¸Δy£z›¸ òy£zˆÏ›¸ΔyÓƒyQÓ˚ òyõÑ¸ x¸ôÓ˚ ~Ñ¸!›¸ ÓƒyÑ¸ˆÏ›¸!ÓˆÎ˚y ≤Ã¶¸yˆÏÓ òy£zˆÏ›¸Δˆ Ï›¸ ¸ô!Ó˚ì¸ £Î˚ ÈÙÙÙÈ òy£zˆÏ›¸ΔyÓƒyQÓ˚ 2NO 3 - + O 2 2NO 3 + Sòy£zˆÏ›¸Δ›¸V ~£z î%£z!›¸ !Ó!e´Î˚y£z x!:ˆÏãˆÏòÓ˚ v¸z¸ô!fl¸!ì¸ˆÏì¸ á›¸ Ìy Ñ¸ ~ÓÇ ~£z á›¸ò¸ôy

100% **MATCHING BLOCK 72/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÏÑ¸ òy£z!›¸Δ!ö¸ˆ ÏÑ¸üò (Nitrification) ÓˆÏú–

fl¸∫ˆÏ¶¸yã# v¸z!qî¢õ)£ ~£z òy£zˆÏ›¸Δ›¸ @˘Ã£í Ñ¸ˆÏÓ˚ ~ÓÇ Öyîƒü‚C˚ˆÏúÓ˚ ¢)â¸òy £Î˚ – xyÓyÓ˚ ˆÎ ¸ôk¸!ì¸ˆÏì¸ òy£zˆÏ›¸Δ›¸ !Ó!Ÿ‹T £

75% **MATCHING BLOCK 73/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Î˚ ì¸yˆÏÑ¸ !v¸ÈÙÈòy£z!›¸Δ!ö¸ˆÏÑ¸üò (Denitrification) ÓˆÏú–

52% **MATCHING BLOCK 74/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó˚y£zˆÏãy!ÓÏÎ˚yõ òyõÑ¸ ~Ñ¸≤ÃÑ¸yÓ˚ ÓƒyÑ¸ˆÏ›¸!ÓˆÎ˚y Ó¢Óy¢ Ñ¸ˆÏÓ˚ – ~£z ÓƒyÑ¸ˆÏ›¸!ÓˆÎ˚y=!ú ≤Ãì¸ƒ«¸¶¸yˆÏÓ õ¸!_Ñ¸y!fl¸ïì¸ òy£zˆÏ›¸ΔyˆÏãò @˘Ã£í Ñ¸ˆÏÓ˚ ì¸

yˆÏÑ¸ òy£zˆÏ›¸ΔˆÏ›¸ ¸ô!Ó˚ì¸ Ñ¸ˆÏÓ˚ v¸z!qîˆÏÑ¸ ¢Ó˚ÓÓ˚y£ Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ – ¢yïyÓ˚ì¸ òy£zˆÏ›¸ΔyˆÏãò òy£zˆÏ›¸ΔˆÏ›¸ ¸ô!Ó˚ Ó!ï≈ì¸ £ÓyÓ˚ ¸ ôÓ˚ v¸z!qî myÓ˚y ˆüy!ºì¸ £

100% **MATCHING BLOCK 75/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Î˚ – ≤Ãyí# ~ÓÇ v¸z!qˆÏîÓ˚ õ¸ì%¸ƒÓ˚ ¸ôÓ˚ ì¸yˆ

ÏîÓ˚ ˆî£!fl¸ïì¸ ˆ≤Ãy!›¸ò õy!›¸ˆÏì¸ !õˆÏü ÌyÎ˚ – xyÓyÓ˚ ≤Ãyí#Ó˚ õúõ)e !ÓˆÏŸ!ºì¸ £ˆÏÎ˚ xƒyˆÏõy!òÎ˚y Ü!‡¸ì¸ £Î˚ – ~£z xƒyˆÏõy!òÎ˚y õ¸!_Ñ¸yÎ˚ xÓ!fl¸ïì¸

91% **MATCHING BLOCK 77/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

òy£z!›¸Δö¸y£zÇ ÓƒyÑ¸ˆÏ›¸!ÓˆÎ˚yÓ˚ Sòy£zˆÏ›¸ΔyˆÏ¢yˆÏõyòy¢

Á òy£zˆÏ›¸ΔyÑ¸E¸y¢V ¢y£yˆÏÎƒ xyÓyÓ˚ òy£zˆÏ›¸Δ›¸ úÓˆÏí ¸ô!Ó˚î¸ £Î˚ – ~£z òy£zˆÏ›¸ΔˆÏ›¸Ó˚ !Ñ¸ä%È›¸y v¸z!qî xyd¢yÍ Ñ¸ˆÏÓ˚ ~ÓÇ !Ñ¸Î˚îÇü !v¸

100% **MATCHING BLOCK 78/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

òy£z!›¸Δö¸y£zÇ ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚y

SÌyˆÏÎ˚yÓƒy!¢úy¢ñ õy£zˆÏe´yÑ¸E¸yV myÓ˚y õ%_´ òy£zˆÏ›¸ΔyˆÏãˆÏò ¸ô!Ó˚î¸ £ˆÏÎ˚ ÓyÎ˚%õ[¸ˆÏú !ö¸ˆÏÓ˚ ÎyÎ˚ – ~£z ≤ÃyÑ,¸!ì¸Ñ¸ ≤Ã!e´Î˚y=!úÓ˚ ö¸ˆÏú ≤ÃÑ,¸!ì¸fl¸i òy£zˆÏ›¸ΔyˆÏãò ÓyÎ˚%õ[¸ú ˆÌˆÏÑ¸ õy!›¸ˆÏì¸ñ õy!›¸ ˆÌˆÏÑ¸ v¸z!qˆÏîñ v¸z!qî ˆÌˆÏÑ¸ ≤Ãyí#ˆÏîˆÏ£ ~ÓÇ ¢ˆÏÓ≈y¸ô!Ó˚ v¸z!qî Á ≤Ãyí#Ó˚ ˆî£ ˆÌˆÏÑ¸ ¸ô%òÓ˚yÎ˚ õy!›¸ˆÏì¸ ~ÓÇ õy!›¸ ˆÌˆÏÑ¸ ÓyÎ˚%õ[¸ˆÏú !ö¸ˆÏÓ˚ xyˆÏ¢– ~£z fl¸∫ì¸É!òÎ˚!s¸fì¸ ≤Ã!e´Î˚yˆÏÑ¸ òy£zˆÏ›¸ΔyˆÏãò â¸e´ Óˆú– NSOU ? AE-ES-21 ? 55

!â¸e ≠ ≤ÃÑ,¸!ì¸ˆÏì¸ òy£zˆÏ›¸ΔyˆÏãò â¸e´ 3.11 xò%ü#úò# ¢!‡¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚&ò ≠ S1V Óylfl¸ì¸ˆÏs¸fÓ˚ ü!_´ ≤ÃÓy£ (i) ~Ñ¸õ%Ö# (ii) !mõ%Ö# (iii) Ó˝õ%Ö# (iv) ˆÑ¸yò!›¸ òÎ˚ S2V Ecology ü∑!›¸ ˆÑ¸ ≤ÃÓì≈¸ò Ñ¸ˆÏÓ˚ò/ (i) ~ !ã ›¸ƒy™!ú (ii) xyÓ˚ˆÏòfi›¸ ˆ£ˆÏÑ¸ú (iii) Áv¸yõ (iv) ÁˆÏÎ˚Ófi›¸yÓ˚ S3V Óylfl¸ì¸ˆÏs¸fÓ˚ ü!_´ !¸ôÓ˚y!õv¸ ¢Ó¢õÎ˚ÈÙÙÈ (i) Öyv¸¸y (ii) v¸zŒ›¸yˆÏòy (iii) Ñ¸ÖˆÏòy Öyv¸¸y Ñ¸ÖˆÏòy v¸zŒ›¸yˆÏòy (iv) ~Ñ¸!›¸Á òÎ˚ S4V ¸ôÓ˚ã#Ó#ˆÏîÓ˚ ˆ«¸ˆÏe ã#Ó¶¸Ó˚ !¸ôÓ˚y!õv¸ (i) Öyv¸¸y (ii) v¸zŒ›¸yˆÏòy (iii) Ñ¸ÖˆÏòy Öyv¸¸y Ñ¸ÖˆÏòy v¸zŒ›¸yˆÏòy (iv) ~Ñ¸!›¸Á òÎ˚ S5V MAB ÓúˆÏì¸ ˆÓyG¸yÎ˚ (i) Man and bacteria (ii) Man and Biosphere (iii) Man and biology (iv) Man and Biotic Community S6V Óylfl¸ì¸s¸f ˜ì¸!Ó˚ £Î˚ÈÙÙÈ 56 ? NSOU ? AE-ES-21

(i) ˜ãÓ v¸z¸ôyîyò myÓ˚y (ii) x˜ÏãÓ v¸z¸ôyîyò myÓ˚y (iii) ˜ãÓ Á x˜ÏãÓ v¸z¸ôyîyò myÓ˚y (iv) fl¸∫ˆÏ¶¸yã# ã#Ó myÓ˚y S7V Óylfl¸ì¸ˆÏs¸fÓ˚ ~Ñ¸!›¸ hfl¸Ó˚ ˆÌˆÏÑ¸ xyÓ˚ ~Ñ¸!›¸ hfl¸ˆÏÓ˚ ü!_´Ó˚ ¢Ó˚Óy£ £Î˚ÈÙÙÈ (i) 90% (ii) 100% (iii) 10% (iv) 1% S8V ˆÑ¸yò!›¸ ¢!‡¸Ñ¸ÈÙÙÈ (i) ˆüÎ˚yú < Óyá < !¢v¸zˆÏv¸yˆÏõyòy¢ < áy¢ < ÖÓ˚ˆÏÜy¢ (ii) áy¢ < !¢v¸zˆÏv¸yˆÏõyòy¢ < ÖÓ˚ˆÏÜy¢ < ˆüÎ˚yú < Óyá (iii) áy¢ < ˆüÎ˚yú < !¢v¸zˆÏv¸yˆÏõyòy¢ < ÖÓ˚ˆÏÜy¢ < Óyá (iv) áy¢ < ÖÓ˚ˆÏÜy¢ < ˆüÎ˚yú < Óyá < !¢v¸zˆÏv¸yˆÏõyòy¢ S9V ¢õ%ˆÏoÓ˚ õ%Öƒ v¸zÍ¸ôyîÑ¸ (i) ã%≤'yB¸›¸ò (ii) ö¸y£zˆÏ›¸y≤'yB¸›¸ò (iii) ˆòÑ¸›¸ò (iv) Ñ¸â%¸!Ó˚ ¸ôyòy S10V Óylfl¸ì¸ˆÏs¸f ü!_´Ó˚ v¸zÍ¢ (i) ì¸y¸ôü!_´ (ii) ˆ¢ÔÓ˚ü!_´ (iii) ¶)¸ì¸y¸ô ü!_´ (iv) ATP x!ì¸¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V Óylfl¸ì¸s¸f Ñ¸yˆÏÑ¸ ÓˆÏú/ ~£z ü∑!›¸ ˆÑ¸ ≤ÃíÎ˚ò Ñ¸ˆÏÓ˚ò/ S2V ÓyˆÏÎ˚yõ Ñ¸yˆÏÑ¸ ÓˆÏú/ v¸zîy£Ó˚í !îò– S3V ¢yõ%!oÑ¸ Óylfl¸ì¸ˆÏs¸fÓ˚ õ%Öƒ v¸zÍ¸ôyîÑ¸=!úÓ˚ òyõ !úÖ%ò– S4V ˆ¸ôÔ!‹TÑ¸ hfl¸Ó˚ Ñ¸yˆÏÑ¸ ÓˆÏú/ S5V ¢Ó≈¶)¸Ñ¸ Ñ¸yˆÏîÓ˚ ÓˆÏú/ v¸zîy£Ó˚í !îò– ¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V Óylfl¸ì¸ˆÏs¸fÓ˚ !Ó!¶¸ß¨ v¸z¸ôyîyò=!ú v¸zîy£Ó˚í ¢£ ÓƒyÖƒy Ñ¸Ó˚&ò– S2V Öyîƒ ü‚Cú Á Öyîƒ ãyú Ñ¸yˆÏÑ¸ ÓˆÏú v¸zîy£Ó˚í ¢£ ÓƒyÖƒy Ñ¸Ó˚&ò– S3V Óylfl¸ì¸ˆÏs¸fÓ˚ Öyîƒ ≤ÃÓy£ ì¸y¸ôÜ!ì¸!ÓîƒÓ˚ !òÎ˚õyò%¢yˆÏÓ˚ â¸ˆÏúÈÙÙÈxyˆÏúyâ¸òy Ñ¸Ó˚&ò– S4V Óylfl¸ì¸y!s¸fÑ¸ !¸ôÓ˚y!õv¸ !Ñ¸/!Ó!¶¸ß¨ ïÓ˚ˆÏòÓ˚ !¸ôÓ˚y!õv¸ ¢¡

100% **MATCHING BLOCK 76/200** **W**

ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S5V

òy£zˆÏ›¸ΔyˆÏãò â¸e´ Ñ¸yˆÏÑ¸ ÓˆÏúñ Óí≈òy !îò– v¸z_Ó˚ ¢ÇˆÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (i) ~Ñ¸õ%Ö# S2V (ii) xyÓ˚ˆÏòfi›¸ ˆ£ˆÏÑ¸ú S3V (i) Öyv¸¸y S4V (ii) v¸zŒ›¸yˆÏòy S5V (ii) Man and Biosphere S6V (iii) ˜ãÓ Á x˜ÏãÓ v¸z¸ôyîyò myÓ˚y S7V (iii) 100% S8V (iv) áy¢ < ÖÓ˚ˆÏÜy¢ < ˆüÎ˚yú < Óyá < !¸ôv¸zˆÏv¸yˆÏõyòy¢ S9V (ii) ö¸y£zˆÏ›¸y≤'yflÒ›¸ò S10V (ii) ˆ¢ÔÓ˚ü!_´ NSOU ? AE-ES-21 ? 57

~Ñ¸Ñ¸ 4 ã#Ó˜ÏÓ!â¸eƒ Á ì¸yÓ˚ ¢ÇÓ˚«¸í (Biodiversity and its conservation) Ü‡¸ò 4.0 v¸zˆÏjüƒ 4.1 ≤Ãhfl¸ÏyÓòy 4.2 ã#Ó ˜Ó!â¸ˆÏeƒÓ˚ ≤ÃÑ¸yÓ˚ˆÏ¶¸î (Types of Biodiversity) 4.3 !ÓŸªÈÙÈã#Ó˜ÏÓ!â¸eƒ (Global Biodiversity) 4.4 !Ó!¶¸ß¨ì¸yÓ˚ fl¸iy!òÑ¸ õy¸ôÑ¸y!‡¸ (Spatial Scales of Diversity) 4.5 ¶¸yÓ˚ˆÏì¸Ó˚ ã#ÓÈÙÈˆ¶¸ÔˆÏÜy!úÑ¸ ˆ◊!í!ÓòƒyÓ˚ (Biogeological Classification of India) 4.6 ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ =Ó˚&c (Values of Biodiversity) 4.7 ã#Ó˜ÏÓ!â¸eƒÈÙÈïòƒ xM¸Èú (Biodiversity Hotspots) 4.8 Ó‚£Í ã#Ó˜ÏÓ!â¸eƒ¸ô)í≈ ˆîü (Mega Biodiversity Nation) 4.9 ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÑ¸›¸ (Threats to Biodiversity) 4.10 ¶¸yÓ˚ˆÏì¸Ó˚ ¢ÇÑ¸›¸y¸ôß¨ Á xyM¸È!úÑ¸ ≤Ãäy!ì¸Ó˚ ã#Ó (Threatened and Endemic species of India) 4.11 ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÓ˚«¸í ≠ £zòÈÙÈ!¢›%¸ Á ~:ÈÙÈ!¢›%¸ (Conservation of Biodiverity: In-Situ & Ex- Situ) 4.12 Óylfl¸¢Çfl¸iyò ¸ô!Ó˚ˆÏ°ÏÓy (Ecosystem Services) 4.13 xò%ü#úò# 4.0 v¸zˆÏjüƒ ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ˆÏÓ˚ xy¸õ!l !l¡¨!°!áï¸ !Ó£ÏÎ˚=!° çylˆÏï¸ ¸õyÓ˚ˆÏÓl– ? ç#Ó˜ÏÓ!ã¸eƒ Ü¸yˆÏÜ¸ ÓˆÏ° ~ÓÇ !Ó!Ë¸ß¨ ≤ÃÜ¸yÓ˚ ç#Ó˜ÏÓ!ã¸eƒ– ? !ÓŸªç#Ó ˜Ó!ã¸eƒ G !Ó!Ë¸ß¨ï¸Ó˚ fliy!lÜ¸ Ùy¸õÜ¸y!ë¸– ? xyÙyˆÏòÓ˚ Ë¸yÓ˚ï¸ÓˆÏ£Ï≈Ó˚ ç#ÓÈüÈˆË¸ÔˆÏày!°Ü¸ ˆ◊î#!Ólƒy§– ? ç#Ó˜ÏÓ!ã¸ˆÏeƒÓ˚ =Ó˚&c ~ÓÇ §ÇÜ¸ê¸– ? Ë¸yÓ˚ˆÏï¸Ó˚ §ÇÜ¸ê¸y¸õß¨ G xyMÈ¸!°Ü¸ ≤Ãçy!ï¸Ó˚ ç#ˆÏÓÓ˚ ï¸y!°Ü¸y– ? •zlÈü!§ê%¸ G ~:ÈüÈ!§ê%¸ ¸õk¸!ï¸ˆÏï¸ ç#Ó˜ÏÓ!ã¸ˆÏeƒÓ˚ §ÇÓ˚«¸î–

4.1 ≤Ãhfl¸ÌyÓòy 1968 ¢y˘Ìú ≤ÃÖƒyì¸ !ÓK¸yò# Ú˘Ó˚õu¸ÈÙÈ~ö¸ÈÙÈv¸y¢õƒyòÛ (Raymond F. Dasmen) ì¸yÓ˚ ˆúÖy Ó£z "A different kind of country" ˆì¸ ¢Ó≈≤ÃÌõ ã#Ó˘ÏÓ!â¸eƒ (Biodiversity) ü∑!›¸Ó˚ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ò– ã#Ó˘ÏÓ!â¸eƒ ü∑!›¸Ó˚ v¸zqÓ £Î˚ ÚÚã#ÓãÜ˘Ì¸Ó˚ ˘Ó!â¸eƒ ˆÌˆÏÑ¸ÛÛñ Ñ¸Ìy!›¸ W. G. Robsen, 1985 ¢y˘Ìú ÈNational Forum on Biological DiversityÙÈ ˆì¸ Ó˚ˆÏúò– ! Ñ¸ls¸ v¸z£zú¢ò (E. O. Wilson) 1988 ¢y˘Ìú ~Ñ¸!›¸ ¸ô%!hfl¸Ñ¸yÎ˚ ã#Ó˘ÏÓ!â¸ˆÏeƒÓ˚ ¢¡ô˘ÏÑ≈¸ !Óhfl+¸ì¸ Óí≈òy Ñ¸ˆÏÓ˚ò– ü∑!›¸Ó˚ Ó#ã !ò£#ì¸ !äÈú â¸yú≈¢ v¸yÓ˚v¸z£z˘ÏòÓ˚ Ú≤ÃyÑ¸Ì¸!ì¸Ñ¸ !òÓ≈yâ¸òÓyî ì¸˘Ï_¥Û S1859V– !ì¸!ò !ÓŸªy¢ Ñ¸Ó˚˘Ìì¸ò Ó˚*¸ô˘Ï¶¸î xõ)úÑ¸ Óy xÑ¸yÓ˚í òÎ˚ñ ã#Ó !ÓÓì≈¸˘ÏòÓ˚ öyïƒ˘Ïõ òyòy Ó˚*¸ô˘Ï¶¸î ¸ô!Ó˚Ó!ì≈¸ì¸ £Î˚– xyò%öy!òÑ¸ ¸ôßyâ¸ ˆÑ¸y!›¸Ó˚Á ˆÓ!ü ã#ÓÑ)¸ú ¸ô¸!ÌÓ#˘Ì¸ !ÓîƒÕöyò– ~Ñ¸õye ¸ô¸!ÌÓ#˘Ì¸£z ˆ¢ÓÓ˚ãÜ˘Ì¸Ó˚ õ˘Ïïƒ ≤Ãy˘ÏíÓ˚ x!hfl¸c xy˘ÏäÈ– ì¸yÓ˚ ~Ñ¸õye Ñ¸yÓ˚í ¢)Î≈ ˆÌˆÏÑ¸ ¢!‡¸Ñ¸ î)Ó˚c ÓãyÎ˚ ÌyÑ¸yÓ˚ ãòƒñ ÌyÓ˚ ö¸úfl¸ÍÓ˚*¸ô Üv¸¸ ì¸y¸õòyey 15 0 c ~ÓÇ ÓyÎ˚%õ[¸ˆÏúÓ˚ v¸z¸ô!fl¸ì!ì¸Ó˚ ö¸ˆÌú «¸! ì¸Ñ¸yÓ˚Ñ¸ xy˘ÏúyÑ¸Ó˚!Ÿ¬ ˆÏõòÈÙÙÙÈ õ£yÜ!ì¸Ñ¸ Ó˚!Ÿ¬x!ì¸˘ÏÓ=ò# Ó˚!Ÿ¬ ≤ÃÑ¶¸!ì¸ ¸ô¸!ÌÓ#˘Ì¸ xy¢˘Ì¸ ¸ôy˘ÏÓ˚ òyì¸yÓ˚ ö¸ˆÌú ã#ÓÑ)¸ú !ÓòœT £Î˚ òy– ¢Ó≈¢yÑ%¸ ˆÏúƒ ¸ôÎ≈yÆ ¢)Î≈yúÑ¸ñ äúÓyÎ˚% ¢‚!œTÓ˚ ¢!‡¸Ñ¸ v¸z¸ô!fl¸ì!ì¸Ó˚ äòƒ ¸ô¸!ÌÓ# ≤ÃyˆÏíÓ˚ ! ÓÑ¸yˆÏüÓ˚ äòƒ v¸z¸ôÎ%_ £ˆÏÌ v¸zˆÏ‡¸ˆÏäÈ– ã#Ó˘ÏÓ!â¸eƒ Ñ¸#›¸ ¸ô¸!ÌÓ#ˆÌ¸ ≤ÃÌõ ≤ÃÏyˆÏúÓ˚ ¢M¸ÈyÓ˚ £Î˚ xyò%öy!òÑ¸ 3.7 üì¸ˆÏÑ¸y!›¸ ÓäÈÓ˚ xyˆÏÜ– ì¸yÓ˚ ¸ôÓ˚ ˆÌˆÏÑ¸ òyòy x!¶¸ˆÏyãò Á !ÓÓì≈¸˘ÏòÓ˚ öyïƒ˘Ïõ !Ó!¶¸ß˚ ˘Ó!ü‹TƒïyÓ˚# ã#ˆÏÓÓ˚ ¢¸!‹T £ˆÏÎ˚ˆÏäÈ– ~Ñ¸!›¸ Óylfl¸ì¸ˆÏs¸fÓ˚ õ˘Ïïƒ !Ó!¶¸ß˚ ã#Ó Á ≤Ãäy!ì¸Ó˚ õ˘Ïïƒ ˆÏ ˘Ó!â¸ˆÏeƒÓ˚ ¸ôyÌ≈Ñ¸ƒ ú«¸ Ñ¸Ó˚y ÌyÎ˚ ì¸yˆÏÑ¸ ˙ Óylfl¸ì¸ˆÏs¸fÓ˚ ã#Ó˘ÏÓ!â¸eƒ Óúy £Î˚– !Ó˚ÁÈÙÈ!v¸ÈÙÈ˘ã!ò˘ÏÓ˚y˘Ïì¸ S1992V ¢y˘Ìú xò%!¤¸ì¸ !ÓŸªãyì¸# ¢˘Ïìøú˘Ïò ã#Ó˘ÏÓ! â¸eƒˆÏÑ¸ ¢ÇK¸y!Î˚ì¸ Ñ¸Ó˚y £Î˚ ~ÓÇ Óúy £Î˚ ¶)¸ÈÙÈ¶¸yÜñ ¢õ%o Á xòƒòyòƒ ãú¶¸yÓ˚ ˘ÏÜÓ˚ Óylfl¸ì¸ˆÏs¸fÓ˚ õ˘Ïïƒ xÓfl¸iyòÑ¸yÓ˚# ã#! Óì¸ ≤ÃyÍ# Óy v¸z!q˘ÏîÓ˚ ˆÎ ¸ôyÌ≈Ñ¸ƒ ú«¸ƒ Ñ¸Ó˚y ÌyÎ˚ ì¸yˆÏÑ¸ ã#Ó˘ÏÓ!â¸eƒ Óúy £Î˚– 4.2 ã#Ó ˘Ó!â¸ˆÏeƒÓ˚ ≤ÃÑ¸yÓ˚ˆÏ¶¸î (Types of Biodiversity) ã#Ó˘ÏÓ!â¸eƒ ≤Ãîyòì¸ !ì¸ò!›¸ ¸ôÎ≈y˘ÏÎ˚ !ÓÑ¸_´– ˆÌõòÈÙÙÙÈ S1V ≤Ãäy!ì¸ã!òì¸ ˘Ó!â¸eƒ (Species Diversity) S2V !äò ã! òì¸ ¸ôyÌ≈ˆÏÑ¸ƒÓ˚ Ñ¸yÓ˚ ˆÏí ¢¸!‹T ˘Ó!â¸eƒ (Genetic Diversity) S3V Óylfl¸ì¸s¸f ã!òì¸ ˘Ó!â¸eƒ (Ecosystem Diversity)– S1V ≤Ãäy!ì¸ã!òì¸ ˘Ó!â¸eƒ (Species Diversity) ≠ ã#ˆÏÓÓ˚ üyÓ˚#Ó˚Ñ¸ ˘Ó!ü‹Tƒ=!úÓ˚ Óy ˆö¸ˆÏòy›¸y£z!¸ôÑ¸ â¸!Ó˚e=!úÓ˚ õ˘Ïïƒ !Ó!¶¸ß˚ì¸y˘ÏÑ¸ ≤Ãäy!ì¸ã!òì¸ ˘Ó!â¸eƒ Óúy £Î˚– â¸!Ó˚e=!ú £ú xDfl¸iy!òÑ¸ñ üyÓ˚#Ó˚Ó˚Ó‚_#Ì˘ñ ˘ãÓ Ó˚y¢yÎ˚ˆÏ!òÑ¸ Óy fl¸∫¶¸yÓÜì¸ – v¸zîyÓ˚í fl¸∫Ó˚*¸ô Óúy ÌyÎ˚ ¢õ@˘Ã !ÓˆÏŸª ˆöy›¸ ≤ÃyÎ˚ 6100 ïÓ˚ˆÏòÓ˚ öyˆÏäÈÓ˚ ≤Ãäy!ì¸ xyˆÏäÈ– S2V !äòÜì¸ ˘Ó!â¸eƒ (Genetic Diversity) ≠ ¢yõyòƒì¸õ !ãˆÏòÓ˚ ¢ÇÜ‡¸ˆÏòÓ˚ ¸ôyÌ≈ˆÏÑ¸ƒÓ˚ Ñ¸yÓ˚ˆÏí ~Ñ¸£z ≤Ãäy!ì¸Ó˚ !¶¸ß˚ ¢î˘ÏÇƒÓ˚ õ˘Ïïƒ !

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Ó!¶¸ß˚ì¸y úÑ¸ƒ Ñ¸Ó˚y ÌyÎ˚– ˆ

Ìõò ~Ñ¸!›¸ ≤Ãäy!ì¸Ó˚ õ˘Ïïƒ ¶¸ƒÓ˚yÓ˚y£z!›¸ñ v¸z¸ôãy!ì¸ ~ÓÇ strain ¸ô!Ó˚ú!«¸ì¸ £Î˚ Ìy ~ˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ ˆÌˆÏÑ¸ ¢yõyòƒ £˘ÏúÁ xyúyîyñ xy«¸!ÓˆÏÑ¸ ¶¸yˆÏÓ Óúy â¸ˆÌú ã#òÜì¸ ˘Ó!â¸eƒ £ú ~Ñ¸!›¸ ã#ˆÏÓÓ˚ õ˘Ïïƒ !òv¸z!Ñœ¸Á›¸y£zv¸ñ ˆe´yˆÏyãõ Á !äˆÏòÓ˚ !Ó!¶¸ß˚ì¸y– S3V Óylfl¸ì¸s¸f ã!òì¸ ˘Ó!â¸eƒ (Ecosystem Diversity) ≠ ~Ñ¸!›¸ ˆ¶¸Ô˘ÏÜy!úÑ¸ ˆ«¸ˆÏeÓ˚ õ˘Ïïƒ Óylfl¸ì¸s¸f=!úÓ˚ õ˘Ïïƒ ˆÎ !Ó!¶¸ß˚ì¸y ˆÏÖ˘Ïì¸ ¸ôyÁÎ˚y ÌyÎ˚ ì¸yÓ˚ Óylfl¸ì¸s¸f ã!òì¸ ˘Ó!â¸eƒ Óúy £Î˚– ~Ñ¸!›¸ Óylfl¸ì¸ˆÏs¸fÓ˚ ˘Ó!â¸ˆÏeƒÓ˚ ¸ô!Ó˚Ó!ì≈¸ò £ˆÏú ì¸yÓ˚ ¸ flìiy˘Ïò Ó¢Óy¢Ñ¸yÓ˚# ã#ˆÏÓÓ˚ üyÓ˚#Ó˚Ñ¸ Óy !äòÜì¸ ˘Ó!â¸ˆÏeƒÓ˚Á ¸ô!Ó˚Ó!ì≈¸ò £Î˚– ì¸y£z Óylfl¸ì¸ˆÏs¸fÓ˚ ˘Ó!â¸ˆÏeƒ ã#Ó˘ÏÓ! â¸ˆÏeƒÓ˚ ~Ñ¸!›¸ v¸z˘ÏÕ˘ÏÖÜˆÏÌyÜƒ v¸z¸ôyîyòÁ Óy â¸ˆÌú– NSOU ? AE-ES-21 ? 59

4.3 !ÓŸªÈÙÈã#Ó˘ÏÓ!â¸eƒ (Global Biodiversity) ¸ô¸!ÌÓ#˘Ì¸ ¢!‡¸Ñ¸ Ñ¸ì¸=!ú ≤Ãäy!ì¸ xyˆÏäÈ ì¸yÓ˚ ˆÑ¸yò ¢!‡¸Ñ¸ v¸z_Ó˚ £Î˚ òy ì¸ˆÌÓñ ≤ÃyÎ˚ 100ÈÙÈ130 ú«¸ ≤Ãäy!ì¸ ÌyÑ¸ˆÌ¸ ¸ôyˆÏÓ˚ ì¸y !ÓK¸yò# õ£ú xò%õyò Ñ¸ˆÏÓ˚ò– Óúy £Î˚ ~Öò ¸ôÎ≈hs¸ ¸ô¸!ÌÓ#˘Ì¸ Ó¢ÓyÜÑ¸yÓ˚# ã#ˆÏòÓ˚ öye 30% ≤Ãäy!ì¸ˆÏÑ¸ !â¸!£´!Ñ¸Ó˚í Ñ¸Ó˚y ¢Ω¸Ó £Î˚ˆÏäÈ– ˆöy›¸ 1.5ÈÙÈ1.76 !õ!úÎ˚ò ≤Ãäy!ì¸Ó˚ õ˘Ïïƒ 10ñ20ñ007 ≤Ãäy!ì¸Ó˚ ¸ôì¸D ˆ◊!í 2ñ50ñ000 =ÆÓ#!ã v¸z!qî ~ÓÇ 1ñ02ñ000 xˆÏõÓ˚&î[¸# ≤Ãyí# ~ÓÇ Óy!Ñ¸ ≤Ãäy!ì¸ñ ˆõÓ˚&î[¸#ñ Óƒy_Ó#!ãñ äÈÈeyÑ¸ Á xyò%Ó#«¸!íÑ¸ ã#ˆÏÓÓ˚ xhs¸Ü≈ì¸– !ÓŸªã#Ó ˘Ó!â¸eƒ (World Biodiversity Data) e˙!õÑ¸ ¢ÇÖƒy @˘Ã&¸ô ≤Ãäy!ì¸Ó˚ ¢ÇÖƒy 1 xyò%Ó#«¸!íÑ¸ ã#Ó 11ñ512 2 äÈeyÑ¸ 46ñ983 3 úy£zˆÏÑ¸ò 17ñ000 4 ˘üÓyú 40ñ800 5 Ó˚yˆÏ¸ö¸y£z›¸ 14ñ500 6 ˆ›¸!Ó˚ˆÏv¸yö¸y£z›¸ 12ñ000 7 Óƒy_Ó#!ã 650 8 =ÆÓ#!ã 250ñ000 9 ¸ôì¸D 10ñ20ñ007 10 ˆ≤Ãy˘ì¸y˘Ïãy˘Îy 31ñ250 11 õyäÈ 32ñ120 12 v¸z¶¸â¸Ó˚ 6ñ771 13 ¢Ó˚#¢¸ô 9ñ230 14 ¸ô«¸# 9ñ026 15 hfl¸ôƒ ¸ôyÎ˚# 5ñ516 Sv¸zÍ¢ ≠ India's 5th National Report to the convention on Biological Diversity, 2014V 4.4 !Ó!¶¸ß˚ì¸Ó˚ fl¸iy!òÑ¸ õy¸ôÑ¸y!‡¸ (Spatial Scales of Diversity) 1960 ¢y˘Ìú ˘£zˆÏ›¸Ñ¸yÓ˚ (Whittaker) ã#Ó˘ÏÓ!â¸eƒˆÏÑ¸ñ ˆ¶¸Ô˘ÏÜy!úÑ¸ xÓfl¸iyˆÏòÓ˚ !¶¸!_ˆÌ¸ ≤Ãäy!ì¸Ó˚ !Ó!¶¸ß˚ì¸yˆÏÑ¸ !ì¸ò!›¸ hflˆÏÓ˚ ¶¸yÜ Ñ¸ˆÏÓ˚ò– 60 ? NSOU ? AE-ES-21

S1V xyúö¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ (ααααα-Diversity) ≠ ~Ñ¸!›¸ ˆäÈy›¸ ~Ñ¸£z Ó˚Ñ¸õ ˆ¶¸Ô˘ÏÜy!úÑ¸ fl¸iy˘ÏòÓ˚ õ˘Ïïƒ Ì¸=!ú !¶¸ß˚ ≤Ãäy!ì¸ xÓfl¸iyò Ñ¸Ó˚ˆÌ¸ ¸ôyˆÏÓ˚ ì¸yˆÏÑ¸ ÁÆz fl¸iyˆÏòÓ˚ xyúö¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ Óúy £Î˚– S2V !Ó›¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ (βββββ-Diversity) ≠ î%!›¸ ˆ¶¸Ô˘ÏÜy!úÑ¸ fl¸iyˆÏòÓ˚ õ˘Ïïƒ ~ˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ ˆÌˆÏÑ¸ Ì¸=!ú !¶¸ß˚ ≤Ãäy!ì¸ xÓfl¸iyò Ñ¸ˆÏÓ˚ ì¸yˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ fl¸∫yˆÌ¸ô˘Ï«¸ !Ó›¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ Ó˚ˆÏú– !Ó›¸yÈÙÈ!v¸¶¸yÓ˚!¢!›¸Ó˚ xÌ≈ £ú Ñ¸õ ¢yõyO¢ƒ ô)Ïí≈ ≤Ãäy!ì¸Ó˚ xÓfl¸iyò– S3V ÜyõyÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ (γγγγγ-Diversity) ≠ ~Ñ¸!›¸ Ó¸£Î˚ ˆ¶¸Ô˘ÏÜy!úÑ¸ ˆ«¸ˆÏeÓ˚ õ˘Ïïƒ xÓfl¸iyòÑ¸yÓ˚# ¢õ@˘Ã !Ó!¶¸ß˚ ≤Ãäy!ì¸ˆÏÑ¸ ˆ«¸ˆÏeÓ˚ ÜyõyÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ Óúy £Î˚ – ~!›¸ !Ñ¸ä%È›¸y xyúö¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸Ó˚ ôyÎ˚ – ÷ï%õye Ó¸£Î˚ ˆ¶¸Ô˘ÏÜy!úÑ¸ ˆ«¸ˆÏeÓ˚ ~Ó˚ Ü!íòy Ñ¸Ó˚y £Î˚ – !ò˘Ïì¸ ˆ«¸ˆÏÓ˚ ~ˆÏÓ˚ Ü!íòy Ñ¸Ó˚y £Î˚ – !ò˘Ïì¸ˆÏÓ˚ ~ÓÇ ÜyõyÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ (α, β & γ Diversity) ÓƒÓÖƒ Ñ¸Ó˚y £ú e˙!õÑ¸ Ñ¸y"!òÑ¸ xÓ˚ˆÏïƒ â¸yÓ˚í¶) !õ âúy¶)!õ ¢ÇÖƒy v¸z!qî ≤Ãäy!ì¸ 1 AA + + + 2 Aa + - - 3 BB + + - 4 Bb + - - 5 CC + - + 6 Cc - + + 7 DD + + - 8 Dd - + - 9 EE + - - 10 Ee + - - 11 FF + - - 12 Ff + + + xyúö¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ 10 6 4 ! Ó›¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ xÓ˚ˆÏïƒ≠ â¸yÓ˚í¶) !õ = 8 â¸yÓ˚í¶) !õ≠ äúy¶) !õ = 4 äúy¶) !õ≠ â¸yÓ˚í¶) !õ = 8 ÜyõyÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ 12 NSOU ? AE-ES-21 ? 61

4.5 ¶¸yÓ˚ˆÏì¸Ó˚ ã#ÓÈÙÈˆ¶¸Ô˘ÏÜy!úÑ¸ ˆ◊!í!ÓóƒyÜ (Biogeological Classification of India) ã#Óõ[¸ˆÏúÓ˚ ˆ¶¸Ô˘ÏÜy!úÑ¸ Ó˚^˘›¸ˆÏòÓ˚ õ%Öƒ xyˆÏúyâ¸ƒ !ÓÓ°Ï˚ £ú ≤Ãyí# Á v¸z!qî˘ÏÓ˚ Ó˚^˘›¸ò– ¶¸yÓ˚ˆÏì¸Ó˚ ˆÓ˚°Ï≈Ó˚ ≤ÃÑ¸!ì¸ñ ˆ¶¸Ô˘ÏÜy!úÑ¸ xÓfl¸iyòñ äúÓyÎ˚%Ó˚ v¸z¸ôÓ˚ ! ¶¸!_ Ñ¸ˆÏÓ˚ Ü˘Ìv¸¸ Á‡¸y ≤Ãyí# Á v¸z!qî˘ÏÜy¤¸#ˆÏÑ¸ 10!›¸ õ%Öƒ xM¸Èˆ˘Ìú ¶¸yÜ Ñ¸Ó˚y £ˆÏÎ˚ˆÏäÈ– ~£z xM¸Èú=!ú˘Ì¸ !Ó!¶¸ß˚ Óylfl¸ì¸ˆÏs¸fÓ˚

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v¸z¸ô!fl¸i!ì¸ ú«¸ƒ Ñ¸Ó˚y Îyΰ – ˆ

ÎõòÈÙÙÙÈ Óò¶)¸!õñ ì,¸í¶)¸!õñ ãúyüΈñ òî#ñ ãúy¶)¸!õ £zì¸ƒy!îñ ˆÎÖyˆÏò Ö%Ó£z !ò!î≈‹T ïÓ˚ˆÏíÓ˚ ≤Ãyí# Á v¸z!qî Ó¢Óy¢ Ñ¸ˆÏÓ˚ – ¶¸yÓ˚ˆÏì¸Ó˚ ã#ÓÈÙÈˆ¶¸ÔˆÏÜy!úÑ¸ xM¸Èú=!ú £ú≠ S1V !£õyúˆÏΈÓ˚ ì¸Ó˚y£z xM¸Èú ≠ !£õyúˆÏΈ v¸z_Ó˚ ¸ôyÓ≈ì¸ƒ xM¸ÈˆÏúÓ˚ ÓÓ˚yö¸yÓ‚ì¸ ü#ì¸ú úyîyÖ xM¸Èú– S2V

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ã¡ø% Á Ñ¸yŸ¬#Ó˚ñ !£õyâ¸ú ≤ÃˆÏîüñ

v¸z_Ó˚yÖˆÏ[¸Ó˚ ~ÓÇ v¸z_Ó˚ÈÙÈ¸ô!ÿ¸ˆÏõÓ˚ Ó˚yãƒ=!úÓ˚ !£õyúΈ ¸ôyÓ≈ì¸ƒ xM¸Èú– S3V fl¸∫“ ÷‹Ò xM¸Èú ≠ õÓ˚&¶)¸!õ ~ÓÇ ¸ô!ÿ¸õáy›¸ ¸ôÓ≈ì¸ õyúyÓ˚ õïƒÓì≈¸# ì,¸í¶)¸!õ xM¸Èú Îy õïƒ≤ÃˆÏîüñ äÈ!_üÜv¸¸ñ =ãÓ˚y›¸ ¸ôÎ≈hs¸ !Óhfl+¸ì¸ – S4V ¸ô!ÿ¸õáy›¸ ¸ôÓ≈ì¸õyúy ≠ ì¸y!Æ òî# ˆÌˆÏÑ¸ î!«¸í ¶¸yÓ˚ˆÏì¸Ó˚ õ£yÓ˚y‹T…ñ Ñ¸í≈y›¸Ñ¸ñ ˆÑ¸Ó˚yúy ¸ôÎ≈hs¸ !Óhfl+¸ì¸ – S5V v¸z_Ó˚ ¸ô)ˆÏÓ≈Ó˚ õÓ˚&¶)¸!õ xM¸Èú ≠ ¶¸yÓ˚ˆÏì¸Ó˚ ¢õ@˘Ã õÓ˚&¶)¸!õ xM¸Èúñ Ñ¸FäÈñ Ó˚yãfl¸iyòñ !î!Õ‘Ó˚ !Ñ¸ä%È xÇü ~£z xM¸ÈˆÏúÓ˚ xhs¸¶%≈¸_´– S6V ˆv¸Ñ¸yò õyú¶)¸!õ ≠ Ó‚!‹T¸ôyì¸ Ö%Ó£z fl¸∫“ £Î˚ ≤ÃyΈ 100 mmñ ˆäÈy›¸òyÜ¸ô%Ó˚ õyú¶)¸!õ ~£z xM¸ÈˆÏúÓ˚ õˆÏïƒ xÓ!fl¸ìì¸ – S7V ÜyˆÏDΈ xÓÓy!£Ñ¸y ≠ ÜDy òî#Ó˚ ¸ôyŸª≈Óì≈¸# xM¸Èú ~ÓÇ ˆÓúy¶)¸!õ– v¸z_Ó˚ÈÙÈ¸ô)Ó≈ ¶¸yÓ˚ˆÏì¸Ó˚ ~£z xM¸Èú ã#ÓÓ¢! ì¸ ¸ô)í≈ £Î˚ñ ¢yïyÓ˚îì¸ !â¸Ó˚£!Ó˚ì¸ ≤ÃÑ,¸!ì¸Ó˚ v¸z!qî ãß√yΈ ~ÓÇ

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Óy!°Ï≈Ñ¸ Ó‚!‹T¸ôyˆÏì¸Ó˚ ¸ô!Ó˚

õyí 1000 cm– xy¢yõñ !e¸ô%Ó˚yñ õ!í¸ô%Ó˚ £zì¸ƒy!î ~Ó˚ xhs¸¶≈%¸_´– S8V m#¸ô xM¸Èú ≠ xy®yõyò !òˆÏÑ¸yÓÓ˚ m#¸ô¸ô%Óñ ~ÖyˆÏò õƒyòˆÏ@˘Ãy¶¸ ãyì¸#Î˚ v¸z!qî ˆîÖˆÏì¸ ¸ôyÁΈy Îyΰ – S9V v¸z¸ôÑ)¸ú xM¸Èú ≠ ¶¸yÓ˚ˆÏì¸Ó˚ v¸z¸ôÑ)¸ú Ó‚£í xM¸Èú ã%ˆÏv¸¸ ! Óhfl+¸ì¸ ¢yïyÓ˚îì¸ òyÓ˚ˆÏÑ¸ú ÜyäÈñ õÍ¢ â¸y°Ïñ ~ÓÇ õƒyòˆÏ@˘Ãy¶¸ ≤Ããy!ì¸Ó˚ ÜyˆÏäÈÓ˚ ¢Ω¸yÓ˚ – 4.6 ã#ÓˆÏÓ!â¸ˆÏeƒÓ˚ =Ó˚&c (Values of Biodiversity) ã#ÓˆÏÓ!â¸eƒ ÓúˆÏì¸ ¸ô‚!ÌÓ#Ó˚ ≤Ãyí ¢¡ôîˆÏÑ¸£z ˆÓyG¸yΈ – ~£z ã#ÓˆÏÓ!â¸eƒˆÏÑ¸ ¶¸yú Ñ¸ˆÏÓ˚ ˆÓyG¸y îÓ˚Ñ¸yÓ˚ Ñ¸yÓ˚í ~Ó˚ v¸z¸ôÓ˚ ¸ô‚!ÌÓ#Ó˚ ˆÎ ˆÑ¸yò ≤Ãyí#Ó˚ ≤Ãyí ïyÓ˚í !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚ – ¸ô‚!ÌÓ#Ó˚ ≤ÃˆÏì¸ƒÑ¸!›¸ ã#Ó ˆÑ¸yò òy ˆÑ¸yòÁ ¶¸yˆÏÓ ~ˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ Á¸ôÓ˚ !ò¶≈¸Ó˚ü#ú– ~£z ã#ÓˆÏÓ!â¸eƒ ˜îò!®ò òyòy¶¸yˆÏÓ !Óò‹T £ˆÏFäÈñ ˆÎõòÈÙÙÙÈ Ó‚«¸ˆÏäÈîòñ Óò¶)¸!õ !Óò‹T Ñ¸Ó˚í– ¢ˆÏÓ≈y¸ô!Ó˚ ¸ô!Ó˚ˆÏÓü î)!°Ïì¸ £ˆÏFäÈ ì¸y ÓyΈ%ñ õ‚!_Ñ¸yñ ãú Óy ¢yõ%!oÑ¸ î)°Ïí£z ˆ£yÑ¸ òy ˆÑ¸ò– ¸ô%ˆÏÓ˚y¸ô%!Ó˚ õyòÓ ¢¡±îyˆÏΈ Ó˚ ¸ô!Ó˚ˆÏ≤Ã!«¸ˆÏì¸ ã#ÓˆÏÓ!â¸eƒˆÏÑ¸ ú«¸ƒ Ñ¸Ó˚ˆÏú Ó˝ã#ˆÏÓÓ˚ ÓƒÓ£y!Ó˚Ñ¸ v¸z¸ôˆÏÎy!Üì¸y ú«¸ƒ Ñ¸Ó˚

87% **MATCHING BLOCK 83/200** **J**

y Îyΰ – ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £

ú ≠ÈÙÈ 62 ? NSOU ? AE-ES-21

??õyò%°Ï Ó˝ îyòy ü¢ƒñ üyÑ¸¢∂#ñ ö¸úñ ö%¸úñ õyäÈñ õyÇ¢ñ !v¸õ £zì¸ƒy!î Öyîƒ !£¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ – ~!›¸ ã#ÓˆÏÓ! â¸ˆÏeƒÓ˚ ÓƒÓ£yÎ≈ƒ !îÑ¸ – ??ˆÓ!üÓ˚ ¶¸yÜ Öyîƒ e´yhs¸#Î˚ ãDˆÏúÓ˚ v¸z!qî ˆÌˆÏÑ¸ xyˆÏ¢– ??~ÖˆÏòy ¸ôÎ≈hs¸ Ü!Ó˚Ó ~ÓÇ xy! îÓy¢#Ó˚y ¸ôÓ˚¡ôÓ˚yÜì¸ ¶¸yˆÏÓ ÓˆÏòÔ°Ï!ïÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú– ??xyï%!òÑ¸ Ó˝ Ë°Ïï !òõ≈yí ¢Çfl¸iy Ó˝ Óòƒ≤Ãyí# ~ÓÇ

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v¸z!qˆÏîÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#

úñ ˆÎõòÈÙÙÙÈ !¢ˆÏB¸yòy ˆÌˆÏÑ¸ õƒˆÏú!Ó˚Î˚yÓ˚ Ë°Ïï ˜ì¸!Ó˚ £Î˚ñ Ó˚yv¸zú!ö¸Î˚y ¢yˆÏ¸ô≈!r›¸òy ˆÌˆÏÑ¸ v¸zFâ¸ Ó˚_´â¸yˆÏ¸ôÓ˚ Ë°Ïï ≤Ãlfl¸!ì¸ˆÏì¸ Ñ¸yˆÏã úyˆÏÜñ ˆÑ¸yˆÏÑ¸y xƒyòˆÏfl¸i!›¸Ñ¸ !£¢yˆÏÓ ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – ??Ó˝ xyò%Ó#«¸!íÑ¸ ≤Ãyí# xyˆÏäÈ îyÓ˚y Ö! òã ˆÓÓ˚ Ñ¸Ó˚ˆÏì¸ ~ÓÇ ¸ô!Ó˚ˆÏÓü î)°Ïí !òÓyÓ˚í Ñ¸Ó˚ˆÏì¸ ¸ôˆÏÓ˚ – ˆÎõòÈÙÙÙÈ !¢v¸zˆÏv¸yˆÏõyòy¢ ¸ô%!›¸v¸y (Pseudomonas putida) S¢%¸ôyÓ˚ÓyÜV Îy xˆÏΈú!fl¸ôúˆÏÑ¸ Ñ¸õyˆÏì¸ ¸ôyˆÏÓ˚ – ??~äÈyv¸¸y ã#ÓˆÏÓ!â¸eƒ ãDú ¸ôÎ≈›¸òñ ¸ô!«¸îü≈òñ ˆö¸yˆÏ›¸y@˘Ãy! ö¸ £zì¸ƒy!îÓ˚ ãòƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ– ¢õ@˘Ã !ÓˆÏŸªÓ˚ ¶¸yÓ˚¢yõƒ Ó˚«¸yÓ˚ ãòƒ ã#ÓˆÏÓ!â¸eƒ ~

100% **MATCHING BLOCK 86/200** **SA** Indrani-Bhattacharya_AsishKumarDas_History_Swa ... (D129738480)

Ñ¸!›¸ =Ó˚&c¸ô)í≈ ¶)¸!õÑ¸y ¸ôyúò Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– 4.7

ã#Ó˜ÏÓ!â¸eƒÈÙÈïòƒ xM¸Èú (Biodiversity Hotspots) ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢Ω¸yÓ˚ ¸ô,!ÌÓ#Ó˚ ¢Ó≈e ¢õ¶¸yˆÏÓ Ó!^˘›¸ì¸ òÎ˚– @˘Ã#‹øõ[¸ú#Ó˚ ˆîü=!úˆÏì¸ ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢õyˆÏÓü ¢ÓˆÏÌˆÏÑ¸ ˆÓ!ü– 1988 ¢yˆÏú !Ó !›¸ü ã#Ó !ÓΚ¸yò xyˆÏò≈fi›¸ ˆòyÓ˚õyò ˆõyÎ˚yÓ˚¢ (Ernest Norman Myers) ≤ÃÌõ Úã#Ó˜ÏÓ!â¸eƒÈÙÈïòƒ xM¸ÈúÛ (Biodiversity hotspot) ü∑!›¸ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ò– !ì¸!ò ¸ô,! ÌÓ#Ó˚ 18!›¸ x!ì¸≤Ããy!ì¸ ïòƒ xM¸Èú !ò!î≈‹T Ñ¸ˆÏÓ˚ò ~ÓÇ ~ˆÏîÓ˚ ã#Ó˜ÏÓ!â¸eƒ ïòƒ xM¸ÈˆÏúÓ˚ õˆÏïƒ ÌyÑ¸ˆÏì¸ £ˆÏú î%!›¸ õ%Öƒ ˜Ó! ü‹Tƒ ÌyÑ¸ˆÏì¸ £ˆÏÓ– ??Ñ¸õ¸ôˆÏ«¸ 0.5% Óy 1500 ≤Ããy!ì¸Ó˚ fl¸iyò#Î˚ v¸z!qî ÌyÑ¸ˆÏì¸ £ˆÏÓ– ??Ñ¸õ¸ôˆÏ«¸ 70% v¸z!qî ≤Ããy!ì¸ ≤ÃyÌ! õÑ¸ xÓfl¸iyò ˆÌˆÏÑ¸ ò‹T £ˆÏÎ˚ ˆÜˆÏäÈ– ¢õ@˘Ã !ÓˆÏŸª ~£zÓ˚Ñ¸õ ˆõy›¸ 34!›¸ xM¸Èú Ó˚ˆÏÎ˚ˆÏäÈ– ~£z xM¸Èú=!ú ¢õ@˘Ã !ÓˆÏŸªÓ˚ ≤Ãyí# v¸z!qˆÏîÓ˚ ≤ÃyÎ˚ 60% x!ïÑ¸yÓ˚#– ¶¸yÓ˚ˆÏì¸ Óì≈¸õyˆÏò 4!›¸ 'Hotspot' xyˆÏäÈ– ÎìyÈÙÙÙÈ S1V !£õyúÎ˚ xM¸Èú ≠ ~£z xM¸ÈˆÏúÓ˚ xhs¸¶%≈¸_´ñ ¶¸yÓ˚ˆÏì¸Ó˚ ¢õ@˘Ã !£õyúˆÏÎ˚Ó˚ xM¸Èú S~ÓÇ ¸ôy!Ñ¸hfl¸yòñ !ì¸Óπì¸ñ ˆò¸ôyúñ ¶%¸›¸yòñ â¸#ò Á õyÎ˚yòõyˆÏÓ˚Ó˚ !£õyúÎ˚ xM¸ÈúV S2V £zˆÏ®yÓyõ≈y xM¸Èú ≠ xy¢yõ äÈyv¸¸y ¢õ@˘Ã v¸z_Ó˚ÈÙÈ¸ô)Ó≈ ¶¸yÓ˚ì¸ ~ÓÇ xy®yõyò m#¸ô¸ô%O S~ÓÇ õyÎ˚yòõyÓ˚ñ Ìy£zúƒyu¸ñ !¶¸ˆÏÎ˚ì¸òyõñ Ñ¸ˆÏ¡∫y!v¸Î˚y ~ÓÇ î!«¸í â¸#òV ~£z xM¸ÈˆÏúÓ˚ xhs¸Ü≈ì¸– S3V ¢ %u¸yúƒyu¸ ≠ !òˆÏÑ¸yÓÓ˚ m#¸ô¸ô%O S~ÓÇ £zˆÏ®yˆÏò!üÎ˚yñ õyúˆÏÎ˚!üÎ˚yñ !¢Dy¸ô%Ó˚ñ ˆÓy!í≈Áñ !ö¸!ú!¸ôò¢V– S4V ¸ô!ÿ¸õáy›¸ ¸ôÓ≈ì¸õyúy ~ÓÇ ◊#úB¸y ≠ ¢õ@˘Ã ¸ô!ÿ¸õáy›¸ ¸ôÓ≈ì¸õyúy S~ÓÇ ◊#úB¸yV ~£z xM¸ÈˆÏúÓ˚ xhs¸Ü≈ì¸– NSOU ? AE-ES-21 ? 63 !â¸e ≠ ã#Ó˜ÏÓ!â¸eƒ ïòƒ xM¸Èú (Biodiversity hotspot in the world) 4.8 Ó,£Í ã#Ó˜ÏÓ!â¸eƒ¸ô)í≈ ˆîü (Mega Biodiversity Nation) ! ÓˆÏŸªÓ˚ ¢ÓˆÏÌˆÏÑ¸ ˆÓ!ü ã#Ó˜ÏÓ!â¸eƒ¸ô)í≈ ˆîü=!úˆÏÑ¸ Ó,£Í ã#Ó˜ÏÓ!â¸eƒ¸ô)í≈ ˆîü Óúy £Î˚ (Mega Biodiversity Nation)– ¢yïyÓ˚í ¶¸yˆÏÓ ˆõÜyÈÙÈÓyˆÏÎ˚yv¸y£z¶¸yÓ˚!¢!›¸ ˆîü=!ú v¸z°åõ[¸ˆÏú xÓ!fl¸ìì¸ Îy õÑ¸Ó˚e´y!hs¸ Á Ñ¸Ñ≈¸›¸e´ys¸f#Î˚ xM¸ÈˆÏúÓ˚ õˆÏïƒ xÓfl¸iyò Ñ¸ˆÏÓ˚– World Conservation Monitoring Center of the United Nation Environmental Program (UNEP-WCMC), 1988 ¢yú ˆÌˆÏÑ¸ ~£z !Ó°ÏÎ˚ !òˆÏÎ˚ Ñ¸yã Ñ¸ˆÏÓ˚ xy¢ˆÏäÈ– Óì≈¸õyˆÏò !ÓˆÏŸªÓ˚ 18!›¸ Ó,£Í ã#Ó˜ÏÓ!â¸eƒ¸ô)í≈ xM¸Èú xyˆÏäÈ ÎyˆÏîÓ˚ ÜˆÏv¸¸ 5000ÈÙÈ~Ó˚ ˆÓ!ü fl¸iy!òÑ¸ v¸z!qî xyˆÏäÈ– ˆîü=!ú £úÈÙÙÙÈ S1V Ó y!ãú S2V Ñ¸ú!¡ÍÎ˚y S3V £zÑ%¸ˆÏÎ˚v¸Ó˚ S4V Î%_´Ó˚y‹T…ñ S5V ˆõ!:ˆÏÑ¸y S6V ˆ¸ôÓ˚& S7V ˆ¶¸ˆÏòã%ˆÏÎ˚úy S8V !ö¸!ú¸ôy£zò S9V ¶¸yÓ˚ì¸ S10V £zˆÏ®yˆÏò!üÎ˚y S11V õyúˆÏÎ˚!üÎ˚y S12V â¸#ò S13V õyîyÜyfl¸ÒyÓ˚ S14V Üîì¸y!s¸fÑ¸ Ñ¸ˆÏDy ≤Ããyì¸s¸f S15V Üîì¸y!s¸fÑ¸ î!«¸í xy!ö ¸Ñ¸y S16V xˆÏfl¸T…!úÎ˚y S17V ¸ôy¸ô%Î˚y !òv¸z!Ü!ò S18V £zÓ˚yò– ~ˆÏîÓ˚ õˆÏïƒ Ó y!ãú ¢ˆÏÓ≈yFâ¸ fl¸iyò x!ïÑ¸yÓ˚ Ñ¸ˆÏÓ˚ xyˆÏäÈ– xyõyˆÏîÓ˚ ˆîü 11ì¸õ fl¸iyòy!ïÑ¸yÓ˚#– £zv¸z˚ÏÓ˚yˆÏ¸ô ˆÑ¸yˆÏòy Megadiversity ˆîü ˆò£z– 4.9 ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÑ¸›¸ (Threats to Biodiversity) Mass Extinction ! ÓÓì≈¸ˆÏòÓ˚ ~Ñ¸!›¸ v¸zˆÏÕ'ÖˆÏÌyÜƒ xÇü ~Ó˚ ö¸ˆÏú ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ £‡¸yÍ Ñ¸ˆÏÓ˚ áy›¸!ì¸ áˆÏ›¸– ~äÈyv¸¸y ≤ÃyÑ,¸!ì¸Ñ¸ ! Ó¸ôÎ≈ˆÏÎ˚Ó˚ SˆÎõòÈÙÙÙÈ Óòƒyñ ¢%òy!õñ ¶)¸!õÑ¸¡ô £zì¸ƒy!îV ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ £…y¢

ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚ ì¸ˆÏÓ ì¸y

xˆÏòÑ¸›¸y xyM¸È!úÑ¸ñ !ÓŸªÓƒy¸ô# ~Ó˚ ≤Ã¶¸yÓ ¸ôˆÏv¸¸ òy– ˆü°Ï mass extinction xÌ≈yÍ 65 !õ!úÎ˚ò ÓäÈÓ˚ xyˆÏÜ 64 ? NSOU ? AE-ES-21

v¸y£zˆÏòy¢ˆÏÓ˚Ó˚ !Óú%!ÆÓ˚ ¸ôÓ˚ ˆÌˆÏÑ¸ õyò%ˆÏ°ÏÓ˚ xy!Ó¶≈¸yˆÏÓÓ˚ ¸ôÓ˚ õyò%ˆÏ°ÏÓ˚ !e´Î˚yÑ¸úyˆÏ¸ôÓ˚ ãòƒ ã#Ó˜ÏÓ! â¸ˆÏeƒÓ˚ £…y¢ áˆÏ›¸ˆÏäÈ ì¸yˆÏÑ¸ Holocene !Óú%!Æ (Holocene Extinction) Óúy £Î˚– ~£z ÈHolocene ExtinctionÙÈ~Ó˚ ≤Ãïyò Ñ¸yÓ˚í=!ú £ú ≠ÈÙÙÙÈ S1V ã#ˆÏÓÓ˚ xyÓyÓ˚ ïπÇ¢ (Habitat loss) ≠ Óy¢fl¸iyˆÏòÓ˚ xyÎ˚ì¸ò ~ÓÇ ≤Ããy!ì¸Ó˚ ¢ÇÖƒy ¢Ó˚y¢!Ó˚ ¶¸yˆÏÓ ~ˆÏÑ¸ x¸ôˆÏÓ˚Ó˚ ¢yˆÏÌ ã!v¸¸ì¸– ãò¢ÇÖƒyÓ˚ x!ì¸Ó,!k¸ñ õò%°Ïƒ Óy¢fl¸iyò ~ÓÇ Ó˚yhfl¸y ˜ì¸!Ó˚Ó˚ ãòƒ Óò¶)¸!õ ïπÇ¢ Ó,£Í ãúyïyÓ˚ ˜ì¸!Ó˚ñ Ö!ò ~ÓÇ ¸ô!ÓˆÏÓü î)°ÏˆÏíÓ˚ ãòƒ ã#ˆÏÓÓ˚ Óy¢fl¸iyò ïπÇ¢ £ˆÏFäÈ– ~£z Óy¢fl¸iyò ïπÇ¢ ã#ˆÏÓÓ˚ !Óú%!ÆÓ˚ ~Ñ¸!›¸ xòƒì¸õ Ñ¸yÓ˚í– ˆÑ¸yˆÏòy fl¸iyˆÏò ~Ñ¸!›¸ ≤Ããy!ì¸Ó˚ ¢ÇÖƒy ˆÓ!ü ¸ô!Ó˚õyˆÏí ïπÇ¢ £ˆÏú ì¸yÓ˚ Öyîƒˆχ!íÓ˚ ≤Ããy!ì¸Ó˚ ¢ÇÖƒy Ó,!k¸ ¸ôyÎ˚ñ ö¸úfl¸∫Ó˚*¸ô ì¸yÓ˚ ¸ô)Ó≈Óì≈¸# ˆ¸ôÔ!‹TÑ¸ hfl¸ˆÏÓ˚Ó˚ ≤Ãyí#Ó˚ ¢ÇÖƒy £…y¢ ¸ôyÎ˚– v¸zîy£Ó˚í fl¸∫Ó˚*¸ôÈÈÙÙÙÈ Ñ¸ˆÏÎ˚y!›¸Ó˚ ¢ÇÖƒy £…y¢ ¸ôyÓyÓ˚ ö¸ˆÏú î!«¸í Ñ¸ƒy!úˆÏö¸y!ò≈ÎyÓ˚ Ñ¸ˆÏÎ˚y!›¸Ó˚ Öyîƒˆχ!í Ó˚ƒyÑ%¸òÈÙÈ~Ó˚ ¢ÇÖƒyÓ˚ Ó,!k¸ ¸ôyÎ˚ ÎyÓ˚ ö¸úfl¸∫Ó˚*¸ô Üyò Ñ¸Ó˚y ¸ôy!ÖÓ˚ ¢ÇÖƒy £…y¢ ¸ôyˆÏFäÈ– Óy¢fl¸iyò ïπÇ¢ (Fragmentation) £ˆÏú !ãòÜì¸ viability £…y¢ áˆÏ›¸ ~ÓÇ xÓˆÏü°Ï !ãòÜì¸ «¸Î˚¢yïò (Genetic erosion) áˆÏ›¸– S2V x!ì¸!Ó˚_´ ¢¡ôî xy£Ó˚í (Over Exploitation) ≠ 700 ˆÑ¸y!›¸ ãò¢ÇÖƒy ≤ÃyÎ˚ xˆÏï≈Ñ¸ Óò¶)¸!õ @˘Ãy¢ Ñ¸ˆÏÓ˚ ˆö¸ˆÏúˆÏäÈ– ~£z ïπÇ¢ú#úy ˆü°Ï £Î˚!ò– e´õÓì≈õyò ¶¸yˆÏÓ õyòÓ ¢¶¸fì¸y ë%¸ˆÏÑ¸ ¸ôv¸¸ˆÏäÈ ≤Ãyí#Ó˚ ò#Ó˚Ó Óy¢fl¸iyˆÏòÓ˚ õˆÏïƒ– ~Ó˚ ~Ñ¸!›¸ Óv¸¸ v¸zîy£Ó˚í £ú õ£yÓ˚yˆÏ‹T…Ó˚ !Ü!Ó˚ ãyì¸#Î˚ v¸zîƒyˆÏòÓ˚ õïƒ !îˆÏÎ˚ ˜ì¸!Ó˚ £ˆÏÎ˚ˆÏäÈ !õ›¸yÓ˚ ˆÜã ˆÓ˚úúy£zòñ Ó˚yãƒ ¢v¸¸Ñ¸ ~ÓÇ 3 Öyòy õ!®Ó˚– ~Ó˚ ö¸ˆÏú ¶¸yÓ˚ˆÏì¸Ó˚ !¢ÇˆÏ£Ó˚ ~Ñ¸õye Óy¢fl¸iyòÁ xyã ¢%Ó˚!«¸ì¸ òÎ˚– ÷ï%õye fl¸iúã ≤Ãyí# òy Óì≈¸õyˆÏò ¢yõ%!oÑ¸ ≤Ãyí#Ó˚ 14% £…y¢ ˆ¸ôˆÏÎ˚ˆÏäÈñ ~Ó˚ ≤Ãïyò Ñ¸yÓ˚í £ú ¸ô,!ÌÓ#Ó˚ ì¸y¸ôõyey Ó,!k¸ñ òyòy¶¸yˆÏÓ ãú î)°Ïí ~ÓÇ x¸ô!ÓˆÑ¸!"ì¸ Á ÎˆÏÌFäÈ õÍ¢ !üÑ¸yÓ˚– ~£z ¢õhfl¸ !Ñ¸ä%ÈÓ˚ õ)ˆÏú xyˆÏäÈ î#á≈ˆÏõÎ˚yî# ¸ô! Ó˚Ñ¸"òy òy ÌyÑ¸y ~ÓÇ ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ôˆÏîÓ˚ !ÓÑ¸" ÓƒÓ£yÓ˚ òy Ñ¸ˆÏÓ˚ Óy ¸ô%òÓ˚fl¸iy¸ôˆÏòÓ˚ ˆâ¸‹Ty òy Ñ¸ˆÏÓ˚ ÎˆÏÌFäÈ ¶¸yˆÏÓ ì¸y xy£Ó˚í ~ÓÇ !Óò‹TÑ¸Ó˚í– S3V !ÓˆÏîü# ≤Ããy!ì¸ (Exotic Species) ≠ ã#Ó˜ÏÓ!â¸eƒ ¢ÇÑ¸ˆÏ›¸Ó˚ xyÓ˚ ~Ñ¸!›¸ Ñ¸yÓ˚í £ú ! ÓˆÏîü# ≤Ããy!ì¸Ó˚ xyÜõò– ~£z !ÓˆÏîü# xyÜyäÈy xyÜõˆÏòÓ˚ ö¸ˆÏú â¸y°Ï ã!õñ Óò¶)¸!õ ≤Ã¶,¸!ì¸Ó˚ ≤ÃyÑ,¸!ì¸Ñ¸ ÓylÎfl¸ìˆÏs¸fÓ˚ ¸ô! Ó˚Óì≈¸ò áˆÏ›¸ ~õò!Ñ¸ Öyîƒ ü,Cú ¸ôÎ≈hs¸ !Ó!á¯ì¸ £Î˚– ~äÈyv¸¸y ~£z !ÓˆÏîü# ≤Ããy!ì¸Ó˚ xyÜyäÈy Óy v¸z!qî v¸z_´ fl¸iyˆÏòÓ˚ fl¸iyò#Î˚ v¸z!qîˆÏîÓ˚ fl¸iyò îÖú Ñ¸ˆÏÓ˚ñ ö¸úfl¸∫Ó˚*¸ô Ó˝ v¸z!qî !Óú%Æ £ˆÏÎ˚ ¸ôˆÏv¸¸ˆÏäÈ– ÷ï% ì¸y£z òÎ˚ fl¸iyò#Î˚ v¸z!qî Óy áyˆÏ¢Ó˚ !Óú%!ÆÓ˚ ãòƒ Ó˝ ¸ôì¸D ~ÓÇ ¸ôy!Ö !Óú%!ÆÓ˚ ¸ôˆÏÌ x@˘Ã¢Ó˚ £ˆÏFäÈ– Óì≈¸õyˆÏò Óv¸¸ Óv¸¸ ›¸∆úyˆÏÓ˚Ó˚ õyïƒˆÏõ ¢õ%ˆÏo õyey!ì¸!Ó˚_´ õÍ¢ƒ !üÑ¸yˆÏÓ˚Ó˚ ö¸ˆÏú õÍ¢ƒ ¢¡ôˆÏîÓ˚ £…y¢ á›¸ˆÏäÈ– ~£z õÍ¢ƒ !üÑ¸yˆÏÓ˚Ó˚ ¢õÎ˚ Ó˝ x≤ÃˆÏÎ˚yãò#Î˚ ≤Ãyí# ÎyÓ˚y õyäÈ ïÓ˚yÓ˚ ãyˆÏú ïÓ˚y ¸ôˆÏv¸¸ xÑ¸yÓ˚ˆÏí ì¸yˆÏîÓ˚ õ,ì%¸ƒ áˆÏ›¸ñ ˆÎõòÈÙÙÙÈ Ñ¸FäÈ¸ôñ !G¸ò%Ñ¸ñ üyõ%Ñ¸ñ !Ñ¸ä%È ¢ÇÑ¸›¸¸y¸ôß¨ £yDÓ˚ ≤Ããy!ì¸– !ÓˆÏî!ü ≤Ããy!ì¸Ó˚ ã#Ó fl¸iyò#Î˚ ≤Ãyí# Óy v¸z!qˆÏîÓ˚ Óy¢fl¸iyò îÖú Ñ¸ˆÏÓ˚ ì¸yˆÏîÓ˚ Öyîƒ !£¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚ñ xye´yhs¸ Ñ¸ˆÏÓ˚ ~ÓÇ ì¸yˆÏîÓ˚ ¢yˆÏÌ !õ!úì¸ £ˆÏÎ˚ ≤ÃãòòÁ á›¸yÎ˚ñ ~Ó˚ ö¸ˆÏú fl¸iyò#Î˚ ≤Ããy!ì¸Ó˚ ïπÇ¢ Á !ãòÜì¸ ¸ô! Ó˚Óì≈¸ò áˆÏ›¸– S4V ˆâ¸yÓ˚y!üÑ¸yÓ˚ (Poaching) ≠ !ÓŸªÓyãyˆÏÓ˚ !Ó!e´Ó˚ ãòƒ ~ÓÇ x!ïÑ¸ ›¸yÑ¸y v¸z¸ôyã≈ˆÏòÓ˚ ãòƒ ˆÓxy£z!ò ¶¸yˆÏÓ ˆâ¸yÓ˚y !üÑ¸yÓ˚#Ó˚yñ ã#Óãls¸Ó˚ £ì¸ƒy Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– ÷ï%õye £y!ì¸Ó˚ î∫yì¸ñ Ü[¸yˆÏÓ˚Ó˚ !üÇñ ¢%Ü!ı¸ !£¢yˆÏÓ õ,Üòy¶¸# ~ÓÇ ÓyˆÏáÓ˚ â¸yõv¸¸y £zì¸ƒy!îÓ˚ ãòƒ ~£z NSOU ? AE-ES-21 ? 65

ˆâ¸yÓ˚y !üÑ¸yÓ˚#Ó˚y Ó˝ ≤Ãyí#Ó˚ £ì¸ƒy Ñ¸ˆÏÓ˚ !ÓˆÏîˆÏü Ó˚Æyò# Ñ¸Ó˚ˆÏäÈ– ~äÈyv¸¸y Óy!v¸¸ˆÌ¸ ˆ¸ôyüyÓ˚ ãòƒ !Ó!¶¸ß¨ ¢%®Ó˚ ¸ôy!Öñ ≤Ãyí# ˆÎõò !ÓˆÏîˆÏü Ó˚Æyò# £ˆÏFäÈ ˆì¸õ!ò ~ˆÏîˆÏüÁ xy¢ˆÏäÈ xˆÏòÑ¸– ~äÈyv¸¸y Ë°Ïï ≤Ãlfl¸ì¸ Ñ¸Ó˚yÓ˚ ãòƒ xˆÏòÑ¸ ≤Ãyí#Ó˚ ˆîˆÏ£Ó˚ xÇü Ñ¸yˆÏã úyˆÏÜ Îy xy£z!ò¶¸yˆÏÓ Óy ˆÓxy£z!ò¶¸yˆÏÓ Ë°Ïï ≤Ãlfl¸ì¸Ñ¸yÓ˚#Ó˚y Ñ¸yˆÏã úyÜyˆÏFäÈ– ì¸yäÈyv¸¸y Ó˝ õ)úƒÓyò x!Ñ≈¸v¸ñ äÈeyÑ¸ñ õ¢ £zì¸ƒy!î òyòy ˆ¶¸°Ïã Ë°ÏˆÏïÓ˚ Ñ¸yˆÏã úyÜyÓ˚ ãòƒ !Óò‹T £ˆÏFäÈ !îˆÏòÓ˚ ¸ôÓ˚ !îò– S5V î)°Ïí (Pollution) ≠ ~£z ¢Ñ¸ú Ñ¸yÓ˚ˆÏíÓ˚ v¸z¸ôˆÏÓ˚ Ó˚ˆÏÎ˚ˆÏäÈ î)°Ïí– ¸ô!Ó˚ˆÏÓü î)°ÏˆÏíÓ˚ ö¸ˆÏú Ó˝ ≤Ãyí# õyÓ˚y ÎyˆÏFäÈ ~ÓÇ ˆÎ ¢Ñ¸ú ≤Ããy!ì¸ ˆÓ!ü õyeyÓ˚ î)°Ïí ¢£ƒ Ñ¸Ó˚ˆÌ¸ ¸ôyˆÏÓ˚ òy ì¸yÓ˚y ¢B¸›¸y¸ôß¨ ˆÌˆÏÑ¸ !Óú%!ÆÓ˚ ¸ôˆÏÌ ~!ÜˆÏÎ˚ â¸ˆÏúˆÏäÈ– ~äÈyv¸¸y ¸ô!Ó˚ˆÏÓü î)°ÏˆÏíÓ˚ ö¸úfl¸∫Ó˚*¸ô ˆÎ !ÓŸª v¸z°åyÎ˚ò á›¸ˆÏäÈ ì¸yÓ˚ ö¸ˆÏú Ó˝ ã#Ó ≤Ããy!ì¸ ~Öò !Óú%!ÆÓ˚ ¸ôˆÏÌ !ÓˆÏü°Ï Ñ¸ˆÏÓ˚ ˆõÓ˚&ˆîü#Î˚ ≤Ãyí# ˆÎõòÈÙÙÙÈ ˆõÓ˚&ˆÏîü#Î˚ ¢yîy ¶¸yÕ'%Ñ¸ñ !¢ú õyäÈñ ˆ¸ôD%£zò £zì¸ƒy!îV– 4.10 ¶¸yÓ˚ˆÌ¸Ó˚ ¢ÇÑ¸›¸y¸ôß¨ Á xyM¸È!úÑ¸ ≤Ããy!ì¸Ó˚ ã#Ó (Threatened and Endemic species of India) ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ !ò!Ó˚ˆÏÖ ¶¸yÓ˚ì¸Ó°Ï≈ !ÓˆÏŸª 11 ò¡∫Ó˚ fl¸iyòy! ïÑ¸yÓ˚#– ~õò!Ñ¸ Ó˝ ≤Ãyí# Á v¸z!qî xyˆÏäÈ Îy ¶¸yÓ˚ì¸Ó°Ï≈ äÈyv¸¸y !ÓˆÏŸª xòƒ ˆÑ¸yˆÏòy fl¸iyˆÏò ¸ôyÁÎ˚y ÎyÎ˚ òy– xyM¸È!úÑ¸ ≤Ããy!ì¸ (Endemic Species) ≠ xyM¸È!úÑ¸ ≤Ããy!ì¸ ì¸yˆÏîÓ˚£z Óúy £ˆÏÎ˚ ÌyˆÏÑ¸ ÎyˆÏîÓ˚ !ò!î≈‹T fl¸iyò äÈyv¸¸y !ÓˆÏŸª xòƒe ˆÑ¸yÌyÁ ¸ôyÁÎ˚y ÎyÎ˚ òy ì¸yˆÏîÓ˚ ˙ ~úyÑ¸yÓ˚ xyM¸È!úÑ¸ ≤Ããy!ì¸ ÓˆÏú Üíƒ £ˆÏÎ˚ ÌyˆÏÑ¸– ~!›¸ !Ó!¶¸ß¨ ≤ÃÑ¸yˆÏÓ˚Ó˚ £ˆÏÎ˚ ÌyˆÏÑ¸– ˆÎõòÈÙÙÙÈ S1V fl¸iyòá!›¸ì¸ xyM¸È!úÑ¸ ≤Ããy!ì¸ SˆÎõòÈÙÙÙÈ ¸ôy£y!v¸¸ñ õÓ˚&¶)¸!õÓ˚ ≤Ããy!ì¸V S2V ˆîüá!›¸ì¸ xyM¸È!úÑ¸ ≤Ããy!ì¸ SˆÎõòÈÙÙÙÈ ¶¸yÓ˚ì¸#Î˚ ≤Ããy!ì¸V S3V ˆ¶¸ÔˆÏÜy!úÑ¸ fl¸iyòá!›¸ì¸ xyM¸È!úÑ¸ ≤Ããy!ì¸ SˆÎõòÈÙÙÙÈ !£õyúÎ˚ xM¸ÈˆÏúÓ˚ ≤Ããy!ì¸V– ¶¸yÓ˚ì¸ÓˆÏ°Ï≈Ó˚ Ó˝ ≤Ãyí# Á v¸z!qî !Ó¸ôß¨ Á ¢ÇÑ¸›¸y¸ôß¨ñ ˆ¢£z Ñ¸yÓ˚ˆÏí IUCN ˆ¢£z ¢Ñ¸ú ã#ˆÏÓÓ˚ òyõñ ¸ô!Ó˚!â¸!ì¸ñ Óy¢fl¸iyò £zì¸ƒy!î ò!Ì¶%¸_´ Ñ¸ˆÏÓ˚ò– Red Data Book òyˆÏõ ~!›¸ ¸ô!Ó˚!â¸ì¸– International Union for the Conservation of Nature and Natural Resources (IUCN)-~Ó˚ WCMC ~ÓÇ Species Survival Commission (SSC) ~£z ò!Ì!›¸ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚– !Ó¸ôß¨ì¸yÓ˚ xÓfl¸iyˆÏ¶¸ˆÏî ~£z ì¸Ìƒ!›¸ ˜ì¸!Ó˚ Ñ¸Ó˚y £Î˚– ˆÎõòÈÙÙÙÈ S1V !Óú%Æ (Extinct, Ex) ≠ !ÓÜì¸ 50 ÓäȈÏÓ˚ ~£z ¸≤Ããy!ì¸Ó˚ ˆÑ¸yˆÏòy ≤Ãyí# ˆîÖy ÎyÎ˚!ò Óy ˆîÖˆÌ¸ ¸ôyÁÎ˚yÓ˚ ˆÑ¸yò ¢Ω¸yÓòy ˆò£z xÌ≈yÍ ˆü°Ï ≤Ãyí#!›¸Á õyÓ˚y ˆÜˆÏäÈñ ˆÎõòÈÙÙÙÈ v¸y£zˆÏòy¢Ó˚ñ ì¸y¢õy!òÎ˚yÓ˚ Óyá (Thylacinus cynocephalus)ñ ˆv¸yˆÏv¸y ¸ôy!Ö (Raphus cucullatas)ñ õƒyõÌ £zì¸ƒy!î– S2V ÓˆÏòƒÓ˚ !Óú%Æ (Extinct in the wild, Ew) ≠ ˆÎ ¢Ñ¸ú ≤Ãyí# ÓˆÏòƒ xyÓ˚ ˆîÖˆÌ¸ ¸ôyÁÎ˚y ÎyÎ˚ òy !Ñ¸ls¸ Ó!® xÓfl¸iyÎ˚ Óy ¢ÇÓ˚!«¸ì¸ xÓfl¸iyÎ˚ ˆîÖˆÌ¸ ¸ôyÁÎ˚y ÎyÎ˚– Ñ¸yˆÏúy òÓ˚õ ˆÖyˆÏúÓ˚ Ñ¸FäȸÔ (Nilssonia nigricans)ñ ˆ¸ôy›¸!¢ ¸ôyö¸ õyä (Cyprinodon alvarezi)È– S3V =Ó˚&ì¸Ó˚ ¢ÇÑ¸›¸y¸ôß¨ (Critically Endangered, CE) ≠ ˆÎ ¢õhfl¸ ≤Ããy!ì¸ ÓˆÏòƒ !Óú%Æ £ÓyÓ˚ ¢Ω¸yÓòy xˆÏòÑ¸ ˆÓ!ü ì¸yˆÏîÓ˚ =Ó˚&ì¸Ó˚ ¢ÇÑ¸›¸y¸ôß¨ hfl¸ˆÏÓ˚ Ó˚yÖy £ˆÏÎ˚ˆÏäÈ– ˆÎõòÈÙÙÙÑ¸yˆÏúy Ü[¸yÓ˚È (Diceros bicornis), Ñ¸yˆÏúy Ü[¸yÓ˚ â¸y!Ñ¸ì¸y !›¸!›¸ ÓyòÓ˚ (Callicebus caquetensis) £zì¸ƒy!î– 66 ? NSOU ? AE-ES-21

S4V !Ó¸ôß¨ (Endangered, Ew) ≠ !Óú%Æ £ÓyÓ˚ Ñ¸yÓ˚í=!úÓ˚ ¢õyïyò òy Ñ¸Ó˚y ˆÜˆÏú Îy x!â¸Ó˚ ¶¸!Ó°Ïƒˆ̸ !Óú%Æ £ˆÏÓñ ì¸yˆÏîÓ˚ !Ó¸ôß¨ ≤Ããy!ì¸ ÓˆÏú– ˆÎõòÈÙÙÙÈ Óyá (Panthera tigris), ¶¸yÓ˚ì¸#Î˚ £y!ì¸ (Elephas maximus)ñ úyú ¸ôy[¸y (Ailurus fulgens)ñ ò#ú ! ì¸!õ (Balaenoptera musculus)ñ ¸ôy£yv¸¸# Ñ¸lfl¸!Ó˚ õ,Ü (Moschus leucogaster)ñ ¸ôy£zò (Pinus radiata) ≤Ã¶,¸!ì¸– S5V ¢ÇÑ¸›¸≤ÃÓí (Vulnerable, V) ≠ !Ó¸ôß¨ £ÓyÓ˚ Ñ¸yÓ˚í=!ú î)Ó˚ òy £ˆÏú ~Ó˚y x!â¸ˆÏÓ˚ !Ó¸ôß¨ £ˆÏÓ– ˆü°Ï 10 ÓäȈÏÓ˚ ~£z ≤Ããy!ì¸Ó˚ ãò¢ÇÖƒy ≤ÃyÎ˚ 50% Ñ¸ˆÏõˆÏäÈ– v¸zîy£Ó˚íÈÙÙÙÈ ˆÜyÖˆÏÓ˚y ¢y¸ô (Ophiophagus hannah)ñ ¢yõ%!oÑ¸ xŸª (Hippocampus histrix)ñ ãú£hfl¸# (Hippopotamus amphibious)ñ xy!ö ¸Ñ¸yÓ˚ !¢Ç£ (Panthera leo) £zì¸ƒy!î– S6V !òÑ¸›¸ ¢ÇÑ¸›¸y¸ôß¨ (Near Threatened, NT) ≠ ¶¸! Ó°Ïƒˆ̸ ~£z ¢Ñ¸ú ≤Ããy!ì¸Ó˚ ¢ÇÑ¸›¸y¸ôß¨ xÓfl¸iyÎ˚ ÎyÓyÓ˚ ¢Ω¸yÓòy ≤ÃÓú– v¸zîy£Ó˚í ≠ ãy=Î˚yÓ˚ (Panthera onca)ñ Ñ¸°å¢yÓ˚ õ,Ü (Antilope cervicapra)ñ ›¸y£zÜyÓ˚ ¢yÑ≈¸ (Galeocerdo cuvier) – S7V fl¸∫"=Ó˚&c (Least Concern, LC) ≠ ~£z ¢Ñ¸ú ≤Ããy!ì¸ˆÏîÓ˚ ¢ÇÖƒy Óì≈¸õyˆÏò v¸zˆÏÕ'ÖˆÏÎ˚yÜƒ ¶¸yˆÏÓ £…y¢ ¸ôyÎ˚!ò Óy !fl¸i!ì¸ü#ú– ˆÎõòÈÙÙÙÈ !ãÓ˚yö¸ (Giraffa camelopardalis)ñ !â¸ì¸ú £!Ó˚í (Axis axis)– ÈÙÙÙÈ~äÈyv¸¸yÁ !Ñ¸ä%È ≤Ããy!ì¸Ó˚ ¢¡∫ˆÌ¸ ˆÑ¸yò ¢¡ô)í≈ ì¸Ìƒ!î ˆò£z ÎyÓ˚ myÓ˚y ˙ ≤Ããy!ì¸Ó˚ !Ó¸ôß¨ì¸yÓ˚ ¸ô!Ó˚õy¸ô Ñ¸Ó˚y ÎyÎ˚ (Data deficient) !â¸e ≠ !Ó¸ôß¨ì¸yÓ˚ hfl¸Ó˚ NSOU ? AE-ES-21 ? 67

4.11 ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÓ˚«¸í ≠ £zòÈÙÈ!¢›%¸ Á ~:ÈÙÈ!¢›%¸ (Conservation of Biodiverity: In-Situ & Ex-Situ) ¶¸yÓ˚ˆÌ¸ ¢Ó≈¢yÑ%¸ˆÏúƒ ≤Ãyí# Á v¸z!qî ≤Ããy!ì¸Ó˚ ¢ÇÖƒy ú«¸y!ïÑ¸– Óì≈¸õyò ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¶¸yÓ˚¢yõƒ ÓãyÎ˚ Ó˚yÖyÓ˚ ãòƒ ~ÓÇ ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ £…y¢ ˆÓ˚yï Ñ¸Ó˚yÓ˚ ãòƒ ¢ÇÓ˚«¸í ≤ÃˆÏÎ˚ãò– ~£z ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÓ˚«¸ˆÏíÓ˚ ì¸y!ÜˆÏî ¶¸yÓ˚ì¸ ¢Ó˚Ñ¸yÓ˚ ~Ñ¸!›¸ xy£zò ≤Ãâ¸úò Ñ¸ˆÏÓ˚ò Îy Óòƒã#Ó ¢ÇÓ˚«¸í xy£zòñ 1972 òyˆÏõ ≤Ãâ¸!úì¸ (Wildlife Protection Act, 1972)– National Biodiversity Action Plan (NBAP)ñ 2002ÈÙÈ16ÈÙÈ~Ó˚ ì¸Ìƒyò%ÎyÎ˚# ¶¸yÓ˚ˆÌ¸Ó˚ ˆõy›¸ ¶)¸ÈÙȶ¸yˆÏÜ 4.90% fl¸iyò ¢ÇÓ˚!«¸ì¸ ~úyÑ¸yÓ˚ xhs¸Ü≈ì¸ !Ñ¸ls¸ ¶¸!Ó°Ïƒˆ̸ ì¸y xyˆÏÓ˚y Ó,!k¸ Ñ¸ˆÏÓ˚ ≤ÃyÎ˚ 5.47% Ñ¸Ó˚yÓ˚ ¸ô!Ó˚Ñ¸"òy xyˆÏäÈ– ~Ó˚ ˆõy›¸ ~úyÑ¸y 1ñ61ñ22ñ157 ÓÜ≈ !Ñ¸ˆÏúy!õ›¸yÓ˚ ~ÓÇ ¢ÇÓ˚!«¸ì¸ ~úyÑ¸yÓ˚ ¢ÇÖƒy 668!›¸ S2011 ¢yˆÏúÓ˚ ì¸Ìƒ xò%ÎyÎ˚#V– ¢ÇÓ˚«¸í õ)úì¸ î% £z¶¸yˆÏÓ Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ÈÙÙÙÈ S1V £zò !¢›%¸ ~ÓÇ S2V ~: !¢›%¸ ¢ÇÓ˚«¸í S1V £zòÈÙÈ!¢›%¸ ¢ÇÓ˚«¸í (In-Situ Conservation) ≠ ~£z ¸ôk¸!ì¸ˆÌ¸ ã#ÓˆÏÑ¸ ì¸yÓ˚ !òˆÏãÓ˚ Óy¢fl¸iyò Óy ~Ñ¸£z Ó˚Ñ¸õ Óy¢fl¸iyˆÏòÓ˚ õˆÏïƒ ¢ÇÓ˚«¸í Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸– ~£z ¸ôk¸! ì¸ˆÌ¸ ˆÎ ¢Ñ¸ú üì≈¸yÓú# ã#Ó=!ú !Ó¸ôß¨ £ÓyÓ˚ ãòƒ îyÎ˚# ì¸y ¢ÇÓ˚!«¸ì¸ ~úyÑ¸y=!ú ˆÌˆÏÑ¸ !òõ≈)ú Ñ¸Ó˚y £Î˚ – v¸zîy£Ó˚íÈÙÙÙÈ ã#Óõ[¸ú ¢ÇÓ˚!«¸ì¸ xM¸Èú (Biosphere Reserve)ñ ãyì¸#Î˚ v¸zîƒyò (National Park)ñ ¢ÇÓ˚!«¸ì¸ Óò¶)¸!õ (Reserve Forest) £zì¸ƒy!î– Óì≈¸õyˆÏò ¶¸yÓ˚ˆÌ¸ 102!›¸ ãyì¸#Î˚ v¸zîƒyòñ 18!›¸ ã#Óõ[¸ú ¢ÇÓ˚!«¸ì¸ xMȸúñ 515!›¸ x¶¸Î˚yÓ˚íƒ ~ÓÇ 47!›¸ ¢ÇÓ˚!«¸ì¸ Óò¶)¸!õ xyˆÏäÈ– ì¸ˆÏÓ ~£z ¸ôk¸!ì¸ˆÌ¸ ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ !Óhfl¸#í≈ ~úyÑ¸yÓ˚ ≤ÃˆÏÎ˚yãò– ? x¶¸Î˚yÓ˚íƒ (Sanctuary) ≠ ~£z ¢ÇÓ˚!«¸ì¸ ~úyÑ¸y=!ú ˆÑ¸w ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ xyÁì¸yÎ˚ xhs¸¶%≈¸_´ – õ%Öƒ ú«¸ƒ £ú ã#Ó¢ÇÓ˚«¸í– ~!›¸ ˆÑ¸yò Óƒ!_´ñ ¢Çfl¸iy Óy ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ ì¸_¥yÓïyˆÏò ÌyÑ¸ˆÌ¸ ¸ôyˆÏÓ˚– Î!îÁ !üÑ¸yÓ˚ Óy ˆâ¸yÓ˚y!üÑ¸yÓ˚ !òˆÏ°Ïï !Ñ¸ls¸ fl¸iyò#Î˚ ãòÜíñ ö%¸úñ ö¸úñ ãµyúy! òÓ˚ Ñ¸y‡¸ £zì¸ƒy!î ¢Ç@˘Ã£ Ñ¸Ó˚ˆÌ¸ ¸ôyˆÏÓ˚– ˆÎõòÈÙÙÙÈ ˆÑ¸îyÓ˚òyÌ Sv¸z_Ó˚≤ÃˆÏîüV– ? ãyì¸#Î˚ v¸zîƒyò (National Park) ≠ ãyì¸#Î˚ v¸zîƒyˆÏòÓ˚ ~úyÑ¸y !Ó!ïÓk¸ xy£zò myÓ˚y ¢ÇÓ˚!«¸ì¸ñ õyò%ˆÏ°ÏÓ˚ ≤ÃˆÏÓü !òˆÏ°Ïï ~ÓÇ ¢yˆÏÌ ¢yˆÏÌ Óòã ¢¡ôîñ ˆÎõòÈÙÙÙÈ ãµyúy!òÓ˚ Ñ¸y‡¸ñ ö%¸úñ ö¸ú £zì¸ƒy!î ¢Ç@˘Ã£ Ñ¸Ó˚y !òˆÏ°Ïï– ì¸ˆÏÓ v¸zFâ¸ !ò!î≈‹T îÆˆÏÓ˚Ó˚ xò%õ!ì¸ myÓ˚y äÈ!Ó ˆì¸yúyñ ÜˆÏÓ°Ïíy Á !ü«¸y ¢Çe´yhs¸ Ñ¸yãÑ¸ˆÏõ≈ ≤ÃˆÏÓü Ñ¸Ó˚y ¢Ω¸Ó– ãyì¸#Î˚ v¸zîƒyò ì%¸úòyõ)úÑ¸ ¶¸yˆÏÓ x!ïÑ¸ ¢ÇÓ˚!«¸ì¸– v¸zîy£Ó˚íÈÙÙÙÈ ¢%®Ó˚Óò S¸ô!ÿ¸õÓDñ Ñ¸y!ãÓ˚yDy Sxy¢yõVñ Ñ¸Ó˚ˆÏÓ›¸ Sv¸z_Ó˚yÖ[¸Vñ !ÜÓ˚ S=ãyÓ˚y›¸Vñ Ñ¸yò£y Sõïƒ≤ÃˆÏîüVñ ˆÑ¸£zÓ%ú úyõÜ§yÁ Sõ!í¸ô%Ó˚V ~äÈyv¸¸yÁ Ú£zòÈÙÈ!¢›%¸Û ¢ÇÓ˚«¸ˆÏíÓ˚ õˆÏïƒ !Ó!¶¸ß¨ ¢ÇÓ˚«¸í ≤ÃÑ¸" â¸ˆÏú ÌyˆÏÑ¸

100% **MATCHING BLOCK 84/200** W

ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ £

úÈÙÙÙÈ Óƒyá ≤ÃÑ¸" (Tiger Project) ≠ ¢Ó≈≤ÃÌõ 1973ÈÙÈ74 ¢yˆÏú ~£z ≤ÃÑ¸" ÷Ó˚& £Î˚ – National Tiger Conservation Authority (NCTA) myÓ˚y ~£z ≤ÃÑ¸" !òÎ˚!s¸fi¸ £Î˚ – 2008 ¢yˆÏú ˆõy›¸ ÓyˆÏáÓ˚ ¢ÇÖƒy !äÈú 1411!›¸ Îy 2011 ¢yˆÏú ÈNCTAÙÈ~Ó˚ ì¸Ìƒ xò%ÎyÎ˚# ˆÓˆÏv¸¸ îßyv¸¸yÎ˚ 1706!›¸ ~ÓÇ 2014 ¢yˆÏú 2226– ≤ÃyÎ˚ ¢Ó ãyì¸#Î˚ v¸zîƒyˆÏò ~£z ≤ÃÑ¸" â¸úˆÏäÈ ì¸yÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒÈÙÙÙÈ ¢%®Ó˚Óòñ Ñ¸yò£yñ Ñ¸Ó˚ˆÏÓ›¸ñ Ó˚íÌΩ¸Ó˚ñ Óyı¸ÓÜv¸¸ £zì¸ƒy!î– 68 ? NSOU ? AE-ES-21
~äÈyv¸¸y Ü[¸yÓ˚ ≤ÃÑ¸"ÈÙÙÙÈ ãúîy¸ôyv¸¸y S¸ô!ÿ¸õÓDVñ Ñ¸y!ãÓ˚yDy Sxy¢yõVñ !¢Ç£ ≤ÃÑ¸"ÈÙÈ!ÜÓ˚ S=ãÓ˚y›¸V– S2V Ú~:ÈÙÈ! ¢›%¸Û ¢ÇÓ˚«¸í (Ex-Situ Conservation) ≠ ˆÑ¸yò ˆÑ¸yò !ÓˆÏü°Ï Ñ¸yÓ˚ˆÏí !òãfl¸∫ ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüÈÙÈ~Ó˚ xò%¸ô!fl¸i!ì¸Ó˚ ãòƒ xò%Ó˚*¸ô Ñ,¸!eõ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢,!‹T Ñ¸ˆÏÓ˚ ì¸yˆÏì¸ ì¸yˆÏîÓ˚ ¢ÇÓ˚«¸í Ñ¸Ó˚y £Î˚ñ ~£z ¸ôk¸!ì¸ˆÏÑ¸ Ú~: !¢›%¸Û ¢ÇÓ˚«¸í Óúy £Î˚ – ¢yïyÓ˚ îì¸ x!ì¸ !Ó¸ôß¨ Óy !Óú%Æ ≤ÃyÎ˚ ≤Ãyí# Óy v¸z!qîˆÏîÓ˚ ¢ÇÓ˚«¸ˆÏíÓ˚ ãòƒ ~£z Ú~: !¢›%¸Û ¢ÇÓ˚«¸í ÓƒÓfl¸iy– ~£z ¸ôk¸!ì¸Ó˚ õˆÏïƒ v¸zˆÏÕ'Öƒñ v¸z!qî v¸zîƒyò (Botanical Garden) ~ÓÇ ¸ô÷üyúy (Zoological Park)ñ v¸z!qî Á ≤Ãyí#Ó˚ ¢ÇÓ˚«¸í ≤Ããòò ~ÓÇ ãò ¢ˆÏâ¸ì¸òì¸y ≤Ãïyò v¸zˆÏjüƒ– ~äÈyv¸¸y xyˆÏÓ˚y òyòy ¸ôk¸!ì¸ xyˆÏäÈ ˆÎõòÈÙÙÙÈ fl¸ôyõ≈ ÓƒyB¸ñ !¢v¸ ÓƒyB¸ñ ˆfl¸ôyÓ˚ ÓƒyB¸ñ ãyõ≈ ≤'yãõ ÓƒyB¸ £zì¸ƒy!î ÓƒÓfl¸iyˆÏì¸ ¶¸!Ó°ÏƒˆÏì¸Ó˚ òyòy î%ú≈¶¸ ≤Ããy!ì¸Ó˚ ˆÑ¸y°Ï Á Ó#ã ¢ÇÓ˚«¸í Ñ¸ˆÏÓ˚ Ó˚yÖyÓ˚ xì¸ƒyï%! òÑ¸ ÓƒÓfl¸iy S!£õy!Î˚ì¸ Ó#ã ¢ÇÓ˚«¸íV xyˆÏäÈ– ~£z ¸ôk¸!ì¸ˆÏì¸ !ãòÜì¸ ˜Ó!â¸eƒ Ó˚«¸y Ñ¸Ó˚y ~ÓÇ !Óú%Æ≤ÃyÎ˚ ≤Ãyí#Ó˚ ¢ÇÖƒyÁ Ó,!k¸ Ñ¸Ó˚y ¢Ω¸Ó– v¸zîy£Ó˚í fl¸∫Ó˚*¸ô Óúy Îy Î˚ !Ó¸ôß¨ £ˆÏÏ˚ ¸ôv¸¸y Ñ%¸!õˆÏÓ˚Ó˚ ¢ÇÖƒy Ói≈¸õyˆÏò ~: !¢›%¸ ¢ÇÓ˚«¸ˆÏíÓ˚ õyïƒˆÏõ xyã xˆÏòÑ¸ !fl¸i!ì¸ü#ú xÓfl¸iy @˘Ã£í Ñ¸ˆÏÓ˚ˆÏäÈ– 4.12 Óylfl¸¢Çfl¸iyò ¸ô!Ó˚ˆÏ°ÏÓy (Ecosystem Services) Óylfl¸ì¸s¸f òyòy !e ´Î˚yÑ¸úyˆÏ¸ôÓ˚ õyïƒˆÏõñ ˆÎõò ÓƒÓ£yÎ≈ Ólfl¸ ~ÓÇ ˆ¢Óy myÓ˚y ≤

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îy ¸ô)Ó˚í Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸– ~£z !e´Î˚yÑ¸úy¸ô

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õ)úì¸ â¸yÓ˚!›¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚

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S1V !
òÎ˚s¸fíõ)úÑ¸ !e´Î˚yÑ¸úy¸ô ≠ Óylfl¸ì¸s¸f ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¶¸yÓ˚¢yõƒ Ó˚«¸yÓ˚ ãòƒ òyòy v¸z¸ôîyòˆÏÑ¸ !òÎ˚s¸fí Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸–

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úÈÙÙÙÈ ??¢yˆÏúyÑ¸ ¢ÇˆÏŸ'ˆÏ°ÏÓ˚ õyïƒˆÏõ Óyì¸yˆÏ¢Ó˚ Üƒy¢#Î˚ v¸z¸ôyîyˆÏòÓ˚ õˆÏïƒ ¢yõO¢ƒ ¢yïò– ??ãúÓyÎ˚% !òÎ˚s¸fí– ??ãú ¢Ó˚ÓÓ˚y£ ~ÓÇ ãúâ¸e´ !òÎ˚s¸fí– ??¶)¸!õ«¸Î˚ ˆÓ˚yïñ õy!›¸ v¸zÓ≈Ó˚ì¸y !òÎ˚s¸fí– ??î)°Ïí !òÎ˚s¸fí– S2V Óy¢fl¸iyò õ)úÑ¸ !e´Î˚yÑ¸úy¸ô ≠ Óylfl¸ì¸s¸f Ó˝ ≤Ãyí# Á v¸z!qˆÏîÓ˚ ˆÓ§ˆÏâ¸ ÌyÑ¸yÓ˚ ãòƒ ì¸yÓ˚ v¸z¸ôÎ%_´ ≤ÃyÑ,¸!ì¸Ñ¸ Óy¢fl¸iyò ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ~!›¸ ã#Ó˜ÏÓ! â¸eƒ !fl¸i!ì¸fl¸iy¸ôò ~ÓÇ ¢ÇÓ˚«¸ˆÏí

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v¸zˆÏÕ'ÖˆÏÎyÜƒ ¶)¸!õÑ¸y @˘Ã£í Ñ¸ˆÏÓ˚ –

S3V v¸zÍ¸ôyîò õ)úÑ¸ !e´Î˚yÑ¸úy¸ô≠ Óylfl¸ì¸ˆÏs¸f xÓfl¸iyòÑ¸yÓ˚# fl¸∫ÈÙÈˆ¶¸yã# v¸z!qîÓ˚y ¢yˆÏúyÑ¸¢ÇˆÏŸ'ˆÏ°ÏÓ˚ õyïƒˆÏõ ˆ¢ÔÓ˚ü!_´ˆÏÑ¸ ¸ô!Ó˚Óì≈¸ò á!›¸ˆÏÎ˚ Öyˆ ÏïƒÓ˚*¸ôyhs¸Ó˚ á›¸yÎ˚ ~ÓÇ ì¸y ¸ôÓ˚Óì≈¸# ÖyîÑ¸Ó˚y Öyîƒ !£¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ñ ~äÈyv¸¸y Óylfl¸ì¸s¸f ˆ¢Ô®Î≈yÎ˚ˆÏòÓ˚ ãòƒ òyòy ö%¸ú x!Ñ≈¸v¸ñ ÓˆÏòÔ°Ï!ï ~ÓÇ !ãòÜì¸ ¢¡ôî v¸zÍ¸ôyîò Ñ¸ˆÏÓ˚ – S4V ì¸Ìƒ¢ ¡±îyò õ)úÑ¸ !e´Î˚yÑ¸úy¸ô ≠ Óylfl¸ì¸ˆÏs¸fÓ˚ ˆ¢Ô®Î≈ƒñ â¸y!£îy ~ÓÇ !Ó!¶¸ß¨ì¸y õyò%°ÏˆÏÑ¸ v¸zß¨ì¸ Á ¸ô!Ó˚Ó!ì≈¸ì¸ £ˆÏì¸ ¢y£Îƒ Ñ¸ˆÏÓ˚ˆÏäÈ– ~äÈyv¸¸y Óylfl¸ì¸s¸f ≤ÃyÑ,¸!ì¸Ñ¸ ºõí Á !â¸_ !ÓˆÏòyîˆÏò ¢y£Îƒ Ñ¸ˆÏÓ˚ – õyò%ˆÏ°ÏÓ˚ õˆÏïƒ !ü"# ¢_yÓ˚ !ÓÑ¸yü ¢yïò Ñ¸ˆÏÓ˚ – ~äÈyv¸¸y òyòy !ü«¸yõ)úÑ¸ K¸yò Á ÜˆÏÓ°ÏíyÓ˚ ì¸Ìƒ Óylfl¸ì¸s¸f ˆìˆÏÑ¸ ¸ôyÁÎ˚y ÎyÎ˚ – NSOU ? AE-ES-21 ? 69

4.13 xò%ü#úò# ¢!‡¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚&ò ≠ S1V ˆÑ¸yò‰ õ£yˆÏîˆÏü ˆÑ¸yˆÏòy Mega Diversity ˆîü ˆò£zÈÙÙÙÈ (i) ~!üÎ˚y (ii) £zv¸zˆÏÓ˚y¸ô (iii) xy!ö ¸Ñ¸y (iv) xyˆÏõ!Ó˚Ñ¸y S2V ˆÑ¸yò!›¸ ÚÚ£zòÈÙÈ!¢›%¸ÛÛ ¢ÇÓ˚«¸í òÎ˚ÈÙÙÙÈ (i) ãyì¸#Î˚ v¸zîƒyò (ii) x¶¸Î˚yÓ˚íƒ (iii) ¢ÇÓ˚!«¸ì¸ Óò¶)¸!õ (iv) v¸z!qî v¸zîƒyò S3V IUCNÈÙÈ~Ó˚ ¸ô%ˆÏÓ˚y Ñ¸ÌyÈÙÙÙÈ (i) International Union for Conservation of Nature (ii) International United Conservation Nations (iii) Internal Union for Conservation of Nature (iv) Internal Union for Conversion of Nature S4V ˆv¸yˆÏv¸y ¸ôy!Ö £úÈÙÙÙÈ (i) !Ó¸ôß¨ ≤Ãäy!ì¸ (ii) !Óú%Æ ≤Ãyí# (iii) ¢ÇÑ¸›¸y¸ôß¨ ≤Ãyí# (iv) !Óú%Æ ≤ÃyÎ˚ S5V !ÓˆÏŸª !Óú%Æ ã#ˆÏÓÓ˚ ¸ô!Ó˚õyíÈÙÙÙÈ (i) 99.9% (ii) 50.9% (iii) 23% (iv) 10% x!ì¸¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V !ãò ˜Ó!â¸eƒ !Ñ¸/S2V xyúö¸yÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ Ñ¸yˆÏÑ¸ ÓˆÏú/S3V ã#Ó˜ÏÓ!â¸eƒ ïòƒ xM¸Èú Ñ¸yˆÏÑ¸ ÓˆÏú/S4V !Óú%Æ≤Ãyí# Ñ¸yˆÏÑ¸ ÓˆÏú/v¸zîy£Ó˚í !îò– S5V Ú£zòÈÙÈ!¢›%¸Û ¢ÇÓ˚«¸í Ñ¸yˆÏÑ¸ ÓˆÏú/v¸zîy£Ó˚í !îò– ¢Ç!«¸Æ v¸z_Ó˚!¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ã#Ó ˜Ó!â¸eƒ Ñ¸Î˚ ≤ÃÑ¸yÓ˚/S2V xyúö¸yñ !Ó›¸yñ Á ÜyõyÈÙÈv¸y£z¶¸yÓ˚!¢!›¸ Ñ¸yˆÏÑ¸ ÓˆÏú ÓƒyÖƒy !îò– S3V ¶¸yÓ˚ˆÏì¸ Ñ¸Î˚!›¸ ã#Ó˜ÏÓ!â¸eƒ ïòƒ xM¸Èú xyˆÏäÈ Á !Ñ¸ !Ñ¸/S4V ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÑ¸ˆÏ›¸Ó˚ Ñ¸yÓ˚í=!ú ÓƒyÖƒy Ñ¸Ó˚&ò– S5V Óylfl¸ì¸ˆÏs¸fÓ˚ ¸ô!Ó˚ˆÏ°ÏÓy=!ú ÓƒyÖƒy Ñ¸Ó˚&ò– v¸z_Ó˚ ¢ÇˆÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (ii) £zv¸zˆÏÓ˚y¸ô S2V (iv) v¸z!qî v¸zîƒyò S3V (i) International Union for Conservation of Nature S4V (ii) !Óú%Æ ≤Ãyí# S5V (i) 99.9% 70 ? NSOU ? AE-ES-21

~Ñ¸Ñ¸È 5 ¸ô!Ó˚ˆÏÓü î)°Ïí (Environmental Pollution) Ü‡¸ò 5.0 v¸zˆÏjüƒ 5.1 ≤Ãhfl¸ÏyÓòy 5.2 ÓyÎ˚%î)°Ïí (Air Pollution) 5.2.1 ÓyÎ˚%î)°ÏˆÏíÓ˚ ≤ÃÑ¸yÓ˚¶¸ˆÏî 5.2.2 ÓyÎ˚%î)°ÏˆÏíÓ˚ Ñ¸yÓ˚í 5.2.3 ÓyÎ˚%î)°ÏˆÏíÓ˚ «¸!ì¸Ñ¸yÓ˚Ñ¸ ö¸úyö¸ú 5.3 ãúî)°Ïí (Water Pollution) 5.3.1 ãúî)°ÏˆÏíÓ˚ v¸zÍ¢ 5.3.2 !Ó÷k¸ ãˆÏúÓ˚ ïõ≈ Á =íyÓ!ú 5.3.3 ãúî)°ÏˆÏíÓ˚ ö¸ˆÏú õyòÓˆÏîˆÏ£ ¢‚‹T ˆÓ˚yÜÓƒy!ï 5.3.4 ãúî)°Ïí !òÎ˚s¸fí Á î)Ó˚#Ñ¸Ó˚ˆÏíÓ˚ v¸z¸ôyÎ˚ 5.4 ¶)¸!õî)°Ïí (Land Pollution) 5.4.1 õ‚!_Ñ¸y (Soil) 5.4.2 õ‚!_Ñ¸yÓ˚ xÓòõˆÏòÓ˚ Ñ¸yÓ˚í Á ì¸yÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ (Cause of Soil degradation and its prevention) 5.4.3 Óã≈ƒ ¸ôîyÌ≈ã!òì¸ î)°Ïí (Pollution due to waste matter) 5.5 ü∑ î)°Ïí (Noise Pollution) 5.5.1 ü∑î)°ÏˆÏíÓ˚ !Ó!¶¸ß¨ v¸zÍ¢ (Different sources of noise pollution) 5.5.2 üˆÏ∑Ó˚ ≤ÃyÓúƒõyey (Intensity) 5.5.3 ãòfl¸∫yˆÏfl¸iƒÓ˚ v¸z¸ôÓ˚ ü∑î)°ÏˆÏíÓ˚ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ 5.5.4 ü∑î)°Ïí !òÎ˚s¸fˆÏí Ñ¸Ó˚í#Î˚ 5.6 ¢yõ%!oÑ¸ î)°Ïí (Marine Pollution) 5.6.1 ¢yõ%!oÑ¸ î)°ÏˆÏíÓ˚ v¸zÍ¢

5.6.2 ¢yõ%!oÑ¸ î)°ÏˆÏíÓ˚ ≤Ã¶¸yÓ (Impact of Marine Pollution) 5.6.3 ¢yõ%!oÑ¸ î)°Ïí !òÎ˚s¸fí Á ≤Ã!ì¸ˆÏÓ˚yï 5.7 ì¸y¸ô#Î˚ î)°Ïí (Thermal Pollution) 5.7.1 ì¸y¸ô#Î˚ ≤Ã¶¸yÓ (Effects of Thermal Pollution) 5.7.2 ì¸y¸ô#Î˚ î)°ÏˆÏíÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ 5.8 Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ Á ì¸yÓ˚ ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Solid Waste Management) 5.8.1 Ñ¸!‡¸ò Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ≤ÃÑ¸yÓ˚ˆÏ¶¸î (Types of Solid Waste) 5.8.2 Ñ¸!‡¸ò ¸Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Solid Waste Management) 5.9 ¸ô!Ó˚ˆÏÓü !Ó¸ôî≈Î˚ (Environmental Disaster) 5.9.1 !Ó¸ôî≈ˆÏÎ˚Ó˚ ÓƒÓfl¸iy¸ôòy (Disaster Management) 5.9.2 Óòƒy (Flood) 5.9.3 ¶)¸!õÑ¸¡ô (Earthquake) 5.9.4 á%í≈yÓì≈¸ (Cyclone) 5.9.5 ¶)¸!õï¢ (Landslide) 5.10 xò%ü#úò# 5.0 v¸zˆÏjüƒ ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ˆÏÓ˚ xy¸õ!l !l¡¨!°!áï¸ !Ó£ÏÎ˚=!° çylˆÏï¸ ¸õyÓ˚ˆÏÓl– ? ¸õ!Ó˚ˆÏÓ¢ ò)£Ïî Ü¸yˆÏÜ¸ ÓˆÏ° ~ÓÇ ò)£Ïîç!lï¸ xÓ«¸Î˚ – ? ÓyÎ˚%ò)£ÏˆÏîÓ˚ §ÇK¸yñ ≤ÃÜ¸yÓ˚ˆÏË¸òñ Ü¸yÓ˚îñ Ê¸°yÊ¸°– ? ç°ò)£ÏˆÏîÓ˚ §ÇK¸yñ í¸zÍ§ñ Ê¸°yÊ¸° G ò)£Ïî ò)Ó˚#Ü¸Ó˚ˆÏîÓ˚ í¸z¸õyÎ˚ – ? xyˆÏ§≈!lÜ¸ ò)£Ïî– ? Ë)¸!Ùò)£Ïî G ¢∑ò)£ÏˆÏîÓ˚ !Ó!Ë¸ß¨ í¸zÍ§ñ ÙylÓˆÏòˆÏ• ¢∑ò)£ÏˆÏîÓ˚ «¸!ï¸Ü¸Ó˚ ≤ÃË¸yÓ– ? §yÙ%!oÜ¸ ò)£ÏˆÏîÓ˚ í¸zÍ§ñ ≤ÃË¸yÓñ !lÎ˚sfî– ? Ü¸!ë¸l Óç≈ƒ ¸õòyÌ≈ G ï¸yÓ˚ ¸õ!Ó˚ã¸y°l ÓƒÓfliyñ ~ÓÇ !Ó!Ë¸ß¨ ≤ÃÜ¸yÓ˚ ¸õ!Ó˚ˆÏÓˆÏ¢Ó˚ !Ó¸õî≈Î˚ §¡õˆÏÜ≈¸– 72 ? NSOU ? AE-ES-21

5.1 ≤Ãhfl¸ÏyÓòy ¸ô!Ó˚ˆÏÓü ÓúˆÏì¸ ¢yïyÓ˚í¶¸yˆÏÓ xyõÓ˚y Ó%!G¸ !Ó!¶¸ß¨ ¢ã#Ó Á ãv¸¸ v¸z¸ôyîyˆÏòÓ˚ ¢õßÍÎ˚ ~ÓÇ ¸

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fl¸i fl¸∫y¶¸y!ÓÑ¸ ≤ÃÑ,¸!ì¸ñ Îy ã#ÓˆÏòÓ˚ v¸zÍ¢ Á Ó,!k¸Ó˚ ¢£yÎ˚Ñ¸ – ≤ÃÑ,¸!ì¸Ó˚ !òãfl¸∫ Ü!ì¸õÎ˚ì¸yÓ˚ Ñ¸yÓ˚ˆÏí ¸ô!Ó˚ˆÏÓü ¢îy ¸ô! Ó˚Óì≈¸òü#ú– xÌ≈yÍ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ v¸z¸ôyîyò=!úÓ˚ xyò%¸ôy!ì¸Ñ¸ £yÓ˚ñ xÓfl¸iyòñ !Ó÷k¸ì¸y Óy !Ó!¶¸ß¨ v¸z¸ôyîyˆÏòÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡ôÑ≈¸ÈÙÙÈ !Ñ¸ä%È£z !fl¸iÓ˚ òÎ˚ – ~£z ¸ô!Ó˚Óì≈¸òˆÏÑ¸ xyõÓ˚y ì¸Öò£z î)°Ïí Óˆ Ïú Ìy!Ñ¸ñ Î!î ¸ô!Ó˚Óì≈¸ò!›¸ ã#Ó˚ˆÏòÓ˚ x!hfl¸c Óy Ó,!k¸Ó˚ ¸ôˆÏ«¸ ˆÑ¸yòÁ ¶¸yˆÏÓ «¸!ì¸Ñ¸Ó˚ £ˆÏÎ˚ ÁˆÏ‡¸ – ¢£ã ¶¸y°ÏyÎ˚ Óúˆ Ïì¸ ˆÜˆÏúñ ¸ô!Ó˚ˆÏÓü î)°Ïí £ˆÏúy ¸ô! Ó˚ˆÏÓˆÏüÓ˚ ˆÑ¸yòÁ ˆò!ì¸Óyâ¸Ñ¸ ¸ô!Ó˚Óì≈¸ò Îy ã#Ó Á ãv¸¸ v¸z¸ôyîyò=!úÓ˚ fl¸∫y¶¸y!ÓÑ¸ ¢yõƒ Óy ì¸yˆÏîÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢ ¡ôÑ≈¸ myÓ˚y Ü!‡¸ì¸ ¢yõ!@˘ÃÑ¸ ≤ÃÑ,¸!ì¸Ó˚ =íÜì¸ õyˆÏòÓ˚ xÓò!ì¸ á›¸yÎ˚ – ~£z ¢yõ!@˘ÃÑ¸ xÓò!ì¸ˆÏÑ¸ xyõÓ˚y ÓƒyÖƒy Ñ¸!Ó˚ ¸ô! Ó˚ˆÏÓˆÏüÓ˚ xÓ«¸Î˚Ó˚*ˆÏ¸ô– ¢,!‹TÓ˚ ¢)â¸òy ˆÌˆÏÑ¸ ≤ÃÑ,¸!ì¸ ì¸yÓ˚ !òãfl¸∫ !òÎ˚ˆÏõ e´õ¸ô!Ó˚Óì≈¸òü#ú– ~£z ¸ô!Ó˚Óì≈¸ˆÏòÓ˚ xD !£ ¢yˆÏÓ ¸ô,!ÌÓ#Ó˚ ãv¸¸ Á ã#ÓãÜˆÏì¸Ó˚ !ÓÓì≈¸ò áˆÏ›¸ ~ˆÏ¢ˆÏäÈ– ã#ÓãÜˆÏì¸ òì%¸ò ≤Ãäy!ì¸Ó˚ ¢,!‹T ì¸yÓ˚ !ÓÓì≈¸ò ~ÓÇ ˆ«¸e! ÓˆÏüˆÏ°Ï xÓú%!Æ ì¸yÓ˚ ¢Ó£z ≤ÃÑ,¸!ì¸Ó˚ ¢)e ˆõˆÏò £ˆÏÎ˚ ~ˆÏ¢ˆÏäÈ– !Ó!¶¸ß¨ ã#Ó˚ˆÏÜy¤¸# ~ÓÇ ã#ÓãˆÏv¸¸Ó˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢ ¡ôˆÏÑ≈¸Ó˚ õyïƒˆÏõ ì¸yˆÏîÓ˚ ¶¸yÓ˚¢yõƒ !òÎ˚s¸fˆÏíÓ˚ Ñ¸yã!›¸Á ≤ÃÑ,¸!ì¸£z Ñ¸ˆÏÓ˚ˆÏäÈ– ≤ÃÑ,¸!ì¸ myÓ˚y !òÎ˚!s¸fì¸ !ÓK¸yˆÏòÓ˚ Óylfl¸ì¸ˆÏs¸fÓ˚ !òÎ˚õ¶¸D Á ì¸yÓ˚ myÓ˚y ¢ÇÜ!‡¸ì¸ ≤ÃyÑ,¸!ì¸Ñ¸ xÓ«¸ˆÏÎ˚Ó˚ ≤Ãïyò Ñ¸yÓ˚Ñ¸ £ˆÏúy õyò%ˆÏ°ÏÓ˚ x¸ô!Ó˚íyõîü≈# fl¸∫yÌ≈!â¸hs¸y ÎyÓ˚ ãòƒ xyã ¸ô!Ó˚ˆÏÓˆÏüÓ˚ !Ó!¶¸ß¨ ¸v¸z¸ôyîyò=!ú «¸!ì¸@˘Ãhfl¸ ~ÓÇ xòƒyòƒ ã#Ó˚ˆÏÜy¤¸#Ó˚ õˆÏì¸y ~Ó˚ ö¸úˆÏ¶¸yÜ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ õyòÓãy!ì¸ˆÏÑ¸Á– ¸ô,!ÌÓ#Ó˚ ãò¢ÇÖƒyÓ˚ xì¸ƒ!ïÑ¸ Ó,!k¸Ó˚ ö¸ˆÏú Óylfl¸ì¸ˆÏs¸fÓ˚ v¸z!qîÈÙÈ≤Ãyí#Ó˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¶¸yÓ˚¢yˆÏõƒ «¸!ì¸ £Î˚ – õyò%°Ï !òˆÏãÓ˚ xÌ≈˜Ïò!ì¸Ñ¸ úy¶¸ñ ¢yõy!ãÑ¸ v¸zß¨!ì¸Ó˚ ãòƒ ˜ÓK¸y!òÑ¸ ~ÓÇ ≤ÃÎ%!_´Üì¸ K¸yˆÏòÓ˚ ˆÎ Óƒy¸ôÑ¸ ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ ÷Ó˚& Ñ¸ˆÏÓ˚ ì¸yÓ˚ ãòƒ ≤ÃˆÏÎ˚yãò#Î˚ ¸ô!Ó˚ˆÏÓüÓ˚«¸y ¢Çe´yhs¸ ¢ì¸Ñ≈¸ì¸y Ñ¸Öò£z ˆòÁÎ˚y £Î˚!ò– x!ì¸ o&ì¸£yˆÏÓ Ó!ï≈ì¸ ãò¢ÇÖƒyÓ˚ â¸yˆÏ¸ô â¸y!£îy ¢,!‹T £Î˚ Ó¢!ì¸ñ â¸y°ÏxyÓyˆÏîÓ˚ fl¸iyò £zì¸ƒy!îÓ˚ – ~£z ¢Ñ¸ú ≤ÃˆÏÎ˚yãˆÏò xÓ˚ˆÏíƒÓ˚ !Óòyüñ !Ó!¶¸ß¨ ˜ÓK¸y!òÑ¸ v¸zqyÓòã!òì¸ Ñ¸yÓ˚ˆÏí ãúñ õy!›¸ñ ÓyÎ˚%Ó˚ fl¸∫y¶¸y!ÓÑ¸ =íÜì¸ õyˆÏòÓ˚ xÓ«¸Î˚ ~ÓÇ ˆ«¸e!ÓˆÏüˆÏ°Ï üÖ Óy úyˆÏ¶¸Ó˚ ãòƒ ÎˆÏÌFäÈ ¸ô!Ó˚õyí ≤Ãyí# Á v¸z!qî ïÇ¢ Ñ¸Ó˚yÓ˚ ö¸ˆÏú xyã ¸ô!Ó˚ˆÏÓˆÏü ≤ÃyˆÏíÓ˚ x!hfl¸c ¢ì¸ƒ£z !Ó¸ôß¨– ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢Ñ¸ú ¢¡ôî ˆÎõò ˆ¶¸Ôì¸ SÓlfl¸Üì¸V v¸z¸ôyîyòñ xyÓ£yÁÎ˚y Á ÓyÎ˚%õ[¸ú ~ÓÇ Óylfl¸ì¸ˆÏs¸fÓ˚ xÓ˚íƒ Á ãúã ≤Ãyí ¢¡ôî £zì¸ƒy!îÓ˚ ÎyÌ !Ó÷k¸Ñ¸Ó˚í Á ¢ÇÓ˚«¸ˆÏíÓ˚ õyïƒˆÏõ ¸ô!Ó˚ˆÏÓü î)°Ïí !òÎ˚s¸fˆÏíÓ˚ ˆâ¸‹Ty õyò%ˆÏ°ÏÓ˚ ¢Ó≈≤ÃÌõ Á ≤Ãïyò Ñ¸ì≈¸Óƒ– xyõyˆÏîÓ˚ õˆÏò Ó˚yÖˆÏì¸ £ˆÏÓ xyõÓ˚y ~Ñ¸£z¢yˆÏÌ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ v¸z¸ôyîyò ~ÓÇ v¸z¸ôyîyˆÏòÓ˚ !òÎ˚s¸fÑ¸ – 5.2 ÓyÎ˚%î)°Ïí (Air Pollution) ÓyÎ˚% ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ~õò ~Ñ¸ v¸z¸ôyîyò ÎyÓ˚ !Ó÷k¸ì¸y ã#ˆÏÓÓ˚ x!hfl¸c Ó˚«¸yÎ˚ x¸ô!Ó˚£yÌ≈– xyõyˆÏîÓ˚ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ≤Ãïyòì¸õ v¸z¸ôyîyò ÓyÎ˚% ÎyÓ˚ õˆÏïƒ ˆÌˆÏÑ¸ Ÿªy¢@˘Ã£í Ñ¸ˆÏÓ˚ xyõÓ˚y ≤Ã!ì¸ õ%£)ˆÏì≈¸ ˆÓ§ˆÏâ¸ ÌyÑ¸yÓ˚ Ó˚¢î ¢Ç@˘Ã£ Ñ¸!Ó˚ – ÓyÎ˚% v¸z!qî Á ≤Ãyí# !ò!Ó≈ˆÏüˆÏ°Ï ¢Ñ¸ú ã#ˆÏÓÓ˚ ã#Ó˚ˆÏòÓ˚ v¸zÍ¢– ÓyÎ˚!ÓÑ¸ v¸z¸ôyîyˆÏòÓ˚ !Ó!òõˆÏÎ˚Ó˚ õyïƒˆÏõ ¢,‹T ¸

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ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸yÓ˚

myÓ˚y Óylfl¸ì¸ˆÏs¸fÓ˚ Ñ¸y‡¸yˆÏõy ÜˆÏv¸¸ ÁˆÏ‡¸ – ˆÑ¸yò fl¸iyˆÏòÓ˚ ÓyÎ˚%Ó˚ fl¸∫y¶¸y!ÓÑ¸ v¸z¸ôyîyˆÏòÓ˚ ˆÑ¸yò ≤ÃÑ¸yÓ˚ ¸ô! Ó˚Óì≈¸ò ì¸y£z ¢õ@˘Ã ¸ô,!ÌÓ#Ó˚ ¸ôˆÏ«¸£z !Ó¸ôîãòÑ¸ £ˆÏÎ˚ v¸z‡¸ˆÏì¸ ¸ôyˆÏÓ˚ – ~£z xÇˆÏü xyõÓ˚y ÓyÎ˚%î)°ÏˆÏíÓ˚ ¢ÇK¸yñ Ñ¸yÓ˚íñ ö¸úyö¸ú Á ¢Ω¸yÓƒ ≤Ã!ì¸Ñ¸yÓ˚ ¸ôk¸!ì¸ !òˆÏÎ˚ xyˆÏúyâ¸òy Ñ¸Ó˚ˆÏÓy– NSOU ? AE-ES-21 ? 73 ¢ÇK¸y ≠ ¸ô,!ÌÓ#Ó˚ ÓyÎ˚%õ[¸ˆÏúÓ˚ ˆÑ¸yò hfl¸ˆÏÓ˚ !Ó!¶¸ß¨ ˆ¶¸Ôì¸ñ Ó˚y¢yÎ˚!òÑ¸ Á ˜ãÓ ¸ôîyˆÏÌ≈Ó˚ xò%≤ÃˆÏÓü Óy ÓyÎ˚%Ó˚ fl¸∫y¶¸y!ÓÑ¸ v¸z¸ôyîyò=!úÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ xò%¸ôyˆÏì¸Ó˚ ¸ô!Ó˚Óì≈¸ò Îy ≤Ãyí# Óy v¸z!qˆÏîÓ˚ ã#Óòõyeyî˚ ˆÑ¸yòÁ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ !Óhfl¸yÓ˚ Ñ¸ˆÏÓ˚ ì¸yˆÏÑ¸ xyõÓ˚y ÓyÎ˚%î)°Ïí Óˆ Ïú Ìy!Ñ¸ – ÓyÎ˚% ã#ÓãÜì¸ˆÏÑ¸ !áˆÏÓ˚ ÌyÑ¸y ~Ñ¸ !õ◊ñ â¸úõyò Á ¢îy ¸ô! Ó˚Óì≈¸òü#ú Üƒy¢#Î˚ ¸ôîyÌ≈– ÓyÎ˚%î)°Ïí ì¸y£z ¢Ó≈îy ¢yõ!@˘ÃÑ¸ xÓ«¸ˆÏÎ˚Ó˚ ¢)â¸Ñ¸ Îy ¸ô!Ó˚ˆÏÓˆÏüÓ˚ xòƒ¢Ñ¸ú v¸z¸ôyîyò=!úˆÏÑ¸ ¢Ó≈y!ïÑ¸ ≤Ã¶¸y!Óì¸ Ñ¸ˆÏÓ˚ ~ÓÇ o&ì¸ ~Ñ¸ fl¸iyò £ˆÏì¸ xòƒfl¸iyˆÏò äÈ!v¸¸ˆÏÎ˚ ¸ôˆÏv¸¸ – ì¸y£z ~!›¸ ~Ñ¸ xyhs¸ã≈y!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü ¢õ¢ƒyÓ˚*ˆÏ¸ô !â¸!£´ì¸ £ˆÏÎ˚ˆÏäÈ– ÓyÎ˚%î)°ÏˆÏíÓ˚ ö¸ˆÏú ÁˆÏãyò hfl¸ˆÏÓ˚ «¸Î˚ ¢,!‹Tñ ˆ@’yÓyú ÁÎ˚y!õ≈Ç Á @˘Ã#ò£yv¸z¢ ~ˆÏö¸Q õyòÓãy!ì¸Ó˚ x!hfl¸ˆÏ¢Ó˚ ¸ôˆÏ«¸ ~Ñ¸ xü!ò¢ÇˆÏÑ¸ì¸ £ˆÏÎ˚ ˆîÖy !îˆÏFäÈ– ÓyÎ˚%î)°ÏˆÏíÓ˚ òyòy ≤Ã¶¸yˆÏÓÓ˚ ö¸ˆÏú ¢,!‹T £ÁÎ˚y !Ó!¶¸ß¨ x¢%Ö ¢Çe´õí Á ì¸ Íã!òì¸ õ,ì¸%ƒÓ˚ £yÓ˚ xy«¸!ÓÑ¸ xˆÏÌ≈£z v¸zˆÏmÜãòÑ¸ – ÓyÎ˚%î)°Ïí ≤Ãïyòì¸ É ÓyÎ˚%õ[¸ˆÏúÓ˚ ò#ˆÏâ¸Ó˚ hfl¸Ó˚=!ú xÌ≈yÍ ¢õõ[¸ˆÏúÓ˚ (Homosphere) hfl¸Ó˚=!úˆÏì¸ xyÓk¸ – ¶)¸¸ô,¤¸ ¢Çú@¿ ã#Óãls¸ˆÏÑ¸ !áˆÏÓ˚ ÌyÑ¸y «%¸∏¸õ[¸ˆÏú (Troposphere) ÓyÎ˚%î)°ÏˆÏí ≤Ã¶¸yÓ ¢Ó≈ydÑ¸ ~ÓÇ fl¸∫y¶¸y!ÓÑ¸¶¸yˆÏÓ «%¸∏¸õ[¸ú î)°ÏˆÏíÓ˚ ö¸ú ã#ÓÑ%¸ˆÏúÓ˚ x!hfl¸ˆÏ¢Ó˚ ¸ôˆÏ«¸ õyÓ˚ydÑ¸ – 5.2.1 ÓyÎ˚%î)°ÏˆÏíÓ˚ ≤ÃÑ¸yÓ˚¶¸ˆÏî î)°ÏÑ¸¸ ¸ôîyˆÏÌ≈

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Ó˚ ≤ÃÑ,¸!ì¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚

ÓyÎ˚%î)°ÏíˆÏÑ¸ â¸yÓ˚!›¸ ˆ◊!íˆÏì¸ ¶¸yÜ Ñ¸Ó˚y ¢Ω¸Ó– S1V Üƒy¢#Î˚ î)°Ïí ≠ ÓyÎ˚%ˆÏì¸ ˆÑ¸yòÁ !Ó°Ïy_´ Óy «¸!ì¸Ñ¸Ó˚ Üƒy ˆÏ¢Ó˚ !õˆÏü ÎyÁÎ˚yÓ˚ ö¸ˆÏú ~£z ≤ÃÑ¸yÓ˚ ÓyÎ˚%î)°Ïí áˆÏ›¸ – Ñ¸ˆÏÎ˚Ñ¸!›¸ ≤Ãïyò î)°ÏÑ¸ Üƒy¢ £ˆÏúy Ñ¸yÓ≈ò õˆÏòy:y£zv¸ (CO)ñ ¢yúö¸yÓ˚ v¸y£zÈÙÈx:y£zv¸ (SO 2)ñ òy£zˆÏ›¸∆yˆÏãˆÏòÓ˚ !Ó!¶¸ß¨ x:y£zv¸ SN 2 O, NO, NO 2 £zì¸ƒy!îVñ ~äÈyv¸¸y !Ó!¶¸ß¨ £y£zˆÏv»¸yÑ¸yÓ≈ò £zì¸ƒy!î– ˆ«¸e!ÓˆÏüˆÏ°Ï xòƒ!Ñ¸ä%È !Ó°Ïy_´ Üƒy¢ ˆÎõò xƒyˆÏõy!òÎ˚y (NH 3)ñ £y£zˆÏv»¸yˆÏãò ¢yúö¸y£zv¸ñ ˆÑœ¸y!Ó˚ò £zì¸ƒy!î ˆÑ¸yòÁ ¶¸yˆÏÓ ÓyÎ˚%ˆÏì¸ !õˆÏü ¸ô!Ó˚ˆÏÓüˆÏÑ¸ ≤Ãâ¸[¸¶¸yˆÏÓ «¸!ì¸@˘Ãhfl¸ Ñ¸ˆÏÓ˚ – xyÓyÓ˚ ˆÑ¸yòÁ Ñ¸yÓ˚ˆÏí ÓyÎ˚%Ó˚ Üƒy¢#Î˚ v¸z¸ôyîyò=!úÓ˚ fl¸∫y¶¸y!ÓÑ¸ xò%¸ôyˆÏì¸ ¸ô!Ó˚Óì≈¸ò á›¸yÓ˚ ö¸ˆÏú ÓyÎ˚%î)°Ïí ¢,!‹T £ˆÏÎ˚ ÌyˆÏÑ¸ – ˆÎõò Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zv¸ Üƒy¢!›¸ ÓyÎ˚%

83% **MATCHING BLOCK 94/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó˚ ~Ñ¸!›¸ =Ó˚&c¸ô)í≈ v¸z¸ôyîyòñ Ñ¸yÓ˚í ~!›¸ ≤

ÃyÌ!õÑ¸ ÖyîÑ¸ xÌ≈yí ¢Ó%ã v¸z!q ˆÏîÓ˚ Öyîƒ v¸zÍ¸ôyî ˆÏòÓ˚ Ñ¸yˆÏã ~Ñ¸!›¸ xòƒì¸õ ≤Ãïyò ¸ôîyÌ≈ Ó˚*ˆÏ¸ô ÓƒÓ£*ì¸ £Î˚ – Óì≈¸õyˆÏò ¸ô,! ÌÓ#ˆÏì¸ ≤Ãyí# !ÓˆÏü°Ïì¸É õyò%ˆÏ°ÏÓ˚ ¢ÇÖƒy xì¸ƒy!ïÑ¸ ˆÓˆÏv¸¸ ÎyÁÎ˚yÓ˚ ö¸ˆÏú v¸z!qî ≤Ãyí#Ó˚ ¢ÇÖƒyÓ˚ fl¸ƒy¶¸y!ÓÑ¸ xò%¸ôyì¸ ÓƒÉì¸ £ˆÏÎ˚ˆÏäÈ ~ÓÇ xì¸ƒy!ïÑ¸ ≤Ãyí#Ó˚ Ÿªy¢Ñ¸yˆÏÎ≈Ó˚ ö¸ˆÏú !òÜ≈ì¸ ~ÓÇ Ñ¸Î˚úyãyì¸ ¸ôîyÌ≈ î£ˆÏòÓ˚ ö¸ˆÏú Óyì¸yˆÏ¢

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Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí

xì¸ƒy!ïÑ¸ ˆÓˆÏv¸¸ ˆÜˆÏäÈ– ~Ó˚ ö¸ˆÏú ¸ô,!ÌÓ#Ó˚ ÓyÎ˚%õ[¸ˆÏúÓ˚ Üv¸¸ v¸z_y¸ô !òÎ˚ì¸ Ó,!k¸ ¸ôyˆÏFäÈ Îy ¸ô,!ÌÓ#Ó˚ xyÓ£yÁÎ˚yÎ˚ ~Ñ¸!›¸ õyÓ˚ydÑ¸ ï)°Ïí ~ÓÇ ¢õhfl¸ ¸ô,!ÌÓ#Ó˚ !ÓK¸yò#Ñ%¸ú ~£z ÚÚˆ@'yÓyú ÁÎ˚y!õ≈ÇÛÛ ¢õ¢ƒyÎ˚ xì¸ƒhs¸ v¸z!m@¿– S2V ¶¸y¢õyò Ñ¸!‡¸ò Ñ¸íyã!òì¸ ï)°Ïí ≠ ÓyÎ˚%ˆÏì¸ !Ó!¶¸ß¨ ˜ãÓ Ñ¸íy ˆÎõò ö%¸ˆÏúÓ˚ ¸ôÓ˚yÜ ã#Óyí% £zì¸ƒy!î ~ÓÇ !Ñ¸ä%È ¢)" ï)!úÑ¸íy !õˆÏü ÌyˆÏÑ¸ Îy ≤ÃÑ¸,!ì¸ãyì¸ ~ÓÇ fl¸ƒy¶¸y!ÓÑ¸ – ~Ó˚ v¸z¸ôÓ˚ls¸ õyò%ˆÏ°ÏÓ˚ myÓ˚y !Ó!¶¸ß¨ ¶¸yˆÏÓ òyòy ïyì¸Ó ¸ôîyÌ≈ Óy Ó˚y¢yÎ˚!òÑ¸ oˆÏÓƒÓ˚ ¢)" Ñ¸íy Óy Ñ¸Î˚úyÓ˚ =§ˆÏv¸¸y ÓyÎ˚%ˆÏì¸ !õüˆÏäÈ Îy Ÿªyˆ Ï¢Ó˚ ¢ˆÏD üÓ˚#ˆÏÓ˚ ë%¸ˆÏÑ¸ õyò%°Ï Á xòƒyòƒ ≤Ãyí#Ó˚ ˆîˆÏ£ òyòy x¢ %ˆÏÖÓ˚ ¢)â¸òy Ñ¸ˆÏÓ˚ – S3V ¶¸y¢õyò ì¸Ó˚ú Ñ¸íyã!òì¸ ÓyÎ˚%ï)°Ïí ≠ ÓyÎ˚%ˆÏì¸ ˆÑ¸yòÁ Ó˚y¢yÎ˚!òÑ¸ ì¸Ó˚ú¸ôîyˆÏÌ≈Ó˚ ¢)" Ñ¸íy ¶¸y¢õyò xÓfl¸iyÎ˚ ˆÌˆÏÑ¸Á ï)°Ïí ¢,!‹T Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ – ˆÎõò Óyì¸yˆÏ¢ v¸z¸ô!fl¸ïì¸ xïyì¸Ó x:y£zv¸=!ú ãú#Î˚ Óyˆ‹ôÓ˚ ¢yˆÏÌ ≤Ã!e´Î˚y Ñ¸ˆÏÓ˚ 74 ? NSOU ? AE-ES-21

!Ó!¶¸ß¨ xƒy!¢v¸Ñ¸íy v¸zÍ¸ôß¨ Ñ¸ˆÏÓ˚ – ~äÈyv¸¸y !Ó!¶¸ß¨ Ñ¸yÓ˚ÖyòyÎ˚ xì¸ƒ!ïÑ¸ xƒy!¢v¸ ÓƒÓ£yˆÏÓ˚Ó˚ ö¸ˆÏú ¢Ç!Ÿ'‹T ~úyÑ¸yÓ˚ Óyì¸yˆÏ¢ xƒy!¢v¸ ˆïßyÎ˚yüyÓ˚ ≤Ãyî%¶≈¸yÓ áˆÏ›¸ – Óyì¸yˆÏ¢ ~£z¢Ó xƒy!¢v¸ ~úyÑ¸yÓ˚ áÓ˚Óyv¸¸# Á ˆ¢ÔˆÏïÓ˚ v¸z¸ô!Ó˚hfl¸Ó˚ˆÏÑ¸ ≤ÃÓú¶¸yˆÏÓ «¸!ì¸@˘Ãhfl¸ Ñ¸ˆÏÓ˚ – ÓúyÓy˝úƒ ˆÎ Óyì¸yˆÏ¢ ~£z ïÓ˚ˆÏòÓ˚ xƒy!¢v¸Ñ¸íyÓ˚ v¸z¸ô!fl¸i!ì¸ ~úyÑ¸yÓ˚ õyò%ˆÏ°ÏÓ˚ üÓ˚#ˆÏÓ˚ î#á≈ˆÏõÎ˚yî# ÌyˆÏÑ¸ñ ~õò!Ñ¸ ˆ«¸e!ÓˆÏüˆÏ°Ï ≤Ãyíáyì¸# ˆÓ˚yÜ ¢,!‹T Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ – S4V ˆì¸ã!‹;¸Î˚ ¸ôîyÌ≈ ã!òì¸ ÓyÎ˚%ï)°Ïí ≠ ¸ô!Ó˚ˆÏÓ˚ˆÏü ˆ

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ì¸ã!‹;¸Î˚ ¸ôîyˆÏÌ≈Ó˚ v¸z¸ô!fl¸i!ì¸

Ó˚ !Ñ¸ä%È fl¸ƒy¶¸y!ÓÑ¸ v¸zÍ¢ xyˆÏäÈ– ˆÎõò v¸zÕÒy¸ôyì¸ £zì¸ƒy!îÓ˚ õyïƒˆÏõ Óy£zˆÏÓ˚ ˆÌˆÏÑ¸ ¸ô,!ÌÓ#Ó˚ xyÓ£õ[¸ˆÏú ˆõüyñ ¸ô! Ó˚ˆÏÓˆÏü v¸z¸ô!fl¸ïì¸ !Ñ¸ä%È !ÓˆÏü°Ï ïyì¸% Óy ïyì¸Ó ˆÎÔÜ ˆÌˆÏÑ¸ !òÉ¢ì¸ xyí!ÓÑ¸ ï)°ÏˆÏíÓ˚ ¸ô!Ó˚õyˆÏò òÜíƒ– ¸ôyÓ˚õyí!ÓÑ¸ ÜˆÏÓ°ÏíyÜyÓ˚ñ Ñ¸yÓ˚Öyòy Óy !â¸!Ñ¸Í¢yˆÏÑ¸w Óy ¢%Ó˚«¸y ¸ôÓ˚#«¸yÎ˚ ÓƒÓ£*ì¸ X-ray, ˆì¸ã!‹;¸Î˚ SˆÓ˚!v¸Î˚yõV v¸yÎ˚yúÎ%_´ á!v¸¸ñ ˆú¢yÓ˚ ›¸â≈¸ ≤Ã¶¸,!ì¸ ˆÌˆÏÑ¸ xyí!ÓÑ¸ !Ó!Ñ¸Ó˚í ~ÓÇ !ÓˆÏü°Ïì¸É ¸ôyÓ˚õyí!ÓÑ¸ xˆÏfl¸fÓ˚ ¸ôÓ˚#«¸yõ)úÑ¸ !ÓˆÏfl¸≥¸yÓ˚ˆÏíÓ˚ ö¸ˆÏú ¸ô!Ó˚ˆÏÓˆÏü ˆì¸ã!‹;¸Î˚ ï)°ÏˆÏíÓ˚ ≤Ãyî%¶≈¸yÓ áˆÏ›¸ – ˆì¸ã!‹;¸Î˚ ï)°ÏˆÏíÓ˚ ö¸ˆÏú õyòÓˆÏïˆÏ£ ≤ÃyÌ!õÑ¸ ≤Ã!ì¸!e´Î˚y=ˆÏúy Ó!õñ î%Ó≈úì¸yñ Ó˚_´ÈÙÈ¸ôyÎ˚ÖyòyÎ˚ñ ¢Çe´yõÑ¸ x¢%ˆÏÖ ˆ¶¸yÜy £zì¸ƒy!î ˆîÖy ÎyÎ˚ – ¸ôÓ˚Óì≈¸# ¸ôî≈yˆÏÌ≈ !Ó!¶¸ß¨ ≤ÃÑ¸yÓ˚ â¸õ≈ˆÏÓ˚yÜ ˆÎõò â¸yõv¸¸yÎ˚ ˆö¸yfl¸Ó˚y ¸ôv¸¸yñ ˆö¸ˆÏ›¸ ÎyÁÎ˚yñ Ó˚_´¸ôv¸¸yñ â%¸ú v¸zˆÏ‡¸ ÎyÁÎ˚y £zì¸ƒy!î áˆÏ›¸ – ˆì¸ã!‹;¸Î˚ì¸yÓ˚ î#á≈fl¸iyÎ˚# «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yˆÏÓñ òyòy õyÓ˚ydÑ¸ ˆÓ˚yÜ ¢,!‹T £Î˚ ˆÎõò !úv¸z!Ñ¸!õÎ˚yñ Ñ¸ƒy™yÓ˚ñ äÈy!ò Á xòƒ ˆâ¸yˆÏÖÓ˚ ˆÓ˚yÜñ Ìy£zÓ˚ˆÏÎ˚ˆÏv¸Ó˚ x¢%Ö £zì¸ƒy!î– v¸zîy£Ó˚ífl¸ÍÓ˚*¸ô ‹T…ò!¢Î˚yõñ !¢!ãÎ˚yõñ Ñ¸yÓ≈ò (C 14) £zì¸ƒy!î !Ó!¶¸ß¨ «¸!ì¸Ñ¸Ó˚ ˆì¸ã!‹;¸Î˚ ï)°ÏÑ¸ ¸ôîyÌ≈ SÓy ì¸y ˆÌˆÏÑ¸ v¸zÍ¸ôß¨ !Ó!¶¸ß¨ Ó˚!Ÿ¬¢õ)£ñ ˆÎõòÈÙÙÙÈ Üyõy Ó˚!Ÿ¬ñ xyúö¸y Ó˚!Ÿ¬ñ !Ó›¸y Ó˚!Ÿ¬ñ X-ray Ó˚!Ÿ¬ £zì¸ƒy!îV– 5.2.2 ÓyÎ˚%ï)°ÏˆÏíÓ˚ Ñ¸yÓ˚í S1V ≤ÃyÑ¸,!ì¸Ñ¸ Ñ¸yÓ˚í ≠ !Ó!¶¸ß¨ ≤ÃyÑ¸,!ì¸Ñ¸ !Ó¸ôî≈Î˚ ~ÓÇ ≤ÃyÑ¸,!ì¸Ñ¸ ¸ô! Ó˚Óì≈¸ˆÏòÓ˚ ö¸ˆÏú ÓyÎ˚%ï)°Ïí áˆÏ›¸ ÌyˆÏÑ¸ñ Î!îÁ ì¸yÓ˚ ¸ô!Ó˚õyí ~ÓÇ «¸!ì¸Ñ¸yÓ˚ Ñ¸ì¸y õyò%ˆÏ°ÏÓ˚ myÓ˚y Ñ¸,ì¸ ï)°ÏˆÏíÓ˚ ì%¸úòyÎ˚ òÜíƒ– ÓyÎ˚%ï)°ÏˆÏíÓ˚ ¸Ñ¸ˆÏÎ˚ Ñ¸!›¸ ≤Ãïyò ≤ÃyÑ¸,!ì¸Ñ¸ Ñ¸yÓ˚í £úñ SÑ¸V îyÓyòúñ xyˆÏ@¿Î˚!Ü!Ó˚ ˆÌˆÏÑ¸ x@¿%ƒÍ¸ôyˆÏì¸Ó˚ ö¸ˆÏú ¢,‹T ¢yúö¸yÓ˚ v¸y£zÈÙÈx:y£zv¸ Üƒy¢ Á ¢yúö¸yÓ˚ñ õƒyDyò#ãñ ˆÑœ¸y!Ó˚òñ ˆÓ y!õò ≤Ã¶¸,!ì¸ ïyì¸% Óy xïyì¸Ó Ñ¸íyãyì¸#Î˚ ¸ôîyÌ≈– SÖV ãúy¶)¸!õ xM¸Èˆ Ïú Óy ã#ÓˆÏîˆÏ£Ó˚ ¸ôâ¸ˆÏòÓ˚ ö¸ˆÏú ¢,‹T !õˆÏÌò (CH 4) Üƒy¢– SÜV Ñ¸Î˚úy Á ˆ¸ôˆÏ›¸∆y!úÎ˚yõ Ö!òãyì¸ Üƒy¢ñ ˆÎõòÈÙÙÙÈ !õˆÏÌò (CH 4)ñ Ñ¸yÓ≈ò õˆÏòy:y£zv¸ (CO) SáV v¸zÕÒy¸ôyˆÏì¸Ó˚ ö¸ˆÏú ïyì¸% Ñ¸íy SàV õ£yãyÜ!ì¸Ñ¸ ¶¸y!Ó˚ ï)!úÑ¸íyñ Sâ¸V @˘Ã£=!úÓ˚ xyÓì≈¸ò Á ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ï)Ó˚ˆÏ¢Ó˚ £…y¢ Ó,!k¸Ó˚ ö¸ˆÏú ¢Çá!›¸ì¸ òyòy

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xyˆÏúyÑ¸ Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚y

ãyì¸ ÓyÎ˚%ï)°Ïí– SäÈV !Ó!¶¸ß¨ ≤ÃyÑ¸,!ì¸Ñ¸ î%á≈›¸òyÓ˚ ö¸ˆÏú ¢,‹T ¶¸y£zÓ˚y¢ñ ÓƒyÑ¸ˆÏ›¸!ÓˆÏÎ˚yñ xƒyúy!ã≈ñ ö¸yòãy£z £zì¸ƒy!î– ! ÓK¸yò#Ó˚y xÓüƒ ~£z ¢Ñ¸ú ≤ÃyÑ¸,!ì¸Ñ¸ v¸z¸ôyˆÏîÎ˚ ¢,‹T ÓyÎ˚%ï)°Ïí ˆÌˆÏÑ¸ xˆÏòÑ¸ ˆÓü# v¸zˆÏmÜãòÑ¸ ÓˆÏú õˆÏò Ñ¸ˆÏÓ˚òñ õyò%ˆÏ°ÏÓ˚ myÓ˚y ¢,‹T !Ó!¶¸ß¨ Ñ¸,!eõ ÓyÎ˚%ï)°ÏˆÏíÑ¸ñ ˆÑ¸òy Î!îÁ ~£z ¢Ó ï)°Ïí=!úÓ˚ !òÎ˚s¸fí ¢Ω¸Óñ ì¸Ó%Á ÷ï%õye NSOU ? AE-ES-21 ? 75

õyò%ˆÏ°ÏÓ˚ x!ÓˆÏÓâ¸òyÓ˚ ö¸ˆÏú ~£z ï)°ÏˆÏíÓ˚ ¸ô!Ó˚õyí !òÓ˚hs¸Ó˚ o&ì¸£yˆÏÓ˚ ˆÓˆÏv¸¸£z â¸ˆÏúˆÏäÈ ~ÓÇ ~Ó˚ «¸!ì¸Ñ¸yÓ˚ì¸y ≤ÃˆÏì¸ƒÑ¸ ˆ«¸ˆÏe£z xì¸ƒhs¸ Óƒy¸ôÑ¸– õyòÓ ¢¶¸ƒì¸yÓ˚ x@ˆÃÜ!ì¸Ó˚ ¢yˆÏÏ ¢yˆÏÏ !ÓÜì¸ Ñ¸ˆÏÏ˚Ñ¸ üì¸y∑#ˆÏì¸ !Ó!¶¸ß¨¶¸yˆÏÓ Óyî˚%ï) °Ïí áˆÏ›¸ˆÏäÈ îyÓ˚ ≤Ã¶¸yˆÏÓ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ xòƒ v¸z¸ôyîyò=!úÁ òyòy¶¸yˆÏÓ ï)!°Ïì¸ Óy «¸!ì¸@ˇÃhfl¸ £ˆÏÏ˚ˆÏäÈ– Ñ¸ˆÏÏ˚Ñ¸!›¸ ≤Ãïyò ï) °ÏíÑ¸yÓ˚Ñ¸ ¢¡Ïˆ Ïì¸ ~ÕyˆÏò xyˆÏúyâ¸òy Ñ¸Ó˚y £ˆÏúy– S2V îyòÓy£ò ¢¸‹T Óyî˚%ï)°Ïí ≠ õyò%ˆÏ°ÏÓ˚ ÓƒÓ£*ì¸ !Ó!¶¸ß¨ xyï%!òÑ¸ ¸ô! Ó˚Ó£ò õyïƒõ ˆÌˆÏÑ¸ !òÉ¢¸ì¸ ˆïßyÎ˚y ¸ô!Ó˚ˆÏÓüˆÏÑ¸ ï)!°Ïì¸ Ñ¸ˆÏÓ˚– fl¸iú¸ôˆÏÏ îye#Óy£# îyò Óy õyúÜy!v¸¸ !£¢yˆÏÓ ÓƒÓ£*ì¸ Óy¢ñ ˆ›¸∆òñ ˆõy›¸Ó˚Üy!v¸¸ñ ˆ›¸ˆÏ¡ïyñ ú!Ó˚ñ ›¸∆yÑ¸ £zì¸ƒy!ï ãµyúyò# !£¢yˆÏÓ ÓƒÓ£*ì¸ ÷k¸ Óy x÷k¸ ˆ¸ôˆÏ›¸∆yúñ !v¸ˆÏãú £zì¸ƒy!ïÓ˚ ¢ ¡ô)í≈ Á x¢¡ô)í≈ î£ˆÏòÓ˚ ö¸ˆÏú !Ó!¶¸ß¨ !Ó°Ïy_´ Üƒy¢ ˆÎõò Ñ¸yÓ≈ò õˆÏòy:y£zv¸ (CO)ñ òy£zˆÏ›¸∆yˆÏãˆÏòÓ˚ !Ó!¶¸ß¨ x:y£zv¸ñ ¢yúö¸yÓ˚ v¸y£zÈÙÈx:y£zv¸ (SO 2) ˆúv¸ÈÙÈx:y£zv¸ ≤Ã¶¸¸!ì¸ Óyì¸yˆÏ¢ !õˆÏü îyÎ˚– ~äÈyv¸¸y î£ò òy £ÁÎ˚y !Ñ¸ä%È £y£zˆÏv»¸yÑ¸yÓ≈ò ãyì¸#Î˚ ˆÎÔÜñ ¸ô!ú!òv¸z!Ñœ¸Î˚yÓ˚ £y£zˆÏv»¸yÑ¸yÓ≈ò Óy Ñ¸yÓ≈ò Ñ¸íy ~ÓÇ ˆúv¸ Óyî˚%ˆÏì¸ ¶¸y¢õyò xÓfl¸iyî˚ !õˆÏü îyÎ˚– ~ˆÏíÓ˚ õˆÏïƒ ˆúv¸ î%_´ ˆ¸ôˆÏ›¸∆yú ˆÌˆÏÑ¸ ¢¸‹T ˆúv¸ Ñ¸íy Á ˆúv¸ÈÙÈx:y£zv¸ Üƒy¢ ≤Ãâ¸[¸ !Ó°Ïy_´ îy üÓ˚#ˆÏÓ˚ ! â¸Ó˚fl¸iyî˚# Óƒy!ï ¢¸!‹T Ñ¸ˆÏÓ˚– fl¸∫¶¸yÓì¸£z ü£ÓˆÏyM¸ÈˆÏú îyòÓy£ò ~ÓÇ õyúÜy!v¸¸Ó˚ xì¸ƒy!íÑ¸ ÓƒÓ£yˆÏÓ˚Ó˚ ö¸ˆÏú ~£z ãyì¸#Î˚ Óyî˚%ï)°ÏˆÏíÓ˚ ¸ô!Ó˚õyí xì¸ƒy!íÑ¸– ~Ñ¸!›¸ ¸ô!Ó˚¢ÇÖƒyò xò%¢yˆÏÓ˚ ¶¸yÓ˚ˆÏì¸Ó˚ Óv¸¸ üÉÓ˚=!úˆÏì¸ ˆõy›¸ Óyî˚% ï)°ÏˆÏíÓ˚ xˆÏï≈Ñ¸ ¶¸yÜ ¢¸!‹T £Î˚ ¸ô!Ó˚Ó£ò ¢Çe´yhs¸ x¢ì¸Ñ≈¸ì¸yÓ˚ îÓ˚&í– ~ äÈyv¸¸y ¢yõ%!òÑ¸ Á ÓyÎ˚%ÌyòÓ˚ ˆÌˆÏÑ¸ !òÜ≈ì¸ ˆïßyÎ˚y !ÓˆÏüºì¸ Î%k¸îyò Óy xòƒ ¢yõ!Ó˚Ñ¸îyò !òÉ¢¸ì¸ Üƒy¢=!ú ¸ô!ÓˆÏÓ˚ˆÏüÓ˚ÑÑ¸ ≤ÃÓú õyeyÎ˚ ï)!°Ïì¸ Ñ¸ˆÏÓ˚– ¸ô!ÓˆÏ£ˆÏòÓ˚ äõƒ Ó˚yhfl¸yñ ¸ô%ú £zì¸ƒy!ï ˆì¸!ÓˆÏÓ˚ ˆ!¸âÓ˚ ÜüyˆÏòyÓ˚ ¢õÎ˚ ˆïßyÎ˚y ˆÓˆÏÓ˚yÎ˚ ì¸yˆÏì¸ ˆÓÓy¸ôy£z!Óˆò ˆÎÔÜ ìyˆÏÏÑ¸ îyÓ˚ ˆÌˆÏÑ¸ Ñ¸ƒyò¢yÓ˚ ˆÓ˚yÜ £ÎÎ˚ – S3V !ü“ãyì¸ Óyî˚%ï)°Ïí ≠ !ü“yM¸Èú=!úÓ˚ Ñ¸úÑ¸yÓ˚Öyòy ˆÌˆÏÑ¸ òyòy Üƒy¢ñ ˆïßyÎ˚y ~ÓÇ ì¸yˆÏì¸ ¶¸y¢õyò x!ì¸«%¸o îyì¸Ó Óy xïyì¸Ó Óyî¢ yÎ˚ !òÑ¸ ¸ôîyˆÏÏ≈Ó˚ ¸Ñ¸íy Óyî˚%ˆÏì¸ !õˆÏü îyÎ˚– ≤Ãïyì¸É Üì¸ üì¸y∑#Ó˚ !ü“!Ó≤´ˆÏÓÓ˚ ¸ôÓ˚Óì≈¸# ¸ôÓ≈y ˆÎÏ˚ ! ü“yM¸ÈˆÏúÓ˚ xì¸ƒy!íÑ¸ ≤Ã¢yÓ˚ Á ˆ¢Óy ˆÏò ≤ÃˆÏÏ˚yã#Î˚ ¢ì¸Ñ≈¸ì¸y äÈyv¸¸y£z òyòy «¸!ì¸Ñ¸Ó˚ Óy¢yÓ˚ !òÑ¸ ¸ôîyˆÏÏ≈Ó˚ ÓƒÓ£yÓ˚ ~£z ï)°ÏˆÏíÓ˚ Ñ¸yÓ˚Ñ¸– ≤ÃyÎ˚!õÑ¸¶¸yˆÏÓ ~£z ï)°Ïí ÷ï%õye ¢Ç!Ÿ‹T ~úyÑ¸yˆÏÌ ≤Ã¶¸y!ÓÓ˚ì¸ Ñ¸Ó˚ˆÏÓ˚ ˆúÁ ¸ôÓ˚ˆÏúÓ≈ò ¸ ŠÑ¸ Óyî˚% Á ã ˆÏúÓ ≤ÃÓy£ ¸ôy£zÓ˚ Óy£zÓ˚ˆ Ó˚ õy¸ôÑ¸ ¢£ ˆì¸ ∆! ¶¸yˆÏÓ ˆõyÓ˚ Ó÷ÑÁ
ãˆÏúÓ˚ ≤ÃÓy£Ì¸ò¸ ô ˆÏú Óy v¸¸Ñ¸yîy Ñ¸ˆÏÓ˚ ¸ôˆÏÓ˚ ˆ!ü“Ó§¸ ˆÓÓy˚ ¸ôyãyˆÏÏ≈ ÓyÓy¸ôˆÏÏ˚ ÓÃÓy£ !Ó!¶¸ß¨ ¸ôyˆÏÌÓ˚ ì¸y Óy!¸ô ì¸ Ñ¸Ó˚ˆÏ¸ ¶¸yˆÏÓ ~£z ¸ôÓ Ó˚ì≈¸ í ˆÎÏ˚ ˆ¢

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Ïúy– ¶)¸¸ôyú Üƒy¢ î%á≈›¸òyÈÙÙÈ !ü“ Ñ¸yÓ˚Öyòyî˚ î%á≈›¸òyÓ˚ ö¸ˆÏú ¢Ó≈ydÑ¸ Óyî˚%ï)°ÏíÓ˚ á›¸òy!›¸ áˆÏ›¸!äÈˆÏúy ¶¸yÓ˚ˆÏì¸Ó˚ ¶)¸¸ôyú üÉˆÏÓ˚ 1984 ¢yˆÏúÓ˚ 3Ó˚y !v¸ˆÏ¢¡ÍÓ˚ ì¸y!Ó˚ˆÏÖ– ˙!òò Ñ¸#›¸òyüÑ¸ oÓƒ ≤Ãlfl¸ì¸Ñ¸yÓ˚# £zv¸z!òÎ˚ò Ñ¸yÓ≈y£zv¸ Ñ¸yÓ˚ÖyòyÎ˚ !òÑ¸ ≤'ƒyr›¸ ˆÌˆÏÑ¸ !òÑ¸ (MIC) Óy !õÌy£zú xy£zˆÏ¢yÈÙÈ¢yÎ˚y!ˆòy›¸ òyõÑ¸ x!ì¸ !Ó°Ïy_´ Á v¸zmyÎ˚# Üƒy¢ õ%_´ ¸ô!ÓˆÏÓ˚ˆÏüÓ˚ ÓyÎ˚%ˆÏì¸ !õˆÏü !ü“ˆÏÏ˚ Óƒy¸ôÑ¸ ã#Óò£y!ò á›¸yÎ˚– ¢ÓˆÑ¸yÓ˚!Ó ˙ˆÌˆÏì¸ ¸ôy›≈¸ xò%¢yˆÏÓ˚ 2300 õyò%°Ï ~ˆÏì¸ õyÓ˚y ¸ôˆÏv¸¸– î%ú«¸ õyò%°Ï ¸ôD% £ˆÏÏ˚ îyÎ˚– x¢ÇÜƒ ã#Óäls¸ S!ÓˆÏü°Ïì¸É ÜÓy!î ¸ô÷V Á ÜyäÈ ¸ôyúy ïπÇ¢ £ˆÏÏ˚ îyÎ˚– î%á≈›¸òyÓ˚ !òÑ¸ !õÑ¸ Üƒy¢ ›¸ƒy¨ÏB¸Ó˚ ¢Çú@¿ !ö ¸ã ÖyÓ˚y¸ô £ˆÏÏ˚ Üƒy¢ˆÏ¢Ó˚ v¸z°ài¸y 0°C ˆÌˆÏÑ¸ Óy!v¸¸ˆÏÏ˚ ˆîÏ˚– xì¸É¸ôÓ˚ ˆÑ¸yˆÏòy¶¸yˆÏÓ Üƒy¢!›¸ ãˆÏúÓ˚ Ó˚yÓ˚yˆÏ ¢yˆ Ïú ˆ›¸ƒy¨ÏB¸Ó˚ ˆ¢ö¸!›¸ ¶¸yúÓ Ö%ˆÏú ´ !Ó°Ïy_´ Üƒy¢ Óyì¸yˆÏ¢ äÈ!v¸¸ˆÏÏ˚ îyÎ˚– !òÓ˚y¸ô_y ÓƒÓfl¸iy=!ú fl¸∫y¶¸y!ÓÑ¸¶¸yˆÏÓ â¸yú% òy ìyÑ¸yÎ˚ Üƒy¢!›¸ 76 ? NSOU ? AE-ES-21

îy£ƒ £ˆÏúÁ ¸ô%!v¸¸ˆÏÏ˚ ˆîÁÎ˚y Óy xòƒ ›¸ƒy¨ÏB¸ fl¸iyòyhs¸Ó˚ Ñ¸Ó˚y ¢Ω¸Ó £Î˚!ò– î%¶≈¸yÜƒãòÑ¸¶¸yˆÏÓ Ñ¸yÓ˚ÖyòyÓ˚ ¸ôyˆÏüÓ˚ Ó!hfl¸ xM¸ÈˆÏú ÌyÑ¸y £ãyÓ˚ £ãyÓ˚ õyò%°Ï ¢ì¸Ñ≈¸ £ÓyÓ˚ ¢yõyòƒì¸õ ¢%ˆÏÎyÜ%ÑÌ%Ñ¸ Á ¸ôyò!ò ~ÓÇ x¢£yÎ˚ ¶¸yˆÏÓ õyÓ˚y îyò– 1952 ¢yˆÏú úu¸ˆÏòÓ˚ ¢¸‹T !Ó°Ïy_´ ¢yúö¸yÓ˚ v¸y£zÈÙÈx:y£zv¸ ˆïßyÎ˚yüyÓ˚ ö¸ˆÏú ì¸yÎ˚«¸!íÑ¸¶¸yˆÏÓ ≤ÃyÎ˚ 4 £yãyÓ˚ õyò%°Ï õyÓ˚y îyÎ˚ ~ÓÇ ¸ôÓ˚Óì≈¸# Ñ¸ˆÏÏ˚Ñ¸ õy¢ˆÏ¢ xyÓ˚ 8 £yãyÓ˚ õyò%°Ï õyÓ˚y îyÎ˚– 1979 ¢yˆÏú ˆ¢y!¶¸ˆÏÏ˚ì¸ Óy!üÎ˚y ~Ñ¸!›¸ ˜ãÓ xfl¸ƒ ÜˆÏÓ°ÏíyÜyˆÏÓ˚ xfyò ˆÌˆÏÑ¸ : ˆÎÔÜ !òÉ¢ÓˆÏíÓ˚ ö¸ˆÏú Ñ¸ˆÏÏ˚Ñ¸ˆÏüy õyò%°Ï õyÓ˚y îyò– S4V Ü£ãyì¸ Óyî˚%ï)°Ïí ≠ õyò%ˆÏ°ÏÓ˚ Óy¢Ü£ Á Ñ¸õ≈≤Ã!ì¸¤¸yˆÏò Óˆì¸ò Óy v¸z_y¸ô ¢¸‹TÓ˚ ãòƒ ÓƒÓ£*ì¸ ãµyúyò#Ó˚ x¢¡ô)í≈ î£ˆÏòÓ˚ ö¸ˆÏú Ñ¸yÓ≈ò õˆÏòy:y£zv¸ Óy x!Ó÷k¸ ãµyúyò# î£ˆÏòÓ˚ ö¸ˆÏú xòƒyòƒ ïyì¸Ó Óy xïyì¸Ó x:y£zv¸ v¸zÍ¸ôß¨ £Î˚ îyÓ˚ x!ïÑ¸yÇü£z !Ó°Ïy_´– xì¸ƒy!íÑ¸ õyeyÎ˚

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v¸zÍ¸ôß¨ Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ £ˆ

Ïúy ¸ô!Ó˚ˆÏÓˆÏüÓ˚ xÓ«¸Î˚ á›¸yÎ˚ – ~äÈyv¸ ¸y ãõy xyÓã≈òyÓ˚ ¸ôâ¸òñ òî≈õy £zì¸ƒy!î ˆÌˆÏÑ¸ x˜ÏãÓ Üƒy¢ñ ã#Óyí% Á ¶¸y£zÓ˚y¢ £zì¸ƒy!îÓ˚ ¢¸!‹T £Î˚ – ãõy ãÓyú ¸ô%!v¸ ¸ˆÏÏ˚ ˆö¸ú˜Ïì¸ !Ü˜ÏÏ˚Á !Ñ¸ä%È «¸!ì¸Ñ¸Ó˚ Üƒy¢ ˜ì¸!Ó˚ £Î˚ – ˆÎõò ≤'y!fi›¸Ñ¸ î£ò– ¸ô¸!ÌÓ#Ó˚ ! Ñ¸ä%È xÇˆÏü ¶)¸ ¸ô¸¤¸ ˆÌˆÏÑ¸ ˆÓ˚!v¸Á xƒyÑ¸!›¸¶¸ !Ó!Ñ¸Ó˚í á˜Ï›¸ Ìy˜ÏÑ¸ ÎyÓ˚ ˆÌˆÏÑ¸ ˆÓ˚v¸ò (Rn) Üƒy¢ v¸zÍ¸ôß¨ £Î˚ – Ü¸£ Óy xòƒ xyÓk¸ fl¸iyˆÏò ~£z Üƒy¢ !Ó!Ñ¸!Ó˜ì¸ £˜Ïì¸ òy ¸ôyÓ˚yÓ˚ ö¸˜Ïú õy!›¸ ¢Çú@¿ ~Ñ¸!›¸ !Ó°Ïy_´ Üƒy¢ hfl¸Ó˚ ˜ì¸!Ó˚ £Î˚ – ˆÓ˚v¸ò Üƒyˆ Ï¢Ó˚ Ñ¸yÓ˚ˆÏí ¢y¡±!ì¸Ñ¸Ñ¸yˆÏú xy˜Ïõ!Ó˚Ñ¸yÎ˚ î%£yãyÓ˚ ˆúyˆÏÑ¸Ó˚ õ¸ì%¸ƒ á˜Ï›¸ ˆÏäÈ– Óy!v¸ ¸ ˜ì¸!Ó˚Ó˚ Ñ¸yˆÏã ÓƒÓ£*ì¸ ≤'y£zv¸zv¸ Á Ñ¸yˆÏ¸ô≈!r›¸Ç ¸ôîyÌ≈ ˆÌˆÏÑ¸ ö¸Ó˚õƒú!v¸£y£zv¸ Üƒy¢ ~ÓÇ Ó˚àñ Óy!ò≈ü Á Ó˚ˆÏàÓ˚ oyÓÑ¸ £zì¸ƒy!î ÷Ñ¸yˆÏòyÓ˚ ¢õÎ˚ ì¸y ˆÌˆÏÑ¸ !Ó!¶¸ß¨ ˜ãÓ ˆÎÔˆÏÜÓ˚ Üƒy¢ v¸zÍ¸ôß¨ £Î˚ – Ó˚à ˆÌˆÏÑ¸ ¢#¢y Óy ˆúv¸ x:y£zv¸ ÓyÎ˚ˆ%˜Ïì¸ !õˆÏü ÎyÎ˚ – ö¸yÎ˚yÓ˚ˆÏ≤'¢ Óy Ó˚yß¨yÓ˚ ˆfi›¸y¶¸ñ v¸zò%òñ Óyò≈yˆÏÓ˚ ÓƒÓ£*ì¸ Ñ¸y‡¸ñ Ñ¸Î˚ˆúyñ ˆÑ¸ˆÏÓ˚y!¢ò £zì¸ƒy!î î£ˆÏò v¸zÍ¸ôß¨ ˆïßyÎ˚yñ Üƒy¢ ~ÓÇ Ñ¸!‡¸ò Ñ¸íy ãyì¸#Î˚ ï)°Ïí Ÿªy¢Ñ¸‹T ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ï)õ¸ôyˆÏòÓ˚ ö¸˜Ïú Ñ¸yÓ≈ò õˆÏòyx:y£zv¸ ~ÓÇ !Ñ¸ä%È !òˆÏÑ¸y!›¸ò ˆÎÔÜ v¸zÍ¸ôß¨ £Îˆñ Îy ï)õ¸ôyÎ˚ #Î˚ ~ÓÇ xyˆÏü¸ôyÓ˚ˆÏüÓ˚ ¢Ñ¸ú Óƒ!_´Ó˚ üÓ˚#ˆÏÓ˚Ó˚ ¸ôˆÏ«¸ «¸!ì¸Ñ¸Ó˚ – ≤Ãì¸ƒ«¸ Á ¸ôˆÏÓ˚y«¸ Óyì¸ˆ%ï)°ÏÑ¸ ≠ !Ó!¶¸ß¨ ≤ÃyÑ¸!ì¸Ñ¸ Óy õyò%ˆÏ°ÏÓ˚ myÓ˚y Ñ¸ì¸ Óyì¸ˆ%ï)°Ïí ÎyÓ˚ ¢¡ˆÏì¸ ãyòyüyõ ˆ¢=!ú £ˆÏúy v¸zÍ¢ ˆÌˆÏÑ¸ ¢Ó˚y¢!Ó˚ ¢¸‹T Óyì¸ˆ%ï)°Ïí– ÎyˆÏÑ¸ xyõÓ˚y ≤ÃyÌ!õÑ¸ Óy ≤Ãì¸ƒ«¸ Óyì¸ˆ%ï)°ÏÑ¸ ÓˆÏú ÌyÑ¸ – ~£z ïÓ˚ˆÏòÓ˚ !Ñ¸ä%È ï)°ÏÑ¸ ¸ôîyÌ≈ Óyì¸ˆ%õ[¸ú Óy ¸ô!Ó˚ˆÏÓ˚ˆÏüÓ˚ xòƒ v¸z¸ôÎ˚yˆÏòÓ˚ ¢Çfl¸ôˆÏü≈ ~ˆÏ¢ ˆÑ¸yò !ÓÏe´Î˚yÓ˚ ö¸˜Ïú xyÓ˚ Á ˆÓ!ü «¸!ì¸Ñ¸Ó˚ ï)°ÏÑ¸ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ÎyˆÏÎ˚Ó˚ ¸ôˆÏÓ˚y«¸ ï)°Ïí Óúy ÎyÎ˚ – v¸zìyÎ£Ó˚í fl¸ÍÓ˚*¸ô Óy!v¸ ¸Ó˚ Ó˚yß¨yÓ˚ ñ ÎyòÓy£ò Á Ñ¸úÑ¸yÓ˚Öyòy !òÉ¢ì¸ ˆïßyÎ˚y Á Ó˚y¢yÎ˚!òÑ¸ ¸ôîyÌ≈=!ú ¢) ˆÏÏ≈Ó˚ xyˆÏúyÓ˚ ¢Çfl¸ôˆÏü≈

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xyˆÏúyÑ¸ Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚yÓ˚

ö¸˜Ïú ~Ñ¸ !Ó°Ïy_´ ˆïßyÎ˚yü ¢¸!‹T Ñ¸ˆÏÓ˚ – ÎyÓ˚ õˆÏÏƒ !Ó!¶¸ß¨ xƒyú!v¸£y£zv¸ Á !Ñ¸˜Ï›¸yò ˆÎÔÜñ ¸ôyÓ˚ x!: xƒy!¢›¸y£zú òy£ˆÏ›¸Δ›¸ £zì¸ƒy!î Óyì¸ˆ%ï)°ÏÑ¸ !õ!◊ì¸ ÎyˆÏÑ¸ – !Ñ¸ä%È ï)°ÏÑ¸ ≤Ãì¸ƒ«¸ ~ÓÇ ¸ôˆÏÓ˚y«¸ v¸z¶¸Î˚ ¶¸yˆÏÓ£ ¢¸‹T £˜Ïì¸ ¸ ¸ôyˆÏÓ˚ – !Ó!¶¸ß¨ ïyì%¸ƒ Ñ¸íy Óyì¸y¢Ó˚ x!:ˆÏãòÓ˚ ¢Çfl¸ôˆÏü≈ v¸z¸ô%´ ì¸y ¸ô Á â¸y¸ô ˆ ¸ôˆÏú !Ó°Ïy_´ x:y£zv¸ Óy ã ˆÏúÓ˚ ¢Çfl¸ôˆÏü≈ xƒy!¢v¸ Óy‹ô ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ˆÎõò xy@ ˆÃyÎ˚ ˆî%ôy ì¸#Ó˚ ÓÌ≈ ˆ ¸ôˆÏ›¸Δy!úÍyõ ˆüyïòyÜyÓ˚ !òÉ¢ì¸ ¢yúö¸yÓ˚ v¸y£zÈÜÈx:y£zv¸ ˆ xÇˆÏüÓ˚ ÓyÎ˚ˆ%˜Ïì¸ xì¸ƒ!îÑ¸ ¸ô!Ó˚ˆÏÓ˚ ˆÏüÓ˚ îyÎ˚#˚ ÓyˆÏ‹ÓÓ˚ ¢yˆÏÏ î%_´ £ˆÏú ¢

100%	MATCHING BLOCK 101/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

yú!ö¸v¸z!Ó˚ Ñ¸ xƒy!¢v¸ (H 2 SO 4) ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚

Îy ì¸yõ£ˆÏúÓ˚ õyˆÏÓ≈ú ¸ôyÌˆÏÓ˚ ˆÌˆÏÑ¸ xˆÏòÑ¸yÇˆÏü «¸Î˚ ≤ÃyÆ Ñ¸ˆÏÓ˚ î%¸ˆÏúˆÏäÈ– ÓòyM¸È ˆÏú £...y¢ ≠ !ò!Ó≈â¸yˆÏÓ˚ òÜÓ˚yÎ˚ ˆò ~ÓÇ !ü"yÎ˚ˆÏòÓ˚ ≤ÃˆÏÏ˚yã ˆÏò x!ì¸ o&ì¸ £yˆÏÓ˚ ÓòyM¸Èú ï¡Ç Ñ¸Ó˚yÓ˚ ö¸ˆÏú ≤ÃÑ¸!ì¸ ˜ì¸ ¢Ó%ã v¸z!qˆÏí xò%¸ôyì¸ ≤ÃyÎí#Ó˚ ì%¸úòyÎ˚ xì¸ƒhs¸ Ñ¸ˆÏõ ˆÜˆÏäÈ– ¢Ó%ã v¸z!qîñ Îy ¢yˆÏúyÑ¸¢Ç ˆÏŸ°ˆÏ Ñ¸yˆÏú ÓyÎ˚ %Ó

52%	MATCHING BLOCK 102/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zÈÜÈx:y£zv¸ £...y¢ Ñ¸ˆÏÓ˚ !Ó÷k¸ x!:ˆÏãò v¸zÍ¸ôß¨ Ñ¸

ÏÓ˚ ¸ô!Ó˚ˆÏÓüˆÏÑ¸ !ò˜õ≈ú ÓyÖˆÏì¸y ì¸ ì¸ xyã !Óú%Æ ≤ÃyÎ˚ – NSOU ? AE-ES-21 ? 77
Ó!í≈ì¸ ãò¢ÇÖƒyÓ˚ â¸y!£îy ¸ô)ÌÓ˚ˆÏí Ó¢!ì¸xM¸Èúñ !ü"yM¸Èú Á Ñ¸¸!°Ïã!õÓ˚ ¸ô!Ó˚õyí xì¸ƒ!ïÑ¸ Ó¸!k¸ ˆ¸ôˆÏÏ˚ ˆÏäÈ– ö¸ˆÏú Óò¶) ¸!õñ ¸ôy£y!v¸ ¸ Óy!Üâ¸y ¸y £zì¸ƒy!î ¸ô%!v¸ ¸ ˆÏÏ˚ Óy ˆÑ¸ˆÏ›¸ ãyÎˆÜy Ñ¸Óy ¸y £ˆÏFäÈ– xyÓyÓ˚ Ñ¸!°ÏãõÓ ö¸¢ˆÏúÓ˚ xÓ˚ˆÏü°Ï ¸ô%!v¸ ¸ˆÏÏ˚ ˆÏÏ˚Á Üƒy¢ v¸zÍ¸ôß¨ £ˆÏFäÈ– ≤Ãì¸ÓyÈÓ˚ e´yhs¸#Î˚ ÓòyM¸ÈˆÏúÓ˚ ≤ÃyÎ˚ 3 ˆÑ¸y!›¸ Óò¶)¸!õ ~¶¸yˆÏÓ òÃT £ˆÏFäÈ– xì≈yÍ Ñ¸yÓ≈ò v¸y£zÈÜÈx:y£zv¸ Üƒyˆ Ï¢Ó˚ ˆüy°ÏÑ¸ ¢Ó%ã v¸z!qî xhs¸!£≈ì¸ £ˆÏFäÈ ~ÓÇ x¸ôÓ˚ ¸ôˆÏ«¸ ~Ñ¸£z ¢yˆÏÏ Óyì¸ˆ%ï)°Ï

90%	MATCHING BLOCK 103/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zÈÜÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí xfl¸ƒy¶¸

y!ÓÑ¸ ¶¸yˆÏÓ Ó!k¸ ¸ôyˆÏFäÈ– ~äÈyv¸ ¸y ¸ô)ˆÏÓ≈ xyˆÏúy!â¸ì¸ v¸z¸ôyˆÏÏ˚ ≤Ãâ%Ó˚ ï)°ÏÑ¸ Üƒy¢ !ÓˆÏü°Ïì¸ É Ñ¸yÓ≈ò õˆÏòy:y£zv¸ Á

100%	MATCHING BLOCK 104/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zÈÜÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí Ó!k¸ ¸

ôyˆÏFäÈ– ≤Ãyò üÉÓ˚=!ú áòÓ¢!ì¸Ó˚ Ñ¸yÓ˚ˆÏí ï)°ÏˆÏíÓ˚ ¸ô!Ó˚õyí !Ó¸ô¢#õy äÈy!v¸ ¸ˆÏÏ˚ ≤Ãâ¸[¸¶¸yˆÏÓ ˆÓ˚ˆÏv¸ ¸ ˆÜˆÏäÈ– ¢)" Ñ¸!‡¸ò Ñ¸íyì¸ !Ñ¸ä%È !ÓˆÏü°Ï ≤ÃÑ¸yÓ˚ ÓyÎ˚%ï)°Ïí ≠ ÓyÎ˚%õ[¸ˆÏú ¢Ó≈îyÎ£ òyòy ≤ÃÑ¸yÓ˚ ¢)" Ñ¸!‡¸ò Ñ¸íyÓ˚ x!hfl¸c Óì≈¸õyò– Îî !Ñ¸ä%È ¢)" Ñ¸íyÓ˚ ˆÓ!ü õyeyÎ˚
v¸z¸ô!fl¸!ì¸ ¸ô!Ó˚ˆÏÓˆÏü

100%	MATCHING BLOCK 105/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

v¸z¸ôÓ˚ «¸!ì¸Ñ¸Ó˚ ¸≤Ã¶¸yÓ ˆö¸ˆÏú

ì¸ˆÏÓ ì¸y ÓyÎ˚%î)ºÏí Ó˚*ˆÏ¸ô !â¸!£´ì¸ £Î˚ – S1V ï%ˆÏúyÈÙÙÈ !Ó!¶¸ß¨ Ólfl¸Ó˚ ≤Ã!e´Î˚yÑ¸Ó˚ˆÏíÓ˚ ¢õÎ˚ ì¸yÓ˚ ¢)" Ñ¸íy ÓyÎ˚%ˆÏì¸ !õˆÏü ÎyÎ˚ñ Îy ÓyÎ˚%Ó˚ ≤ÃÓy£õyòì¸yÓ˚ ö¸ˆÏú «¸Î˚≤ÃyÆ £ˆÏÎ˚ xyÓ˚Á ¢)"Ñ¸íy Ó˚*ˆÏ¸ô ÓyÎ˚%ˆÏì¸ ˆÌˆÏÑ¸ ÎyÎ˚ – ˆÎõòñ Ñ¸y‡¸ Óy Ñ¸Î˚úyÓ˚ =§ˆÏv¸¸yñ äÈy£zñ Óy!úñ !¢ˆÏõr›¸ £zì¸ƒy!î– ~£z¢Ó Ñ¸!‡¸ò Ñ¸íyÓ˚ õy¸ô ¢yïyÓ˚î¸É 0.1 ˆÌˆÏÑ¸ 75 õy£ze´ò ¸ôÎ≈hs¸ £Î˚ – S2V Óy‹ôÈÙÙÈ Ó˚y¢yÎ˚!òÑ¸ !ü“ Á Ö!òã !ü“ ˆÌˆÏÑ¸ v¸zq$ì¸ ÓyˆÏ‹ôÓ˚ áò#¶¸ÓˆÏòÓ˚ ö¸ˆÏú ¢)" Ñ¸!‡¸ò Ólfl¸Ñ¸íyÎ˚ Ó˚*¸ôyhs¸Ó˚ – Ñ¸íyÓ˚ õy¸ô 0.03 õy£ze´ò ˆÌˆÏÑ¸ 0.3 õy£ze´ò– S3V !õfi›¸ÈÙÙÈ !Ó!¶¸ß¨ Ó˚y¢yÎ˚!òÑ¸ !ü“ Óy ≤Ã!e´Î˚yãyì¸ Ñ¸yÓ˚ˆÏí v¸zÍ¸ôß¨ ÓyˆÏ‹ôÓ˚ áò#¶¸ÓˆÏòÓ˚ ö¸ˆÏú ¢)" ì¸Ó˚ú Ñ¸íyÓ˚ ¢¸!‹T Îy ÓyÎ˚%ˆÏì¸ ¶¸y¢õyò xÓfl¸iyÎ˚ ÌyˆÏÑ¸ – Ñ¸íyÓ˚ õy¸ô 0.5

96%	MATCHING BLOCK 106/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

õy£ze´ò ˆÌˆÏÑ¸ 3 õy£ze´ò ¸ôÎ≈hs¸ £ˆÏì¸ ¸ôyˆÏÓ˚ –

S4V ˆï§yÎ˚yÈÙÙÈ Ñ¸yÓ≈òãyì¸ Ólfl¸Ó˚ x¢¡ô)í≈ î£ˆÏòÓ˚ ö¸ˆÏú v¸zÍ¸ôß¨ Ñ¸!‡¸ò Ñ¸íy Î%_´ ÓyÎ˚%– Ñ¸íyÓ˚ õy¸ô 0.05

96%	MATCHING BLOCK 107/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

õy£ze´ò ˆÌˆÏÑ¸ 1 õy£ze´ò ¸ôÎ≈hs¸ £ˆÏì¸ ¸ôyˆÏÓ˚ – 5.2.3

ÓyÎ˚%î)ºÏˆÏíÓ˚ «¸!ì¸Ñ¸yÓ˚Ñ¸ ö¸úyö¸ú ¸ô)ˆÏÓ≈ xyˆÏúy!â¸ì¸ !Ó!¶¸ß¨ v¸zÍ¢ ˆÌˆÏÑ¸ ¢¸‹T ÓyÎ˚%î)ºÏÑ¸ ¸ôîyÌ≈=!ú e´õye´ˆÏõ ÓyÎ˚%õ[¸ˆÏú ! õˆÏü ÓyÎ˚%Ó˚ fl¸ÍÎy¶¸y!ÓÑ¸ !õ◊ˆÏíÓ˚ xò%¸ôyì¸ˆÏÑ¸ ≤Ã¶¸y!Óì¸ Ñ¸Ó˚ˆÏäÈ– ÓyÎ˚% î)!ºì¸ £ˆÏú ˆ¢£z ÓyÎ˚%ˆÏì¸ Ÿªy¢ ˆòÁÎ˚yÓ˚ ¢õÎ˚ «¸! ì¸Ñ¸Ó˚ Üƒy¢#Î˚ ¸ôîyÌ≈ Á Ñ¸yÓ≈ò Ñ¸íy=!ú õyò%ºÏ Á xòƒ ≤Ãyí#Ó˚ ˆîˆÏ£ !õˆÏü ÎyˆÏFäÈ– ˆ«¸e!ÓˆÏüˆÏºÏÓ˚ ö¸ˆÏú õ¸ì%¸ƒ £ÁÎ˚yÎ˚Á x¢Ω¸Ó òÎ˚ – ÓyÎ˚%ˆÏì¸ v¸z¸ô!fl¸iì¸ !Ó!¶¸ß¨ ¢)" Ñ¸!‡¸ò Ñ¸íy !òÉŸªyˆÏ¢Ó˚ õyïƒˆÏõ ö%¸¢ö%¸ˆÏ¢ ãõy £ˆÏú ì¸yÓ˚ ö¸ˆÏú !Ó!¶¸ß¨ ˆÓ˚yÜ ˆîÓy !îˆÏì¸ ¸ôyˆÏÓ˚ – ˆÎõò Óy!úÑ¸íy ãˆÏõ !¢!úˆÏÑ¸y!¢¢ñ Ñ¸Î˚úyÓ˚ =§ˆÏv¸¸y ˆÌˆÏÑ¸ xƒyòì y ˆÏÑ¸y!¢¢ñ xƒy¢ˆÏÓ¢›¸¢‰ ˆÌˆÏÑ¸ xƒy¢ˆÏÓ¢ˆÏ›¸y!¢¢‰ £zì¸ƒy!î– ÓyÎ˚%î)ºÏˆÏíÓ˚ ö¸ˆÏú v¸z!qˆÏîÓ˚ ö¸úò Á Ó¸!k¸ˆÏì¸Á òyòy «¸!ì¸ áˆÏ›¸– ~äÈyv¸¸y Óy!v¸¸ Óy ˆ¢ÔˆÏíÓ˚ Óy£zˆÏÓ˚ ˆîÁÎ˚yˆÏú «¸Î˚«¸!ì¸ áˆÏ›¸– Ñ¸ˆÏÎ˚Ñ¸!›¸ ≤Ãïyò î)ºÏˆÏÑ¸Ó˚ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ ~ÖyˆÏò ÓƒyÖƒy Ñ¸Ó˚y £ˆÏúy– Ñ¸yÓ≈ò õˆÏòy:y£zv¸ È(CO)ÙÙÈ Üƒy¢!›¸ ~Ñ¸!›¸ !ÓºÏy_´ ¸ôîyÌ≈– ~!›¸ ÓyÎ˚%ˆÏì¸ !õˆÏü ˆÜˆÏú õyÌyÎs¸fíyñ Ÿªy¢Ñ¸‹Tñ Ó!õ¶¸yÓñ Ñœ¸y!hs¸ £zì¸ƒy!î ≤Ã!ì¸!e´Î˚y ¢¸!‹T Ñ¸ˆÏÓ˚ – ~!›¸ £*îÎˆÏs¸fÓ˚ ¸ôˆÏ«¸ «¸!ì¸Ñ¸Ó˚ ~ÓÇ Ó˚ˆÏ_´ x!:ˆÏãˆÏòÓ˚ ¸ô!Ó˚Ó£ò «¸õì¸y Ñ¸!õˆÏÎ˚ ˆîÎ˚ – ÓyÎ˚%ˆÏì¸ x!ïÑ¸ õyeyÎ˚ Ñ¸yÓ≈ò õˆÏòy:y£zˆÏv¸Ó˚ v¸z¸ô!fl¸i!ì¸ õ¸ì%¸ƒÓ˚ Ñ¸yÓ˚í £ˆÏì¸ ¸ôyˆÏÓ˚ – ¢yúö¸yÓ˚ v¸y£zÈÙÈx:y£zv¸ (SO 2)ÈÙÙÈ !ÓºÏy_´ ˆï§yÎ˚y ¢¸!‹T Ñ¸ˆÏÓ˚ – ÓyÎ˚%ˆÏì¸ !õˆÏü õyò%ˆÏºÏÓ˚ üÓ˚#ˆÏÓ˚Ó˚ ¢Çfl¸ôˆÏü≈ ~ˆÏú ˆâ¸yÖ ãµyúy Ñ¸ˆÏÓ˚ñ Ÿªy¢òyú#ˆÏì¸ ≤ÃîyÎ˚£ £Î˚ñ òyÑ¸ñ Üúy Á ö%¸¢ö%¸ˆÏ¢Ó˚ «¸!ì¸ Ñ¸ˆÏÓ˚ – Ó ÇÑ¸y£z!›¸¢ñ £§y¸ôy!ò ˆÌˆÏÑ¸ Ñ¸ƒy™yÓ˚ ¸ôÎ≈hs¸ á›¸ˆÏì¸ ¸ôyˆÏÓ˚ – 78 ? NSOU ? AE-ES-21

ÓyÎ˚%Ó˚ x!:ˆÏãò Á ãú#Î˚ ÓyˆÏ‹ôÓ˚ ¢yˆÏÌ !õˆÏü ¢

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yú!ö¸v¸z!Ó˚Ñ¸ xƒy!¢v¸ (H 2 SO 3) ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚

Îy xƒy!¢v¸ Óy‹ô Á xƒy!¢v¸ Ó,!‹T á›¸yÎ˚ – xƒy!¢v¸ Ó,!‹TÓ˚ ö¸ˆÏú ö¸¢ˆÏúÓ˚ «¸!ì¸ £Î˚ñ ÓòyM¸È ˆÏúÓ˚ ¢Ó%ã v¸z!qˆÏîÓ˚ ¸ôyì¸yÓ˚ ˆÑœ¸yˆÏÓ˚y!ö¸ú Sĺy ì¸yÓ˚ Öyîƒ v¸z¸ôyîyˆÏòÓ˚ xyïyÓ˚V ò‹T Ñ¸ˆÏÓ˚ v¸z!qˆÏîÓ˚ «¸!ì¸ Ñ¸ˆÏÓ˚ ~Ó˚ ö¸ˆÏú Ó˚!Óü°Ïƒ Á ö¸ˆÏúÓ˚ â¸y°Ï ≤Ãâ¸[¸¶¸yˆÏÓ «¸!ì¸@ˆÃhfl¸ £Î˚ñ !Ó°Ïy_´ ˆïßyÎ˚yüy ¢,!‹T Ñ¸ˆÏÓ˚ ~!›¸ Ó˝ õyò%ˆÏ°ÏÓ˚ ≤ÃyíÉy!ò á›¸yˆÏì¸ ¸ôyˆÏÓ˚ ~ÓÇ Óy!v¸¸ñ ˆ¢ÔÏ £zì¸ƒy!îÓ˚ Ó!£Ü≈yˆÏe «¸Î˚ ¢,!‹T Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ – òy£zˆÏ›¸Δyˆ‹ãò v¸y£zÈÙÈx:y£zv¸ (NO 2)ÈÙÙÙÈ Óyì¸yˆÏ¢ x!ïÑ¸ ¸ô!Ó˚õyí òy£zˆÏ›¸Δyˆ‹ãò v¸y£zÈÙÈx:y£zv¸ v¸z¸ô!fl¸ìi¸ ÌyÑ¸ˆÏú ö%¸¢ö%¸¢ Á £*ÏÎ˚Ïs¸fÓ˚ x¢%Ö ˆîÖy ˆîÎ˚ – Ÿªy¢òyú# ~ÓÇ fl¸ſÓ˚òyú#ˆÏì¸ ãµyúy Ñ¸ˆÏÓ˚ Á «¸Î˚ á˜Ï›¸ – !òv¸z˜Ïõy!òÎ˚yñ Ó B¸y£z!›¸¢ñ fl¸¨yÎ˚%ãyì¸ ˆÓ˚yÜ ˆîÖy ˆîÎ˚ – £zòöœ$¸ˆÏÏ˚Oy ≤Ã¶¸¸!ì¸ ¢Çe´yõÑ¸ ˆÓ˚yÜ ≤Ã!ì¸ˆÏÓ˚yˆÏîÓ˚ «¸õì¸y Ñ¸ˆÏõ ÎyÎ˚ – ~£z Üƒyˆ‹¢Ó˚ Óyì¸yˆÏ¢ õye 0.05 üì¸yÇü v¸z¸ô!fl¸ì!ì¸£z õyò%ˆÏ°ÏÓ˚ õ¸ì%¸ƒÓ˚ Ñ¸yÓ˚í £ˆÏì¸ ¸ôyˆÏÓ˚ – x¸ôÓ˚ ¸ôˆÏ«¸ v¸z!qˆÏîÓ˚ v¸z¸ôˆÏÓ˚ Á ~Ó˚ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ xì¸ƒhs¸ ≤ÃÑ¸›¸ – Î!ìÁ v¸z!qˆÏîÓ˚ Öyîƒ v¸zí¸ôyîˆÏòÓ˚ Óy xì≈yí ¢yˆÏúyÑ¸¢Ç ˆÏŸ'°Ï ¸ôk¸!ì¸Ó˚ ãòƒ òy£zˆÏ›¸Δyˆ‹ãò á!›¸ì¸ ˆÎÔÜ ≤ÃˆÏÏ˚yão !Ñ¸ls¸ ì¸yˆÏîÓ˚ ˆ«¸ˆÏeÁ Óyì¸yˆÏ¢ NO 2 Óy òy£zˆÏ›¸Δyˆ‹ãˆÏòÓ˚ xòƒyòƒ x:y£zv¸=!ú ˆÎõò N 2 O Óy òy£zˆÏ›¸Δyˆ‹ãˆÏòÓ˚ x:y£zv¸=!ú ˆÎõò N 2 O, NO, N 2 O 5 £zì¸ƒy!îÓ˚ v¸z¸ô!fl¸ì!ì¸ «¸!ì¸Ñ¸yÓ˚Ñ¸ £ˆÏÎ˚ ˆîÖy ˆîÎ˚ – ~Ó˚ ö¸ˆÏú v¸z!qˆÏîÓ˚ ¸ôyì¸yÓ˚ ¢Ó%ã Ó˚à Óy ˆÑœ¸yˆÏÓ˚y!ö¸ú Ñ¸íy ò‹T £Î˚ñ ö¸ˆÏú ¢yˆÏúyÑ¸¢Ç ˆÏŸ'°ÏÓ˚ £yÓ˚ Ñ¸ˆÏõ v¸z!qˆÏîÓ˚ Ó,!k¸ ÓƒÓ£¸ì¸ £Î˚ – â¸yÓ˚yÜyÈ Óy úì¸yãyì¸#Î˚ v¸z!qî ÷!Ñ¸ˆÏÎ˚ ÎyÎ˚ – £y£zˆÏv»¸yˆ‹ãò ¢yúö¸y£zv¸ (H 2 S)ÈÙÙÙÈ Óyì¸yˆÏ¢ ~£z Üƒyˆ‹¢Ó˚ v¸z¸ô!fl¸ì!ì¸ !ü“ Ñ¸yÓ˚Öyòy˚ ì)°Ïí !òÏ˚s¸fˆÏíÓ˚ ÓƒÓfl¸iy òy ÌyÑ¸yÓ˚ ö¸ú– ~£z Üƒyˆ‹¢Ó˚ Ñ¸yÓ˚ ˆÏí üÓ˚#ˆÏÓ˚ ì¸yí«¸!íÑ¸¶¸yˆÏÓ fl¸¨yÎ˚%ÓÓ˚ ˆÓ˚yÜ Sˆîòò õyÌy ïÓ˚yV £Î˚ üÓ˚#ˆÏÓ˚Ó˚ v¸zß√%_´ x¢ˆÏüñ ˆâ¸yÖ Á Ÿªy¢òyú#ˆÏì¸ ãµyúy Ñ¸ˆÏÓ˚ñ «%¸ïyõ®ñ £ãõ òy £ÁÎ˚yñ Üy Ó!õ ¶¸yÓñ Ÿªy¢Ñ¸‹T ˆîÖy ÎyÎ˚ – Áˆ‹ãò È(O 3)ÙÙÙÈ Óyì¸yˆÏ¢ Áˆ‹ãò Üƒyˆ‹¢Ó˚ v¸z¸ô!fl¸ì!ì¸Ó˚ ö¸ˆÏú õyÌy Ïs¸fíy ˆâ¸yˆÏÖÓ˚ ˆÓ˚yÜ £zì¸ƒy!î ì¸yí«¸!íÑ¸ ¢õ¢ƒy ˆîÖy ˆîÎ˚ – ~£z Üƒyˆ‹¢Ó˚ v¸z¸ô!fl¸ì!ì¸ î#á≈fl¸iyÎ˚# Á x!ïÑ¸ ¸ô!Ó˚õyí £ˆÏú Sĺy ~Ñ¸yhs¸£z ≤ÃÑ¸¸!ì¸!ÓÓ˚ &k¸V ì¸y üÓ˚#ˆÏÓ˚Ó˚ ˆÓ˚yÜ ≤Ã!ì¸ˆÏÓ˚yí «¸õì¸y ò‹T Ñ¸ˆÏÓ˚ ~ÓÇ e´!òÑ¸ Ó B¸y£z!›¸¢ñ ö%¸¢ö%¸¢ˆÏ¢ Ó˚ˆ_´«¸Ó˚í Á Ñ¸ƒyò¢yÓ˚ ãyì¸#Î˚ ˆÓ˚yˆÏÜÓ˚ ¢)e ¸ôyì¸ á›¸yˆÏì¸ ¸ôyˆÏÓ˚ – ¢Ó%ã v¸z!qˆÏîÓ˚ ¸ôyì¸y ˆÑœ¸yˆÏÓ˚y!¢¢ ˆÓ˚yˆÏÜ £ú%Ï £ˆÏÏ˚ ÎyÎ˚ – ˆÑœ¸y!Óò (Cl 2)ÈÙÙÙÈ xƒy!¢v¸ Óy ïyì%¸ !ò‹Óy°Ïí ≤Ã¶¸¸!ì¸ !ü“ãyì¸ ˆÑœ¸y!Óò Óy ïyì¸Ó ˆÑœ¸yÓ˚y£zv¸ Üƒy¢=!úÓ˚ Óyì¸yˆÏ¢ v¸z¸ô!fl¸ì!ì¸ Ÿªy¢Ñ¸‹T ~ÓÇ ˆâ¸yˆÏÖÓ˚ ˆÓ˚yÜ Ó,!k¸ Ñ¸ˆÏÓ˚ – £y£zˆÏv»¸yÑ¸yÓ≈ò ˆÎÔÜÈÙÙÙÈ ˆÓ!OˆÏòÓ˚ ãyì¸#Î˚ ˆÎÔÜ Óyì¸yˆÏ¢ ˆÓü# õyeyÎ˚ v¸z¸ô!fl¸ìi¸ ÌyÑ¸ˆÏú ˆŸ'°Ïy Ó,!k¸ Ñ¸ˆÏÓ˚ Ÿªy¢òyú# Ó˚&k¸ Ñ¸ˆÏÓ˚ ˆìÁÎ˚yñ ö%¸¢ö%¸¢ˆÏ¢Ó˚ «¸!ì¸ñ Ñ¸ƒyò¢yÓ˚ ˆÓ˚yÜ ≤Ã¶¸¸!ì¸ á˜Ï›¸ – £z!Ï!úò Óy xƒy!¢!›¸!úˆÏòÓ˚ ≤Ã¶¸yˆÏÓ v¸z!qˆÏîÓ˚ ¢yˆÏúyÑ¸¢Ç ˆÏŸ'°ÏÓ˚ £yÓ˚ Ñ¸ˆÏõ ÎyÎ˚ ö¸úfl¸ſÓ˚*¸ô ö¸¢ú v¸zí¸ôyîòñ Ó¸ˆÏ«¸ Ó˚ Ó,!k¸Ó˚ ÓƒÓ£¸ì¸ £Î˚ – S1V Ñ¸úÑ¸yÓ˚Öyòyñ !ü“ ˆ«¸ˆÏe ~ÓÇ ãõã#ÓˆÏò ÓƒÓ£*ì¸ Ïs¸f¸ôy!ì¸ ~ÓÇ ÎyòÓy£ò ˆÏˆÏÑ¸ !òÜ≈ì¸ Üƒy¢ˆÏÑ¸ ¢Ó˚y¢!Ó˚ Óyì¸yˆÏ¢ ä£yv¸¸yÓ˚ xyˆÏÜ Îy!s¸fÑ¸ v¸z¸ôyˆÏÏ˚ ¸ô!Ó˚÷k¸ Ñ¸Ó˚y– ÎyòÓy£ò Á Ó˚yß˚yíˆÏÓ˚ ãµyúyò#Ó˚ î£ˆÏò ¢,‹T Üƒyˆ‹¢

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Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ äÈyv¸¸y

Î !Ó°Ïy_´ ¸ôîyÌ≈=!ú òyòy¶¸yˆÏÓ ¢,‹T £Î˚ ì¸yÓ˚ ì)Ó˚#Ñ¸Ó˚ˆÏÓ˚ ˆÏí ÓƒÓfl¸iy !òˆÏì¸ £ˆÏÓ– ~£z ¸ôîyÌ≈=!ú !ö¸Œ›¸yÓ˚ ¢y£zˆÏÑœ¸yò ˆ¢¸ôyˆÏÓ˚ˆ›¸Ó˚ Si%ˆÏúyõÎ˚ úy x¸ô¢yÓ˚ˆÏíÓ˚ äòƒVñ Ñ¸ƒ›¸yúy£z!›¸Ñ¸ Ñ¸ò¶¸y›≈¸yÓ˚ õˆÏòy:y£zv¸ Á £y£zˆÏv»¸yÑ¸yÓ≈ò ˆÎÔÜ=!úÓ˚ äyÓ˚ˆÏîÓ˚ xˆÏì¸ò«¸yÑ¸¸ì¸ Ñ¸õ «¸!ì¸Ñ¸Ó˚ ì)°ÏˆÏÏ˚Ñ¸ Ó˚*¸ôyhs¸!Óì¸ Ñ¸Ó˚ Ó˚yÓ˚ äòƒVñ £zˆÏúÑ¸ˆÏ›¸Δyfi›¸ƒy!›¸Ñ¸ ˆ≤Ã!¢!¸ô›¸yÓ˚ Sxì¸ƒhs¸ ¢)" Óífl¸Ñ¸íy ¸ôìÑ¸ Ñ¸Ó˚yÓ˚ äòƒ !Óü°Ïì¸ ì¸yõyñ îhfl¸y !ü˝ ÓƒÓ£*ì¸ £Î˚V ≤Ã¶¸¸!ì¸ Ïs¸f ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ ¸ôìÑ¸ Ñ¸Óy £Î˚ – NSOU ? AE-ES-21 ? 79
S2V v¸zß¨ì¸ ≤ÃÎ%!_´

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Ó˚ ¢y£yˆÏÏƒ ~õò ¸ôk¸!ì¸ xÓú¡ò Ñ¸Óy £ˆÏÓ ÎyÓ˚ ö¸ˆÏú

ì)!°Ïì¸ ¸ôîyˆÏÌ≈Ó˚ v¸zí¸ôyîò Ñ¸ˆÏõ ÎyˆÏÓ– ö¸ˆÏú ÎyòÓy£òñ Ïs¸f¸ôy!ì¸ñ Ñ¸úÑ¸yÓ˚Öyòy ˆÏˆÏÑ¸ Üƒy¢ Óy Ñ¸!‡¸ò ì)°ÏíÑ¸yÓ˚# Ñ¸íyÓ˚ ! òÉ¢yÓ˚í !òÏ˚!s¸fi¸ £Î˚ – S3V î£ˆÏòÓ˚ äôƒ ÓƒÓ£yˆÏÓ˚Ó˚ ¸ôò)ˆÏÓ≈ ãµyúyò#Ó˚ !Ó÷k¸Ñ¸Ó˚íÑ¸Ó˚ˆÏì¸ £ˆÏÓñ ÎyÓ˚ ö¸ˆÏú ˆúv¸ Á «¸! ì¸Ñ¸Ó˚ ïyì¸Ó x:y£zv¸ ≤Ã¶¸¸!ì¸ !Ó°Ïy_´ ïyì%¸ãyì¸ Ó˚ˆy¢Óy˚ì¸ !òÑ¸ ì)°Ïí v¸zí¸ôyîò Ñ¸õˆÏÓ– S4V ã#ÓyŸ¬ ãµyúyò#Ó˚ ÓƒÓ£yÓ˚ Ñ¸õ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ïyì%¸!òÑ¸Óyüò â%¸Õ'# !òÜ≈ì¸ Üƒy¢ Á ˆïßyÎ˚y ˆÏÎÑ¸ ¸ô!Ó˚ fl¸À%ì¸ Ñ¸ˆÏÓ˚ Óyì¸yˆÏ¢ ˆïßyÎ˚yüy !Óü°Ïì¸ ¢yúö¸

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yÓ˚ v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí

Ñ¸õyˆÏì¸ £ˆÏÓ– S5V ÎˆÏì‹T ¸ô!Ó˚õyˆÏí ÜyäÈ úy!Üˆ˚Ï˚ Óò¢,ãò Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ÎyÓ˚ ö¸ˆÏú ¸ô!Ó˚ˆÏÓ˚ˆÏü x!ì¸!Ó˚_´

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Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí £...y¢ ¸

óyÎ˚ – S6V x≤Ãâ¸!úì¸ Óy !â¸Ó˚yâ¸!Ó˚ì¸ ü!_´Ó˚ v¸zí¢ ¢ı¸yò Á ì¸yÓ˚ ¢!‡¸Ñ¸ ÓƒÓ£y˚ÏÓ˚Ó˚ õyiƒ˚Ïõ Ñ¸Î˚úyñ ˆ¸ô˚Ï›¸∆y!úÎ˚yõ î£˚ÏòÓ˚ ¸ô!Ó˚õyí Ñ¸õy˚Ïì¸ £˚ÏÓ– S7V Ñ¸y˚Ï‡¸Ó˚ ˆâ¸yÓ˚yâ¸yúyò ÓƒÓ¢y Óı¸ Ñ¸Ó˚˚Ïì¸ £˚ÏÓ ~ÓÇ !ÓÑ¸“Ólfl¸ !ò!õ≈ì¸ xy¢Óy˚ÏÓÓ˚ ÓƒÓ£yÓ˚ ÷Ó˚&Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– S8V ˜ãÓ xyÓã≈òyÓ˚ ¢!‡¸Ñ¸ Ó˚*¸ôyhs¸Ó˚ á›¸y˚Ïì¸ £˚ÏÓ Îy˚Ïì¸ !õ˚Ïìò Üƒy˚Ï¢Ó˚ ¸ô!Ó˚õyí Ó¸!k¸ òy ¸óyÎ˚ – S9V ˆÑœ¸y˚ÏÓ˚yöœ$¸ˆÏÓ˚yÑ¸yÓ≈˚ÏòÓ˚ ÓƒÓ£yÓ˚ !òÎ˚!s¸fi¸ Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– S10V ˆì¸ã!‹;¸Î˚ î)°Ïí ˆÓ˚y˚ÏíÓ˚ äòƒ ¸ôyÓ˚õyí!ÓÑ¸ Ü˚ÏÓ°ÏíyÓ˚=!ú˚Ïì¸ Î˚Ï‹T ¢yÓïyòì¸y xÓú¡ò Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– X- ray ˆõ!üòñ ˆÓ˚!v¸Á˚ÏÓ˚y!¸ôÓ˚ ¢y˚Ïì Î%_´ Óƒ!_´˚ÏíÓ˚ äòƒ !Ó˚Ïü°Ï ˆ¸ôyüyÑ¸ Á xòƒyòƒ ˆì¸ã!‹;¸Î˚ì¸y ˆÓ˚yiÑ¸ ÓƒÓfl¸iy @˜Ã£í Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– 5.3 ãúî)°Ïí (Water Pollution) !Ó÷k¸ ãú £ú î%£z ¸ôÓ˚õyí% £

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y£z˚Ïv»¸y˚Ïãò Á ~Ñ¸ ¸ôÓ˚õyí% x!:˚Ïãò myÓ˚y Ü!‡¸ì¸ ~

Ñ¸!›¸ ˆÎÔÜ (H 2 O)– ¸ô¸!ÌÓ# ¸ô¸ˆÏ¤ fl¸∫y¶¸y!ÓÑ¸¶¸y˚ÏÓ ¸ôyÁÎ˚y ã˚Ïú !Ó!¶¸ß¨ ˜ãÓñ x˜ÏãÓ ¸ôîyÌ≈ñ òyòy ˆ¶¸Ôì¸ Á Ó˚y¢yÎ˚!òÑ¸ Ñ¸íy ~ÓÇ òyòy ã#Óyí% £zì¸ƒy!î ¶¸y¢õyò Óy oÓ#¶)¸ì¸ xÓfl¸iyÎ˚ lyÑ¸ˆÏì¸ ¸ôyˆÏÓ˚ – Î!î ~£z ¶¸ÓÓ˚ˆÏòÓ˚ ˆÑ¸yò v¸z¸ô!fl¸i!ì¸Ó˚ ö¸˚Ïú ã˚ÏúÓ˚ =íÜì¸ õy˚ÏòÓ˚ !Ó˚Ïü°Ï¶¸y˚ÏÓ xÓò!ì¸ á˚Ï›¸ ~ÓÇ ¨ ãú Ñ¸!°ÏÑ¸yã Á ¸ôyò#Î˚ !£¢y˚ÏÓ ÓƒÓ£y˚ÏÓ˚Ó˚ x˚ÏÎyÜƒ £˚ÏÎ˚ ¸ô˚Ïv¸¸ì¸ˆÏÓ xyõÓ˚y ~˚ÏÑ¸ ã˚ÏúÓ˚ î)°Ïí Ó˚Ïú !â¸!£˚ì¸ Ñ¸˚ÏÓ˚ ly!Ñ¸– ¢ÇK¸y≠ã˚ÏúÓ˚ õ˚Ïiƒ ˆÑ¸yò xÓy!N¸ì¸ ¸ôîyÌ≈ !õ˚Ïü ÎyÓyÓ˚ ö¸˚Ïú Î!î ã˚ÏúÓ˚ ˆ¶¸Ôì¸ïõ≈ Óy Ó˚y¢yÎ˚!òÑ¸ ïõ≈ Óy ˜ãÓ ˜Ó!ü‹Tƒ Á =íõy˚ÏòÓ˚ ~õò ˆÑ¸yò ¸ô!Ó˚Óì≈ò £Î˚ ÎyÓ˚ ö¸˚Ïú ãúã v¸z!qî Óy ≤Ãyí# Óy õyò%˚Ï°ÏÓ˚ «¸!ì¸Ó˚ ¢Ω¸yÓòy á˚Ï›¸ ì¸˚ÏÓ ˆ¢£z ¸ô!Ó˚Óì≈ò˚ÏÑ¸ ãúî)°Ïí Óúy £Î˚ – 5.3.1 ãúî)°ÏÓ˚ ˆÏíÓ˚ v¸zí¢ S1V õyò%˚Ï°ÏÓ˚ ˜ò!®ò ã#ÓòÎyeyÓ˚ ö¸˚Ïú ì¸yÓ˚ myÓ˚y ÓƒÓ£*ì¸ ¶)¸¸ô¸¤ ¢Çú@¿ ã˚ÏúÓ˚ v¸zí¢=!ú î)!°Ïì¸ £Î˚ – áÓ˚Óy!v¸¸Ó˚ ˜ò!®ò xyÓã≈òy õy!›¸ˆÏì¸ ˆö¸úyÓ˚ ö¸˚Ïú õy!›¸Ó˚ ˆ¶¸Ôõ ãúhfl¸Ó˚ î)!°Ïì¸ £Î˚ ~ÓÇ ã˚Ïú òyòy Ó˚y¢yÎ˚!òÑ¸ Á ˆÓ˚yÜ¢¸!‹TÑ¸yÓ˚# ã#Óyí% !õ˚Ïü ÎyÎ˚ – õy!›¸Ó˚ ˆ¶¸Ôõãú ˆÌˆÏÑ¸ ¨ î)°Ïí ¸ôyŸª≈Óì≈¸# ˆäÈy›¸ ˆäÈy›¸ ãúyiyÓ˚ ˆÎõò ¸ô%Ñ%¸Ó˚ñ Ñ%¸ˆÏÌ˚y 80 ? NSOU ? AE-ES-21 £zì¸ƒy!îÓ˚ ãú˚ÏÑ¸ î)!°Ïì¸ Ñ¸˚ÏÓ˚ – ö¸˚Ïú ã˚Ïú !Ó!¶¸ß¨ Ó˚àÁ î%Ü≈ı¸ ˜ì¸!Ó˚ £Î˚ – ≤ÃyÌ!õÑ¸ ¶¸y˚ÏÓ ãú ˆáyúy˚Ï›¸ £˚ÏÏ˚ Á˚Ï‡¸ñ ¸ôˆÏÓ˚ î)°Ï¸ÏíÓ˚ ¸ô!Ó˚õyí Á ≤ÃÑ¸!ì¸ xò%¢y˚ÏÓ úyú˚Ïâ¸ñ ¢Ó%ã Óy Ñ¸y˚Ïúy £˚ÏÏ˚ ÎyÎ˚ – ¢yiyÓ˚í¶¸y˚ÏÓ ˜ãÓ xƒyõy£z˚ÏòyÓ˚ v¸z¸ô!fl¸i!ì¸ˆÏì¸ ã˚Ïú x§yü˚Ï›¸ Üı¸ñ ˜ãÓ !£v¸zõy˚Ï¢Ó˚ v¸z¸ô!fl¸i!ì¸ ˆÏì¸ ˆ¢§yÎy Üı¸ñ £yƒ£z˚Ïv»¸y˚Ïãò ¢yúö¸y£zv¸ Óy ö¸¢ö¸Ó˚y¢ Î%_´ ã˚Ïú ¸ôâ¸y !v¸˚ÏõÓ˚ Üı¸ ly˚ÏÑ¸ – S2V !ü“Ñ¸yÓ˚Öyòy=!úÓ˚ ¸ô!Ó˚ì¸ƒ_´ xyÓã≈òy Á v¸zm‚_Ó˚y¢yÎ˚!òÑ¸ ¸ôîyÌ≈ ¢yiyÓ˚ í¸ òî≈õy !Î˚Ïî˚ ¢Çú@¿ ˆÑ¸yò ã˚ÏúÓ˚ v¸zí˚Ï¢ fl¸iyòyhs¸Ó˚ Ñ¸Ó˚y £Î˚ñ ˆÎõò ¢õ%oñ òî#ñ Öyú £zì¸ƒy!î– ¢Ó xyÓã≈òyÓ˚ õ˚Ïiƒ !Ó!¶¸ß¨ îyì%¸ ˆÎõò ¢#¢yñ ì¸yõyñ îhfl¸y Ñ¸fyv¸!õÎ˚yõ Óy !Ó!¶¸ß¨ îyì¸Ó ˆÎÔÜñ ˜ãÓ ¸ôîyÌ≈ ~ÓÇ x˜ÏãÓ ¢yúö¸y¸yÓ˚ˆñ ö¸¢ö¸Ó˚ñ õœ$¸Á!Ó˚ˆá!›¸¸ ˆÎÔÜ îyˆÏì¸Ó˚ Ñ¸yÓ˚ñ Ñ¸!Ñ¸Ñ¸ Ñ¸!ÑŸõy˚ÏÓ˚ ÿy˚ÏòÓ˚ ã˚Ïú !õ˚Ïü ÎyÎ˚ – ~=!ú ãú˚ÏÑ¸ î)!°Ïì¸ Ñ¸˚ÏÓ˚ – !Ó!¶¸ß¨ !ü“˚Ï“Ó˚ ˆ«¸ˆÏe «¸!ì¸Ñ¸Ó˚ !ü“ãyì¸ Óã≈ƒ ¸ôîyÌ≈=!úÓ˚ õ˚Ïiƒ ≤ÃyòÑ¸ ˆÏì¸ˆÏÑ¸ £˚ÏÌÌÈ£ÜÙÙÜÈ SÑ¸V ¸ôÓ˚õyí% ü!_´ˆÏÑ¸ ˆÌw ˆöœ¸yÓ˚y£zv¸ ˆÎÔÜñ SÖV Üƒy¢ Á ˆÑ¸yÑ¸ !ü“ãyì¸ xƒy˚Ïõy!òÎ˚yñ ˆö¸¸òú ¢yÎ˚ˆÏòy£zv¸ñ ¢yúö¸y£zv¸ ˆÎÔÜñ SÜV Ó˚ˆÇ Á Óƒ›¸yÓ˚# !ü“ãyì¸ ¢#¢y Á ¢#¢yÓ˚ x:y£zv¸ñ SáV õÎ Á xòƒ Ó˚y¢yÎ˚!òÑ¸ !ü“ãyì¸ x˜ÏãÓ xƒy!¢v¸ñ ˆö¸òú ˆÎÔÜ ~ÓÇ ˜ãÓ xƒy!¢v¸ñ ˆÎÔÜñ ˆì¸úñ â¸!Óñ !@˜Ãã £zì¸ƒy!îñ S⸨V â¸õ≈!ü“Ï” ÓƒÓ£*ì¸ ›¸ƒy!òÑ¸ xƒy!¢v¸ñ ˆö¸òúñ ¢yúö¸y£zv¸ Á ˆe´y!òÎ˚yõ ˆÎÔÜñ SäÈV ¢yÓ˚ !ü“˚ÏÓ˚ v¸z¸ôãyì¸ ö¸¢ˆÏö¸›¸ Á ˆÑœ¸yÓ˚y£zv¸ ˆÎÔÜ £zì¸ƒy!î– S3V üÉÓ˚ Á @˜Ãy˚ÏõÓ˚ ¢yiyÓ˚í ˆüÔâ¸ÓƒÓfl¸iyÎ˚ ≤Ãˆì¸ƒÑ¸ òîÎ˚õy v¸zß√%_´ £Î˚ ˆÑ¸yò Ó¸£Î˚ ãúyüÎ˚ ˆÎõò Öyúñ òî#ñ ¢õ%o £zì¸ƒy!î˚Ïì¸ ~ÓÇ ì¸yÓ˚ ¸ô)˚ÏÓ≈ î)!°Ïì¸ ã˚ÏúÓ˚ ˆüyˆÏòÓ˚ ˆÑ¸yÁ v¸z¸ôÎ%_´ ÓƒÓfl¸iy ˆòÁÎ˚y £Î˚ òy– ~äÈyv¸¸y Ó¸!‹TÓ˚ ãú xyhfl¸yÑ%§v¸v¸¸ñ Öy›¸yúñ Ÿ¬üyòñ ¶¸yÜ˚Ïv¸¸Ó˚ v¸z¸ôÓ˚ !ˆÏÌ˚ ≤ÃÓy!£ì¸ £Î˚ ãÓ˚ 䌀 õyÓ£yÓ˚ Á ìv›¸yÓ˚ˆ˚Ïãı¸ñ !ˆÏÌ˚ ãyõyÑ¸y¸ôv¸¸ñ Óy¢ò ˆiyÎ˚y £Î˚ñ ÎyÓ˚ ö¸˚Ïú Óã≈ƒ ã˚Ïú fl¸iyÎ˚#¶¸y˚ÏÓ !Ñ¸Ñ¸ ˆÓ˚yÜ¢¸!‹TÑ¸ ˆÎõ˚ÏÓ˚ ì¸y˚Ï¢Ó˚ ¸ô!ˆÏÌ≈Ó˚ xò%≤ÃˆÏÓü á˚Ï›¸ ÎyÓ˚ ¸ô! Ó˚ ˆÏüyò ˆÓú Ñ¸!‡¸ò– S5V ˜ãÓ xyÓã≈òy ˆÎõ ÜyˆÏãÈÓ˚ ¸ôyì¸yñ õ¸ì¸ ≤Ãyí#Ó˚ ˆÎ£yÓ˚ˆÏü°ÏÎ˚ñ «%¸o ãúã v¸z!qîñ Ñ¸#›¸¸ò¸ôì¸D ¸ôâ¸ˆÏòÓ˚ ö¸˚Ïú ¸ôâ¸òü#ú ¢)" ˜ãÓ Ñ¸íyñ ˆÓ˚yÜã#Óyí%ñ ¶¸y£zÓ˚y¢ñ ÓƒÑ¸!›¸!Ó˚ÎÎ˚y ≤Ã¶¸¸!ì¸Ó˚ v¸zqÓ á˚Ï›¸ – S6V î%á≈›¸òy Óy Î%k¸!Ó@˜Ã˚ÏÓ˚ ö¸˚Ïú Ó!ü˚Ïà ˆì¸ú Á ˆì¸˚ÏúÓ˚ v¸z¸ôãyì¸ oÓƒ!î ¢õ%˚Ïo ¸ôv¸¸ˆ˚Ïú ì¸y ≤Ãyíyì¸# î)°Ïí ¢¸!‹T Ñ¸˚ÏÓ˚ – ãy£yã v%¸!Óñ î%!›¸ ãy£y˚ÏãÓ˚ õ˚Ïiƒ Óy ˆÑ¸yò ãy£y˚ÏãÓ˚ ¢y˚Ïì ˆâ¸yÓ˚y¸ôy£yv¸ñ v%¸˚ÏÎy¸ôyÌÓ˚ñ !£õ˚Ïü˚ÏúÓ˚ iyÉyñ ›¸ƒyB¸yÓ˚ ˆÌ˚ÏÑ¸ ! äÈo¸ô˚Ïì ˆì¸ú â%§¸£z˚Ïì ¸ôv¸¸yñ ¢õ%˚Ïo ›¸ƒyB¸yÓ˚ ¢yö¸ Ñ¸Ó˚yñ ¢õ%Ü˚Ï¶≈¸Ó˚ ˆì¸ú˚Ï«¸e ˆÌˆÏÑ¸ ˆì¸ú v¸zˆÏ_yú˚ÏòÓ˚ ¢õÎ˚ î%á≈›¸òyñ ¢õ%o ì¸ú˚ÏÏ˚ÜÓ˚ ˆì¸˚ÏúÓ˚ ¸ôyÓ£zúyÓ£zò=!ú ˆÌ˚ÏÑ¸ ˆì¸ú ¸ôv¸¸y £zì¸ƒy!î ¶¸y˚ÏÓ ¢õ%˚Ïo ˆì¸ú !õü˚Ïì¸ ¸ôyÓ˚ˆÏÓ – Óì≈¸õyòÑ¸y˚Ïú £zÓ˚yÑ¸ ÑÈ£zÓ£zÓyòÈÑ%¸˚ÏÌ˚ì¸ ¢Çú@¿ ¢õ%˚Ïo î%Ñ¸ úyÜyÓ˚ ö¸˚Ïú ˆì¸ú ˆë¸˚Ïú üe&¸ô˚Ï«¸Ó˚ «¸!ì¸ Ñ¸Ó˚yÓ˚ ˆâ¸‹Tyî˚ ¢õ%˚ÏoÓ˚ £yãyÓ˚ £yãyÓ˚ ≤Ãyí# õyÓ˚y ˆÜ˚ÏäÈ– ¢õ%˚ÏoÓ˚ v¸z¸ô!Ó˚ì¸˚Ïú ¶¸y¢õyò ˆì¸˚ÏúÓ˚ xyhfl¸Ó˚í ˆì¸!Ó˚ £˚ÏÏ˚äÈÑ¸ ÎyÓ˚ ö¸˚Ïú ã˚ÏúÓ˚ v¸z!qî Á ≤Ãyí#Ó˚ Ÿª¢Ñ¸yÎ≈ Á ã#ÓòÏyÓ˚ ˆÏì¢Ó¢ƒ £˚ÏöäÈ– ˙ ì¸yú ãúÓy!Ó£ì¸ £˚ÏÎ˚ !ÓÓ˚ˆy›¸ ~úyÑ¸yÎ˚ ¢yÓ%!oÑ¸ Óyilfl¸ì¸¸s¸ƒ ~ÓÇ v¸z¸ôÑ)¸úÓ˚ú˚Ïã≈ı¸# xM¸È˚ÏúÓ˚ ã#ÓÒÏyeyÓ˚Ñ¸ òyòy¶¸y˚ÏÓ «¸!ì¸@˜Ãhfl¸ Ñ¸Ó˚ˆÏãÈ– NSOU ? AE-ES-21 ? 81 S7V ¸ôyÓ˚õyí!ÓÑ¸ xfl¸fñ ˆÓyõy £zì¸ƒy!î ¢õ%oì¸ˆÏú ¸ôÓ˚#«¸yõ)úÑ¸¶¸y˚ÏÓ !Ó˚Ïfl¸≥¸yÓ˚í Ñ¸Ó˚yÓ˚ ö¸˚Ïú ≤ÃÓú £y˚ÏÓ˚ ¢yõ%!oÑ¸ ≤Ãyí#Ó˚ õ¸ì¸%ƒ Á î#á≈fl¸iyÎ˚ # Ó˚y¢yÎ˚!òÑ¸ î)°Ïí ¢¸!‹T £Î˚ – S8V ì¸y¸ô!Óî%ƒfí ˆÑ¸w=!ú ˆì¸ÏÑ¸ !òÜ≈ì¸ ÜÓ˚õ ã˚Ïú !Ó!¶¸ß¨ ïyì¸Ó ˆÎÔÜ !õ˚Ïü ãúyüˆÏÎ˚ Ó˚ v¸z°ài¸y ÓÑ¸!k¸ Ñ¸ˆÏÓ˚ ~ÓÇ ã˚ÏúÓ˚ ˆ¶¸Ôì¸ñ Ó˚y¢yÎ˚!òÑ¸ Á ˜ãÓ î˚Ïõ≈Ó˚ ¸ô!Ó˚Óì≈ò á›¸yÎ˚ – S9V xƒy!¢v¸ Ó¸!‹TÓ˚ ö¸˚Ïú ã˚Ïú x¡˚Ïõ≈ ˆÎÔy ˆî˚ – ö¸˚Ïú ÷î% ¸ôyò#Î˚ !£¢y˚ÏÓ£z òÎ˚ flˆyò ~ÓÇ Ñ¸!°ÏÑ¸y˚Ïõ≈ ÓƒÓ£y˚ÏÓ˚Ó˚ ¸ôˆÏ«¸Á ¨ ãú î)!°Ïì¸ Ó˚ú Üiƒ £Î˚ – ≤Ãyòì¸Ó¸ É Óyì¸y˚Ïì¢ SO 2 Á NO 2 Üƒy˚Ï¢Ó˚ î)°Ïí ˆÏìÑ¸ xƒy!¢v¸ Ó¸!‹TÓ˚ ¢¸!‹T £Î˚ – 2SO 2 + O 2 = 2SO 3 H 2 O + SO 3 = H 2 SO 4 H 2 O + NO 2 = H 2 NO 3 Óyì¸y˚Ï¢Ó˚ ãú#Î˚ Óy˚Ï‹ôÓ˚ ¢y˚Ïì oÓ#¶)¸ì¸ xÓfl¸iyÎ˚ ~£z xƒy!¢v¸ xí%=!ú ly˚ÏÑ¸ ly ˆÓ!ü áò#¶)¸ì¸ xÓfl¸iyÎ˚ !ü!üÓ˚ Á Ó¸!‹TÓ˚ ã˚Ïú oÓ#¶)¸ì¸ £˚ÏÎ˚ ¸ô¸!ÌÓ#˚Ïì¸ ~˚Ï¢ ¸ôˆÏv¸¸ – S10V Ñ¸!°ÏˆÏ«¸ˆÏe ÓƒÓ£*ì¸ x!ì¸!Ó˚_´ ¸ô!Ó˚õyí ¢yÓ˚ ñ !Ó˚°Ïy_ Ñ¸#›¸òyüÑ¸ ¸ôîyÌ≈ Á xyÜyäÈòyüÑ¸ Á°ÏÎ%ï £zì¸ƒy!î ˆÌˆÏÑ¸ òy£z˚Ï›¸¸∆ñ ö¸¢ˆÏö¸›¸ñ ¸ô›¸y¢˚ÏÑ¸ òyòy ˆÎÔÜ ˆì¸!Ó˚ £Î˚ – ~äÈyv¸¸y ã˚ÏúÓ˚ ≤ÃÓy£õyòì¸yÓ˚ îÓ˚&ì¸ «¸Î˚ ≤ÃyÆ õy!›¸Ó˚ Ñ¸íyÓ˚ ¢y˚Ïì ˆ¸ô˚Ï›¸∆y!úÎ˚yõ ˆÎÔÜ !õ˚Ïü ãú î)°Ïí á›¸yÎ˚ – 5.3.2 ! Ó÷k¸ ã˚ÏúÓ˚ ïõ≈ Á =íÓ!ú ã˚ÏúÓ˚ !Ó÷k¸ì¸y ~ÓÇ =íy=í !ò¶≈≈¸Ó˚ Ñ¸˚ÏÓ˚ ì¸yÓ˚ ¢Ñ¸ú ˆ¶¸Ôì¸ñ Ó˚y¢yÎ˚!òÑ¸ ïõ≈ ~ÓÇ ˜ãÓ ≤ÃÑ¸!ì¸Ó˚ v¸z¸ôÓ˚ – Ñ¸ì¸=!ú ˆ¶¸Ôì¸ïõ≈ Îy ã˚ÏúÓ˚ !Ó÷k¸ì¸y !Óâ¸yˆÏÓ˚ ¢Ó≈

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ì¸y ~Öyˆïò ¢Çˆï«¸ˆï¸ô xyˆïúyâ¸òy Ñ¸Ó˚y £ú–

S1V oÓ#¶)¸ì¸
Óy ¶¸y¢õyò ¸ôîyÌ≈ ≠ ãˆïú òyòyïÓ˚ˆïòÓ˚ ¸ôîyÌ≈ ¶¸y¢õyò Óy oÓ#¶)¸ì¸ xÓfl¸iyÎ˚ ÌyÑ¸ˆïì¸ ¸ôyˆïÓ˚ – ¶¸y¢õyò ¢)" Ólfl¸Ñ¸íyñ ˜ãÓ ¸ôîyÌ≈ Sˆîõò ì¸ls¸ñ ì%¸úyñ ˜üÓyúñ ã#Óyí% £zì¸ƒy!îV xÌÓy x˜ïãÓ ¸ôîyÌ≈ Sˆîõò õy!›¸ñ ¸ôyÌÓ˚ñ £z›¸ £zì¸ƒy!îV î)°ïí !£¢yˆïÓ v¸z¸ô!fl¸ìì¸ ÌyÑ¸ˆïì¸ ¸ôyˆïÓ˚ – !Ñ¸ä%È ¸ôîyÌ≈ ¢Ó˚y¢!Ó˚ î)°ïí !£¢yˆïÓ Ñ¸yã Ñ¸ˆïÓ˚ ˆîõò ÓƒyÑ¸!›¸!Ó˚Î˚y ã#Óyí% £zì¸ƒy!îñ xyÓyÓ˚ !Ñ¸ä%È ¸ôîyÌ≈ xòƒ ˆÑ¸yò ¸ôîyˆïÌ≈Ó˚ ¢yˆïÌ !Ó!e´Î˚y Ñ¸Ó˚ˆïú v¸zÍ¸ôß¨ ˆîÔÜ!›¸ î)°ïÑ¸ ¸ôîyÌ≈ £Î˚ – ˜ãÓ ¸ôk¸!ì¸ˆïì¸ ˜ãÓ î)°ïí ˆìˆïÑ¸ «¸!ì¸Ñ¸Ó˚ ¸ôîyÌ≈ v¸zÍ¸ôß¨ £Î˚ – ãˆïú ¶¸y¢õyò Ñ¸íyãyì¸#Î˚ î)°ïíˆïÑ¸ !ö¸ú‰›¸yÓ˚ ¸ôk¸!ì¸ˆïì¸ ˆüyïò Ñ¸Ó˚y £Î˚ – S2V ïyì¸Ó xyïyˆïòÓ˚ v¸z¸ô!fl¸i!ì¸ ≠ v¸zÍ¢ xò%¢yˆïÓ˚ Óã≈ƒ ãˆïú òyòy ïÓ˚ˆïòÓ˚ ïyì%¸Ó˚ ì¸!v¸¸Íî%_´ ¸ôÓ˚õyí% v¸z¸ô!fl¸ìì¸ Ìyˆ ïÑ¸ – ¢yïyÓ˚î¸É xyõÓ˚y «¸!ì¸Ñ¸Ó˚ ì¸!v¸¸Í xyïyò Ó˚*ˆï¸ô !â¸!£´ì¸ Ñ¸ˆïÓ˚ Ìy!Ñ¸ õyÑ≈¸yÓ˚#ñ xyˆï¢≈!òÑ¸ñ xƒy!r›¸õ!òñ ˆe´y!õÎ˚yõñ Ñ¸ƒv¸!õÎ˚yõñ ˆÓ!Ó˚Î˚yõñ ˆÑ¸yÓyŒ›¸ ≤Ã¶¸¸!ì¸ ïyì%¸Ó˚ xyòÎ˚ˆïÑ¸ñ Îy x"õyeyˆïì¸£z !Ó°ïy_´ £ˆïÎ˚ ¸ôˆïv¸¸– ~äÈyv¸¸y fl¸∫" «¸!ì¸Ñ¸Ó˚ ïyì%¸ !£¢yˆïÓ xyˆïäÈÈÙÙÙÈ ˆ¢y!v¸Î˚yõñ xyÎ˚Ó˚òñ õƒyDy!òãñ xƒyú%!õ!òÎ˚yõñ !ãB¸ £zì¸ƒy!î– ïyì¸Ó ì¸!v¸¸Í xyïyˆïòÓ˚ õ)ú v¸zÍ¢ £ú òyòy Ó˚y¢yÎ˚! òÑ¸ !ü"ñ ì¸!v¸¸Í ≤Ãˆïú¸ôò ~ÓÇ ïyì¸Ó oˆïÓƒÓ˚ !ö¸!ò!üÇÈÙÈ~Ó˚ ãòƒ– ãˆïú ˆÑ¸yò ïyì%¸Ó˚ xyïyò xyˆïäÈñ ì¸y ãyòy ÌyÑ¸ˆïú Ó˚y¢yÎ˚! òÑ¸ ¸ôk¸!ì¸ ÓƒÓ£yÓ˚ Ñ¸ˆïÓ˚ ïyì%¸!›¸ˆïÑ¸ xòƒ ˆÑ¸yò ¸ôîyˆïÌ≈Ó˚ ¢yˆïÌ !Ó!e´Î˚y Ñ¸ˆïÓ˚ xoyÓƒ xïÉˆï«¸¸ô v¸zÍ¸ôß¨ Ñ¸ˆïÓ˚ ¸ô¸ÌÑ¸ Ñ¸ˆïÓ˚ ˆòÁÎ˚y ¢Ω¸Ó– 82 ? NSOU ? AE-ES-21
S2V «¸yÓ˚ì¸yÈÙÙÙÈ «¸yÓ˚ì¸yÓ˚ õy¸ôÑ¸ õyey £ˆïúy pHñ !Ó÷k¸ ãˆïúÓ˚ pH ≤ÃyÎ˚ ¢yì¸ – ~Ó˚ Ñ¸õ pH î%_´ ãúˆïÑ¸ xy!¡Ñ¸ ~ÓÇ ~Ó˚ ˆìˆïÑ¸ ˆÓ!ü pH î%_´ ãúˆïÑ¸ «¸yÓ˚#Î˚ Óúy £Î˚ – xy!¡Ñ¸ Á «¸yÓ˚#Î˚ v¸z¶¸Î˚ ≤ÃÑ¸yÓ˚ ãú «¸!ì¸Ñ¸Ó˚ – ì¸y£z ãˆïúÓ˚ pH ¢Ó≈îy ¢yˆïì¸Ó˚ Ñ¸yäÈyÑ¸y!äÈ £ÁÎ˚y xì¸ƒhs˘¸ ≤Ãˆïΰyã– S3V Óí≈ Á Üı¸ÈÙÙÙÈ !Ó÷k¸ ãú Óí≈£#ò ~ÓÇ Üı¸£#ò– ˆÑ¸Óúõye oÓ#¶)¸ì¸ Óy ¶¸y¢õyò Ñ¸íyÓ˚ ãòƒ ãˆïú Óí≈ Óy Üı¸ ˆîÖy !îˆïì¸ ¸ôyˆïÓ˚ – !Ó!¶¸ß¨ Ó˚y¢yÎ˚!òÑ¸ !üˆï"Ó˚ S≤ÃïyòÌ¸ Ñ¸y¸ôv¸¸ Óy xòƒ oˆïÓƒ Ó˚à Ñ¸Ó˚yV v¸zÍÓ,_ Óã≈ƒ ãˆïú Ó˚!àò î)°ïÑ¸ Ñ¸íyÓ˚ v¸z¸ô!fl¸i!ì¸ Ìyˆ ïÑ¸ – Îy xyõyˆïîÓ˚ üÓ˚#ˆïÓ˚Ó˚ ¸ôˆï«¸ «¸!ì¸Ñ¸yÓ˚Ñ¸ – Óí≈ Á Üı¸ ãˆïú î)°ïˆïíÓ˚ ¸ô!Ó˚â¸yÎ˚Ñ¸ – S4V ì¸y¸ôõyey ÈÙÙÙÈ ãˆïú v¸z¸ô!fl¸ìì¸ òyòy ˜ãÓ Á x˜ïãÓ ¸ôîyÌ≈ ãˆïúÓ˚ ì¸y¸ôõyey !òÎ˚s¸ƒˆïí

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v¸zˆïÕ'Öˆïîy܃ ¶)¸!õÑ¸y ¸ôyúò Ñ¸ˆïÓ˚ –

ãˆïúÓ˚ ì¸y¸ôõyeyÓ˚ v¸z¸ôÓ˚ ˙ ãˆïú Ó¢Óy¢Ñ¸yÓ˚# v¸z!qîÈÙÈ≤Ãyí# Á ã#Óyí%ˆïîÓ˚ ã#Óò !ò¶≈¸Ó˚ Ñ¸ˆïÓ˚ – ¢yïyÓ˚î¸ ¶)¸ì¸ú!fl¸ìì¸ ãú Á !üˆï"Ó˚ Óã≈ƒ ãˆïú ì¸y¸ôõyey ˆÓ!ü Ìyˆ ïÑ¸ Îy ˆÑ¸yòÁ ¶¸yˆïÓ ãúyüˆïÎ˚ !õüˆïú ãúyüˆïÎ˚Ó˚ ì¸y¸ôõyì¸yÓ˚ ì¸yÓ˚ì¸õƒ ¢¸!‹T Ñ¸ˆïÓ˚ – S5V oÓ#¶)¸ì¸ x!:ˆïãò È(Dissolved Oxygen)ÙÙÙÈ ¸ô!Ó˚õyí ˆîˆïÊì%¸ ãúã v¸z!qî Á ≤Ãyí# ãˆïú oÓ#¶)¸ì¸ x!:ˆïãòˆïÑ¸ Ÿªy¢@ˇÃ£ˆïíÓ˚ Ñ¸yˆïã ÓƒÓ£yÓ˚ Ñ¸ˆïÓ˚ñ ì¸y£z ãˆïú v¸z¸ô!fl¸ìì¸ x!:ˆïãˆïòÓ˚ ¸ô!Ó˚õyí ˙ ¢Ó ≤Ãyí#ˆïîÓ˚ ã#Óˆïò Ó˚ ãòƒ ~Ñ¸!›¸ =Ó˚&c¸ô)í≈ v¸z¸ôyîyò– ~£z ¸ô!Ó˚õyíˆïÑ¸ ≤ÃÑ¸yü Ñ¸Ó˚y £Î˚ DO õyey Ó˚*ˆï¸ô– ãúã v¸z!qˆïîÓ˚ ¢yˆïúyÑ¸¢Çˆïÿ'°ï ~ÓÇ ÓyÎ˚%Ó˚ x!:ˆïãò £ú ãˆïú v¸z¸ô!fl¸ìì¸ x!:ˆïãˆïòÓ˚ v¸zÍ¢– ˜ãÓ x!:ˆïãò â¸y!£îy (Biological Oxygen Demand — BOD) ≠ ˜ãÓ x!:ˆïãˆïòÓ˚ â¸y!£îy (Bilogocial Oxygen Demand) Óy ¢Çˆï«¸ˆï¸ô BOD Óúˆïì¸ ãˆïú v¸z¸ô!fl¸ìì¸ ˜ãÓ ¸ôîyÌ≈ ˆîõò ãúã ÓƒyÑ¸!›¸!Ó˚Î˚y ~ÓÇ xòƒyòƒ xí%ã#Ó#ˆïíÓ˚ fl¸∫y¶¸y!ÓÑ¸ Ñ¸yãÑ¸õ≈ Á Óyv¸¸Ó¸!k¸Ó˚ ãòƒ ãˆïú oÓ#¶)¸ì¸ x!:ˆïãˆïòÓ˚ â¸y!£îy Óy e´õ£…y¢õyò xÓfl¸iyˆïÑ¸ ˆÓyG¸yˆïòy £Î˚ – ~!›¸ ÚÚ!õ!ú@ˇÃyõ ≤Ã!ì¸ !ú›¸yÓ˚ÛÛ ~Ñ¸ˆïÑ¸ ≤ÃÑ¸yü Ñ¸Ó˚y £Î˚ – !ü"ÈÙÈÑ¸yÓ˚Öyòy Óy ˆ¸ôÔÓ˚ ~úyÑ¸yÎ˚ ÓƒÓ£*ì¸ Óã≈ƒ ãˆïú v¸z¸ô!fl¸ìì¸ ˜ãÓ ¸ôîyÌ≈=!ú !Ñ¸ä%È x!ì¸ «%¸o ãúâ¸Ó˚ ≤Ãyí#Ó˚ Öyîƒ– ˙ ¢Ó ˜ãÓ Ólfl¸ˆïÑ¸ ˜ãÓ «¸!Î˚°%å (biodegradable) Óˆïú– ˆîõò üÑ≈¸Ó˚yñ ˆ≤Ãy!›¸òñ ˆfl¸¨£ãyì¸#Î˚ ¸ôîyÌ≈ñ xƒyúˆïÑ¸y£úñ xƒyú!v¸£y£zv¸ñ ~fi›¸yÓ˚ £zì¸ƒy!î ~ÓÇ

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v¸z!qî Á ≤Ãyí#Ó˚ ˆî£yˆïü°ï–

ãú ~£z ¢Ñ¸ú ˜ãÓ ¸ôîyÌ≈ myÓ˚y î)!°ïì¸ £ˆïú ˆ¢£z î)!°ïì¸ ¸ôîyÌ≈ˆïÑ¸ Ó˚y¢yÎ˚!òÑ¸¶¸yˆïÓ !Óˆï°Î˚y!ãì¸ Ñ¸Ó˚yÓ˚ ãòƒ ≤Ãˆï°Î˚yã ÓƒyÑ¸!›¸!Ó˚Î˚y Á xí%ã#Ó# ≤Ãyí#– xyõÓ˚y ¢yïyÓ˚í¶¸yˆïÓ ãy!ò ˆî ãú îì¸ ˆÓü# ¸ô!Ó˚õyí î)!°ïì¸ £ˆïÓñ ì¸ì¸£z ˆ¢£z ãˆïú v¸z¸ô!fl¸ìì¸ ÓƒyÑ¸!›¸!Ó˚Î˚y Á ã#Óyí%Ó˚y ¢ÇÖƒyÎ˚ Óyv¸¸ˆïÓ ~ÓÇ !òˆïãˆïîÓ˚ ˆÓßˆïâ¸ ÌyÑ¸yÓ˚ ≤Ãˆïΰyãˆïò ãˆïú v¸z¸ô!fl¸ìì¸ î)!°ïì¸ ¸ôîyÌ≈ˆïÑ¸ ¸ô!â¸ˆïÎ˚ ¸ô%!‹T¢M¸ÈÎ˚ Ñ¸Ó˚ˆïì¸ â¸y£zˆïÓ– ~Ó˚ ãòƒ ãˆïú v¸z¸ô!fl¸ìì¸ x!:ˆïãò ˆÓ!ü ¸ô!Ó˚õyˆïí ÓƒÓ£*ì¸ £ˆïì¸ ÌyÑ¸ˆïÓ– ö¸ˆïú î)!°ïì¸ ãˆïú ã#Óyí%Ó˚ ¢ÇÖƒy ìì¸ Óyv¸¸ˆïÓ oÓ#¶)¸ì¸ x!:ˆïãòÓ˚ ¸ô!Ó˚õyí ì¸ì¸ Ñ¸õˆïÓ– ˜ãÓ ¸ôîyˆïÌ≈Ó˚ ã#Óyí%å!›¸ì¸ «¸Î˚ £Î˚ î%£z ≤ÃÑ¸yˆïÓ˚ ÈÙÙÙÈ S1V ¢Óyì¸ ≤Ã!e´Î˚yÎ˚

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Ñ¸yÓ≈ò v¸zy£zÈÙÈx:y£zv¸ Á ãú v¸zÍ¸ôß¨ £Î˚

x!:ˆïãò myÓ˚y î)°ïÑ¸ ˜ãÓ ¸ôîyˆïÌ≈Ó˚ ãyÓ˚í áˆï›¸ – S2V xÓyì¸ ≤Ã!e´Î˚y £ˆïúy !ÓãyÓ˚í ¸ôk¸!ì¸ ÎyÓ˚ myÓ˚y ££zˆïv»¸yÑ¸

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yÓ≈òñ Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸

ñ xƒy ̂Ïõy!òÎ ̊yñ £y£z ̂Ïv»¸y ̂Ïãò ¢yúö¸y£zv¸ ≤Ã¶,¸!ì¸ v¸zÍ¸ôß¨ £Î ̊ – xÌ≈yí ã ̂Ïú v¸z¸ô!fl¸ii¸ ̃ãÓ«¸!Î ̊°%å ï)°ÏÑ¸ ̃ã!ÓÑ¸ ¸ôîy ̂Ïì≈Ó ̊ ¸ô! Ó ̊õyí Á£z ã ̂Ïú v¸z¸ô!fl¸ii¸ xyí%Ó#«¸!íÑ¸ ≤Ãyí# ̂ÏïÓ ̊ x!: ̂Ïãò â¸y!£îy ̂Ì ̂ÏÑ¸ ¸ô!Ó ̊õy¸ô Ñ¸Ó ̊y £Î ̊ – xÌ≈yí ̃ãÓ x!: ̂Ïãò â¸y!£îy myÓ ̊y xyõÓ ̊y ã ̂ÏúÓ ̊ ̃ãÓ ï)°Ï ̂ÏíÓ ̊ õyey NSOU ? AE-ES-21 ? 83

!òí≈Î ̊ Ñ¸!Ó ̊ ~ÓÇ ≤Ã!ì¸ !ú›¸yÓ ̊ Óã≈ƒ ã ̂Ïú v¸z¸ô!fl¸ii¸ ̃ãÓ ¸ôîy ̂Ïì≈Ó ̊ ¢Óyì¸ ̃ãÓ «¸ ̂ÏÎ ̊Ó ̊ ãòƒ Îì¸ !õ!ú@ ̆Ãyõ x!: ̂Ïãò ≤Ã ̂ÏÎ ̊yãò ì¸y ̂ÏÑ¸ Á£z ã ̂ÏúÓ ̊ BOD õyey Óúy £Î ̊ – ¸ôÓ ̊#«¸yõ)úÑ¸ ¶¸y ̂ÏÓ Á£z õyò !òí≈ ̂ÏÎ ̊Ó ̊ ãòƒ ̂Ñ¸yò ã ̂ÏúÓ ̊ òõ%òy ̂ÏÑ¸ ¸ôßyâ¸!îò 20°C ì¸y¸ôõyeyÎ ̊ ̂Ó ̊ ̂ÏÖ oÓ#¶)¸ì¸ x!: ̂Ïã ̂ÏòÓ ̊ ¸ô!Ó ̊õyí Ñ¸ì¸›¸y Ñ¸ ̂Ïõ ̂ÏäÈ

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ì¸y ¸ô!Ó ̊õy¸ô Ñ¸Ó ̊y £Î ̊ –

Ó ̊y¢yÎ ̊ !òÑ¸ x!: ̂Ïãò â¸y!£îy (Chemical Oxygen Demand) ≠ Ñ,¸!°Ï Á !ü" ̂«¸ ̂Ïe ÓƒÓ£*ì¸ ã ̂Ïú ≤ÃyÎ ̊£z !Ó!¶¸ß¨ ã!›¸ú ̃ãÓ ̂ÎÔ ̂ÏÜÓ ̊ ï) °Ïí á ̂Ï›¸ Îy o&ì¸ ̃ãÓ «¸Î ̊≤ÃyÆ £Î ̊ òy ~ÓÇ ~ ̂ÏïÓ ̊ ¸ô!Ó ̊õyí BOD myÓ ̊y õy¸ôy ¢Ω¸Ó– ~=!ú ¢yïyÓ ̊í¶¸y ̂ÏÓ Î ̂Ïì‹T fl¸iyÎ ̊# ̃ãÓ ̂ÎÔÜ Îy ¢£ ̂Ïã !Ó ̂ÏÎ ̊y!ãì¸ £Î ̊ òy ~ÓÇ Ó ̋ ÓäÈÓ ̊ ã ̂Ïú x!ÓÑ,¸ì¸ xÓfl¸iyÎ ̊ ̂Ì ̂ÏÑ¸ ÎyÎ ̊ – ̂Ñ¸Óúõye !Ó ̂Ïü°Ï ïÓ ̊ ̂ÏòÓ ̊ ̂Ñ¸yò ã#Óyí%Ó ̊ v¸z¸ô!fl¸i!ì¸ ̂Ïì¸ ï#Ó ̊ Ü!ì¸ ̂Ïì¸ !Ó ̂ÏÎ ̊y!ãì¸ £Î ̊ – ~=!ú fl¸iyÎ ̊# ~ÓÇ xì¸ƒhs¸ «¸!ì¸Ñ¸Ó ̊ ï)°Ïí– v¸zîy£Ó ̊ífl¸ÍÓ ̊*¸ô ̂Ñœ¸y!Ó ̊òÎ%_ ́ ̂ÎÔÜñ !ö¸òú ~ÓÇ !ö¸òú ãyì¸#Î ̊ ã!›¸ú £y£z ̂Ïv»¸yÑ¸yÓ≈òñ !Ñ¸ä%È ¢yÓyò ãyì¸#Î ̊ ̂ÎÔÜñ Ñ¸#›¸òyüÑ¸ ¸ôîy ̂Ïì≈Ó ̊ õ ̂Ïïƒ xÓ!fl¸ii¸ ̃ãÓ ̂ÎÔÜ– ~£z ïÓ ̊ ̂ÏòÓ ̊ ¸ôîy ̂Ïì≈Ó ̊ ̂õy›¸ ¸ô!Ó ̊õy¸ô ̂ÏÑ¸ Óúy COD £Î ̊ – ̃ãÓ v¸z¸ôy ̂ÏÎ ̊ «¸Î ̊≤ÃyÆ £Î ̊ òy ~õò Ó ̊y¢yÎ ̊ !òÑ¸ ¸ôîy ̂Ïì≈Ó ̊ ãòƒ ≤Ã ̂ÏÎ ̊yãò#Î ̊ x!: ̂Ïãò ̂ÏÑ¸ Á£z ã ̂ÏúÓ ̊ Ó ̊y¢yÎ ̊ !òÑ¸ x!: ̂Ïãò â¸y!£îy Óúy £Î ̊ ~ÓÇ !õ!ú@ ̆Ãyõ ≤Ã!ì¸ !ú›¸yÓ ̊ ~Ñ¸ ̂ÏÑ¸ ≤ÃÑ¸yü Ñ¸Ó ̊y £Î ̊ – 5.3.3 ãúï)°Ï ̂ÏíÓ ̊ ö¸ ̂Ïú õyòÓ ̂Ïï ̂Ï£ ¢,‹T ̂Ó ̊yÜÓƒy!ï ãúÓy!£ì¸ Óƒy!ï £ ̂Ïúy ̂Ñ¸yòÁ õy£z ̂Ïe ́yxÜ≈y! ò¢õ‰ÈÙÈ~Ó ̊ ¢Çe ́õí Îy ≤Ãïyòì¸É ¸ôyò#Î ̊ ãú Óy Öyîƒ ≤Ãlfl¸!ì¸Ó ̊ Ñ¸y ̂Ïã ÓƒÓ£*ì¸ ã ̂ÏúÓ ̊ ï)°Ï ̂ÏíÓ ̊ ö¸ú– ¸ô,!Ó# ̂Ïì¸ Ü ̂Ïv¸¸ ≤Ã!ì¸ ÓäÈÓ ̊ ãúÓy!£ì¸ ̂Ó ̊y ̂ÏÜÓ ̊ Ñ¸yÓ ̊ ̂Ïí ≤ÃyÎ ̊ 2 !õ!úÎ ̊ò õyò% ̂Ï°ÏÓ ̊ õ,ì%¸ƒ á ̂Ï›¸ ̂Ïä SWHOÙÈ~Ó ̊ ì¸Ìƒyò%¢y ̂ÏÓ ̊V x!Ó÷k¸ ãú¸ôyòñ ̂üÔâ¸yú ̂ÏÎ ̊Ó ̊ x¸ô!Ó ̊!FäÈß¨ì¸y Óy xfl¸ʃyfl¸iƒÑ¸Ó ̊ v¸z¸ôy ̂ÏÎ ̊ ã ̂ÏúÓ ̊ ÓƒÓ£yÓ ̊ ̂Ì ̂ÏÑ¸ – ãúÓy!£ì¸ ̂Ó ̊yÜ=!úÓ ̊ ¢Çe ́õí ≤Ãïyò Ñ¸yÓ ̊í £Î ̊ ̂≤Ãy ̂Ï›¸∆y ̂ÏãyÎ ̊y Óy ¶¸y£zÓ ̊y¢ Óy ã#Óyí% SÓƒyÑ¸!›¸!Ó ̊Î ̊yV Óy ¸xy!s¸fÑ¸ ¸ôÓ ̊ã#Ó# (intestinal parasites) ≤Ã¶,¸! ì¸Ó ̊ ¢Çe ́õí– !ò ̂Ïâ¸Ó ̊ ì¸y!úÑ¸yÎ ̊ ≤Ãïyò Ñ¸ ̂ÏÎ ̊Ñ¸!›¸ ãúÓy!£ì¸ ̂Ó ̊yÜñ ì¸y ̂ÏïÓ ̊ ïyÓ ̊Ñ¸ Óy£Ñ¸ ~ÓÇ ̂Ó ̊y ̂ÏÜÓ ̊ v¸z¸ô¢Ü≈ Á ≤Ã ̂ÏÑ¸y ̂Ï¸ôÓ ̊ ¢Ç!«¸Æ ¸ô!Ó ̊â¸Î ̊ ̂îÁÎ ̊y £ú– ÓƒÑ¸!›¸!Ó ̊Î ̊y á!›¸ì¸ ̂Ó ̊yÜ ≠ ï)!°Ïì¸ ãú ̂Ì ̂ÏÑ¸ ÓƒÑ¸!›¸!Ó ̊Î ̊y ¢Çe ́õ ̂Ïí òyòy ïÓ ̊ ̂ÏòÓ ̊ ̂Ó ̊yÜ £ ̂Ïì¸ ¸ôy ̂ÏÓ ̊ – ̂Îõò ¸ôyò#Î ̊ Á Öyîƒ ≤Ãlfl¸ ̂Ïì¸ ÓƒÓ£*ì¸ ã ̂ÏúÓ ̊ ï)°Ïí ̂Ì ̂ÏÑ¸ !Ó!¶¸ß¨ ̂Ó ̊yÜ ̂îÓy ̂îÎ ̊ – ̂ÎõòÈÙÙÙÈ (i) Ñ¸ ̂ÏúÓ ̊y ≠ ãúï)°Ï ̂ÏíÓ ̊ ̂Ì ̂ÏÑ¸ ¢,!‹T £ÁÎ ̊y ~£z ̂Ó ̊yÜ ≤ÃyÎ ̊üÉ£z ¶¸yÓ ̊ ̂Ïì¸Ó ̊ òyòy @ ̆Ãyõ Óy õö¸Éfl¸Ʃú ~úyÑ¸yÎ ̊ õ£yõyÓ ̊# xyÑ¸y ̂ÏÓ ̊ ̂îÓy ̂îÎ ̊ – ~Ó ̊ ö¸ ̂Ïú ̂Ó ̊yÜ# !î ̂Ïò 30ÈÙÈ50 ÓyÓ ̊ ã ̂ÏúÓ ̊ õ ̂Ïì¸y ¸ôyÎ ̊Öyòy Á Ó!õ Ñ¸ ̂ÏÓ ̊ – ö¸ ̂Ïú üÓ ̊#Ó ̊ ̂Ì ̂ÏÑ¸ x!ì¸! Ó ̊_ ́¸ ¸ô!Ó ̊õyí ãú ̂Ó!Ó ̊ ̂ÏÎ ̊ !Ü ̂ÏÎ ̊ xì¸ƒ!ïÑ¸ î%Ó≈úì¸yñ õyÌy ̂áyÓ ̊y ≤Ã¶,¸!ì¸ v¸z¸ô¢Ü≈Á ̂îÓy ̂îÎ ̊ – ~!›¸ ~Ñ¸!›¸ ¢Çe ́yõÑ¸ ̂Ó ̊yÜñ ~Ó ̊ ≤Ã!ì¸ ̂ÏÓ ̊y ̂ÏïÓ ̊ ãòƒ ›¸#Ñ¸y ̂òÁÎ ̊y ≤Ã ̂ÏÎ ̊yãò– (ii) ›¸y£zö¸ ̂ÏÎ ̊v¸ ≠ ï)!°Ïì¸ ãú ¸ôyò Ñ¸Ó ̊ ̂Ïú ~£z ≤ÃÑ¸yÓ ̊ ãµÓ ̊ ̂îÓy ̂îÎ ̊ – ~£z ̂Ó ̊yÜ ÓƒÑ¸!›¸!Ó ̊Î ̊y Óy!£ì¸ ~ÓÇ ÖyÓyÓ ̊ Óy ã ̂Ïú õy!äÈ Ó¢yÓ ̊ ö¸ ̂Ïú ~!›¸ äÈv¸¸yÎ ̊ – ~£z ̂Ó ̊y ̂ÏÜÓ ̊ ö¸ ̂Ïú ≤Ãâ¸[¸ ãµÓ ̊ñ üÓ ̊# ̂ÏÓ ̊ ÓƒyÌyñ õyÌyÎs¸fíy Á ̂¸ô ̂Ï›¸Ó ̊ x¢%Ö ̂îÓy ÎyÎ ̊ – ¶¸y£zÓ ̊y¢ á!›¸ì¸ ̂Ó ̊yÜ ≠ ã ̂ÏúÓ ̊ ï)°Ïí ̂Ì ̂ÏÑ¸ !Ó!¶¸ß¨ ¶¸y ̂ÏÓ õyòÓ ̂Ïï ̂Ï£ òyòy ¶¸y£zÓ ̊y¢ á!›¸ì¸ ̂Ó ̊yÜ £ ̂ÏÎ ̊ Ìy ̂ÏÑ¸ ̂Îõòñ ̂£¸ôy›¸y£z!›¸¢‰ A Á B, ̂¸ôy!úÁñ ¶¸y£zÓ ̊y¢ á!›¸ì¸ òyòy ïÓ ̊ ̂ÏòÓ ̊ ãyòy Á xãyòy ãµÓ ̊ Á ≤Ãy¢!DÑ¸ ̂Ó ̊yÜ Óƒ!ï– 84 ? NSOU ? AE-ES-21

(ii) ̂£¸ôy›¸y£z!›¸¢‰ BÈÙÙÙÈ ~!›¸ Öyîƒ Á ã ̂Ïú ¶¸y£zÓ ̊y¢ ¢Çe ́yõ ̂ÏíÓ ̊ ö¸ ̂Ïú á ̂Ï›¸ Ìy ̂ÏÑ¸ – !ü÷Ó ̊y o&ì¸ ~£z ̂Ó ̊y ̂ÏÜ xye ́yhs¸ £Î ̊ – ~£z ̂Ó ̊y ̂ÏÜ õ%ÖÈÙÈ ̂â¸yÖ Á üÓ ̊# ̂ÏÓ ̊Ó ̊ â¸yõv¸¸yÎ ̊ £ú%î Ó ̊ ̂ÏàÓ ̊ xy¶¸y ̂îÓy ÎyÎ ̊ – ̂¸ô ̂Ï›¸ ÓƒÌyñ Ó!õ ¶¸yÓ Á £ã ̂ÏõÓ ̊ ¢õ¢ƒy £Î ̊ – ~£z ̂Ó ̊y ̂ÏÜÓ ̊ ¢!‡¸Ñ¸ !â¸!ÑƒÍ¢y òy £ ̂Ïú !ú¶¸y ̂ÏÓ ̊ Ñ¸ƒy™yÓ ̊ £ÁÎ ̊yÓ ̊ xyüB¸y Ìy ̂ÏÑ¸ – (iii) ̂¸ôy!úÁÈÙÙÙÈ ~£z ̂Ó ̊yÜ !ü÷ ̂ÏïÓ ̊ ̂î ̂Ï£ o&ì¸ ¢Çe ́yhs¸ £Î ̊ – ~Ó ̊ ̂Ì ̂ÏÑ¸ xD !ÓÑ,¸!ì¸ ~ÓÇ ¸ôƒyÓ ̊y!ú!¢¢‰ £ÓyÓ ̊ xyüB¸y ̃ì¸!Ó ̊ £Î ̊ – ã ̂Ïß√Ó ̊ ¸ôÓ ̊ ̂Óü Ñ¸ ̂ÏÎ ̊Ñ¸ÓyÓ ̊ ≤Ã!ì¸ ̂ÏÓ ̊yiÑ¸ ›¸#Ñ¸y @ ̆Ã£í Ñ¸Ó ̊ ̂Ïú ~£z ̂Ó ̊y ̂ÏÜÓ ̊ ¢Ω¸yÓòy !òõ≈)ú £Î ̊ – Ó ̊y¢yÎ ̊ !òÑ¸ ï)°Ïí á!›¸ì¸ ̂Ó ̊yÜ ≠ ã ̂Ïú v¸z¸ô!fl¸ii¸ !Ó!¶¸ß¨ Ó ̊y¢yÎ ̊ !òÑ¸ ¸ôîyÌ≈ ̂Ì ̂ÏÑ¸ òyòy ïÓ ̊ ̂ÏòÓ ̊ ̂Ó ̊yÜ £ ̂Ïì¸ ¸ôy ̂ÏÓ ̊ ̂ÎõòÈÙÙÙÈ (i) xy ̂Ï¢≈!òÑ¸ ̂ÎÔÜ ̂Ì ̂ÏÑ¸ üÓ ̊# ̂ÏÓ ̊Ó ̊ !Ó!¶¸ß¨ xÇ ̂Ïü òyòy õyÓ ̊ydÑ¸ ̂Ó ̊yÜ £ ̂Ïì¸ ¸ôy ̂ÏÓ ̊ – ¸ô ̂ÏÓ ̊ xyõÓ ̊

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y ~ ¢¡ʃ ̂Ïì¸ !Óhfl¸y!Ó ̊ì¸ xy ̂Ïúyâ¸òy Ñ¸

Ó˚ˆÏÓy– (ii) ãˆÏú v¸z¸ô!fl¸iì¸ òyòy ïyì¸Ó ˆÎÔÜ ˆÌˆÏÑ¸ â¸õ≈ˆÏÓ˚yÜ Á ˆ ¸ôˆÏ›¸Ó˚ x¢%Ö £ˆÏì¸ ¸ôyˆÏÓ˚ – (iii) ãúˆÏüyïˆÏòÓ˚ ãòƒ ÓƒÓ£*ì¸ Ó˚y¢yÎ˚!òˆÏÑ¸Ó˚ x¸ô!Ó˚!õì¸ ÓƒÓ£yÓ˚ ~ÓÇ ãú ˆÌˆÏÑ¸ ˆ¢=!ú ¸ô¸ÌÑ¸#Ñ¸Ó˚í òy Ñ¸Ó˚ˆÏì¸ ¸ôyÓ˚yÓ˚ ö¸ˆÏú ãú î)!°Ïì¸ £Î˚ – ˆÎõò ˆÑœ¸y!Ó˚òñ öœ$¸!Ó˚ò á!›¸ì¸ ˆÎÔÜ !õ!◊ì¸ ¸ô!Ó˚ˆÏüyïÑ¸ – ~£z ïÓ˚ˆÏòÓ˚ î)!°Ïì¸ ãú ÓƒÓ£yÓ˚ Ñ¸Ó˚yÓ˚ ö¸ˆÏú â¸õ≈ˆÏÓ˚yÜ ˆÌˆÏÑ¸ ÷Ó˚& Ñ¸ˆÏÓ˚ ÎÑ,¸Í ö%¸¢ö%¸¢ Óy £*îÎˆÏs¸fÓ˚ ¢õ¢ƒy Óy ¸ôƒyÓ˚y!ú!¢¢ ~ÓÇ £yˆÏv¸¸Ó˚ Ü‡¸ˆÏò !ÓÑ,¸!ì¸ á›¸ˆÏì¸ ¸ôyˆÏÓ˚ – !ÓˆÏü°ì¸É õyˆÏÏ˚Ó˚ üÓ˚#ˆÏÓ˚ î)°ÏˆÏíÓ˚ ¢Çe´õí á›¸yÓ˚ ö¸ˆÏú ì¸yÓ˚ !ü÷ !ÓÑ,¸ì¸ xD !òˆÏÎ˚ ãß√@˘Ã£í Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ – ˆÓ˚yÜ ¢Çe´yõí fl¸iyò Óy£Ñ¸ ã#Óyí% ãˆÏú v¸z¸ô!fl¸i!ì¸Ó˚ Ñ¸yÓ˚í ˆÓ˚yˆÏÜÓ˚ v¸z¸ô¢Ü≈ 1V xƒy!õ!ÓÎ˚y!¢¢‰ £yì¸ ˆÌˆÏÑ¸ õ%Ö ˆ≤ÃyˆÏ›¸yˆÏãyÎ˚y x¸ô! Ó˚ˆÏüy!ïì¸ ¸ôyò#Î˚ ãúñ Öyú ì¸ú ˆÏ¸ôˆÏ›¸ ÓƒÌyñ Ñœ¸y!hs¸ñ Áãò ¸ôÎ≈hs¸ Óy òî#òyúyñ Ók¸ ãˆÏú õy!äÈÓ˚ Ñ¸ˆÏõ ÎyÁÎ˚yñ ÓyÓ˚ ÓyÓ˚ Ó!õÈÙÈ Ó¢Óy¢ ¸ôyÎ˚Öyòyñ Üƒyˆ Ï¢Ó˚ ÓƒÌyó ãµÓ˚¶¸yÓ 2V !ãÎ˚yÓ˚!v¸Î˚y ÈÛÛ ÈÛÛ x¸ô!Ó˚ˆÏüy!ïì¸ ãˆÏúÓ˚ ¢Çfl¸ôü≈ñ v¸yÎ˚!Ó˚Î˚yñ ì¸úˆÏ¸ôˆÏ›¸ xfl¸∫!hfl¸ñ ã#Óyí% òyüÑ¸ ÓƒÓ£yÓ˚ òy Ñ¸Ó˚yñ Üƒyˆ Ï¢Ó˚ v¸z¸ôoÓ– ¶¸yDy ¸ôy£zˆÏ¸ôÓ˚ ö%¸ˆÏ›¸yÓ˚ õˆÏïƒ !îˆÏÎ˚ î)!°Ïì¸ ˆ¶¸Ôõãˆ ÏúÓ˚ ≤ÃˆÏÓüñ õyò%°Ï Á ã#Óãls¸Ó˚ ~Ñ¸£z v¸zÍ¢ ˆÌˆÏÑ¸ ãú ÖyÁÎ˚y Óy fl¸¨yò– 3V !e´ˆÏ≤Wzyˆ Ïfl¸ôy!Ó˚ÈÙÈ õ%Ö Á Üúy ÈÛÛ !ö¸Œ›¸yˆÏÓ˚Ó˚ ãy!ú Óy ˆ¶¸ì¸ˆÏÓ˚Ó˚¸ öœ$¸ñ ÓyÓ˚ÓyÓ˚ Ó!õ Á ¸ôyì¸úy !v¸Á!¢¢‰ ¸ôye!›¸ ã#Óyí%õ%_´ òy Ñ¸Ó˚yÓ˚ ö¸ˆÏú ¸ôyÎ˚Öyòyñ üÓ˚#ˆÏÓ˚Ó˚ Áãò ˆ¢Öyˆ Ïò ~£z ˆ≤ÃyˆÏ›¸yˆÏãyÎ˚y ãß√ Ñ¸ˆÏõ ÎyÁÎ˚yñ £ãõ ü!_´ ˆòÎ˚ñ xòƒ ã#Óãls¸Ó˚ üÓ˚#Ó˚ Á ò‹T £ÁÎ˚yñ fi›¸õyˆÏÑ¸Ó˚ Ó,!k¸ñ Óã≈ƒ ˆÌˆÏÑ¸ !Óú £zì¸ƒy!îˆÏì¸ !ÜˆÏÎ˚ Üƒy¢ £ÓyÓ˚ ≤ÃÓîì¸y– ˆõˆÏü– 4V !fl¸ÒˆÏfi›¸yˆÏ¢y!õÎ˚y!¢¢‰ õ%Ö ¸ôƒyÓ˚y¢y£z›¸ ≤ÃÓy£õyò î)!°Ïì¸ ãˆÏú x§yü ÜyˆÏÎ˚Ó˚ â¸yõv¸¸yÎ˚ ãµyúyñ â%¸úÑ¸y!ò üyõ%ˆÏÑ¸Ó˚ ˆÖyú £zì¸ƒy!îˆÏì¸ ~£z ãµÓ˚¶¸yÓñ ¢!î≈ÈÙÈÑ¸y!ü ~ÓÇ ≤ÃÑ¸yÓ˚ ¸ôƒyÓ˚y¢y£z›‰¸ xÓfl¸iyò Ñ¸ˆÏÓ˚ – ˆ¸ô!ü¢M¸Èyúˆ Ïò ¢õ¢ƒy– 5V õƒyˆÏú!Ó˚Î˚y Ó˚_´ ˆ≤ÃyˆÏ›¸yˆÏãyÎ˚y fl¸f# xƒyˆÏòy!ö¸!ú¢ õüy ~£z ˆÓ˚yÜ Ñ§¸y¸ô%!ò !îˆÏÎ˚ o&ì¸ ãµÓ˚ xy¢yñ Ó£ò Ñ¸ˆÏÓ˚ – ˆÖyúy ãyÎ˚ÜyÎ˚ áyõ !îˆÏÎ˚ ãµÓ˚ ˆäÈˆÏv¸¸ ÎyÁÎ˚yñ ¸ô!Ó˚‹ÒyÓ˚ ãˆÏú ~£z õüy ≤Ãâ%¸Ó˚ î%Ó≈úì¸y Áãò £…y¢– ¸ô!Ó˚õyˆÏí ÓÇü!Óhfl¸yÓ˚ Ñ¸ˆÏÓ˚ – NSOU ? AE-ES-21 ? 85

xyˆÏ¢≈!òÑ¸ î)°Ïí ≠ x!ì¸!Ó˚_´ xyˆÏ¢≈!òˆÏÑ¸Ó˚ v¸z¸ô!fl¸i!ì¸Ó˚ Ñ¸yÓ˚ˆÏí ãˆÏú ¢‹T î)°ÏíˆÏÑ¸ xyˆÏ¢≈!òÑ¸ î)°Ïí ÓˆÏú– xyˆÏ¢≈!òÑ¸ ~Ñ¸!›¸ xïyì¸Ó ˆõÔú Îy ïyì¸%Ó˚ ¢ˆÏD !Ó!e´Î˚y Ñ¸ˆÏÓ˚ !Ó!¶¸ß¨ !Ó°Ïy_´ ïyì¸Ó ˆÎÔÜ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ ˆÎõò xy!¢≈ˆÏò›‰¸¢ñ xy!¢≈ò Üƒy¢ñ xy! ¢≈òy£z›¸¢‰ñ xyˆÏ¢≈ò x:y£zv¸ £zì¸ƒy!î Îy ãˆÏú Óy õy!›¸ˆÏì¸ v¸z¸ô!fl¸i!ì¸ ¢õhfl¸ ¸ô!Ó˚ˆÏÓüˆÏÑ¸ î)!°Ïì¸ Ñ¸ˆÏÓ˚ – xyˆÏ¢≈!òÑ¸ ÓƒÓ£yÓ˚ÈÙÙÈ xyˆÏ¢≈!òÑ¸ á!›¸ì¸ ˆÎÔÜ=!ú !Ó°Ïy_´ Á «¸!ì¸Ñ¸Ó˚ £ˆÏúÁ ì¸y !Ó!¶¸ß¨ ≤ÃˆÏÎ˚yãˆÏò ≤ÃyÎ˚£z ÓƒÓ£yÓ˚ Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ – ˆÎõòÈÙÙÈ S1V Ñ,¸!°ÏˆÏ«¸ˆÏe Ñ¸#›¸òyüÑ¸ !£¢yˆÏÓñ S2V Ó˚àñ Á°Ï%ïñ ¢yÓyòñ Óƒy›¸yÓ˚# £zì¸ƒy!î !òõ≈yˆÏí ~ÓÇ £zˆÏúÑ¸›¸Δ!òÑ¸ !üˆÏ“ñ S3V Ñ¸y‡¸ˆÏÑ¸ ¸ôâ¸ò ~ÓÇ Ñ¸#ˆÏ›¸Ó˚ xye´õí ˆÌˆÏÑ¸ Ó˚«¸y Ñ¸Ó˚yÓ˚ ãòƒ Ó˚y¢yÎ˚!òÑ¸ v¸z¸ôyîyò !£¢yˆÏÓñ S4V ÜÓy!î ¸ô÷Ó˚ ˆîˆÏ£ Ñ¸#›¸ £zì¸ƒy!îÓ˚ ¢Çe´õí ˆÓ˚yï Ñ¸Ó˚yÓ˚ ãòƒ– ¢y¡±!ì¸Ñ¸ Ñ¸yˆÏú õy!›¸ˆÏì¸ Ü¶¸#Ó˚ òúÑ)¸¸ô ˆÖ§yv¸¸yÓ˚ Óƒ¸ôÑ¸ì¸yÓ˚ ãòƒ õy!›¸Ó˚ Ü¶¸#Ó˚ hfl¸ˆÏÓ˚ xÓ!fl¸iì¸ xy¢≈!òÑ¸ !Ó°Ïy_´ ˆÎÔˆÏÜ ¸ô!Ó˚îì¸ £ˆÏÎ˚ ¸ôyò#Î˚ ãˆÏú !õˆÏü Îyˆ ÏFäÈ– ! ÓK¸yò#ˆÏîÓ˚ ïyÓ˚íy xò%¢yˆÏÓ˚ î!«¸íÈÙÈ¸ô)Ó≈ ~!üÎ˚yÓ˚ ¶¸yÓ˚ì¸ñ ÓyÇúyˆÏîüñ õyÎ˚òõyÓ˚ñ â¸#òñ ◊#úB¸yñ ì¸y£zÁÎ˚yòñ Ó˚y! üÎ˚y £zì¸ƒy!î ˆîˆÏüÓ˚ õy!›¸Ó˚ Ü¶¸#Ó˚ hfl¸ˆÏÓ˚ xyˆÏ¢≈!òˆÏÑ¸Ó˚ x!hfl¸c xyˆÏäÈ– òúÑ)¸¸ô ˆÖ§yv¸¸yÓ˚ ö¸ˆÏú Á£z xyˆÏ¢≈!òˆÏÑ¸Ó˚ ¢yˆÏÌ ãúñ ÓyÎ˚%Ó˚ x!:ˆÏãˆÏòÓ˚ !Ó!e´Î˚y áˆÏ›¸ ~Ñ¸ !Ó°Ïy_´ ãˆÏú oyÓƒ ¸ôîyÌ≈ ¢,!‹T £Î˚ – Óì≈¸õyˆÏò ¸ô!ÿ¸õÓˆÏD xyˆÏ¢≈!òÑ¸ xye´yhs¸ ˆÓ˚yÜ#Ó˚ ¢ÇÖƒy 10 úˆÏ«¸Ó˚ ˆÓ!ü– xyˆÏ¢≈!òÑ¸ î)°ÏˆÏíÓ˚ ö¸ˆÏú õyò%°Ï Á ÜÓy!î ¸ô÷Ó˚ üÓ˚#ˆÏÓ˚ òyòyò õyÓ˚ydÑ¸ Óƒy!ïÓ˚ ¢,!‹T £Î˚ ˆÎõòÈÙÙÈ xyˆÏ¢≈!òÑ¸ î)°ÏˆÏíÓ˚ ö¸ˆÏú õyòÓˆÏîˆÏ£ ¢‹T ˆÓ˚yÜˆÏÑ¸ xyˆÏ¢≈!òˆÏÑ¸y!¢¢‰ ÓˆÏú– ~Ó˚ v¸z¸ô¢Ü≈=!ú £ˆÏúyÈÙÙÈ S1V â¸yõv¸¸yñ òÖñ â%¸ˆÏú xyˆÏ¢≈!òÑ¸ ãˆÏõ £yˆÏì¸ ¸ôyˆÏÎ˚ Ñ¸yˆÏúy îyÜñ xƒyúy!ã≈ñ ö%¸¢Ñ%¸!v¸¸ñ â%¸úÑ¸y!ò £Î˚ – òˆÏÖ ¢yîy Ö§yã ¢‚!‹T £Î˚ – S2V ÜyˆÏÎ˚ ~ÓÇ õ%ˆÏÖ ò#úˆÏâ¸ ˆäÈy¸ô ˆîÖy ÎyÎ˚ – ¸ôyˆÏÎ˚ Ñ¸yˆÏúy Ó˚ˆÏàÓ˚ áy ˜ì¸!Ó˚ £Î˚ – S3V ö%¸¢ö%¸ˆÏ¢Ó˚ ˆÓ˚yÜñ £§y¸ôy!òñ Ó B¸y£z!›¸¢ £Î˚ – S4V ÎÑ,¸ì¸ Á õ)eòyú#ˆÏì¸ ˆÓ˚yÜ ˆîÖy ˆîÎ˚ – S5V v¸z!qˆÏîÓ˚ ˆÑ¸y°Ï xyˆÏ¢≈!òÑ¸ xye´yhs¸ £ˆÏÎ˚ ò‹T £ˆÏÎ˚ ÎyÎ˚ – S6V ã#Óãls¸Ó˚ ˆîˆÏ£ xyˆÏ¢≈!òˆÏÑ¸Ó˚ ≤Ã¶¸yˆÏÓ â¸õ≈ˆÏÓ˚yÜñ ÎÑ,¸ì¸ Óy ö%¸¢ö%¸ˆÏ¢Ó˚ ˆÓ˚yÜ £Î˚ – S7V ¢y!Ó≈Ñ¸ xyˆÏ¢≈!òÑ¸ î)°ÏˆÏíÓ˚ ö¸ˆÏú õy!›¸ñ ˆ¶¸Ôõãúhfl¸Ó˚ ~ÓÇ ÓyÎ˚% î)!°Ïì¸ £Î˚ – 5.3.4 ãúî)°Ïí !òÎ˚s¸fí Á î)Ó˚#Ñ¸Ó˚ˆÏíÓ˚ v¸z¸ôyÎ˚ ãúî)°ÏˆÏíÓ˚ v¸zÍ¢ Á !Ó!¶¸ß¨ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ=!ú ¢¡∫ˆÏì¸ xyõÓ˚y ¸ô)ˆÏÓ≈ ˆãˆÏò!äÈ– ~ÖyˆÏò xyõÓ˚y ãúî)°Ïí ≤Ã!ì¸ˆÏÓ˚yï ¸ôk¸!ì¸ !òˆÏÎ˚ xyˆÏúyâ¸òy Ñ¸Ó˚ˆÏÓy– 86 ? NSOU ? AE-ES-21

ãúî)°Ïí !òÎ˚s¸fí ÈÙÙÈ ãúî)°Ïí ≤Ã!ì¸ˆÏÓ˚yˆÏï ≤ÃÑ¸yÓ˚ Ñ¸ì≈¸Óƒ £ˆÏúy ãˆÏú î)°ÏˆÏíÓ˚ xò%≤ÃˆÏÓüˆÏÑ¸ Óı¸ Ñ¸Ó˚y Á ¸ôÎ≈yÆ ¢yÓïyòì¸y xÓú¡∫ˆÏò î)°ÏˆÏíÓ˚ !òÎ˚s¸fí– ãú î)°Ïí !òÎ˚s¸fˆÏíÓ˚ Ñ¸ˆÏÎ˚Ñ¸!›¸ v¸z¸ôyÎ˚ £ˆÏúyÈÙÙÈ S1V ãˆÏúÓ˚ ≤Ãïyò ≤Ãïyò xyïyÓ˚ xÌ≈yÍ òî#ñ ¸ô%Ñ%¸Ó˚ñ ÖyúÈÙÈ!Óúñ £…î ~ÓÇ ¢õ%ˆÏo ¢Ó˚y¢!Ó˚ xyÓã≈òy Óy !üˆÏ“ ÓƒÓ£*ì¸ ãú ˆö¸úy Óı¸ Ñ¸Ó˚y– S2V ˆÑ¸yòÁ òî#ñ ¸ô%Ñ%¸Ó˚ Óy ¢õ%ˆÏo ãú ˆö¸úyÓ˚ xyˆÏÜ ãúˆÏÑ¸ v¸z¸ôÎ%_´ ¸ôk¸!ì¸ˆÏì¸ ¸ô!Ó˚ˆÏüy!ïì¸ Ñ¸Ó˚y– S3V ¸ô%Ñ%¸Ó˚ Óy òî#Ó˚ ¸ôyˆÏv¸¸ ãyõyÑ¸y¸ôv¸¸ Óy Óy¢ò¸ôe !v¸›¸yÓ˚ˆÏãr›¸ !îˆÏÎ˚ ˆïyÎ˚y ~ÓÇ ÜÓyî# ¸ô÷Ó˚ fl¸¨yò Ñ¸Ó˚yˆÏòy Óı¸ Ñ¸Ó˚y– S4V â¸y°Ï xyÓyˆÏîÓ˚ Ñ¸yˆÏã x!ì¸!Ó˚_´ ¸ô!Ó˚õyí ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ¸ôîyˆÏÌ≈Ó˚ ≤ÃˆÏÎ˚yÜ Óı¸ Ñ¸Ó˚y– S5V ¢õ%ˆÏoÓ˚ ãˆÏú ˆì¸ú äÈ!v¸¸ˆÏÎ˚ ¸ôv¸¸y Óı¸ Ñ¸Ó˚y– S6V xyÓã≈òy !îˆÏÎ˚ ¸ô%Ñ%¸Ó˚ Óy ãúyüÎ˚ ¶¸Ó˚y›¸ Ñ¸Ó˚y ~ÓÇ ~£z¶¸yˆÏÓ Ó¢Óy¢ˆÏÎyÜƒ ˆ¸ôÔÓ˚ ~úyÑ¸y Óy ! ü“yM¸ÈˆÏúÓ˚ ãòƒ ã!õÓ˚ ¸ô!Ó˚õyí Ó,!k¸ Ñ¸Ó˚yÓ˚ ≤Ã!e´Î˚y Óı¸ Ñ¸Ó˚y– S7V ¸ô!Ó˚ˆÏÓü !Óîƒyñ î)°ÏˆÏíÓ˚ ≤ÃÑ,¸!ì¸ Á ≤Ã¶¸yÓ £zì¸ƒy! î !Ó°ÏˆÏÎ˚ ãò¢ˆÏâ¸ì¸òy Ó,!k¸ Ñ¸Ó˚y ≤ÃˆÏÎ˚yãò– S8V ãúî)°Ïí ¢Çe´yhs¸ xy£zò ≤ÃÓì≈¸ò Á ì¸yÓ˚ ¢!‡¸Ñ¸ ≤ÃˆÏÎ˚yˆÏÜ î)°Ïí ˆÓ˚yï Ñ¸Ó˚yÓ˚ ÓƒÓfl¸iy ˆòÁÎ˚y– ãúî)°Ïí ¸!òÎ˚s¸fˆÏíÓ˚ ãòƒ ≤ÃÌõ 1974 ¢yˆÏú ≤Ã!ì¸ˆÏÓ˚yï Á î)°Ïí !òÎ˚s¸fí xy£zò ≤ÃíÎ˚ò £Î˚ Îy 1978 ¢yˆÏú ¢ÇˆÏüy!ïì¸ £Î˚ – ¸ôÓ˚Óì≈¸#Ñ¸yˆÏú 1977ñ 1988 ~ÓÇ 1991 ¢yˆÏú ãú î)°Ïí !òÎ˚s¸fí Á ≤Ã!ì¸ˆÏÓ˚yˆÏï ˆ¢¢‰ xy£zò ≤ÃíÎ˚ò Ñ¸Ó˚y £Î˚ – Î!îÁ ¢yïyÓ˚í ˆúyˆÏÑ¸Ó˚ õˆÏïƒ ~£z xy£zˆÏòÓ˚ ïyÓ˚y ~ÓÇ ì¸yÓ˚ ≤ÃˆÏÎ˚yÜ !Ó°ÏˆÏÎ˚ ¢ˆÏâ¸ì¸òì¸yÓ˚ x¶¸yÓ xyˆÏäÈ– ãúî)°Ïí !òÎ˚s¸fí xy£zˆÏòÓ˚ ≤Ãïyò v¸zˆÏjüƒ £ˆÏúyÈÙÙÈ (i) ãúî)°Ïí ≤Ã!ì¸ˆÏÓ˚yï Á !òÎ˚s¸fí– (ii) ãˆÏúÓ˚ =íÜì¸ õyò ÓãyÎ˚ Ó˚yÖy– (iii) ãúî)°Ïí

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xy£zò Ñ¸yÎ≈Ñ¸Ó˚# Ñ¸Ó˚yÓ˚ ˆ«¸ˆÏe

Ó˚yãƒ Á ˆ

100%	MATCHING BLOCK 119/200	W

Ñ¸w#Î˚ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈

îˆÏÑ¸ ¸ô)í≈ x!ïÑ¸yÓ˚ îyò– Óã≈ƒ ãˆÏúÓ˚ ˆüyïò Á î)°Ïí î)Ó˚#Ñ¸Ó˚í ≠ !ü“ Á ˆ¸ôÔÓ˚ Ñ¸yˆÏÎ≈ ÓƒÓ£*ì¸ Óã≈ƒ ãˆÏúÓ˚ ¸ô!Ó˚ˆÏüyïˆÏòÓ˚ ! Ó!¶¸ß¨ ¸ôk¸!ì¸=ˆÏúy £ˆÏúyÈÙÙÙÈ (i) ¶¸y¢õyò Ñ¸!‡¸ò ¸ôîyÌ≈ Sˆ¶¸Ôì¸ñ Ó˚y¢yÎ˚!òÑ¸ñ ˜ãÓV î)Ó˚#Ñ¸Ó˚í ~Ó˚ ãòƒ xïÉˆÏ«¸¸ôòñ ¸ô! Ó˚fl¸ÀyÓíñ x!¶¸fl¸ÀyÓíñ ¶¸y¢òñ ¸ôyì¸ò £zì¸ƒy!î ˆ¶¸Ôì¸ ¸ôk¸!ì¸Ó˚ ¢y£yÎƒ ˆòÁÎ˚y £Î˚ – (ii) ˜ãÓ «¸!Î˚°%å ¸ôîyÌ≈ î)Ó˚#Ñ¸Ó˚íÈÙÈ~Ó˚ ãòƒÁ !Ó˚ˆÏü°Ï ˜ãÓ ¸ôk¸!ì¸Ó˚ ¢y£yÎƒ ˆòÁÎ˚y £Î˚ – (iii) !Ó!¶¸ß¨ ˜ãÓ Óy x˜ÏãÓ ¸ôîyÌ≈ ˆÎõòñ òy£zˆÏ›¸∆yˆÏãòñ ö¸¢ö¸Ó˚y¢ £zì¸ƒy!îÓ˚ ˆÎÔÜ á!›¸ì¸ î)°Ïíñ Îy ¢£ã ¸ôk¸!ì¸=!úÓ˚ ¢y£yˆÏÎƒ î)Ó˚ Ñ¸Ó˚y ÎyÎ˚ òy ì¸yÓ˚ ãòƒ Ó˚y¢yÎ˚!òÑ¸ ¸ôk¸!ì¸Ó˚ ≤ÃˆÏÎ˚yÜ– ≤Ãïyòì¸É ~ˆÏ«¸ˆÏe x!:ˆÏãˆÏòÓ˚ ãyÓ˚íÈÙÈ!ÓãyÓ˚í ¸ôk¸!ì¸ Á Ó˚y¢yÎ˚!òÑ¸ ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – NSOU ? AE-ES-21 ? 87

î)!°Ïì¸ ãú ¸ô!Ó˚ˆÏüyïò ¸ôk¸!ì¸ ≠ ãyì¸#Î˚ Á Ó˚yãƒ ¸ô!Ó˚ˆÏÓüò#!ì¸ xò%¢yˆÏÓ˚ ãúî)°ÏˆÏíÓ˚ õyò !òÎ˚s¸fí Ñ¸Ó˚y xì¸ƒhs¸ xyÓüƒÑ¸ – ì¸y£z !ü“ Ñ¸yÓ˚Öyòy Á ˆ¸ôÔÓ˚ ~úyÑ¸yÎ˚ ÓƒÓ£*ì¸ ãú ¸ô!Ó˚ˆÏüyïò òy Ñ¸ˆÏÓ˚ ˆÑ¸yòÁ ãúyïyˆÏÓ˚ ˆÎõò ¸ô%Ñ%¸Ó˚ñ òî#ñ ¢õ%o £zì¸ƒy! îˆÏì¸ ˆö¸úy ¸ô!Ó˚ˆÏÓü !ÓÓ˚&k¸ Ñ¸yã– ˆ¢ãòƒ !ü“ˆÏ«¸ˆÏeÓ˚ Óã≈ƒ ãú ~ÓÇ ˆ¸ôÔÓ˚ ~úyÑ¸yÎ˚ ÓƒÓ£*ì¸ ãú !Ó!¶¸ß¨ ¸ôk¸!ì¸ˆÏì¸ ¸ô! Ó˚ˆÏüyïò Ñ¸Ó˚y ≤ÃˆÏÎ˚yãò– î)!°Ïì¸ ãú ¸

62%	MATCHING BLOCK 123/200	SA	B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

ô!Ó˚ˆÏüyïˆÏòÓ˚ Ñ¸ˆÏÎ˚Ñ¸!›¸ ¸ôk¸!ì¸ ~ÖyˆÏò xyˆÏúyâ¸òy Ñ¸Ó˚y £ú– ¸ô!Ó˚

fl¸ÀyÓíÈÙÙÙÈ ~£z ¸ôk¸!ì¸ˆÏì¸ ãˆÏú ¶¸y¢õyò SxoyÓƒV Ñ¸!‡¸ò Ñ¸íyãyì¸#Î˚ î)°Ïí î)Ó˚ Ñ¸Ó˚y £Î˚ – î)!°Ïì¸ ãúˆÏÑ¸ !Ó!¶¸ß¨ ì¸yÓ˚ãy!úÓ˚ õˆÏïƒ !îˆÏÎ˚ ≤ÃÓy!£ì¸ Ñ¸Ó˚y £Î˚ – ≤ÃÌˆÏõ ÓˆÏv¸¸y xyÑ¸yˆÏÓ˚Ó˚ !äÈoÎ%_´ ãy!ú Á ¸ôˆÏÓ˚ x˜Ï¸ô«¸yÑ,¸ì¸ ˆäÈy›¸ !äÈoÎ%_´ ãy!úÓ˚ õˆÏïƒ !îˆÏÎ˚ ≤ÃÓy!£ì¸ Ñ¸Ó˚yÓ˚ ö¸ˆÏú !Ó!¶¸ß¨ xyÑ¸yˆÏÓ˚Ó˚ î)!°Ïì¸ Ñ¸!‡¸ò ¶¸y¢õyò Ñ¸íy ¸ô‚ÌÑ¸ £ˆÏÎ˚ ÎyÎ˚ – xïÉˆÏ«¸¸ôíÈÙÙÙÈ ãˆÏú ¶¸y¢õyò ¢)" xyÑ¸yˆÏÓ˚Ó˚ Ñ¸!‡¸ò Ñ¸íyãyì¸#Î˚ î)°Ïí î)Ó˚ Ñ¸Ó˚yÓ˚ ãòƒ î)!°Ïì¸ ãúˆÏÑ¸ ~Ñ¸!›¸ Ó‚£Í ãúyïyˆÏÓ˚Ó˚ õˆÏïƒ !îˆÏÎ˚ Ö%Ó£z ï#Ó˚ Ü!ì¸ˆÏì¸ ≤ÃÓy!£ì¸ Ñ¸Ó˚y £Î˚ – ~Ó˚ ö¸ˆÏú Ñ¸!‡¸ò Ñ¸íyãyì¸#Î˚ î)°Ïí ãúyïyˆÏÓ˚Ó˚ ì¸úyÎ˚ xïÉ!«¸Æ £Î˚ – !›¸∆Ñ¸!úÇ !ö¸ú›¸yÓ˚ÈÙÙÙÈ ~!›¸ oyÓƒ Óy xoyÓƒ ˜ãÓ î)°ÏÑ¸ î)Ó˚#Ñ¸Ó˚ˆÏíÓ˚ ~Ñ¸ ¸ô%Ó˚yì¸ò ~ÓÇ v¸z¸ôˆÏÎyÜ# ¸ôk¸!ì¸ – ~ÖyˆÏò ~Ñ¸!›¸ î#á≈ ˆâ¸yàyÑ,¸!ì¸ ¸ôyˆÏe xãfl¸À ò%!v¸¸¸ôyÌˆÏÓ˚Ó˚ hfl¸ˆÏÓ˚Ó˚ õˆÏïƒ !îˆÏÎ˚ ãúˆÏÑ¸ v¸z¸ôÓ˚ ˆÌˆÏÑ¸ ò#ˆÏâ¸ ≤ÃÓy!£ì¸ Ñ¸Ó˚y £Î˚ – ò%!v¸¸Ó˚ õˆÏïƒ !îˆÏÎ˚ ÓyÎ˚%â¸úyâ¸ˆÏúÓ˚ ãòƒ v¸z¸ôÓ˚Á ò#ˆÏâ¸Ó˚ hfl¸ˆÏÓ˚ ì¸y¸ôõyeyÎ˚ ÎˆÏì‹T ö¸yÓ˚yÑ¸ ¢‚!‹T Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ – ö¸úì¸É ò%!v¸¸=!úÓ˚ v¸z¸ôˆÏÓ˚ ˜ãÓ hfl¸Ó˚ Ü‡¸ò £Î˚ Îy xì¸ƒhs¸ áò £ˆÏú ì¸yˆÏÑ¸ ¸ô‚ÌÑ¸ Ñ¸ˆÏÓ˚ ˆòÁÎ˚y £Î˚ – hfl¸Ó˚!›¸Ó˚ õˆÏïƒ ≤ÃÓy!£ì¸ £ÁÎ˚yÓ˚ ¸ôÓ˚ ãú xòƒ ~Ñ¸!›¸ ãúyïyˆÏÓ˚ ¢M¸ÈÎ˚ Ñ¸Ó˚y £Î˚ – ò%!v¸¸=!úÓ˚ v¸z¸ôÓ˚ ¢!M¸Èì¸ ˜ãÓ hfl¸ˆÏÓ˚Ó˚ õˆÏïƒ ÌyÑ¸y äÈeyÑ¸ñ ˜üÓyúñ ¶)¸!õ ≤Ã¶‚¸!ì¸ ≤Ãyí# ãˆÏú v¸z¸ô!fl¸ïì¸ ˜ãÓ î)°ÏíˆÏÑ¸ Öyîƒ !£¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚ ãúˆÏÑ¸ !Ó÷k¸ Ñ¸ˆÏÓ˚ – ¢!e´Î˚ Üyî ¸ôk¸!ì¸ÈÙÙÙÈ ~£z ¸ôk¸!ì¸ˆÏì¸ Óã≈ƒ ãˆÏúÓ˚ õˆÏïƒ ÎˆÏì‹T ¸ô!Ó˚õyˆÏí ã#Óyí%Ñ¸íyÓ˚ v¸z¸ô!fl¸i!ì¸ ÓyÎ˚%Ó˚ Ó%îÓ%ˆÏîÓ˚ ˆfl¸Àyì¸ ≤ÃÓy!£ì¸ Ñ¸Ó˚y £Î˚ – ö¸ˆÏú ã#Óyí%ˆÏîÓ˚

100%	MATCHING BLOCK 124/200	SA	Indrani-Bhattacharya_AsishKumarDas_History_Swa ... (D129738480)

Ó¢ÓyˆÏ¢Ó˚ v¸z¸ôÎ%_´ ¸ô!ÓˆÏü

Ü!‡¸ì¸ £Î˚ – Á£z ¢Ó ã#Óyí% ãˆÏú v¸z¸ô!fl¸ïì¸ ˜ãÓ î)°ÏíˆÏÑ¸ @˘Ã£í Ñ¸ˆÏÓ˚ ˆÓ§ˆÏâ¸ ÌyˆÏÑ¸ – ~£z¶¸yˆÏÓ ˜ãÓ«¸ˆÏÎ˚Ó˚ õyïƒˆÏõ ãˆÏúÓ˚ ˜ãÓî)°ÏÑ¸ ¸ôîyÌ≈ î)Ó˚ Ñ¸ˆÏÓ˚ ~ÓÇ v¸z¸ôãyì¸ ¸ôîyÌ≈Ó˚*ˆÏì¸ô

100%	MATCHING BLOCK 125/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ v¸zÍ¸ôß¨ £Î˚ –

ãyÓ˚íÈÙÙÙÈ ãˆÏú v¸z¸ô!fl¸ïì¸ ˆÓü !Ñ¸ä%È xïyì¸Ó ˆÎÔÜ ˆÎõò òy£zˆÏ›¸∆yˆÏãò Óy ö¸¢ö¸Ó˚y¢ ˆÎÔÜñ ÎyÓ˚ x!ïÑ¸yÇü !Ó°Ïy_´ î%°ÏÑ¸ ¸ôîyÌ≈ ì¸y x!:ˆÏãˆÏòÓ˚ v¸z¸ô!fl¸i!ì¸ˆÏì¸ ãyÓ˚í ¸ôk¸!ì¸ myÓ˚y î)Ó˚ Ñ¸Ó˚y £Î˚ – ≤ÃˆÏÎ˚yãò#Î˚ì¸y xò%¢yˆÏÓ˚ x!:ˆÏãò ¢Ó˚ÓÓ˚yˆÏ£Ó˚ ãòƒ !òÎ˚!s¸fì¸ v¸z¸ôyˆÏÎ˚ ÓyÎ˚% ¢M¸Èyúò Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ – ~£z ¸ôk¸!ì¸ˆÏì¸ !Ó°Ïy_´ î)°ÏÑ¸ ¸ôîyÌ≈ˆÏÑ¸ xoyÓƒ xïÉˆÏ«¸¸ô ¸ô!Ó˚ì¸ Ñ¸ˆÏÓ˚ ¸ô‚ÌÑ¸ Ñ¸Ó˚y £Î˚ xÌÓy ~õò ˆÑ¸yò oyÓƒ ¸ôîyˆÏÎ≈ ¸ô!Ó˚ì¸ Ñ¸Ó˚y £Î˚ – ~äÈyv¸¸y !ü“ˆÏ«¸ˆÏeÓ˚ Óã≈ƒ ãˆÏú òyòy x¡' Óy «¸yÓ˚ ãyì¸#Î˚ ¸ôîyÌ≈ ÌyˆÏÑ¸ – Á£z ïÓ˚ˆÏòÓ˚ Óã≈ƒ ãúõ%_´ ¸ô!Ó˚ˆÏÓ˚ˆÏü v¸zß√%_´ Ñ¸Ó˚yÓ˚ xyˆÏÜ !Ó˚ˆÏü°Ï ¸ôk¸!ì¸ˆÏì¸ ≤ÃÜõò Ñ¸Ó˚y v¸z! â¸ì¸ – 88 ? NSOU ? AE-ES-21

¢yÓ˚í#ÈÙÈ1 ≠ ¸ôyò#Î˚ ã˚ÏúÓ˚ =í õyò !òí≈Î˚ ≠ !òï≈y!Ó˚ì¸ ãyì¸#Î˚ õyey ã˚ÏúÓ˚ ˜Ó!ü‹Tƒ/oÓ#¶)¸ì¸ ¸ôîyÌ≈ ISI Óy ¶¸yÓ˚ì¸#Î˚ ãyì¸#Î˚ õyò xò%¢y˚ÏÓ˚ ¢˚ÏÓ≈yFâ¸ xò%˚Ïõyîò ˆÎyÜƒ î)°Ï˚ÏíÓ˚ ¢#õy S1V « ¸yÓ˚ì¸y SpH õyeyV 5.0 – 9.2 S2V oyÓƒ x!:ˆÏãò SDOV 3.0 ppm S3V ˆÑœ¸yÓ˚y£zv¸ ˆÎÔÜ 1000 !õ!ú@˘Äyõ ≤Ã!ì¸ !ú›¸y˚ÏÓ˚ S4V ¢yúˆÏö¸›¸ ˆÎÔÜ 400 !õ!ú@˘Äyõ ≤Ã!ì¸ !ú›¸y˚ÏÓ˚ S5V ¢yÎ˚yòy£zv¸ ˆÎÔÜ 0.05 !õ!ú@˘Äyõ ≤Ã!ì¸ !ú›¸y˚ÏÓ˚ S6V xy˚Ï¢≈!òÑ¸ ˆÎÔÜ 0.05 !õ!ú@˘Äyõ ≤Ã!ì¸ !ú›¸y˚ÏÓ˚ S7V ˆúv¸ ˆÎÔÜ 0.05 !õ!ú@˘Äyõ ≤Ã!ì¸ ! ú›¸y˚ÏÓ˚ S8V ˆe˙y!õÎ˚yõ ˆÎÔÜ 0.05 !õ!ú@˘Äyõ ≤Ã!ì¸ !ú›¸y˚ÏÓ˚ S9V öœ$¸ÁÓ˚y£zv¸ ˆÎÔÜ 1.50 !õ!ú@˘Äyõ ≤Ã!ì¸ !ú›¸y˚ÏÓ˚ ˆúyÑ¸yú˚ÏÏ˚Ó˚ ¸ôyò#Î˚ ã˚ÏúÓ˚ ≤Äiyò v¸zí¢=!ú ~£z î)°Ïí ¢#õy Ìy˚Ïì¸ x!ì¸e˙õ Ñ¸˚ÏÓ˚ òy ÌyÎ˚ ˆ¢!ˆÏÑ¸ ãò¢yiyÓ˚í Á ≤Äüy¢ò ¢ÓyÓ˚£z ˆÖÎ˚yú Ó˚yÖy v¸z!â¸ì¸ – ≤Ã!ì¸ õy˚Ï¢ xhs¸ì¸ ~Ñ¸ÓyÓ˚ v¸zß√%_´ «%¸o ãúyüÏ˚ ˆÎõò ¸ô%Ñ%¸Ó˚ñ Ñ)¸Î˚yñ òúÑ)¸¸ô £zì¸ƒy!î ˆüyiò Ñ¸Ó˚y˚Ïòy ≤Ã˚ÏÏ˚yãò– ¸ôyò#Î˚ ãúÓy!£ì¸ ˆÓ˚yÜ ≤Ã!ì¸ ˆÏÓ˚y˚ÏÏÓ˚ ¸ôk¸!ì¸ ≠ ¢yiyÓ˚í !ö¸ú›¸yÓ˚ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ ÷ï%õye ¶¸yÓ˚# xoyÓƒ Ólfl¸Ñ¸íy Á Ñ¸!‡¸ò ¸ôîyÌ≈ ãÉyv¸¸y xòƒ ˆÑ¸yò î)°Ïí ¸ô!Ó˚y˚Ïüyiò Ñ¸Ó˚y ¢Ω¸Ó òÎ˚ – x!ì¸ˆÏÓ=ò# Ó˚!Ÿ¬Ó˚ ÓƒÓ£yÓ˚ ~ÓÇ x!:ˆÏãò Ñ¸íyÓ˚ ¸ô!Ó˚â¸ú˚ÏòÓ˚ myÓ˚y ˆüyiò Ñ¸Ó˚y ãú x˚Ï¸ô« ¸yÑ¸‚¸ì¸ ˆÓü# !òÓ˚y¸ôî– ¢Ó˚ ˆÏ˚ÏÑ¸ ¶¸y˚Ïúy £Ïú ¸ôyò#Î˚ ãú ö%¸!›¸ˆÏÏ˚ ÖyÁÎ˚y– S1V ¸ôyò#Î˚ ãú 10-20 !õ!ò›¸ ö%¸!›¸ˆÏÏ˚ ì¸yÓ˚ ¸ôÓ˚ ‡¸y[¸y Ñ¸ˆÏÓ˚ ÖyÁÎ˚y v¸z!â¸ì¸ – ~ãÉyv¸¸y ¸ôyò#Î˚ ãú ¸ô! Ó˚˚Ïüyi˚ÏòÓ˚ ãòƒ !ú›¸yÓ˚ ≤Ã!ì¸ 1›¸y Ñ¸˚ÏÓ˚ £ƒy˚Ïúy˚Ïãò ›¸ƒyÓ˚ú›¸ !î˚ÏÏ˚ xyiá^˘›¸y ¸ôÓ˚ ˆ¢£z ãú ¸ôyò Ñ¸Ó˚y ÌyÎ˚ – ãú Ó˚yÖyÓ˚ ~ÓÇ ÖyÓyÓ˚ Óy¢ò¸ôe ã#Óyí%õ%_´ ~ÓÇ ¸ô!Ó˚ FãÈß¨ Ó˚yÖy ≤Ã˚ÏÏ˚yãò– ¢§ƒyì¸ˆÏ¢˚Ïì¸ Óy ˆòyÇÓ˚y ãyÎ˚ÜyÎ˚ ÖyÓyÓ˚ ãú ˆÖyúy Ó˚yÖy v¸z!â¸ì¸ òÎ˚ – S2V ¸ôyì¸Ñ%¸˚ÏÏ˚y ¸ô!Ó˚ˆüyiˆÏòÓ˚ ãòƒ 300ÈÙÈ500 @˘Äyõ !Óœ!â¸Ç ¸ôyv¸zv¸yÓ˚ ˆë¸˚Ïú ì¸yÓ˚ Ñ¸õ¸ô˚Ï«¸ 12 á^˘›¸y ¸ôÓ˚ ˆ¢£z ¸ôyì¸Ñ%¸˚ÏÏ˚y ˆÌˆÏÑ¸ v¸z¸ô˚ÏÓ˚Ó˚ ˆÓü !Ñ¸ä%È›¸y ãú ≤ÃÌˆÏö ¸ö¸˚Ïú !îˆÏÏ˚ Óy!Ñ¸ ãú ≤Ã˚ÏÏ˚yãòõì¸ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ÌyˆÏÓ– S3V Ü¶¸#Ó˚ òúÑ)¸¸ô Óy !›¸v¸zÓÁ˚ÏÏ˚ ˆÏúÓ˚ ˆ«¸˚Ïe ì¸yÓ˚ ¢y˚ÏÏ˚Î%_´ ¸ôyi¸ô ˆõ!üò!›¸ ≤ÃÌˆÏö Ö%ˆÏú !ò˚ÏÏ˚ ò˚ÏúÓ˚ õ˚Ïíƒ 3ÈÙÈ4 â¸yõâ¸ !Óœ!â¸Ç ¸ôyv¸zv¸yÓ˚ ˆë¸˚Ïú Îs¸f!›¸ xyÓyÓ˚ xy˚ÏÜÓ˚ õ˚Ïì¸y úy!Ü˚ÏÏ˚ !î˚Ïì¸ £ˆÏÓ– ~˚Ï«¸ ˆÏeÁ Ñ¸õ¸ô˚Ï«¸ Óy˚ÏÓ˚y á^˘›¸y ¸ôÓ˚ ≤ÃÌˆÏö v¸z¸ô!Ó˚ì¸˚Ïú ˆÓü !Ñ¸ä%È›¸y ãú ˆÓÓ˚ Ñ¸˚ÏÓ˚ ˆö¸˚Ïú !î˚ÏÏ˚ ì¸yÓ˚ ¸ôÓ˚ Óy!Ñ¸ ãú ÓƒÓ£yÓ˚ Ñ¸Ó˚y Ìy˚ÏÓ– NSOU ? AE-ES-21 ? 89
5.4 ¶)¸!õî)°Ïí (Land Pollution) ¶)¸ÈÙÈ¸ô¸˚Ï¤¸Ó˚ !ì¸ˆÏòÓ˚ ÈÙÈ~Ñ¸ ¶¸y˚ÏÜÓ˚ Á Ñ¸õ S≤ÃyÎ˚ 20%V xÇü !ò˚ÏÏ˚ fl¸iú¶¸yÜ Ü!‡¸ì¸ – ~£z fl¸iú¶¸y˚ÏÜÓ˚ v¸z¸ô˚ÏÓ˚£z õyò%°Ï Á xòƒyòƒ fl¸iúÓy¢# ã#˚ÏÓÓ˚ Óy¢fl¸iyò– ¶)¸!õÓ˚ =íÜì¸ õy˚ÏòÓ˚ Á¸ôÓ˚ ~˚ÏíÓ˚ ˆÓß˚Ïâ¸ ÌyÑ¸y ! ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚ – õyò%˚Ï°ÏÓ˚ ˆÓ!üÓ˚ ¶¸yÜ Ñ¸yãÑ¸õ≈ñ ˆÎõòÈÙÙÈ Ñ¸!°Ïñ Öòòñ !ü‰ ≤Ã¶¸!ì¸ ¶)¸!õ ˆÑ¸!wÑ¸ñ ¢¶¸fi¸yÓ˚ x@˘ÄÜ! ì¸ ~ÓÇ ≤ÃÎ%!_´ v¸zqyÓ˚ˆÏòÓ˚ õyiƒˆÏ¢ õyò%°Ï ¶)¸!õÓ˚ Á¸ôÓ˚ xyáyì¸ ˆ£ˆÏòˆÏäÈ– õyò%˚Ï°ÏÓ˚ ≤Ã˚ÏÏ˚yã˚Ïò x˚ÏòÑ¸ ÓòyM¸Èú ïπÇ¢ £˚ÏÏ˚ ˆÏäÈó x˚ÏòÑ¸ ã#Ó ≤Ãäy!ì¸ !Óú%Æ £˚ÏÏ˚ ˆÏäÈó ~ÓÇ ¶)¸ÈÙÈ¢¡ô˚ÏíÓ˚ Î˚ÏÏ‹T xÓòõò Óy «¸!ì¸ á˚Ïì¸ˆÏäÈ– ¸ô¸!ÌÓ#ˆÏì¸ ã#Ó˚ˆÏòÓ˚ x!hfl¸c Ó˚«¸yÓ˚ ˆ«¸ˆÏe xyã˚ÏÑ¸Ó˚ !ˆÏò ¶)¸!õÓ˚ xÓòõò Óy ¶)¸!õ î)°Ïí ~Ñ¸!›¸ =Ó˚&c¸ô)í≈ î%¶≈≈¸yÓòyÓ˚ !Ó°Ï˚Ï – Î!îÁ ¸ô¸!ÌÓ#ˆÏì¸ ¢yõ!@˘ÄÑ¸ ¶¸y˚ÏÓ Ñ¸!°ÏÎ˚ì¸ ãìõˆÏòÓ˚ õyò ì!«¸í ~!üÎ˚yÎ˚ ~Ó˚ ü¸Ñ¸Ó˚y ¸ô!Ó˚õyí (45%) ¸ô¸!ÌÓ#Ó˚ õ˚Ïìƒ ¢˚ÏÓ≈yFâ¸ – Î%_´Ó˚y‹T... (25%)

100% **MATCHING BLOCK 126/200** SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ñ xy˚Ïõ!Ó˚Ñ¸y Î%_´Ó˚y‹T... (21%)

ñ ãyõ≈yò# (35%)ñ ö ¸y™ (35%) ~ÓÇ xòƒyòƒ v¸zß¨ì¸ ˆïü=!úˆÏì¸ ~£z £yÓ˚ õyG¸y!Ó˚ – xyÓyÓ˚ ¢y£yÓ˚yÓì¸≈# (Sub-Saharan) xy!ö ¸Ñ¸y (7%) Á x˚Ïfl¸‹T…!úÎ˚yÓ˚ (6%) ˆõy›¸ ã!õÓ˚ Ö%Ó ¢yõyòƒ xÇü£z Ñ¸!°Ïã!õ– ¢yÓ˚ˆÏ!íÈÙÈ2 ≠ ¶)¸ÈÙÈ¸ô¸˚Ï¤¸ ã!õ ÓÚ^˘›¸ˆÏòÓ˚ ≤ÃÃÑ¸!ì¸ S!Ó!úÎ˚ò ˆ£QÓ˚ ~Ñ¸ˆÏÑ¸ñ 1 !Ó!úÎ˚ò 1=100 ˆÑ¸y!›¸V ¶)¸ÈÙÈ¸ô¸˚Ï¤¸Ó˚ Ñ¸!°ÏˆÏÎyÜƒ ã!õ fl¸iyÎ˚# ì¸¸í¶)¸!õ Á ÓòyM¸Èú xòƒyòƒ ã!õ S!ò‹≥¸úy Á ˆõy›¸ ã!õ ¸ô÷â¸yÓ˚í ¶)¸!õ Ó¸« ¶)¸!õ xÑ¸!°Ï ˆÎyÜƒ ã!õV 13.00 1.44 3.66 3.89 4.31 (100%) (11%) (26%) (30%) (33%) ~Ñ¸Ìy ¢£˚Ïã£z ˆÓyG¸y ˆÎ ¸ô¸!ÌÓ#Ó˚ ˆõy›¸ ã!õÓ˚ ¸ô!Ó˚õyí !fl¸iÓ˚ ~ÓÇ xö%¸Ó˚ hs¸ òÎ˚ – ¶)¸!õ ≤ÃÑ¸!ì¸Ó˚ £z xDó ~Ó˚ Î˚ÏÏFäÈ x¸ôÓƒÓ£yÓ˚ Ó˚ ö¸˚Ïú ¶)¸!õ «¸Î˚ Á î)°Ïí ¢Çá!›¸ì¸ £˚ÏFäÈ– ¶)¸!õ˚Ïì¸ Óyîƒ v¸zí¸ôy!îì¸ £Î˚ ñ Ü˚Ïv¸¸ Á˚Ï‡¸ xy◊Î˚ fl¸iúÈÙÙÈ ~õò!Ñ¸ ˆ¶¸yÜƒ ¸ô˚ÏíƒÓ˚ ˆÎyÜyòyÓ˚ ãòƒÁ õyò%°Ï ¶)¸!õÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚ – õyò%°Ï ¶)¸!õ˚ÏÑ¸ ≤ÃyÑ¸¸!ì¸Ñ¸ ¢¡ô˚ô x˚Ï¸ô« ¸y ˆ¶¸yÜƒÓlfl¸Ó˚ ˆÎyÜyòyÓ˚ !£¢y˚ÏÓ ˆÓ!ü ˆ¶¸˚Ïã˚ÏÈ– ì¸y£z ≤ÃyÑ¸¸!ì¸Ñ¸ Ó¸ƒÓfl¸iy=!ú (natural systems) õyò%˚Ï°ÏÓ˚ ˆúy¶¸ ã!òì¸ xì¸ƒy!òÑ¸ ÓƒÓ£y˚ÏÓ˚ ö¸˚Ïú õyÓ˚ydÑ¸ «¸!ì¸@˘Ähfl¸ £˚ÏFäÈ– ¶)¸!õ˚ÏÑ¸ ˆÑ¸yò Ó˚ ¢yÎ˚ òyÜy˚ÏÓ˚ Ñ¸!eõ v¸z¸ôy˚ÏÏ˚ ˆì¸!Ó˚ Ñ¸Ó˚y ¢Ω¸Ó òÎ˚ – ì¸y£z ¶)¸!õ« ¸Î˚ Á ¶)¸!õ î)°Ïí £˚Ïì¸ Ó˚«¸y ¸ôyÁÎ˚yÓ˚ ~Ñ¸õye v¸z¸ôyÎ˚ £ú ¶)¸!õ ¢ÇÓ˚«¸í Á ¶)¸!õÓ˚ ÖîÓ˚ ˆÓ˚Ïì¸ £˚Ïì¸ òy ˆîÁÎ˚y–
5.4.1 õ¸!_Ñ¸y (Soil) ¶)¸ì¸˚ÏúÓ˚ ¸ôyì¸úy xyÓÓ˚í õ¸!_Ñ¸y Sxy˚Ïì¸˚ÏúÓ˚ ˆÓy¢yÓ˚ õì¸ ¸ôyì¸úy õye 30-40 !õ›¸yÓ˚ ¸ô%ÓÓ˚&V ã#ÓãÜˆÏì¸Ó˚ Ñ¸y˚ÏÈ xì¸ƒhs¸ =Ó˚&c¸ô)í≈– õ¸!_Ñ¸y ãú ï˚ÏÓ˚ Ó˚yÓ˚ì¸ ¸ôy˚ÏÓ˚ ~ÓÇ v¸z!qî Á x¢ÇÖƒ xò%ã#˚ÏÓÓ˚ (microorganisms) Ó¸!k¸˚Ïì¸ ¢£yÎ˚ì¸y Ñ¸˚ÏÓ˚ – ˆÓ!üÓ˚¶¸yÜ v¸z!qî ì¸y˚ÏÓ˚ ˆÓ§˚Ïâ¸ ÌyÑ¸yÓ˚ ãòƒ õy!›¸ ˆÏ˚ÏÑ¸ ¸ô%!‹T ¸ôîyÌ≈ ¢ÇÆ@˘Ä£ Ñ¸˚ÏÓ˚ – Ñ¸yˆÏ£z ¸ô!Ó˚ˆÏÓüì¸ ¶¸y˚ÏÓ õ¸!_Ñ¸yÓ˚ Î˚Ï‹T =Ó˚&c Ó˚˚ÏÏ˚ˆÏãÈ– !üúyÓ˚ xyÓÓ!Ó˚ˆÏÓ˚Ó˚ Ñ¸yˆÏ˚ÏÓ˚ ˆ (Climatic erosion) ö¸˚Ïú v¸zí¸ôß¨ ˆÓ˚ ˆÏÜy!ú È(regolith)ÙÈ~Ó˚ Á¸ôÓ˚ ãúÓyÎ˚%ñ v¸z!qîñ ¶)¸ÈÙÈ¢Çfl¸iyò £zì¸ƒy!îÓ˚ xhs¸!e´Î˚yÓ˚ ãòƒ õ¸!_Ñ¸yÓ˚ v¸zqÓ á˚Ï›¸ – õ¸!_Ñ¸yÓ˚ !ì¸ò!› fl¸Îì¸s¸f xò%¶)¸!õÑ¸ (horizontal) ì¸ú ˆîÓy ÌyÎ˚ Îye´˚Ïõ 90 ? NSOU ? AE-ES-21
A, B Á C xò%¶)¸!õÑ¸ ì¸ú– ~˚ÏíÓ˚ õ˚Ïìƒ ¢Ó˚˚Ïâ¸ ˚ÏÏ˚ Á¸

78% **MATCHING BLOCK 127/200** SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ô˚ÏÓ˚Ó˚ A hfl¸Ó˚ ˆÌˆÏÑ¸ ˆïÓì¸ÈÙÈ≤Ã!e´Î˚yÎ˚ (

leaching) ¸ôîy˚ÏÌ≈Ó˚ x¸ô¢yÓ˚í õïƒÓ!≈¸# B hfl¸˚ÏÓ˚ A hfl¸Ó˚ ˆÌˆÏÑ¸ â%§¸£z˚ÏÏ˚ xy¢y ¸ôîy˚ÏÌ≈Ó˚ ¢M¸ÈÎ˚ ~ÓÇ ¢Ó˚ì¸˚ÏÏ˚ !ò˚Ïì¸Ó˚ C hfl¸Ó˚!›¸˚Ïì¸ xy!î !úúy (parent rock) ˆîÓy ÌyÎ˚ – õ¸!_Ñ¸yÓ˚ ˜Ó!ü‹Tƒ=!úñ ˆÎõò v¸zÓ≈Ó˚ì¸y õyòñ !Ó˚ü°ÏíÓ˚ ˆÏòÓ˚ ãúÓyÎ˚%Üì¸ Á fl¸∫y¶¸y!ÓÑ¸ v¸z!qî ¢¡ô!Ñ≈ì¸ ¸

66% **MATCHING BLOCK 128/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ô!Ó˚ˆÏÓˆÏü ˆïÔì¸ÈÙ≤Ã!e´Î˚yÎ˚ x¸ô¢y!Ó˚ì¸ ~

ÓÇ ¢!M¸Èì¸ ¸

84% **MATCHING BLOCK 129/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ôîyˆÏì≈Ó˚ ¸ô!Ó˚õyˆÏíÓ˚ Á¸ôÓ˚ !ò¶≈¸Ó˚ü#ú– ¢

Ñ¸ú Ñ,¸!°ÏÑ¸yˆÏãÓ˚ ãòƒ õ,!_Ñ¸yÓ˚ v¸zÓ≈Ó˚ì¸yõyò !ÓˆÏü°Ï ¶)¸!õÑ¸y ¸ôyúò Ñ¸ˆÏÓ˚– !Ñ¸ls¸ xì¸ƒy!ïÑ¸ ÓƒÓ£yÓ˚ Á x! ÓˆÏÓâ¸òy≤Ã¢)ì¸ Ñ,¸!°Ï¸ôk¸!ì¸ xÓú¡∫ˆÏòÓ˚ ãòƒ õ,!_Ñ¸yÓ˚ õyˆÏòÓ˚ xÓòõò áˆÏ›¸– ≤Ã!ì¸ÓäÈÓ˚ üì¸ üì¸ ˆÑ¸y!›¸ ›¸ò v¸z¸ô!Ó˚ õ,!_Ñ¸y (top soil) x¸ô¢yÓ˚ˆÏíÓ˚ ö¸ˆÏú ¶)¸!õÓ˚ ïyÓ˚í «¸õì¸y Ñ¸ˆÏõ îyˆÏFäÈñ îy Ñ,¸!°ÏÑ¸yˆÏãÓ˚ ¸ôˆÏ«¸ î%!ÿ¸hs¸yÓ˚ !Ó°ÏÎ˚– 5.4.2 õ,!_Ñ¸yÓ˚ xÓòõˆÏòÓ˚ Ñ¸yÓ˚í Á ì¸yÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ (Cause of Soil degradation and its prevention) õ,!_Ñ¸yÓ˚ xÓòõò Óy ¶)¸!õ î)°ÏˆÏíÓ˚ !ì¸ò!›¸ ≤Ãïyò Ñ¸yÓ˚í £úÈÙÙÈ (i) ¶)¸!õ«¸Î˚ñ (ii) ã!õˆÏì¸ Î˚ˆÏìFäÈ

100% **MATCHING BLOCK 130/200** **W**

Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ ~

ÓÇ (iii) ¶)¸!õˆÏì¸ úÓíydÑ¸ ãˆÏúÓ˚ x!ïÑ¸ƒ– v¸z¸ôˆÏÓ˚y_´ !ì¸ò!›¸ ≤Ãïyò Ñ¸yÓ˚í äÈyv¸¸yÁ ¶)¸!õ î)°ÏˆÏíÓ˚ xyÓ˚ ~Ñ¸!›¸ xòƒì¸õ Ñ¸yÓ˚í £ú Óã≈ƒ ¸ôîyˆÏì≈Ó˚ x!ïÑ¸ƒ– (i) ¶)¸!õ«¸Î˚ (Soil erosion) ≠ ¶)¸!õÓ˚ v¸z¸ô!Ó˚¶¸yˆÏÜÓ˚ õ,!_Ñ¸yÓ˚ ~Ñ¸ fl¸iyò ˆÌˆÏÑ¸ x¸ôÓ˚ fl¸iyˆÏò ¸ô!Ó˚Óy!£ì¸ (transportation) £ÁÎ˚yÓ˚ á›¸òyˆÏÑ¸ ¶)¸!õ«¸Î˚ Óúy £Î˚– Î!îÁ £z£y ~Ñ¸!›¸ ÓyÎ˚% Á ãú ≤ÃÓy£ã!òì¸ ≤ÃyÑ,¸!ì¸Ñ¸ á›¸òyñ ! Ñ¸ls¸ £z£y x!ì¸õyeyÎ˚ cÓ˚y!ß∫ì¸ £Î˚ õyòÓ ¢õyˆÏãÓ˚ !Ó!¶¸ß¨ Ñ¸yÎ≈yÓú#Ó˚ ãòƒ– ˆÎõòÈÙÙÈ â¸y°Ï xyÓyîñ !òõ≈yí Ñ¸yÎ≈ñ xÓ˚íƒˆÏFäÈîòñ xÓyï ÜÓy!ï ¸ô÷â¸yÓ˚í ~ÓÇ ã!õÓ˚ v¸z¸ô!Ó˚¶¸yˆÏÜÓ˚ ì¸¸íÓ˚y!ã ˆ¸ôyv¸¸yˆÏòy (burning of grass cover)– ¶)¸! õ«¸ˆÏÎ˚Ó˚ ö¸ˆÏú õ,!_Ñ¸yÓ˚ v¸zÓ≈Ó˚ì¸y Á ãúïyÓ˚í «¸õì¸y Ñ¸ˆÏõ îyÎ˚– õ,!_Ñ¸yÓ˚ v¸z¸ô!Ó˚¶¸yˆÏÜÓ˚ «¸Î˚ ãúy¶)¸!õˆÏÑ¸ ¶¸Ó˚y›¸ Ñ¸ˆÏÓ˚ ~äÈyv¸¸yÁ ãúˆÏÑ¸ ˆáyúyˆÏ›¸ Ñ¸ˆÏÓ˚ î)!°Ïì¸ Ñ¸ˆÏÓ˚ñ ö¸ˆÏú ãúã ã#ÓÑ%¸ˆÏúÓ˚ ã#Óò !Ó¸ôß¨ £Î˚– ≤ÃyÑ,¸!ì¸Ñ¸ ¶¸yˆÏÓ 1 £z!M¸È S2.5 ˆ¢.!õ.V õ,!_Ñ¸y ˜ì¸!Ó˚ £ˆÏì¸ ¢yïyÓ˚í¶¸yˆÏÓ 200-1000 ÓäÈÓ˚ ¢õÎ˚ úyˆÏÜ– !Ñ¸ls¸ ¶)¸!õ«¸Î˚ Î!î ¶)¸!õ Ü‡¸ò xˆÏ¸ô«¸y o&ì¸ì¸Ó˚ £ˆÏì¸ ìyˆÏÑ¸ ì¸y£ˆÏú £z£y ~Ñ¸!›¸ ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ôˆÏîÓ˚ x¸ô)Ó˚í#Î˚ «¸!ì¸ !£¢yˆÏÓ ¸ô!Ó˚Ü!íì¸ £ˆÏÓ– îy ¢%î)Ó˚ ¶¸!Ó°Ïƒˆ Ïì¸ õyòÓ ¢õyˆÏãÓ˚ Ñ¸yˆÏäÈ ~Ñ¸ !Ó¸ôîÓyì≈¸y Ó£ò Ñ¸Ó˚ˆÏÓ– ~£z ¶)¸!õ«¸Î˚ ˆÓ˚yˆÏïÓ˚ xòƒì¸õ ≤Ãïyò v¸z¸ôyÎ˚ £úÈÙÈ!ÓK¸yò ¢¡øì¸ ¶¸yˆÏÓ ¶)¸!õÓ˚ ¢ÇÓ˚«¸í ~ÓÇ ÓƒÓ£yÓ˚– ¶)¸!õ ¢ÇÓ˚«¸í ¢yïyÓ˚íì¸ ≤Ãïyò î%!›¸ ≤Ã!e´Î˚yÎ˚ Ñ¸Ó˚y £ˆÏÎ˚ ìyˆÏÑ¸– (a) ~úyÑ¸y !¶¸!_Ñ¸ ¶)¸!õ ¢%Ó˚«¸y (Area treatment which involves treating the land) (b) ≤Ãíyú# Ü‡¸ˆÏòÓ˚ õyïƒˆÏõ ¶)¸!õ ¢%Ó˚«¸y (Drainage-line treatment, which involves treating the natural water courses) NSOU ? AE-ES-21 ? 91

(a) ~úyÑ¸y!¶¸!_Ñ¸ ¶)¸!õ ¢%Ó˚«¸y (Area treatment, which involves treating the land) v¸zˆÏìüƒ ≤Ã!e´Î˚y ö¸úyö¸ú (Purpose) (Treatment measure) (Effect) (1) Ó,!‹T¸ôyì¸ã!òì¸ «¸Î˚ ˆÓ˚yï– xòyÓy!î ã!õˆÏì¸ Ó,«¸ˆÏÓ˚y¸ôí õ,!_Ñ¸yÓ˚ x¸ô¢yÓ˚í £…y¢ (2) õy!›¸Ó˚ ãúïyÓ˚í «¸õì¸y Ó,!k¸– ãúïyÓ˚í «¸õì¸y Ó,!k¸Ó˚ !Ó!¶¸ß¨ ≤Ã!e´Î˚y ¶)¸!õÓ˚ xyo≈ì¸y Ó,!k¸– ˆÎõò Öyú Á òyúy ˜ì¸!Ó˚ ~ÓÇ Ó§yï ˆîÁÎ˚y– (3) õ,!_Ñ¸yÓ˚ ò)ƒòì¸õ x¸ô¢yÓ˚í– ¸ô%Ñ%¸Ó˚ñ Ó§yï £zì¸ƒy!î !òõ≈yí Ñ¸ˆÏÓ˚ Ó,!‹T¸ôyˆÏì¸Ó˚ õ,!_Ñ¸yÓ˚ xyo≈ì¸y Ó,!k¸ ~ÓÇ ¶)¸Üˆ Ï¶≈¸ x!ì¸!Ó˚_´ ãú ¢M¸ÈÎ˚ Ñ¸Ó˚y– ˜Ñ¸!üÑ¸ ãˆÏúÓ˚ Ó,!k¸– (4) ¶)¸!õˆÏì¸ ïyˆÏ¸ô ïyˆÏ¸ô Ó,!‹T¸ôyì¸ Óy ãú ≤ÃÓyˆÏ£Ó˚ ö¸ˆÏú ¶)¸! õÓ˚ v¸z¸ô!

87% **MATCHING BLOCK 131/200** **SA** Geography-CC-1.1.pdf (D142516024)

Ó˚ ~›¸y Ö%Ó =Ó˚&c¸ô)í≈ñ Ñ¸yÓ˚í ~

Ó˚ ö¸ˆÏú v¸z¸ôì¸ƒÑ¸yÓ˚ ¢,!‹T– hfl¸ˆÏÓ˚Ó˚ õy!›¸ îyˆÏì¸ ¢Ó˚y¢!Ó˚ Óy!£ì¸ òy £ˆÏÎ˚ ¶)¸!õÓ˚ ï¢ ˆÓ˚yï Ñ¸Ó˚y îyÎ˚ ~ÓÇ ¶)¸!õÓ˚ ïyˆÏ¸ôñ ïyˆÏ¸ô Óy!£ì¸ £Î˚– ïyÓ˚í «¸õì¸y Ó,!k¸ ¸ôyÎ˚– (b) ≤Ãíyú# Ü‡¸ˆÏòÓ˚ õyïƒˆÏõ ¶)¸!õ ¢%Ó˚«¸y (Drainage-line treatment) v¸zˆÏìüƒ ≤Ã!e´Î˚y ö¸úyö¸ú (Purpose) (Treatment measure) (Effect) (1) ¶)¸!õÓ˚ ï¢ Á ¸ô!úõy!›¸Ó˚ v¸zÍ¸ô!_ fl¸iˆÏú£z ï¢ ˆÓ˚yï Ñ¸Ó˚y– ¶)¸!õ«¸Î˚ ˆÓ˚yï Ñ¸ˆÏÓ˚ ~ÓÇ ¶)¸Ü¶≈¸fl¸i x¸ô¢yÓ˚í ˆÓ˚yï– ãˆÏúÓ˚ ¸ô!Ó˚õyí Ó,!k¸ Ñ¸ˆÏÓ˚– (2) ãú ≤ÃÓyˆÏ£Ó˚ Ü!ì¸£…y¢ Á v¸z¸ô! Ó˚È¶¸yˆÏÜÓ˚ òyúy=!úˆÏì¸ ˆäÈy›¸ ˆäÈy›¸ Ó§yï ˜ì¸!Ó˚– ãú≤ÃÓyˆÏ£Ó˚ Ü!ì¸ £…y¢ ~ÓÇ ¶)¸Ü¶≈¸fl¸i fl¸∫FäÈ ãˆÏúÓ˚ xˆÏïyÜõí Ñ¸Ó˚yˆÏòy– ãˆÏúÓ˚ ¸ô!Ó˚õyí Ó,!k¸– (ii) ã!õˆÏì¸ Î˚ˆÏìFäÈ

100% **MATCHING BLOCK 132/200** **W**

Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ (

Excess use of fertilizers and pesticides) ≠ ¸ô,!ÌÓ#ˆÏì¸ ≤ÃyÎ˚ 25% ü¢ƒ v¸zÍ¸ôyîˆÏò Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ ÓƒÓ£*ì¸– Üì¸ Ñ¸ˆÏÎ˚Ñ¸ îüÑ¸ ïˆÏÓ˚ Ó˚y¢yÎ˚!òÑ¸ ¢yˆÏÓ˚Ó˚ ÓƒÓ£yÓ˚ v¸z_ˆÏÓ˚y_Ó˚ ˆÓ˚ˆÏv¸¸£z â¸ˆÏúˆÏäÈ– õy!›¸Ó˚ v¸zÓ≈Ó˚ì¸y ü!_´ Ó,!k¸ˆÏì¸ ~ÓÇ üˆÏ¢ƒÓ˚ v¸zÍ¸ôyîò Ó,!k¸Ó˚ ãòƒ Ó˚y¢yÎ˚!òÑ¸ ¢yˆÏÓ˚Ó˚ ÓƒÓ£yÓ˚ xòfl¸∫#Ñ¸yÎ≈– Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ ˆÌˆÏÑ¸ ≤ÃyÆ !ì¸ò!›¸ ≤Ãïyò v¸z¸ôyîò ¸ô›¸y!üÎ˚õñ ö¸¢ö¸Ó˚y¢ ~ÓÇ

58% **MATCHING BLOCK 134/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

òy£zˆÏ›¸∆y˜Ïãò ˆÎÔÜ õy!›¸Ó˚ ¸ô%!‹T Ó‚!k¸ ˆÏì¸ ¢y£yÎƒ Ñ¸ˆÏÓ˚ – !

Ñ¸ls¸ Ó˚y¢yÎ˚!òÑ¸ ¢y˜ÏÓ˚Ó˚ x!ïÑ¸ õyeyÎ˚ ÓƒÓ£y˜ÏÓ˚Ó˚ ö¸ˆÏú Ñ‚¸!°Ïã!õÓ˚ !òãfl¸∫v¸zÓ≈Ó˚ «¸õì¸y !î˜Ïò !î˜Ïò £...y¢ ¸ôy˜ÏFäÈ Îy ¶)¸! õ î)°Ï˜ÏíÓ˚ Ñ¸yÓ˚í– ~äÈyv¸¸y ¢Ó˜Ïâ¸˜ÏÎ˚ Óv¸¸ ¢õ¢ƒy £ú Ó˚y¢yÎ˚!òÑ¸ ¢y˜ÏÓ˚Ó˚ ¢y˜Ïì x!ïÑ¸ õyeyÎ˚ Ñ¸#›¸òyü˜ÏÑ¸Ó˚ ÓƒÓ£yÓ˚ – Ñ¸#›¸òyüÑ¸ ÓƒÓ£y˜ÏÓ˚Ó˚ ¢õ¢ƒy (Problems with pesticide use) ≠ ˆÎ ¢õhfl¸ Ó˚y¢yÎ˚!òÑ¸ ¸ôîyÌ≈ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ xÓy!N¸ì¸ äÈeyÑ¸ñ Ñ¸#›¸¸ôì¸D Á xyÜyäÈy ïπÇ¢ Ñ¸Ó˚y £Î˚ ì¸y˜ÏÑ¸ ¸Ñ¸#›¸òyüÑ¸ Ó˜Ïú– Ñ¸#›¸òyüÑ¸ˆ

100% **MATCHING BLOCK 135/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÏÑ¸ !Ó!¶¸ß¨ ¶¸y˜ÏÜ ¶¸yÜ Ñ¸Ó˚y £Î˚

ñ ˆÎõòÈÙÙÙÈ ¸ôì¸DòyüÑ¸ (insecticides)ñ äÈeyÑ¸ òyüÑ¸ (fungicides)ñ £z§î%Ó˚ òyüÑ¸ (rodenticides) ~ÓÇ xyÜyäÈy òyüÑ¸ (herbicides)– Ñ¸#›¸òyüÑ¸ ÷ï% xÓy!N¸ì¸ Ñ¸#›¸¸ôì¸˜ÏDÓ˚ «¸!ì¸ Ñ¸ˆÏÓ˚ òyñ Ó‚£_Ó˚ ã#Ó ¢õyã SõyòÓ ¢õyãV ~ÓÇ ã#Ó â¸˜Ïe´Ó˚Á «¸!ì¸ Ñ¸ˆÏÓ˚ – 92 ? NSOU ? AE-ES-21
fl¸iyÎ˚#˜ÏcÓ˚ !îÑ¸ !î˜ÏÎ˚ Ñ¸#›¸òyüÑ¸ î%£z ≤ÃÑ¸yÓ˚ÈÙÙÙÈ «¸ífl¸iyÎ˚# ~ÓÇ î#á≈fl¸iyÎ˚#– «¸ífl¸iyÎ˚# ¸Ñ¸#›¸òyü˜ÏÑ¸Ó˚ Ñ¸yÎ≈«¸õì¸y ¢yõ!Î˚Ñ¸ ~ÓÇ ~Ó˚ «¸õì¸yÁ fl¸∫“– ö¸ˆÏú £z£y ì¸yí«¸!íÑ¸ xÓy!N¸ì¸ Ñ¸#›¸¸ôì¸D òy˜Ïü ¢£yÎ˚ì¸y Ñ¸ˆÏÓ˚ !Ñ¸ls¸ î#á≈fl¸iyÎ˚# ˆÑ¸y˜Ïòy ≤Ã¶¸yÓ ˆö¸ˆÏú òyñ ö¸ˆÏú ¶)¸!õ î)°Ï˜Ïí ~Ó˚ ¶)¸!õÑ¸y fl¸∫“– î#á≈fl¸iyÎ˚# Ñ¸#›¸òyüÑ¸ ˆÎõò DDTñ ¢£˜Ïã ò‹T £Î˚ òy– £z£y ÓƒÓ£y˜ÏÓ˚Ó˚ ö¸ˆÏú ã!õ˜Ïì¸ ~ÓÇ ã#Ó˜Ïî˜Ï£ î#á≈!îò ¢!M¸Èì¸ £˜ÏÎ˚ Ìy˜ÏÑ¸ – DDT õ)úì¸ õüy òyüÑ¸ñ £z£y ÓƒÓ£y˜ÏÓ˚Ó˚ ≤Ãìõ îü˜ÏÑ¸ S1942-1952V õüÓy!£ì¸ ˆÓ˚y˜ÏÜÓ˚ ≤Ã˜ÏÑ¸y¸ô ˆÌ˜ÏÑ¸ ≤ÃyÎ˚ 50 ú«¸ ã#Óò Ó§y!â¸˜ÏÎ˚˜ÏäÈ– !Ñ¸ls¸ !Ñ¸ä%È ¢õÎ˚ ÓƒÓ£y˜ÏÓ˚Ó˚ ö¸ˆÏú õüy Á xòƒyòƒ Ñ¸#›¸¸ôì¸˜ÏDÓ˚ üÓ˚#˜ÏÓ˚ ÈDDTÙÈ~Ó˚ !ÓÓ˚&˜Ïk¸ ≤Ã!ì¸˜ÏÓ˚yï «¸õì¸y Ü˜Ïv¸¸ Á˜Ï‡¸ (immuned)– ö¸ˆÏú £z£y Ñ¸#›¸òyüÑ¸ Ó˚*˜Ï¸ô Ñ¸yÎ≈Ñ¸Ó˚ £Î˚ òy !Ñ¸ls¸ ~Ó˚ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ ¶)¸!õ xÌ≈yÍ ¸ô!Ó˚˜ÏÓ˜Ïü ~ÓÇ õyòÓ˜Ïî˜Ï£ ˆîÖy ÎyÎ˚ – Ñ¸#›¸¸ôì¸D òy˜Ïü ÓƒÓ£*ì¸ ~£z î#á≈fl¸iyÎ˚# ¸Ñ¸#›¸òyüÑ¸=!ú ¶)¸!õÓ˚ õ˜Ïïƒ ˆÌ˜ÏÑ¸ ÎyÎ˚ ~ÓÇ õ‚!_Ñ¸y Ñ¸íyÓ˚ ¢˜ÏD !õ˜Ïü ~Ñ¸ fl¸iyò ˆÌ˜ÏÑ¸ xòƒ fl¸iy˜Ïò Óy!£ì¸ £Î˚ – ÎyÓ˚ ö¸ˆÏú !Óhfl+¸ì¸ ~úyÑ¸yÓ˚ õy!›¸ î)!°Ïì¸ £Î˚ – Ñ¸#›¸òyüÑ¸ ÓƒÓ£y˜ÏÓ˚Ó˚ xyÓ˚ ~Ñ¸!›¸ «¸!ì¸Ñ¸Ó˚ !îÑ¸ £ú xÓy!N¸ì¸ Ñ¸#›¸¸ôì¸D òy˜ÏüÓ˚ ¢y˜Ïì ¢y˜Ïì x˜ÏòÑ¸ v¸z¸ôÑ¸yÓ˚# ¸Ñ¸#›¸¸ôì¸D ïπÇ¢ Ñ¸ˆÏÓ˚ – Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚Ñ¸yÓ˚# ~ÓÇ Ñ¸#›¸òyüÑ¸ ÓƒÓ£*ì¸ ü¢ƒ @˘Ã£íÑ¸yÓ˚# v¸z¶¸˜ÏÎ˚Ó˚ Ñ¸#›¸òyü˜ÏÑ¸Ó˚ ≤Ã¶¸y˜ÏÓ fl¸∫yfl¸iƒ£y!ò á˜Ï›¸ – î#á≈!îò ï˜ÏÓ˚ fl¸∫“ ¸ô!Ó˚õyí Ñ¸#›¸òyü˜ÏÑ¸Ó˚ ÓƒÓ£y˜ÏÓ˚Á Ñ¸ƒyò¢yÓ˚ (cancer)ÈÙÈ~Ó˚ õ˜Ïì¸y õyÓ˚í ˆÓ˚yÜÁ £˜Ïì¸ ¸ôy˜ÏÓ˚ – ~Ó˚ ö¸ˆÏú Óì≈¸õy˜Ïò ˆÓ!üÓ˚¶¸yÜ Ñ‚¸°ÏÑ¸ Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyü˜ÏÑ¸Ó˚ ¸ô!Ó˚Ó˜Ïì≈¸ xòƒyòƒ v¸z¸ôy˜ÏÎ˚ ü¢ƒ v¸zÍ¸ôyîò Ó‚!k¸Ó˚ ˆâ¸‹Ty Ñ¸Ó˚˜ÏäÈò– ˆÎõò ≤ÃÌyÜì¸ â¸y˜Ï°ÏÓ˚ ¸ô!Ó˚Ó˜Ïì≈¸ î#á≈fl¸iyÎ˚# Ñ‚¸!°Ïã v¸zÍ¸ôyîò (Sustainable agriculture)ñ ˜ã!ÓÑ¸ Ñ‚¸!°Ï (Organic agriculture)ñ ¸ô!Ó˚Óì≈¸ò Ñ‚¸!°Ï (alternative methods) £zì¸ƒy!î– î#á≈fl¸iyÎ˚# Ñ‚¸!°Ïã v¸zÍ¸ôyî˜ÏòÓ˚ õyïƒ˜Ïõ Óylfl¸ì¸s¸f (eco-system) ÓãyÎ˚ ˆÓ˚˜ÏÖ xÌ≈˜Ïò!ì¸Ñ¸ ¶¸y˜ÏÓ Ñ¸yÎ≈Ñ¸Ó˚# ÎìyÌ≈ ¢%Ó˚!«¸ì¸ Öyîƒ v¸zÍ¸ôß¨ Ñ¸Ó˚y £Î˚ – ˜ã!ÓÑ¸ Ñ‚¸!°Ï ¸ôk¸!ì¸˜Ïì¸

88% **MATCHING BLOCK 133/200** **W**

Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ òy Ñ¸ˆÏÓ˚ ˜

ãÓ ¢yÓ˚ S˜Îõò ü˜Ï¢ƒÓ˚ ¸ôyì¸y õ)úVÈÙÈ~Ó˚ õyïƒ˜Ïõ Ñ‚¸!°Ï v¸zÍ¸ôyîò Ó‚!k¸ Ñ¸Ó˚y £Î˚ – ~£z ¸ôk¸!ì¸ ÓƒÓ£y˜ÏÓ˚Ó˚ ö¸ˆÏú ¶)¸!õ«¸Î˚ ˆÓ˚yï Ñ¸Ó˚y ÎyÎ˚ ~ÓÇ ¶)¸Ü¶≈¸fl¸i ˜ã!ÓÑ¸ ¸ôîyÌ≈Á Ó‚!k¸ ¸ôyÎ˚ – ¸ô!Ó˚Óì≈¸ ü¢ƒ Ñ¸°Ï≈˜ÏíÓ˚ õyïƒ˜Ïõ ã!õÓ˚ v¸zÓ≈

100% **MATCHING BLOCK 138/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó˚ì¸y Ó‚!k¸Ó˚ ¢y˜Ïì ¢y˜Ïì ¶)¸!

õ«¸Î˚ ˆÓ˚yïÁ Ñ¸Ó˚y ÎyÎ˚ – Ñ‚¸!°Ïã ã!õ˜Ïì¸

100% **MATCHING BLOCK 136/200** **W**

Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ Ñ¸!

õ˜ÏÎ˚ v¸z¸ô˜ÏÓ˚y_´ ¸ô!Ó˚Óì≈¸ ¸ôk¸!ì¸ xÓú¡∫ò Ñ¸ˆÏÓ˚ ¶)¸!õÓ˚ î)°Ïí ˆÓ˚yï ~ÓÇ v¸zÓ≈Ó˚ì¸y Ó‚!k¸ Ñ¸Ó˚y ¢Ω¸Ó– (iii) ¶)¸!õ˜Ïì¸ úÓíydÑ¸ ã˜ÏúÓ˚ xy!ïÑ¸ƒ (Excess saline water in soil) ≠ Ó‚!‹TÓ˚ ãú ÓƒÓ£y˜ÏÓ˚Ó˚ ¸ô!Ó˚Ó˜Ïì≈¸ xyõy˜ÏîÓ˚ ˆî˜Ïü ˆÓ!üÓ˚¶¸yÜ ˆ«¸˜Ïe ¶)¸Ü¶≈¸fl¸i ãú ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ ü¢ƒ v¸zÍ¸ôyîò £Î˚ – !Ñ¸ls¸ ¶)¸ÈÙÈÜ¶≈¸fl¸i ãú ÓƒÓ£y˜ÏÓ˚ !Ñ¸ä%È «¸!ì¸Ñ¸Ó˚ !îÑ¸ ¸ô!Ó˚ú!«¸ì¸ £˜ÏÎ˚˜ÏäÈ– ~£z ã˜Ïú úÓ˜ÏíÓ˚ xy!ïÑ¸ƒ ˆîÖy ÎyÎ˚ – ö¸úfl¸∫Ó˚*¸ô v¸z°å ãúÓyÎ˚% xM¸È˜Ïú ¶)¸!õÓ˚ v¸z¸ô!Ó˚¶¸y˜ÏÜÓ˚ ãú Óy‹ôy!Î˚ì¸ £˜ÏÎ˚ ˆÜ˜Ïú ¶)¸!õÓ˚ v¸z¸ô!Ó˚¶¸y˜ÏÜ úÓ˜ÏíÓ˚ xy!ïÑ¸ƒ ˆîÖy ÎyÎ˚ – NSOU ? AE-ES-21 ? 93

Îy ˆÌˆÏÑ¸ v¸z!q˜ÏìÓ˚ Ó‚!k¸ £...y¢ ¸ôyÎ˚ ~ÓÇ ü¢ƒ v¸zÍ¸ôyîò «¸õì¸y Ñ¸ˆÏõ ÎyÎ˚ – ~Ñ¸£z ã!õˆÏì¸ î#á≈!ìò ¶)¸ÈÙÈÜ¶≈¸fl¸i ãú ÓƒÓ£yˆÏÓ˚Ó˚ ö¸ˆÏú ¶)¸!õ úÓíydÑ¸ Á xò%Ó≈Ó˚ £ˆÏÏ˚ Áˆ Ï‡¸– ~Ó˚Ñ¸õ ¶)¸!õî)°Ïí ˆÌˆÏÑ¸ ¶)¸!õˆÏÑ¸ Ó˚«¸y Ñ¸Ó˚yÓ˚ ãòƒ <ÃlyÜì¸ â¸yˆÏ°ÏÓ˚ ¸ô!Ó˚Óˆ Ïì≈¸ î#á≈fl¸iyÎ˚# Ñ¸!°Ïã ¸ôk¸!ì¸ˆÏì¸ â¸y°yÓyì Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– 5.4.3 Óã≈ƒ ¸ôîyÌ≈ã!òì¸ î)°Ïí (Pollution due to waste matter) Óì≈¸õyò ¢¶¸ƒì¸yÓ˚ xòƒì¸õ ¢õ¢ƒy £ú !Ó!¶¸ß¨ Ñ¸úÈÙÈÑ¸yÓ˚ Öyòyñ !ü“yM¸Èú Á Ü‚£fl¸iyú#Ó˚ v¸z!FäÈ‹T Óã≈ƒ ¸ôîyÌ≈– ~£z Óã≈ƒ¸ôîyˆÏÌ≈Ó˚ ¢Ó≈ˆÏü°Ï Ühs¸Óƒ £ú õ¸!_Ñ¸y– !Ó!¶¸ß¨ Ó˚y¢yÎ˚ !òÑ¸ Á ˜ã!ÓÑ¸ ¸ôîyˆÏÌ≈Ó˚ !õ◊ˆÏí ¢¸‹T ~£z Óã≈ƒ ¸ôîyÌ≈ ¶)¸!õˆÏÑ¸ ! Ó°Ïy_´ Á î)!°Ïì¸ Ñ¸ˆÏÓ˚ ì%¸úˆÏäÈ– ˆÓ!üÓ˚ ¶¸yÜ Óã≈ƒ ¸ôîyÌ≈ ¸ôâ¸ò«¸õ Óy îÈò ˆÎyÜƒ òÏˆñ ö¸ˆÏú ÓäÈˆÏÓ˚Ó˚ ¸òÓ˚ ÓäÈÓ˚ õy!›¸Ó˚ õˆÏïƒ ˆÌˆÏÑ¸ £z£y ¶)¸!õÓ˚ ¢yˆÏÌ ¢yˆÏÌ ¸ô!Ó˚ˆÏÓúˆÏÑ¸Á î)!°Ïì¸ Ñ¸Ó˚ˆÏäÈ– 5.5 üΣ î)°Ïí (Noise Pollution) üΣ <Ãyí#ãÜˆÏì¸Ó˚ x!hfl¸c Á ¶¸yÓ !Ó!òõˆÏÌ≈Ó˚ õyïƒõñ üΣ äÈyv¸¸y xyõÓ˚y Ñ¸ly Óúˆ Ïì¸ ¸ôy!Ó˚ òy– ¸ôÓ˚fl¸ôÓ˚ ˆÎyÜyˆÏÎyˆÏÜÓ˚ ¶¸y°Ïy Î%!Üˆ Ïì ˆ ˆÏäÈ üΣ– üΣ£#ò ~£z ¸¸ô¸!ÌÓ# xyõÓ˚y Ñ¸“òy Ñ¸Ó˚ˆÏì¸ ¸ôy!Ó˚ òy– üΣ ~Ñ¸ xõ)úƒ ¢¡ôî– !Ñ¸ls¸ ˆÓ¢%ˆÏÓ˚yñ v¸zFâ¸@˘Ãy ˆÏõÓ˚ ~Ñ¸›¸yòy üΣ xyõyˆÏìÓ˚ !ÓÓ˚!_´ v¸zÍ¸ôyîò Ñ¸ˆÏÓ˚ñ ~Ñ¸ xfl¸∫!hfl¸Ñ¸Ó˚ñ Îs¸fíyõÎ˚ xÓfl¸iyÓ˚ ¢¸‹T Ñ¸ˆÏÓ˚– ˆ◊yì¸yÓ˚ Ñ¸yˆÏäÈ xò!¶¸ˆÏ≤Ãì¸ñ xfl¸∫!hfl¸Ñ¸Ó˚ !ÓÓ˚_´ v¸zÍ¸ôyîÑ¸ üΣˆÏÑ¸ ˆÑ¸yúy£ú Óy ◊&!ì¸Ñ¸›)¸ Ñ¸úÓ˚Ó (noise) Óúy £Î˚ – ˆÑ¸yˆÏòy xòyÑ¸y!Cì¸ üΣ Î!î xyõyˆÏìÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ˆÎyÜyˆÏÎyˆÏÜ !Óá˜ á›¸yÎ˚ ñ üyÓ˚#!Ó˚Ñ¸ Óy õyò!¢Ñ¸ ¶¸yˆÏÓ fl¸∫yfl¸iƒ£y!òÑ¸Ó˚ £Î˚ ì¸ˆÏÓ üΣ î)°Ïí £ˆÏÏ˚ ˆÏäÈ Óúy £Î˚ – üΣî)°Ïí üΣü!_´Ó˚ x¸ôâ¸Î˚ !£¢yˆÏÓ Üíƒ Ñ¸Ó˚y ÎyÎ˚ – ¢yïyÓ˚íì¸ ü˜ÏΣÓ˚ <ÃyÓúƒõyey ~ÓÇ !fl¸i!ì¸Ñ¸yú Óy ¸ô%òÉ¸ô%òÉ ¢Çá›¸ˆÏòÓ˚ v¸z¸ôÓ˚ üΣî)°Ïí ˆÏìÓ˚ õyey !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚ – ~Ñ¸›¸yòy £yì%¸!v¸ õyÓ˚yÓ˚ üΣñ ˆõy›¸Ó˚ Üy!v¸¸Ó˚ ~Î˚yÓ˚ £ò≈ ~Ñ¸›¸yòy ˆãyˆÏÓ˚ ÓyãyˆÏòyÓ˚ xyÁÎ˚yã ã ˆÏúÓ˚ ¸ôyjô ¸Óy ˆãyˆÏÓ˚›¸Ó˚ â¸yúyˆÏòyÓ˚ üΣ ~¢Ó üΣî)°Ïí Á Îs¸fíy¢¸!‹TÓ˚ v¸zîyÓ˚íÓ˚ í– üΣî)°Ïíñ ãúñ Óyˆ% î)°ÏˆÏíÓ˚ õˆÏì¸y «¸!ì¸Ñ¸yÓ˚Ñ¸ Óy £ˆÏúÁñ £z£y <ÃÑ¸!¸!ì¸ ¸ô!Ó˚ˆÏÓˆÏÜÓ˚ =ìÜì¸ õyòˆÏÑ¸ !òÛˆõ%Ö# Ñ¸ˆÏÓ˚– ü˜ÏΣÓ˚ <ÃyÓ˚ˆÏúƒÓ˚ õyey Úˆv¸!¢ˆÏÓúÛ (decibel) ~Ñ¸Ñ¸ˆÏÑ¸ õy¸ôy £Î˚ – New Delhi-based National Physical LaboratoryÈÙÈ~Ó˚ ~Ñ¸ ÜˆÏÓ°ÏíyÎ˚ ˆîÏy ˆÜˆÏäÈ üΣî)°ÏˆÏíÓ˚ xòƒì¸õ <Ãiyò Ñ¸yÓ˚í ¸ô›¸Ñ¸y Óy!ã ö¸y›¸y¸yˆÏòy ˆÎÓyˆÏò ü˜ÏΣÓ˚ õyey (125°dB) !ò!î≈‹T õyeyÓ˚ ˆâ¸ˆÏÏ˚ ˆÓ!ü õyeyÎ˚ ÌyˆÏÑ¸ – Enrironment (Protection) (Second amendment) Rules, 1999ÈÙÈ~Ó˚ xò%ˆÏõy! î!¸ ü˜ÏΣÓ˚ <ÃyÓúƒ õyey £ú 65 ˆv¸!¢ˆÏÓú (dB)– 5.5.1 üΣî)°ÏˆÏíÓ˚ !Ó!¶¸ß¨ v¸zÍ¢ (Different sources of noise pollution) üΣî)°ÏˆÏíÓ˚ !Ó! ¶¸ß¨ v¸zÍ¢ ¢õ)£ˆÏÑ¸ <Ãiyòì¸É !ì¸ò!›¸ ˆ◊!íˆÏì¸ !Óò¸ƒhfl¸ Ñ¸Ó˚y Îy˚ ≠ (i) ¸ô!Ó˚ÓÓ£ò ã!òì¸ ñ (ii) !ü“ãyì¸ Á (iii) Ü‚£y¶¸ƒhs¸Ó˚#ò Á ¸ôy! Ó˚ ¸ôy!Ÿª≈Ñ¸ Ñ¸yÎ≈Ñ¸úy¸ô Ñ¸¸ì¸ üΣî)°Ïí– (i) ¸ô!Ó˚ÓÓ£ò (Transportation) ã!òì¸ üΣî)°Ïí ≠ ¶)¸ì¸úñ !ÓõyÒ Á ˆÓ˚ú¸ôˆÌ ¸ô!Ó˚ÓÓ£ò ¢¸‹T üΣñ üΣî)°ÏˆÏíÓ˚ <Ãiyò Ñ¸yÓ˚í– 94 ? NSOU ? AE-ES-21

Óì≈¸õyò ¢¶¸ƒì¸yÓ˚ x@˘ÃÜ!ì¸Ó˚ ¢yˆÏñ ¢yˆÏÌ <ÃÑ¸›¸ì¸ ˆÌˆÏÑ¸ <ÃÑ¸›¸ì¸Ó˚ £ˆÏÏ˚ v¸zˆÏ‡¸ˆÏäÈ ÎyòÓy£ˆÏòÓ˚ !òÓ˚hs¸Ó˚ Ó‚!k¸ – ~£z ÎyòÓy£ˆÏòÓ˚ !ÓÓ˚!FäÈß¨ ¶¸yˆÏÓ ¢Çá!›¸ì¸ üΣñ üΣî)°ÏˆÏÑ¸ Ó!k≈¸ì¸ Ñ¸ˆÏÓ˚ â¸úˆÏäÈ– ü£Ó˚yM¸Èˆú ÎyòÓy£ˆÏòÓ˚ xy!ïÑ¸ƒ ˆÓ!ü £ÁÎ˚yÎ˚ ñ ~£z xM¸Èú ˆÏúÓ˚ õyò%ˆÏ°ÏÓ˚y ì¸yv¸¸yì¸y!v¸¸ üΣî)°Ïí xye´yhs¸ Á «¸!ì¸@˘Ãhfl¸ £ˆÏFäÈ– (ii) !ü“ãyì¸ (Industrial) üΣî)°Ïí ≠ !Ó! ¶¸ß¨ !üˆÏ“ ÓƒÓ£*ì¸ ˆõ!üò â¸úÓyÓ˚ üΣ ~ÓÇ ~¢Ó !üˆÏ“ ¢Çá!›¸ì¸ òyòy!Óï <Ã!e´Î˚ î)°ÏˆÏíÓ˚ ¢õ¢ƒ ¢¸!‹T Ñ¸ˆÏÓ˚ – ~£z ïÓ˚ˆÏòÓ˚ î)°ÏˆÏíÓ˚ !üÑ¸yÓ˚ Ñ¸õ≈Óˆ Ïì¸ ◊!õÑ¸ˆÏÑ¸Ó˚y ~ÓÇ !ü“¢Çú@¿ ~úyÑ¸yÓ˚ õyò%ˆÏ°ÏÓ˚y– (iii) Ü‚£y¶¸ƒhs¸Ó˚#ò (Indoor) Á ¸ôy!Ó˚ ¸ôy!Ÿª≈Ñ¸ (Out door) üΣî)°Ïí ≠ áˆÏÓ˚Ó˚ !¶¸ì¸ˆÏÓ˚ ÓƒÓ£*ì¸ !Ó!¶¸ß¨ ˆõ!üò Á £zˆÏúÑ¸›¸‚!òÑ¸ ¢Ó˚Oyõ ˆÎòò ˆãyˆÏÓ˚›¸Ó˚ñ ã ˆÏúÓ˚ ¸ôyjôõ ÁÎ˚y!üÇ ˆõ!üˆÏòÓ˚ ~Ñ¸›¸yòy xyÁÎ˚yã !›¸.!¶¸.ñ ˆÓ˚!v¸Áñ ˆ›¸¸ô ˆÓ˚Ñ¸v≈¸yˆÏÓ˚Ó˚ v¸zFâ¸@˘ÃyˆÏõ â¸yúyˆÏòyÓ˚ üΣñ ¸ôy!Ó˚ ¸ôy! Ÿª≈ˆÏÑ¸ xò%!¤ì¸ !Ó!¶¸ß¨ ¢yõy!ãÑ¸ Á ïö≈#Î˚ xò%¤yˆÏò ÓƒÓ£*ì¸ õy£zˆÏÑ¸Ó˚ v¸zFâ¸ xyÁÎ˚yã üΣî)°Ïí ¢¸‹TÑ¸yÓ˚ Ñ¸– 5.5.2 ü˜ÏΣÓ˚ <ÃyÓúƒõyey (Intensity) ü˜ÏΣÓ˚ <ÃyÓúƒõyey <ÃÑ¸yü Ñ¸Ó˚y £Î˚ ÚˆÓúÛ Óy Úˆv¸!¢ˆÏÓúÛ ~Ñ¸ˆÏÑ¸ S1 ˆÓú = 10 ˆv¸!¢ˆÏÓúV– îÓ˚y¶¸y°ÏyˆÏÓ˚ xy!Ó‹Òì≈¸y xyˆÏúÑ¸äyu¸yÓ˚ @˘Ãy£yõ ˆÓ˚ˆÏúÓ˚ òyõyò%¢yˆÏÓ˚ ~£z ~Ñ¸ˆÏÑ¸Ó˚ òyõÑ¸Ó˚í– ˆv¸!¢ˆÏÓ˚ˆÏúÓ˚ ¢ÇK¸y Üy!ì!Ñ¸¶¸yˆÏÓ <ÃÑ¸yü Ñ¸Ó˚y ÎyÎ˚ ò#ˆÏã¸Ó˚ ¢õ#Ñ¸Ó˚í!›¸Ó˚ õyïƒˆÏõÈÙÙÈ !òí#≈ì¸ ü˜Σ<ÃyÓúƒ (I) ˆv¸!¢ˆÏÓú (dB) = 10 log 10 <Ãyõyˆ Ïíƒ ü˜Σ<ÃyÓúƒ (I 0) ˆÑ¸yòÁ !ÓˆÏü°Ï ü˜ÏΣÓ˚ <ÃyÓúƒ Î!î <Ãyõyíƒ ü˜ÏΣÓ˚ 10 =í £Î˚ Sxì≈yÍ I I 0 10 ? V ì¸ˆÏÓ ˘ !ÓˆÏü°Ï ü˜ÏΣÓ˚ <ÃyÓúƒ õyey 10 !v¸ˆÏ¢ˆÏÓú £ˆÓ SÑ¸yÓ˚íñ log 10 10 = 1 ¢%ì¸Ó˚yÇ 10×log 10 10 = 10 × 1 = 10V– xyÓyÓ˚ !ÓˆÏü°Ï ˆÑ¸yˆÏòy ü˜ÏΣÓ˚ <ÃyÓúƒ <Ãyõyíƒ üΣ <ÃyÓ˚ˆÏúƒÓ˚ 100 =í £ˆÏú ÁÆz !ÓˆÏü°Ï ü˜ÏΣÓ˚ <ÃyÓúƒõyey £ˆÓ 20 ˆv¸!¢ˆÏÓú SÑ¸yÓ˚íñ log 10 10 = 2 ¢%ì¸Ó˚yÇ 10×log 10 10 = 10 × 2 = 20V– xì≈yÍ 20 ˆv¸!¢ˆÏÓú ü˜ÏΣÓ˚ <ÃyÓúƒõyey 10 ˆv¸!¢ˆÏÓú ü˜ÏΣÓ˚ <ÃyÓúƒõyeyÓ˚ !m=í òÎ˚ ñ 10 =í– xò%Ó˚*ˆÏ¸ô 30 ˆv¸!¢ˆÏÓˆÏúÓ˚ üΣ <ÃyÓúƒõyey 20 ˆv¸!¢ˆÏÓˆÏúÓ˚ 10 =íñ 40 ˆv¸!¢ˆÏÓˆÏúÓ˚ <ÃyÓúƒõyey 30 ˆv¸!¢ˆÏÓˆÏúÓ˚ 10 =í ÈÙÙÙÈ ~¶¸yˆÏÓ ¸ôî≈yÎ˚e´ˆÏõ Óyv¸¸ˆÏ– õyò%ˆÏ°ÏÓ˚ ◊Óíˆ Ïs¸fÓ˚ ü˜ÏΣÓ˚ ì¸#Ó ì¸y @˘Ãí Ñ¸Ó˚yÓ˚ ¢#õy Î!îÁ Ö%Ó ! Óhfl+¸ì¸ñ ì¸Ó% 70 ˆv¸!¢ˆÏÓú ˆÌˆÏÑ¸ ˆÓ!ü ì¸#Ó üΣ õyò%°Ï Á xòƒyòƒ <Ãyí#Ó˚ òyòyÓ˚ Ñ¸õ üyÓ˚#!Ó˚Ñ¸ Á õyò!¢Ñ¸ «¸!ì¸Ó˚ ¸Ñ¸yÓ˚í £Î˚ ÈÙÙÙÈ !ÓˆÏü°Ï Ñ¸ˆÏÓ˚ x!ò!î≈‹TÑ¸yú ïˆÏÓ˚ Î!î ì¸y â¸úˆÏì¸ ÌyˆÏÑ¸ – NSOU ? AE-ES-21 ? 95

¢yÓ˚ !íÈÙÈ3 ≠ ü˜ì¸#Ó ì¸yñ ü˜ÏΣÓ˚ v¸zÍ¢ ~ÓÇ v¸zFâ¸õyeyÓ˚ ü˜ÏΣÓ˚ «¸!ì¸Ñ¸Ó˚ <Ã¶¸yÓ˚ ˆv¸!¢ˆÏÓú õyey ü˜ÏΣÓ˚ v¸zÍ¢ Á ì¸yÓ˚ «¸! ì¸Ñ¸Ó˚ <Ã¶¸yÓ˚ 0 õyò%ˆÏ°ÏÓ˚ ◊&!ì¸ ˆÏÜyâ¸Ó˚ ü˜ÏΣÓ˚ !ò¡ì¸õ õyey– 10 ÜyˆÏäÈÓ˚ ¸ôyì¸y òv¸¸yÓ˚ üΣ– 20 ˆÓì¸yÓ˚ fi›%¸!v¸ÁÓ˚ x¶¸ƒhs¸ˆÏÓ˚Ó˚ üΣ– 30 ¸ôy‡¸yÜyˆÏÓ˚Ó˚ x¶¸ƒhs¸ˆÏÓ˚Ó˚ üΣ– 40 Ü‚ˆÏ£Ó˚ x¶¸ƒhs¸ˆÏÓ˚Ó˚ üΣ– 50 300 !õ›¸yÓ˚ îÓ˚ ˆÌˆÏÑ¸ ◊&!ì¸ £yÕÔy ÎyòÓy£ˆÏòÓ˚ üΣ– 60 ¢yïyÓ˚í Ñ¸ÌyÓyì≈¸y– 70 ˆÓ˚!v¸Áñ úyv¸zv¸ !fl¸ôÑ¸yˆÏÓ˚Ó˚ üΣñ ~£z õyey «¸!ì¸Ñ¸yÓ˚Ñ¸ – 80 ˆõy›¸Ó˚ Üy!v¸¸Ó˚ ~Î˚yÓ˚ £ò≈– 90 ¸ôyì¸yú ˆÓ˚ú ÎyÁÎ˚yÓ˚ üΣ– ~£z õyey fl¸iyÎ˚# «¸!ì¸yÓ˚Ñ¸ – 100 !v»¸ú ˆõ!üˆÏòÓ˚ üΣñ xˆÏÑ≈¸fl¸T...yÓ˚ üΣ– £z£y Ö%Ó «¸!ì¸Ñ¸Ó˚ – 110 Ó˚Ñ¸ !õv¸z!ãˆÏÑ¸Ó˚ üΣ– 120 ü!_´üyú# Óy!ã ¸ô›¸Ñ¸yÓ˚ üΣ– 146 !Óõyò Á‡¸yñòyõyÓ˚ üΣ– £z£y Ö%Ó Îs¸fíy îyÎ˚Ñ¸ – ˆ

100% **MATCHING BLOCK 137/200** W

Ñ¸w#Î˚ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈

î !òï≈yÓ˚í ì¸ !òÓ˚y¸ôî üΣ õyey ò#ˆÏâ¸Ó˚ ¢yÓ˚ !íˆÏì¸ ˆîÏyˆÏòy £ú ≠ ¢yÓ˚ !í 4 ≠ ˆÑ¸yˆÏòy òÜÓ˚#ˆÏì¸ !òï≈yÓ˚ì¸ !òÓ˚y¸ôî üΣ <ÃyÓúƒõyey !ÓˆÏü°Ï ~úyÑ¸y !òï≈yÓ˚ì¸ !òÓ˚y¸ôî üΣ <ÃyÓúƒõyey Sˆv¸!¢ˆÏÓúV !îˆÏò Ó˚yˆÏe (i) Ó¢Óy¢ ~úyÑ¸y 55 45 (ii) !òÉüΣ xM¸Èú S£y¢¸ôyì¸yú fl¸%Óúñ 50 40 Ñ¸ˆÏúã ~¢ˆÏÓÓ˚ 100 !õÉ îÓ˚c ¸ôî≈hs¸ – (iii) Óy!ãƒ ~úyÑ¸y 65 55 (iv) !ü“yM¸Èú 75 65 96 ? NSOU ? AE-ES-21

5.5.3 ãòfl¸Ïy˜Ïfl¸iƒÓ˚ v¸z¸ôÓ˚ ü∑î)°Ï˜ÏíÓ˚ «¸!ì¸Ñ¸Ó˚ ≤Ã¶¸yÓ ü∑î)°Ïí xyõy˜ÏîÓ˚ üyÓ˚#!Ó˚Ñ¸ ~ÓÇ õyò!¢Ñ¸ v¸z¶¸Î˚ ≤ÃÑ¸yÓ˚ «¸! ì¸£z Ñ¸Ó˚˜Ïì¸ ¸ôy˜ÏÓ˚ – ¢yïyÓ˚îì¸ ü∑ ≤ÃyÓúƒõyey ~ÓÇ ü˜Ï∑Ó˚ !fl¸i!ì¸Ñ¸y˜ÏúÓ˚ v¸z¸ôÓ˚ «¸!ì¸Ó˚ õyey !ò¶≈¸Ó˚ Ñ¸˜ÏÓ˚ – !ÓŸª fl¸Ïyfl¸iƒ ¢Çfl¸iy (WHO) !ò˜Ïî≈!üì¸ ü˜Ï∑Ó˚ !òÓ˚y¸ôî ≤ÃyÓúƒõyey £ú 45 ˆv¸!¢˜ÏÓú– 80 ˆv¸!¢˜ÏÓú xyÁÎ˚y˜ÏãÓ˚ ü∑ xyõy˜ÏîÓ˚ e%´k¸ Ñ¸˜ÏÓ˚ ì%¸ú˜Ïì¸ ¸ôy˜ÏÓ˚ñ 85 ˆv¸!¢˜ÏÓú xyÁÎ˚y˜ÏãÓ˚ ü∑ xyõy˜ÏîÓ˚ Ñ¸y˜ÏòÓ˚ «¸!ì¸ Ñ¸Ó˚˜Ïì¸ ÷Ó˚& Ñ¸˜ÏÓ˚ – 88 ˆv¸!¢˜ÏÓ˜ÏúÓ˚ ü∑ ~Ñ¸›¸yòy £˜Ïì¸ ÌyÑ¸˜Ïú xyõy˜ÏîÓ˚ ◊Óí«¸õì¸y Ñ¸˜Ïõ xy¢˜Ïì¸ Ìy˜ÏÑ¸ñ 135 ˆv¸!¢˜ÏÓ˜ÏúÓ˚ xyÁÎ˚yã Îs¸fíyîyÎ˚Ñ¸ ~ÓÇ 150-160 ˆv¸!¢˜ÏÓú xyÁÎ˚yã xyõy˜ÏîÓ˚ ◊Óí õ%£)˜Ïì≈¸£z !â¸Ó˚ì¸˜ÏÓ˚ Ó!ïÓ˚ Ñ¸˜ÏÓ˚ !î˜Ïì¸ ¸ôy˜ÏÓ˚ – ü∑î)°Ï˜ÏíÓ˚ ö¸˜Ïú ◊Óí«¸õì¸y £…y¢ £ÁÎ˚y äÈyv¸¸y Ó˝ üyÓ˚#!Ó˚Ñ¸ Á õyò!¢Ñ¸ «¸!ì¸ £˜Ïì¸ ¸ôy˜ÏÓ˚ – ü∑î)°Ï˜ÏíÓ˚ ö¸˜Ïú õyò%˜Ï°ÏÓ˚ õyò!¢Ñ¸ â¸y¸ô Ó‚!k¸ ¸ôyÎ˚ñ ì§¸yÓ˚y v¸z@˘Ã ˆõãyãñ fl¸¨yÎ˚%!ÓÑ¸ ˆÓ˚yÜñ Ÿªy¢Ñ¸‹Tñ õy£z˜Ï@˘Ãòñ õyÌyïyÓ˚yÎ˚ xye´yhs¸ £˜Ïì¸ ¸ôy˜ÏÓ˚ò– ì§¸y˜ÏîÓ˚ Ñ¸õ≈î«¸ì¸y £…y¢ ˆ¸ô˜Ïì¸ ¸ôy˜ÏÓ˚ñ Ó˚_´â¸y¸ôñ Ó˚˜Ï_´ !â¸!òÓ˚ õyey Ó‚!k¸ ˆ¸ô˜Ïì¸ ¸ôy˜ÏÓ˚ – v¸zFâ¸@˘Ãy˜ÏõÓ˚ ~Ñ¸›¸yòy ü∑ £*î ˆÓ˚yÜ#˜ÏîÓ˚ ¸ô˜Ï«¸ õyÓ˚ydÑ¸ £˜Ïì¸ ¸ôy˜ÏÓ˚ – ≤Ã¢)!ì¸ òyÓ˚# î#á≈Ñ¸yú#ò ü∑Îs¸fíyÓ˚ õ˜Ïïƒ ÌyÑ¸˜Ïú !ÓÑ¸úyD Óy Ñ¸õ Áã˜ÏòÓ˚ ¢hs¸yò ≤Ã¢Ó Ñ¸Ó˚˜Ïì¸ ¸ôy˜ÏÓ˚ò– ~ïÓ˚˜ÏòÓ˚ !ü÷ ãv¸¸Ó%!k¸¢¡ô߈ £ÓyÓ˚Á ¢Ω¸yÓòy Ìy˜ÏÑ¸ – 5.5.4 ü∑î)°Ïí !òÎ˚s¸f˜Ïí Ñ¸Ó˚í#Î˚ xyï%!òÑ¸ ¢¶¸fì¸yÓ˚ x@˘ÃÜ!ì¸Ó˚ ¢y˜Ïì ¢y˜Ïì !Ó¸ôÓ˚#ì¸ ≤Ã!e´Î˚y !£¢y˜ÏÓ !Ó!¶¸ß¨ ≤ÃÑ¸yÓ˚ î)°Ïí xyõy˜ÏîÓ˚ xò%°ÏD £˜ÏÎ˚ ¸ô˜Ïv¸¸˜ÏäÈ– Úü∑î)°ÏíÛ ì¸y˜ÏîÓ˚ õ˜Ïïƒ ~Ñ¸!›¸ñ ~£z î)°Ïí ¢¡ô)í≈Ó˚*˜Ï¸ô Óı¸ Ñ¸Ó˚y ¢Ω¸Ó òÎ˚ñ ì¸˜ÏÓ v¸z¸ôÎ%_´ !Ñ¸ä%È !ÓK¸yò¢¡øì¸ ÓƒÓfl¸iy @˘Ã£˜ÏíÓ˚ õyïƒ˜Ïõ ü˜Ï∑Ó˚ ≤ÃyÓúƒõyey ~ÓÇ î)°Ïíõyey !Ñ¸ä%È›¸y !òÎ˚s¸fí Ñ¸Ó˚y ¢Ω¸Ó– ü∑î)°Ïí !òÎ˚s¸f˜Ïí ≤Ãïyòì¸ â¸yÓ˚ ïÓ˚˜ÏòÓ˚ ¸

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ôk¸!ì¸ xò%¢Ó˚í Ñ¸Ó˚y ˆÎ˚˜Ïì¸ ¸ôy˜ÏÓ˚ ≠ (

i) v¸zÍ˜Ï¢£z¸ ü˜Ï∑Ó˚ ≤ÃyÓúƒõyey Ñ¸!õ˜ÏÎ˚ xyòyñ (ii) v¸zFâ¸@˘Ãy˜Ïõ ü∑ xy¢yÓ˚ ¸ôÌ›¸y£z Óı¸ Ñ¸˜ÏÓ˚ ˆîÁÎ˚yñ (iii) ü∑ v¸zÍ¢ ˆÌ˜ÏÑ¸ ˆ◊yì¸yÓ˚ Ñ¸y˜ÏäÈ ˆ¸ôÔ§äÈyÓyÓ˚ ¸ô˜ÏÌÓ˚ ˜îá≈ƒ Ó‚!k¸ Ñ¸˜ÏÓ˚ ~ÓÇ õyG¸¸ô˜ÏÌ ü∑ ˆüy°ÏÑ¸ !Ñ¸ä%È ÓƒÓfl¸iy @˘Ã£í Ñ¸˜ÏÓ˚ ~ÓÇ (iv) ˆ◊yì¸yÓ˚ ã˜Ïòƒ !Ñ¸ä%È ¢%Ó˚«¸yõ)úÑ¸ ÓƒÓfl¸iy @˘Ã£í Ñ¸Ó˚yñ Ìy˜Ïì¸ v¸zFâ¸ ≤ÃyÓ˚˜ÏúƒÓ˚ ü∑ £…y¢ ˆ¸ô˜ÏÎ˚ ˆ◊yì¸yÓ˚ Ñ¸y˜Ïò ≤Ã˜ÏÓü Ñ¸˜ÏÓ˚ – ¢˜ÏÓ≈y¸ô!Ó˚ ãòÜ˜ÏíÓ˚ õ˜Ïïƒ ü∑î)°Ï˜ÏíÓ˚ «¸Î˚«¸!ì¸ ¢¡∫˜Ïì¸ ¢˜Ïâ¸ì¸òì¸y Ü˜Ïv¸¸ ì%¸ú˜Ïì¸ £˜ÏÓ– ˆÎõò ˆÓ˚!v¸Áñ !›¸.!¶¸.ñ ˆ›¸¸ô˜ÏÓ˚Ñ¸v≈¸yÓ˚ñ õy£z˜Ïe´y˜Ïö¸yò v¸zFâ¸@˘Ãy˜Ïõ Óyãy˜Ïòy Óı¸ Ñ¸Ó˚˜Ïì¸ £˜ÏÓ– ˆõy›¸Ó˚Ìy˜Ïò Ñ¸Ñ≈¸ü xyÁÎ˚y˜ÏãÓ˚ ~Î˚yÓ˚£ò≈ Óyãy˜Ïòy ¸ô%˜ÏÓ˚y¸ô%!Ó˚ Óı¸ Ñ¸Ó˚˜Ïì¸ £˜ÏÓ– Ñ¸úÑ¸yÓ˚Öyòyî ÎÏs¸f¸ôy!ì¸Ó˚ ¢!‡Ñ¸ Ó˚«¸íy˜ÏÓ«¸í ~ÓÇ v¸z¸ôÎ%_´ ≤ÃÎ%!_´Ó˚ ¢y£y˜ÏÎƒ ü∑ ≤ÃyÓúƒ Ñ¸!õ˜ÏÎ˚ xyòyÓyÓ˚ ÓƒÓfl¸iy Ñ¸Ó˚y £zì¸ƒy!î ÓƒÓfl¸iyÓ˚ õyïƒ˜Ïõ ü∑î)°Ïí !Ñ¸ä%È›¸y !òÎ˚s¸fí ¢Ω¸Ó– ~Ñ¸›¸yòy !òÓ˚Ó!FäÈß¨ ≤ÃÓú ü∑£z ¢yïyÓ˚îì¸ ü∑î)°Ïí á›¸yÎ˚ñ ì¸y£z x˜ÏòÑ¸˜Ï«¸˜Ïe ~Ñ¸›¸yòy ü∑˜ÏÑ¸ ˆ¶¸˜ÏD !î˜Ïì¸ ¸ôyÓ˚˜ÏúÁ ü∑î)°Ïí õyey !Ñ¸ä%È›¸y Ñ¸õy˜ÏòyÎ˚ – ü∑ v¸zÍ¢ ˆÌ˜ÏÑ¸ v¸zÍ¢y!Ó˚ì¸ ≤ÃÓú xyÁÎ˚yã ˆ◊yì¸yÓ˚ Ñ¸y˜Ïò ˆ¸ôÔ§äÈyÓyÓ˚ xy˜ÏÜ£z õyG¸¸ô˜ÏÌÓ˚ ˜îá≈ƒ Ó‚!k¸ Ñ¸˜ÏÓ˚ ~ÓÇ õyG¸ ¸ô˜ÏÌ ü∑ ˆüy°Ï˜ÏÑ¸Ó˚ myÓ˚y ≤ÃyÓúƒõyey !Ñ¸ä%È›¸y Ñ¸õy˜ÏòyÎ˚ – ˆÎõò ü∑ ˆÑ¸y˜Ïòy ! ü“ÈÜÈv¸zq$ì¸ £˜Ïú Á£z !ü“yM¸È˜ÏúÓ˚ â¸y!Ó˚!î˜ÏÑ¸ áò ¢ÇÓk¸ !òÓ≈y!â¸ì¸ ÜyäÈ¸ôyúy úy!Ü˜ÏÎ˚ ü∑ ≤ÃyÓúƒ Ñ¸õy˜Ïòy ˆÎ˚˜Ïì¸ ¸ôy˜ÏÓ˚ – ü£˜ÏÓ˚ !ÓK¸y¸ô˜ÏòÓ˚ ãòƒ ˆÎ ˆ£y!v≈¸Ç ÓƒÓ£*ì¸ £Î˚ ˆ¢=!ú ü∑ ˆüy°ÏÑ¸ ¸ôîyÌ≈ !ò!õ≈ì¸ £˜Ïú Ó˚yhfl¸yÎ˚ â¸¸úy ÌyòÓy£òãyì¸ ü˜Ï∑Ó˚ ≤ÃyÓúƒ NSOU ? AE-ES-21 ? 97
!Ñ¸ä%È›¸y Ñ¸õy˜Ïòy ÌyÎ˚ – £y¢¸ôyì¸yú Á !ü«¸y≤Ã!ì¸¤¸yò !á˜ÏÓ˚ ÜyäÈ¸ôyúyÓ˚ áò xy˜ÏÓ‹Tò# ˜ì¸!Ó˚ Ñ¸Ó˚y ≤Ã˜ÏÎ˚yãò– Óv¸¸ Á ÓƒhflÑ¸ Ó˚yhfl¸yÓ˚ ïy˜ÏÓ˚ Óy!v¸¸ Ñ¸Ó˚y Óy ˆÑ¸òy v¸z!â¸ì¸ òÎ˚ xyÓ˚ ì¸y ÌyÑ¸˜Ïú Óy!v¸¸Ó˚ ãyòyúy Á îÓ˚ãyÎ˚ ¶¸yÓ˚# ¸ôî≈y úyÜyÓyÓ˚ ÓƒÓfl¸iy Ñ¸Ó˚˜Ïì¸ ¸ôyÓ˚˜Ïú ¶¸y˜Ïúy– ~äÈyv¸¸y ˆ◊yì¸yÓ˚ ãòƒ Óƒ!_´Üì¸ ¢%Ó˚«¸yõ)úÑ¸ ÓƒÓfl¸iy Ñ¸Ó˚y ˆÎ˚˜Ïì¸ ¸ôy˜ÏÓ˚ – ˆÎõò ü∑ ≤ÃÓí ¸ô!Ó˚˜ÏÓ˚˜Ïü Ñ¸yã Ñ¸Ó˚˜Ïú Ñ¸y˜Ïò £zÎ˚yÓ˚ ≤ÔyÜñ £zÎ˚yÓ˚ õyö¸ Á ò˜ÏÎ˚ã ˆ£ú˜Ïõ›¸ £zì¸ƒy!î ÓƒÓ£yÓ˚

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Ñ¸Ó˚y ˆÎ˚˜Ïì¸ ¸ôy˜ÏÓ˚ – v¸z¸ô˜ÏÓ˚y_´

Îs¸f=!ú ü∑ ˆüy°Ï˜ÏÑ¸Ó˚ Ñ¸yã Ñ¸˜ÏÓ˚ – ~£z ïÓ˚˜ÏòÓ˚ Î˚˜Ïs¸fÓ˚ x¶¸y˜ÏÓ fl¸Ïyfl¸iƒ£y!òÑ¸Ó˚ òÎ˚ ~õò ˆì¸˜Ïú ˆ¶¸ãy˜Ïòy Óy ˆõyõ õyÖy˜Ïòy ì%¸˜Ïúy Ñ¸y˜Ïò !î˜ÏÎ˚ ü∑ ≤ÃÓí ~úyÑ¸yÎ˚ Ñ¸yã

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Ñ¸Ó˚y ˆÎ˚˜Ïì¸ ¸ôy˜ÏÓ˚ – v¸z¸ôÎ%_´ òÜÓ˚ ¸ô!Ó˚Ñ¸“

òyÓ˚ õyïƒˆÏõ v¸zFâ¸ ü∑ v¸zÍ¢ ˆÎõò Ñ¸úÑ¸yÓ˚Öyòyñ ˆÑ¸yúy£ú¸ô)í≈ ÓƒÓ¢yÓy!íˆÏãƒÓ˚ ~úyÑ¸y Ó¢!ì¸ ~úyÑ¸y ˆÌˆÏÑ¸ î)ˆÏÓ˚ fl¸iy¸ôò Ñ¸Ó˚y îÓ˚Ñ¸yÓ˚ – Ó˚yhfl¸yáyˆÏ›¸Ó˚ Ó˚«¸íyˆÏÓ«¸í Á ¢%¤%¸ ¸ô!Ó˚Ñ¸!"ì¸ ›¸∆y!ö¸Ñ¸ ÓƒÓfl¸iyÓ˚ õyïƒˆÏõ ÎyòÓy£ò ã!òì¸ ü∑î)°Ïí xˆÏòÑ¸yÇˆÏü !òÎ˚s¸fí ¢Ω¸Ó– !ÓõyòÓ®Ó˚ñ ˆÓ˚úˆÏfi›¸üò Óy ˆÓ˚ú ¸ô!Ó˚Ó£ò ÓƒÓfl¸iy ãòÓ¢!ì¸ ~úyÑ¸y ˆÌˆÏÑ¸ î)ˆÏÓ˚ £ÁÎ˚y ÓyN¸ò#Î˚ – ¢ˆÏÓ≈y¸ô!Ó˚ ¢y!Ó≈Ñ¸ ¢%¤%¸ ¸ô!Ó˚Ñ¸"òy õy!ö¸Ñ¸ ≤Ãüy¢!òÑ¸ ÓƒÓfl¸iy @˘Ã£íñ ÎìyÎì xy£zò ≤ÃíÎ˚ò ~ÓÇ ˆ¢=!úÓ˚ Ñ¸ˆÏ‡¸yÓ˚ ≤ÃˆÏÎ˚yÜñ Óƒy¸ôÑ¸ ãò¢ˆÏâ¸ì¸òì¸y ÜˆÏv¸¸ ˆì¸yúy ~ÓÇ !òÓ˚Ó!FäÈß¨ Ü‡¸òõ)úÑ¸ Üí xyˆÏ®yúˆÏòÓ˚ õyïƒˆÏõ£z ü∑î)°Ïí ! òÎ˚s¸fí ¢Ω¸Ó– 5.6 ¢yõ%!oÑ¸ î)°Ïí (Marine Pollution) õyò%ˆÏ°ÏÓ˚ ≤Ãì¸ƒ«¸ Óy ¸ôˆÏÓ˚y«¸ !e´Î˚yÑ¸úyˆÏ¸ôÓ˚ õyïƒˆÏõ ˆÑ¸yò ¸ôîyÌ≈ ¢õ%ˆÏoÓ˚ õˆÏïƒ ˆö¸úyÓ˚ ö¸ˆÏú ¢õ%ˆÏoÓ˚ ãˆÏúÓ˚ ÷k¸ì¸y !Óò‹T £Î˚ ~ÓÇ ~Ó˚ ≤Ã¶¸yˆÏÓ ¢õ%ˆÏoÓ˚ Ó¢Óy¢Ñ¸yÓ˚# ã#ˆÏÓÓ˚ «¸!ì¸ ¢yïò £Î˚ñ ~õò!Ñ¸ õ¸ì%¸ƒÁ áˆÏ›¸ ÌyˆÏÑ¸ – ÷ï%õye ¢yõ%!oÑ¸ ≤Ãyí# òÎ˚ õyò%°ÏÁ ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ «¸!ì¸@˘Ãhfl¸ £Î˚ – ~ˆÏÑ¸ ¢yõ%!oÑ¸ î)°Ïí ÓˆÏú– 5.6.1 ¢yõ%!oÑ¸ î)°ÏˆÏíÓ˚ v¸zÍ¢ !Ó!¶¸ß¨ ¶¸yˆÏÓ ¢õ%ˆÏoÓ˚ ≤ÃyÑ¸,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü î)!°Ïì¸ £ˆÏÎ˚ â¸ˆÏúˆÏäÈñ ì¸yÓ˚ ≤Ãïyò Ñ¸yÓ˚í=!ú £úÈÙÙÈ S1V ≤ÃyÎ˚ 40% Óã≈ƒ ¸ôîyÌ≈ ˆÎõò ≤'y!fi›¸Ñ¸ñ ¸ô!úõyÓ˚ãyì¸ oÓƒ Îy ¢£ˆÏã !Óò‹T £Î˚ òy ì¸y ¢õ%ˆÏoÓ˚ ì¸úˆÏîˆÏü ˆö¸úy £ˆÏFäÈ– S2V ü£Ó˚ ~ÓÇ õ£yòÜÓ˚#Ó˚ v¸z¸ôÑ)¸úÓì≈¸# xM¸ÈˆÏúÓ˚ ˆ£yˆÏ›¸úñ Óy!v¸¸ £zì¸ƒy!î ˆÌˆÏÑ¸ v¸zÍ¸ôß¨ ì¸Ó˚ú Óã≈ƒ ¸ôîyÌ≈ ÎyÓ˚ v¸z¸ôyîò !£¢yˆÏÓ v¸z¸ô!fl¸ìi¸ ¢yÓyòñ Ñ¸#›¸òyüÑ¸ñ Ó˚yß¨yáˆÏÓ˚ ÓƒÓ£*ì¸ ˆì¸ú £zì¸ƒy!î Îy ¢Ó˚y¢!Ó˚ ¸ôy£z¸ôúy£zò ~ÓÇ ¸ôˆÏÓ˚ Óv¸¸ Óv¸¸ ˆv»¸ˆÏòÓ˚ õyïƒˆÏõ !ÜˆÏÎ˚ ¸ôv¸¸ˆÏäÈ ¢õ%ˆÏo– S3V ¢õ%o v¸z¸ôÑ)¸úÓì≈¸# xM¸ÈˆÏú xÓ!fl¸ìi¸ Ñ¸yÓ˚Öyòy=!ú !Ó°Ïy_´ ˆì¸ã!‹;¸Î˚ ¸ôîyÌ≈ ¶¸y!Ó˚ ˆõÔú (Cr, As, Cd, Cu, Pb) ¢õ%ˆÏo !òˆÏ«¸¸ô Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ñ ÎyÓ˚ ö¸ˆÏú ¢õ%ˆÏoÓ˚ ÷k¸ì¸y ò‹T £ˆÏÎ˚ ÎyˆÏFäÈ– S4V ãy£yˆÏãÓ˚ ˆÌˆÏÑ¸ ˆÓ˚ˆÏÓ˚yˆÏòyÓ˚ ˆì¸ú Óy Ö!òã ˆì¸ú ˆì¸yúyÓ˚ Ö!ò=!ú ˆÌˆÏÑ¸ ˆì¸ú ˆÓ!Ó˚ˆÏÎ˚ ¢õ%ˆÏoÓ˚ v¸z¸ô! Ó˚¸ô¸ˆÏ¤¸ äÈ!v¸¸ˆÏÎ˚ ÎyÎ˚ñ ÎyÓ˚ ≤Ã¶¸yˆÏÓ ¢õ%ˆÏo Ó¢Óy¢Ñ¸yÓ˚# ≤Ãyí#ˆÏîÓ˚ õˆÏïƒ x!:ˆÏãò áy›¸!ì¸ áˆÏ›¸ – S5V â¸y°ÏyÓyˆÏîÓ˚ ãòƒ ÓƒÓ£*ì¸ ¢yÓ˚ñ Ñ¸#›¸òyüÑ¸ñ ãˆÏú ï%ˆÏÎ˚ ≤ÃìˆÏõ òî#ˆÏì¸ ~ÓÇ ¸ôˆÏÓ˚ ¢õ%ˆÏo ~ˆÏ¢ !õˆÏü– ~äÈyv¸¸yÁ òî#Ó˚ ¸ôyüy¸ôy!ü ü£Ó˚=!ú ˆÌˆÏÑ¸ Óã≈ƒ ¸ôîyÌ≈ !òˆÏÎ˚ ~ˆÏ¢ ¢õ%ˆÏo !òˆÏ«¸¸ô £Î˚ Îy ¢õ%ˆÏoÓ˚ ≤ÃyÑ¸,¸!ì¸Ñ¸ ¶¸yÓ˚¢yõƒ ò‹T Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– 98 ? NSOU ? AE-ES-21

~£z ¢Ñ¸ú Ñ¸yÓ˚í=!ú Óƒyì¸#ì¸ !ÓŸªÈÙÈv¸z°åyÎ˚òñ ãúÓyÎ˚% ¸ô!Ó˚Óì≈¸ò Óyì¸yˆÏ¢

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Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí Ó,!k¸ £

zì¸ƒy!î Á ¢õ%ˆÏoÓ˚ ≤ÃyÑ¸,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓüˆÏÑ¸ ≤Ã¶¸y!Óì¸ Ñ¸ˆÏÓ˚ – 5.6.2 ¢yõ%!oÑ¸ î)°ÏˆÏíÓ˚ ≤Ã¶¸yÓ (Impact of Marine Pollution) ? x!ì¸!Ó˚_´ ˜ãÓƒ ¸ôîyÌ≈ ¢õ%ˆÏoÓ˚ õˆÏïƒ ˆö¸úyÓ˚ ¸ö¸ˆÏú ö¸y£zˆÏ›¸y≤'yB¸›¸ò ~Ó˚ x!ì¸Ó,!k¸ £Î˚ ÎyÓ˚ ö¸ˆÏú !Óüyú ~úyÑ¸y ã%ˆÏv¸¸ ¢õ%o ¸ô¸ˆÏ¤¸Ó˚ Ó˚Ç ¸ô!Ó˚Óì≈¸ò £Î˚ ~ˆÏÑ¸ ÚÚˆÓ˚v¸ ›¸y£zv¸ÛÛ Á ÓˆÏú– ? !Ó°Ïy_´ ¸ôîyÌ≈ ¢õ%ˆÏo !òˆÏ«¸ˆÏ¸ôÓ˚ ö¸ˆÏú ì¸y Öyîƒ ü,Cú ~Ó˚ õˆÏïƒ ≤ÃˆÏÓü Ñ¸ˆÏÓ˚ ~ÓÇ ¸ôÓ˚Óì¸≈#Ñ¸yˆÏú Ó,£Í ≤Ãyí# ˆÜy¤¸#ñ õyò%°ÏˆÏÑ¸ «¸!ì¸@˘Ãhfl¸ Ñ¸ˆÏÓ˚ – ? õyäÈ ïÓ˚yÓ˚ ãyúñ ≤'y!fi›¸Ñ¸ ~ÓÇ !Ó!¶¸ß¨ ¸ô!úõyÓ˚ ãyì¸#Î˚ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ ¢õ%ˆÏo ¸ôv¸¸yÓ˚ ö¸ˆÏú ÖyˆÏîƒÓ˚ ¢yˆÏÌ Óy ì¸yˆÏì¸ xy›¸Ñ¸y ¸ôˆÏv¸¸ ≤Ãâ%Ó˚ ≤Ãyí# ~ÓÇ ¸ô!Ó˚ÎÎ˚# ¸ôy!Ö õyÓ˚y ÎyˆÏFäÈ– ~Ó˚ ≤ÃÑ,‹T v¸zîy£ÓÓ˚í Óì≈¸õyò Ñ¸yˆÏú Ó˝ !ì¸!õ õyˆÏäÈÓ˚ õ¸ì%¸ƒ £ˆÏFäÈ ÎyˆÏîÓ˚ ˆ¸ôˆÏ›¸Ó˚ !¶¸ì¸Ó˚ ˆÌˆÏÑ¸ ¸ôyÁÎ˚y ÎyˆÏFäÈ ˆÑ¸!ã ˆÑ¸!ã ≤'y!fi›¸Ñ¸ – ? õy£zˆÏe´y≤'y!fi›¸Ñ¸ xyã ¢yõ%!oÑ¸ úÓˆÏíÓ˚ õˆÏïƒÁ ¸ôyÁÎ˚y ÎyˆÏFäÈ– ? ¢õ%ˆÏoÓ˚ î)°ÏˆÏíÓ˚ ö¸ˆÏú ¢yõ%!oÑ¸ õyäÈ Á ÖyÓyÓ˚=!úÓ˚ fl¸∫yî ÖyÓ˚y¸ô £ˆÏFäÈ ÎyÓ˚ ö¸ˆÏú ÓyãyÓ˚ õ)úƒ Ñ¸ˆÏõ xy¢ˆÏäÈ– ? xˆÏÏÎ˚ú !fl¸ôú ÷ï%õye ¢yõ%!oÑ¸ ≤Ãyí# òy !Ó!¶¸ß¨ ¸ô!Ó˚ÎÎ˚# ¸ôy!ÖˆÏîÓ˚Á «¸!ì¸ Ñ¸ˆÏÓ˚ – ? xyõÓ˚y ãy!ò ¢õ%ˆÏo ≤Ãâ%Ó˚ ¸ô!Ó˚õyˆÏí Óyì¸yˆÏ¢Ó˚

57%	**MATCHING BLOCK 143/200**	**SA**	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ˆÏÑ¸ ãˆÏú oÓ#¶)¸ì¸ Ñ¸ˆÏÓ˚ Îy Ñ¸yÓ≈!òÑ¸ xƒy!¢ˆ

Ïv¸ ¸ô!Ó˚Ó!ì≈¸ì¸ £Î˚ – ì¸y£z Óyì¸yˆÏ¢Ó˚

68%	**MATCHING BLOCK 144/200**	**SA**	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸yÓ≈òÈ v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí x!ì¸!Ó˚_´ Ó,!k¸Ó˚

Ñ¸yÓ˚ˆÏí ¢õ%ˆÏoÓ˚ ãˆÏúÓ˚ x¡'¢ Ó,!k¸ ¸ôyˆÏFäÈ ÎyÓ˚ ö¸ú !£¢yˆÏÓ ¢yõ%!oÑ¸ ≤ÃÓyú ~ÓÇ üyõ%Ñ¸ñ !G¸ò%ˆÏÑ¸Ó˚ Ñ¸ƒyú!¢Î˚yõ Ü!‡¸ì¸ xyÓÓ˚í ò‹T £ˆÏÎ˚ ÎyˆÏFäÈ– 5.6.3 ¢yõ%!oÑ¸ î)°Ïí !òÎ˚s¸fí Á ≤Ã!ì¸ˆÏÓ˚yï ¢yõ%!oÑ¸ î)°Ïí ≤

100%	**MATCHING BLOCK 145/200**	**SA**	B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

Ã!ì¸Ñ¸yˆÏÓ˚Ó˚ ~Ñ¸õye v¸z¸ôyÎ˚ £

ú ì)!°Ïì¸ ¸ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚õyí £...y¢ Ñ¸Ó˚y– ì¸y£z ì¸Ó˚ú Óã≈ƒ ¸ô!Ó˚ˆÏüyìò ≤Ã!e΂yÓ˚ õyïƒˆÏõ Ü,£fl¸i!úñ Ñ¸yÓ˚Öyòyñ ˆ£yˆÏ›¸ú £zì¸ƒy!íÓ˚ ˆÌˆÏÑ¸ v¸z¸í¸ôß ì¸Ó˚ú Óã≈ƒ ¸ôîyÌ≈ ¸ô!Ó˚ˆÏüyí ˆÏòÓ˚ ¸ôÓ˚ ˆ¢£zì¸Ó˚úˆÏÑ¸ òí# Óy ¢õ%ˆÏo äÈyv¸¸ˆÏì¸ £ˆÏÓ– ? Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ñ ≤'y!fi›¸Ñ¸ñ äy£yˆÏãÓ˚ ¶¸@¿yÓ˚ˆÏü°Ïñ õyäÈ ïÓ˚y äyú £zì¸ƒy!ï ¢õ%ˆÏo ˆö¸úy â¸úˆÏÓ òy ~ÓÇ ì¸y ¢õ%ˆÏoÓ˚ ˆÌˆÏÑ¸ ì%¸ˆÏú Úúƒyu¸!ö¸úÛÈÙÈ~ ˆö¸úˆÏì¸ £ˆÏÓ– ? ¢õ%ˆÏoÓ˚ ¶¸y¢õyò ˆì¸ú x¸ô¢yÓ˚ í Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ì¸y ˜ã!ÓÑ¸ v¸z¸ôyˆÏÎ˚ (Pscudomonas putida) Óy Ó˚y¢yÎ˚!òÑ¸ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ – ? ¢õ%o ˜¢Ñ¸ì¸ ¸ô!Ó˚‹ÒyÓ˚ ¸ô!Ó˚FäÈß¨ñ ≤'y!fi›¸Ñ¸ õ%_´ Ó˚yÖˆÏì¸ £ˆÏÓ– ? ¢õ%ˆÏoÓ˚ v¸z¸ôÑ)¸ˆÏú ¢ÓÓ˚Ñ¸õ x!ÓK¸yò¢¡øì¸ !òõ≈yíõ)úÑ¸ Ñ¸yãÑ¸õ≈ Óı¸ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ? ¢õ%ˆÏoÓ˚ Öyîƒ fl¸∫“ õyeyÓ˚ @˜Ã£í Ñ¸Ó˚ˆÏì¸ £ˆÏÓ Îyˆì¸ x!ìÑ¸ õÍ¢ !üÑ¸yÓ˚ òy £Î˚ ~ÓÇ ¢yõ%!oÑ¸ ã#Ó ˜Ó!â¸ˆÏeƒÓ˚ £...y¢ òy á˚Ì›¸ – ? ≤ÃÎ%!_´Üì¸ v¸zß¨!ì¸ á›¸yˆÏì¸ £ˆÏÓ Îyˆì¸ ¢õ%oˆÏÑ¸ ì)°Ïí õ%_´ Ñ¸Ó˚y ÎyÎ˚ – NSOU ? AE-ES-21 ? 99
5.7 ì¸y¸ô#Î˚ ì)°Ïí (Thermal Pollution) äúyüÎ˚ ñ òí# Óy ¢õ%ˆÏoÓ˚ õˆÏïƒ v¸z_Æ Óã≈ƒ ¸ôîyÌ≈ ˆõüyÓ˚ ö¸ˆÏú ãˆÏúÓ˚ fl¸∫y¶¸y!ÓÑ¸ ì¸y¸ôõyey x!ì¸!Ó˚_´ Ó¸!k¸ ¸ôyÎ˚ ì¸ˆÏÓ ì¸yˆÏÑ¸ ì¸y¸ô#Î˚ ì)°Ïí ÓˆÏú– ¢yiyÓ˚ íì¸ Ñ¸úÑ¸yÓ˚Öyòy ˆÌˆÏÑ¸ !òÜ≈ì¸ v¸z_Æ ì)!°Ïì¸ äú ÓyEzˆÏÓ˚ òí# òyúyˆÏì¸ ˆö¸úy £Î˚ˆñ ~äÈyv¸¸y !Ó!¶¸ß¨ ì¸y¸ô!Óî%ƒí ˆÑ¸w ˆÌˆÏÑ¸ ≤Ãâ%¸Ó˚ ¸ô!Ó˚õyˆÏí v¸z_Æ äú ÓyEzˆÏÓ˚Ó˚ òí# òyúyˆÏì¸ ˆö¸úyÎ˚ ãˆÏúÓ˚ fl¸∫y¶¸y!ÓÑ¸ ì¸y¸ôõyey x!ì¸!Ó˚_´ õyeyÎ˚ Ó¸!k¸ ¸ôyÎ˚ – ˆÎ ˆÑ¸yò Îy!s¸fÑ¸ Ñ¸yãÑ¸ˆÏõ≈Ó˚ ˆ«¸ˆÏe ÷ì%õye 40% ì¸y¸ô Ñ¸yˆÏã úyˆÏÜ Óy!Ñ¸ 60% ì¸y¸ô ò‹T £Î˚ ~ÓÇ ˆ¢£z ì¸y¸ô ¸ô!Ó˚ˆÏÓˆÏü ˆÓ!Ó˚ˆÏÎ˚ ì¸y¸ô#Î˚ ì)°Ïí á›¸yÎ˚ – 5.7.1 ì¸y¸ô#Î˚ ≤Ã¶¸yÓ (Effects of Thermal Pollution) ì¸y¸ô#Î˚ ì)°ÏˆÏíÓ˚ ≤Ã¶¸yˆÏÓÈÙÙÈ S1V ãˆÏú oÓ#¶)¸ì¸ x!:ˆÏãˆÏòÓ˚ ¸ô!Ó˚õyí £...y¢ ¸ôyÎ˚ – S2V v¸z_Æ Óã≈ƒ ¸ôîyÌ≈ ãˆÏú ¸ôv¸¸yÓ˚ ¢yˆÏÎ ¢yˆÏÎ ì¸yÓ˚ xyˆÏü¸ôyˆÏüÓ˚ ì¸y¸ôõyey x!ì¸!Ó˚_´ Ó¸!k¸ ¸ôyÓyÓ˚ ö¸ˆÏú ¢Ñ¸ú ≤ÃyíÓ˚ õ¸ì%¸ƒ á˚Ì›¸ – S3V ì¸y¸ôõyey Ó¸!k¸Ó˚ ö¸ˆÏú ≤Ãyí#Ó˚ ˜ã!ÓÑ¸ !e΂yÑ¸úy¸ô Óƒy£ì¸ £Î˚ñ ≤ÃÄòò Á !v¸õ ¸ôyv¸¸yÁ Óƒy£ì¸ £Î˚ – S4V ì¸y¸ôõyey Ó¸!k¸ ˆ¸ôˆÏú ãˆÏú ì)!°Ïì¸ ¸ôîyÌ≈ xˆÏòÑ¸ ˆÓ!ü ¸ô!Ó˚õyˆÏí oÓ#¶)¸ì¸ £Î˚ – S5V ì¸y¸ôõyey Ó¸!k¸Ó˚ ö¸ˆÏú ˆÎ ¢Ñ¸ú ≤Ãyí# Óy xò%ã#Ó

76%	MATCHING BLOCK 146/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ì¸y¸ôõyey ¢£ƒ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ÷ì% ì¸yÓ˚y£

z ˆÓ§ˆÏâ¸ Îy˚ˆÏÑ¸ Óy!Ñ¸Ó˚y õyÓ˚y ÎyÎ˚ ö¸ˆÏú fl¸∫y¶¸y!ÓÑ¸ Óylfl¸ì¸s¸ƒ !Ó!á˚ì¸ £Î˚ – 5.7.2 ì¸y¸ô#Î˚ ì)°ÏˆÏíÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ ì¸y¸ô#Î˚ ì)°Ïí ! òÎ˚s¸fí Ñ¸Ó˚yÓ˚ äòƒ Ó¸£í Ü¶¸#Ó˚ äúyüÎ˚ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ ì¸yÓ˚ õˆÏïƒ ≤ÃÌˆÏõ v¸z_Æ äú ˆö¸úˆÏú ì¸y‡¸y[¸y £ˆÏì¸ !ıˆÏÎ˚ xyÓyÓ˚ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – Cooling TowerÈÙÈ~Ó˚ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ Á v¸z_Æ ÜÓ˚õ äú ‡¸y[¸y Ñ¸ˆÏÓ˚ ì¸y ¸ô%òÓ˚yÎ˚ ¸ô! Ó˚ˆÏüyìò Ñ¸ˆÏÓ˚ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – ~äÈyv¸¸y äòÜí ì¸yˆÏíÓ˚ ÓƒÓ£*ì¸ Îs¸f¸ôy!ì¸ ¢%ÓƒÓ£yÓ˚ xÌ≈yí x≤Ã˚ˆÏÎ˚ˆyãò#Î˚ ¢õÎ˚ Îs¸fyÇü Óı¸ Ó˚yÖˆÏú ì¸y¸ô v¸zí¸ôß¨ Ñ¸õ £ˆÏÓ– ÓƒÓ£*ì¸ ¢¡ôˆÏíÓ˚ fl¸∫“ v¸zí¸ôyìò Ñ¸Ó˚ˆÏú v¸zí¸ôß¨ ì¸yˆÏ‡¸ôÓ˚ ¸ô!Ó˚õyí fl¸∫“ £ˆÏÓñ Ñ¸yÓ˚Öyòy Óy ì¸y¸ô v¸zí¸ôyìò ˆ«¸ˆÏeÓ˚ â¸y!Ó˚ ¸ôyˆÏÎ˚ª≈ Ó¸«¸ˆÏÓ˚y¸ôˆÏíÓ˚ myÓ˚y ì¸y¸ô#Î˚ ì)°Ïí !òÓyÓ˚í ¢Ω¸Ó– 5.8 Ñ¸! ‡¸ò Óã≈ƒ ¸ôîyÌ≈ Á ì¸yÓ˚ ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Solid Waste Management) Óã≈ƒ ¸ôîyÌ≈ Ñ¸#/Ñ¸yÎ˚≈!¢!k¸ £ÓyÓ˚ ¸ôÓ˚ Óy ÓƒÓ£yÓ˚ Ñ¸Ó˚yÓ˚ ¸ôÓ˚ ˆÑ¸yò Óìfl¸ Óy ¸ôîyÌ≈ ÎÓò xyÓ˚ ÓƒÓ£yÌ≈ ÎyˆÏÑ¸ òy ~ÓÇ ì¸yˆÏÑ¸ ˆö¸úˆÏú ˆìÂ˚y £Î˚ Óy ˆö¸úˆÏú ˆìÂ˚y £ˆÏÓ ÓˆÏú ‡¸Ñ¸ Ñ¸Ó˚y £Î˚ – ˆ¢£z Óìfl¸ Óy ¸ôîyÌ≈ˆÏÑ¸ ˜ãÓ ¸ôîyÌ≈ ÓˆÏú– Ñ¸‡¸ò Óã≈ƒ ¸ôîyÌ≈ÈÙÙÈ xÓƒÓ£*ì¸ Ñ¸‡¸ò Óìfl¸ ¢yõ!@˜Ã Îy xyõÓ˚y ˜ò!®ò !e΂yÑ¸úy¸ôÓ˚ õyïƒˆÏõ xÓ!fl¸ìì¸ Óìfl¸ !£¢yˆÏÓ Óã≈ò Ñ¸ˆÏÓ˚ Îy!Ñ¸ ñ ì¸y£z Ñ¸‡¸ò Óã≈ƒ ¸ôîyÌ≈– ~£z Ñ¸‡¸ò Óã≈ƒ ¸ôîyÌ≈ Ü,£fl¸i!úñ !ü“ˆÏ«¸ ˆÏëñ Ö!òÓ˚ Ñ¸yã Óy Ñ¸,!°Ï 100 ? NSOU ? AE-ES-21
Ñ¸yˆÏãÓ˚ ˆÌˆÏÑ¸ v¸z¸í¸ôß¨ £ˆÏÎ˚ ÌyˆÏÑ¸ – ¸Óã≈ƒ ¸ôîyÌ≈ ˜ãÓ ˆÎõòÈÙÙÈ Óã≈ƒ ÖyîƒyÓ˚ ˆÏü°Ïñ õyäÈñ õyÇˆÏ¢Ó˚ ˆî£yÓ˚ˆÏü°Ï– îy£ƒ ˆÎõòÈÙÙÈ Ñ¸y‡¸ñ Ñ¸yÜãñ Ó˚yÓyÓ˚ ó xîy£ƒÈÙÙÈ ˆÎõòÈÙÙÈÑ§¸yâ¸ñ ìyì¸Ó Óìfl¸ñ ¸ôyÌÓ˚ £zì¸ƒy!î– 5.8.1 Ñ¸!‡¸ò Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ≤ÃÑ¸yÓ˚ˆÏ¶¸î (Types of Solid Waste) ≠ v¸zí¸ô!_

55%	MATCHING BLOCK 148/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ó˚ v¸z¸ôÓ˚ !¶¸!_Ñ¸ ˆÏÓ˚ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ˆÏÑ¸ 3!›¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ –

S1V ˆ¸ôÓÓ˚ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ (Municipal solid waste) ≠ Ü,£fl¸i!ú ˆÌˆÏÑ¸ v¸zí¸ôß¨ Óã≈ƒ ¸ôîyÌ≈ ˆÎõòÈÙÙÈ xy¢ÓyÓ¸ô ˆÏeÓ˚ ¶¸@¿yÓ˚ˆÏü°Ïñ !òõ≈yí Ñ¸yˆÏã v¸zí¸ôß¨ Óã≈ƒñ Ñ¸#›¸òyüÑ¸ñ Ó˚ Çñ ¢yÓyòñ Óƒy›¸y!Ó˚ñ ≤'y!fi›¸ˆÏÑ¸Ó˚ ˜ì¸!Ó˚ Óã≈ƒñ ˆì¸ã!‹¸ ¸ôîyÌ≈ £zì¸ƒy!íñ ˆ¸ôÓÓ˚ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚â¸yúò ~ÓÇ !òÎ˚s¸fí £Î˚ ¢Ó˚Ñ¸yˆÏÓ˚ˆÓ˚ ˜ì¸!Ó˚ Municipal Solid Waste Rules, 2000 xy£zò myÓ˚y– S2V !ü“ˆÏ«¸e Á !Ó¸ôìÑ¸ Óã≈ƒ ¸ôîyÌ≈ ≠ !ü“ˆÏ«¸ˆÏe ÓƒÓ£*ì¸ Ñ§¸yâ¸yõyú Á ¸ôˆÏv¸¸ Îy˚Ñ¸y Óã≈ƒ ¸ôîyÌ≈ ~ÓÇ ! Ó¸ôìÑ¸ Óã≈ƒ ~£z ¶¸yˆÏÜÓ˚ õˆÏïƒ xhs¸Ü≈ì¸ – Hazardus Waste Rules, 1989 myÓ˚y ~£z ïÓ˚ˆÏòÓ˚ Óã≈ƒ !òÎ˚s¸fí Ñ¸Ó˚y £Î˚ – S3V ! â¸!Ñ¸{¢yì¸ Óã≈ƒ ¸ôîyÌ≈ ≠ £¢!¸ô›¸yúñ òy!¢≈Ç ˆ£yõ ˆÌˆÏÑ¸ !â¸!Ñ¸{¢yÓ˚ äòƒ v¸zí¸ôß¨ òyòy Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ ˆÎõòÈÙÙÈ ì%¸úyñ !¢!ÓÓ˚Oñ ä%ÈÈ¸â¸ñ Ë°ïˆÏïÓ˚ ˆÓyì¸úñ Ñ¸ƒyˆÏÌ›¸yÓ˚ ñ x¸ôyˆÏÓ˚ü¸ò Óyí ˆìÂ˚y òyòy xD £zì¸ƒy!î– Biomedical Waste Rules, 1998 myÓ˚y £z£y !òÎ˚!s¸fì¸ £Î˚ – 5.8.2 Ñ¸!‡¸ò ¸Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy (Solid Waste Management) ≠ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ üÉÓ˚yM¸Èúñ !ü“ˆÏ«¸e ˆÌˆÏÑ¸ !ò!î≈‹T ¢õˆÏÎ˚ ¸ôÓ˚ ì¸yÓ˚ !òï≈y!Ó˚ì¸ äyÎ˚ÜyÎ˚ Óyˆ̃Ïã≈ƒÓ˚ !ò‹ô!_ á›¸yˆÏòy £Î˚ – ¢%ì¸Ó˚yÇ Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚â¸yúò ÓƒÓfl¸iyÓ˚ ≤Ãïyò !ì¸ò!› ïy¸ôÈÙÈÓã≈ƒ ¸ôîyÌ≈ ¢Ç@˜Ã£ñ ¸ô!Ó˚Ó£ò Á !ò!î≈‹T fl¸iyˆÏò ì¸yÓ˚ !ò‹ô!_ Ñ¸Ó˚ò– ? Óã≈ ¸ôîyˆÏÌ≈Ó˚ ¢Ç@˜Ã£ ¸ök¸!ì¸ ≠ ¢yiyÓ˚ íì¸ üÉÓ˚yM¸Èú ˆÌˆÏÑ¸ ˆ¸ôÓÓ˚ ¢¶¸yÓ˚ Üy!v¸¸Ó˚ Óy!v¸¸ Óy!v¸¸ ˆÌˆÏÑ¸ Óã≈ƒ ¢Ç@˜Ã£ Ñ¸ˆÏÓ˚ Óy Ó˚yhfl¸yÓ˚ ïyˆÏÓ˚ !Ó!¶¸ß¨ !ò!î≈‹T fl¸iyˆÏò Óã≈ƒ ˆö¸úyÓ˚ äyÎ˚ÜyÎ˚ Ó˚yÖy £Î˚ ì¸ˆÏÓ ì%¢£z ˆ«¸ˆÏe£z ! õ◊Óã≈ƒ ˆö¸úy £Î˚ – ì¸ˆÏÓ ˆÑ¸yò ˆÑ¸yò ˆ«¸ˆÏe ˆ¸ôÓÓ˚ Ñ¸õ≈#ˆÏÓ˚ Óã≈ƒ xyúyîy Ñ¸ˆÏÓ˚ !ò‹ô!_Ó˚ îy!Îc ˆìÂ˚y £Î˚ – ¢yiyÓ˚ íì¸ ¸ôâ¸ò¢%#ú Óìfl¸ ~ÓÇ ¸ô%òÈÓÓ#Ñ¸Ó˚ˆÏí ˆÎyÜƒ Óìfl¸ xyúyîy Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ – ? Óã≈ƒ ¸ôîyÌ≈ ¸ô!Ó˚Ó£ò ≠ Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚ Ó˚Ó£ˆÏòÓ˚ äòƒ !Ó!¶¸ß¨ ïÓ˚ˆÏòÓ˚ Üy!v¸¸Ó˚ ÓƒÓ£yÓ˚ Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ – ˆäÈy›¸ Üy!v¸¸ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ Óy!v¸¸ Óy!v¸¸ ˆÌˆÏÑ¸ Óã≈ƒ ¢Ç@˜Ã£ Ñ¸Ó˚y £Î˚ ~ÓÇ Óv¸¸ Üy!v¸¸ ˆì¸ñ ›¸ΔyÑ¸ Óy â¸yÑ¸y Î%_´ Üy!v¸¸ ˆì¸ Ñ¸ˆÏÓ !ò!î≈‹T fl¸iyˆÏò !òˆÏÎ˚ ÎyÂ˚y £Î˚ – £y¢¸ôyì¸yú äyì¸ Óã≈ƒ ¸ôîyÌ≈ ¸ô!Ó˚Ó£ò Ñ¸Ó˚y £Î˚ – ? Ñ¸!‡¸ò Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ !ò‹ô!_Ñ¸Ó˚í ≠ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyˆÏÌ≈Ó˚ !ò‹ô!_Ñ¸Ó˚í òyòy¶¸

61% **MATCHING BLOCK 147/200** **W**

y˜ÏÓ Ñ¸Ó˚y £˜Ïî˚ ìy˜ÏÑ¸ ì¸y˜ÏìÓ˚ õ˜Ïïƒ v¸z˜ÏÕ'Ö˜ÏîyÜƒ £

úÈÙÙÈ S1V ¢ƒy!ò›¸y!Ó˚ úƒyu¸!ö¸"¸ S2V ¶¸!fl¸ø¶)¸ì¸ Ñ¸Ó˚y S3V Óã≈ƒ ¸ôîyì≈ ¸ô!â¸˜Ïî˚ ˜ãÓ¢yÓ˚ ˜ì¸!Ó˚ Ñ¸Ó˚y– S1V ¢ƒy!ò›¸y!Ó˚ úƒyu¸!ö¸"¸ ≠ ~£z ¸ôk¸!ì¸˜Ïì¸ ~Ñ¸!›¸ !ò!î≈‹T fl¸iyò˜ÏÑ¸ ¸ô%Ñ%¸˜ÏÓ˚Ó˚ òƒyÎ˚ Öòò Ñ¸Ó˚y £Î˚ ~ÓÇ x˜Ï¶¸îƒ xyÓÓ˚í myÓ˚y xyÓ‚ì¸ Ñ¸Ó˚y £Î˚ îy˜Ïì¸ ˆÑ¸yò î)!°ì¸ ¸ôîyì≈ñ ì¸Ó˚ú ¶)¸Ü˜Ï¶≈¸ â¸˜Ïú ˆÎ˜Ïì¸ òy ¸ôy˜ÏÓ˚ – ≤Ãì˜Ïõ xyÓã≈òyÓ˚ ˜ãÓ xÇü xyúyîy Ñ¸˜ÏÓ˚ ~Ñ¸!›¸ hfl¸˜ÏÓ˚ äÈ!v¸¸˜Ïî˚ ˆìÁÎ˚y £Î˚ ~ÓÇ hfl¸˜ÏÓ˚Ó˚ v¸zFâ¸ì¸y 2 !õ›¸y˜ÏÓ˚Ó˚ õ˜Ïì¸y ìy˜ÏÑ¸ – ¸ô˜ÏÓ˚ ≤ÃyÎ˚ 20 ˆ¢.!õ.ÈÙÈ~Ó˚ õ˜Ïì¸y õy!›¸Ó˚ ≤Ã˜Ïú¸ô NSOU ? AE-ES-21 ? 101 ˆìÁÎ˚y £Î˚ – ~£z ¶¸y˜ÏÓ hfl¸!Ó˚ ¶)¸ì¸ Ñ¸Ó˚˜Ïì¸ Ñ¸Ó˚˜Ïì¸ xÓ˜Ïü˜Ï°Ï ~Ñ¸!›¸ ¸ô%Ó˚&õy!›¸Ó˚ hfl¸Ó˚ !î˜Ïî˚ ë¸yÑ¸y ˆìÁÎ˚y £Î˚ îy˜Ïì¸ ˆÑ¸yò £zßî%Ó˚ äyì¸#Î˚ ≤Ãyí# ë%¸Ñ¸˜Ïì¸ òy ¸ôy˜ÏÓ˚ – !Ó˚˜Ïî˚yãÑ¸˜ÏìÓ˚ ˜ãÓ ¸ôîy˜Ïì≈Ó˚ !Ó˚˜Ïî˚yãò !e˜Î˚y á›¸y˜ÏòyÓ˚ ¸ôÓ˚ ˆÎ ˜ãÓÜƒy¢ !òÜ≈ì¸ £Î˚ ì¸y Óy£z˜ÏÓ˚ ˆÓ˚˜ÏÓ˚yÓyÓ˚ äòƒ ¸ôy£z¸ô myÓ˚y ÓƒÓfl¸iy Ñ¸Ó˚y ìy˜ÏÑ¸ – ~£z Üƒy¢ x˜ÏòÑ¸ ¢õî˚ äµyúy!òÓ˚ Ñ¸y˜ÏäÁ ¢Ç@˜Ã£ Ñ¸Ó˚y £Î˚ – ~£z ¸ôk¸!ì¸˜Ïì¸ xyÓã≈òy ã!òì¸ ˆÓ˚yÜä#Óyí% v¸zí¸ôß¨ £Î˚ òy– S2V Óã≈ƒ ¸ôîyì≈ ¶¸!fl¸ø¶)¸ì¸ Ñ¸Ó˚y (Incineration) ≠ x˜ÏãÓ îy£ƒ ¸ôîy˜Ïì≈Ó˚ ˆ«¸˜Ïe ~!›¸ ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – Ü‚£fl¸ì!úÓ˚ ~ÓÇ xîy£ƒ ¸ôîyì≈ SÑ§¸yâ¸ñ ïyì¸Ó ¸ôîyì≈V xyúyîy Ñ¸Ó˚y £Î˚ – ~£z ¢õhfl¸ ¸ôîyì≈˜ÏÑ¸ !Ó˚˜Ïü°Ï¶¸y˜ÏÓ ≤Ãìfl¸ì¸Ñ¸¸ì¸ ö¸yÓ˚˜Ïò˜Ï¢Ó˚ õ˜Ïïƒ v¸zFâ¸ ì¸y˜Ï¸ô ≤ÃyÎ˚ 815°C ì¸y¸ôõyeyÎ˚ x!:˜Ïã˜ÏòÓ˚ v¸z¸ô!fl¸i!ì¸˜Ïì¸ ˆ¸ôyv¸¸y˜Ïòy £Î˚ – ~Ó˚ ö¸˜Ïú Óã≈ƒÓ˚ xyÎ˚ì¸ò ≤ÃyÎ˚ 90% ~ÓÇ Áãò 75% ¸ôî≈hs¸ £...y¢ ¸ôyÎ˚ – ~!›¸Ó˚ ãòƒ Ö%Ó£z fl¸∫" xyÎ˚ì¸˜ÏòÓ˚ äyÎ˚Üy ≤Ã˜Ïî˚yãò– Î!íÁ Óy ~£z ¸ôk¸!ì¸˜Ïì¸ xÓ!ü‹TyÇü äÈy£z !£¢y˜ÏÓ˚ ¸ô˜Ïv¸¸ ìy˜ÏÑ¸ ~ÓÇ Óyì¸y˜Ï¢ î)!°ì¸ Üƒy¢ !òÜ≈õò £Î˚ îy Ö%Ó£z «¸!ì¸Ñ¸yÓ˚Ñ¸ – S3V Óã≈ƒ ¸ôîyì≈ ¸ô!â¸˜Ïî˚ ˜ãÓ¢yÓ˚ ˜ì¸!Ó˚ (Composting) ≠ ~£z ¸ôk¸!ì¸˜Ïì¸ ˜ãÓ ¸ôîyì≈˜ÏÑ¸ Óƒy˜ÏQ!Ó˚˜Î˚y myÓ˚y ¸ôâ¸ò Ñ¸Ó˚y˜Ïòy £Î˚ ~ÓÇ !£v¸zõy˜ÏÇÓ˚ ¢!‹T Ñ¸Ó˚y £Î˚ îy ¸ôÓ˚ Óí≈¸#Ñ¸y˜Ïú ˜ãÓ¢yÓ˚ !£¢y˜ÏÓ˚ ÓƒÓ£*ì¸ £˜Ïì¸ ¸ôy˜ÏÓ˚ – ~£z ¸ôk¸!ì¸!›¸ x!:˜Ïã˜ÏòÓ˚ v¸z¸ô!fl¸i!ì¸ ~ÓÇ xò%¸ô!fl¸i!ì¸ î%£z ¸ôk¸!ì¸˜Ïì¸ Ñ¸Ó˚y ˆÎ˜Ïì¸ ¸ôy˜ÏÓ˚ – ~£z ¸ôk¸!ì¸˜Ïì¸ !¸ô˜Ï›¸Ó˚ õ˜Ïïƒ˜ÏÓ˚ ì¸y¸ôõyey ˆÖü# îyÑ¸yÓ˚ äòƒ õüy õy!äÈÓ˚ úy¶≈¸y Óy !v¸õ !Ñ¸ä%ÈÈ£z ˆÓ§˜Ïã¸ îy˜ÏÑ¸ òy ì¸˜ÏÓ ~£z ¸ôk¸!ì¸˜Ïì¸ äyÎ˚Üy ~ÓÇ ¢õÎ˚ v¸z¶¸Î˚ x!ì¸!Ó˚_´ úy˜ÏÜ– !â¸e 5.1 ≠ ¢ƒy!ò›¸y!Ó˚ úƒyu¸!ö¸"¸ 102 ? NSOU ? AE-ES-21 1998 ¢y˜ÏúÓ˚ Biomedical Waste (Management and Handling) RuleÈÙÈ~Ó˚ !òÎ˚õ xò%¢y˜ÏÓ˚ £y¢¸ôyì¸yúäyì¸ Óã≈ƒ ¸ôîy˜Ïì≈Ó˚ xyúyîy¶¸y˜ÏÓ !òÓ!_ á›¸y˜ÏòyÓ˚ ÓƒÓfl¸iy Ñ¸Ó˚y £˜Ïî˚ ìy˜ÏÑ¸ñ îy !ò˜Ïâ¸ ˆìÁÎ˚y £úÈÙÙÈ e˜!õÑ¸ Ñ¸ƒy˜Ï›¸Ü!Ó˚ Óã≈ƒ !Óòyü ÓƒÓfl¸iy ¢yÇ˜ÏÑ¸!ì¸Ñ¸ Ó˚Ç ¢ÇÖƒy ~ÓÇ xyîyÓ˚ 1 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ1 õyòÓ Óã≈ƒ ≠ ¸ô%!v¸¸˜Ïî˚ ˆö¸úy Óy £ú%î ≤'y!fi›¸Ñ¸ ÓƒyÜ õò%°ïƒüÓ˚#˜ÏÓ˚Ó˚ Ñ¸úyñ xDÈÙÈ≤Ãì¸ƒD ¢õ)£ Ü¶¸#˜ÏÓ˚ ¸ô%§˜Ïì¸ ˆìÁÎ˚y 2 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ2 ≤Ãyí#Ó˚ Óã≈ƒ ≠ ≤Ãyí#Ó˚ Ñ¸úy ¢õ)£ñ xDñ üÓ˚#˜ÏÓ˚Ó˚ xÇüñ ¸ô%!v¸¸˜Ïî˚ ˆö¸úy Óy £ú%î ≤'y!fi›¸Ñ¸ ÓƒyÜ Ó˚_´y_´ xÇü ~ÓÇ üÓ˚#˜ÏÓ˚Ó˚ ì¸Ó˚úñ Ü¶¸#˜ÏÓ˚ ¸ô%§˜Ïì¸ ˆìÁÎ˚y ÜÓy!î ¸ô÷Ó˚ £y¢¸ôyì¸yú Á ˆõ!v¸Ñ¸ƒyú Ñ¸˜Ïúã ˆÎ˜ÏÑ¸ !òÜ≈ì¸ Óã≈ƒ ¢õ)£ 3 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ3 ã#Óyí%!ÓK¸yò Á ã#Ó≤Ã%!_´ ã!òì¸ fl¸iyò#Î˚ x˜Ï›¸y˜ÏÑœ¸¶¸/ £ú%î ≤'y!fi›¸Ñ¸ ÓƒyÜ/úyú Óã≈ƒ ≠ õy£z˜Ïe´yÁ˜Ïî˚¶¸ myÓ˚y ¢Çe´y!õì¸ ≤'y!fi›¸Ñ¸ ÓƒyÜ úƒy˜ÏÓy˜ÏÓ˚›¸!Ó˚ Á Ü˜ÏÓ°ïîyÜì¸ ÓƒÓ£*ì¸ ¸ô%!v¸¸˜Ïî˚ ˆö¸úy/ ¸ô%!v¸¸˜Ïî˚ õyì¸%Ï ~ÓÇ xòƒyòƒ ≤Ãyí#Ó˚ ˆÑ¸y°Ïñ ˆö¸úy xò%ã#Óñ !Ó!¶¸ß¨ ¶¸ƒy!:˜ÏòÓ˚ xÓ!ü‹TyÇüñ !Ó°Ïy_´ Óã≈ƒ ¸ôîyì≈ 4 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ4 ïyÓ˚y˜Ïúy Îfl¸ƒ!î ≠ !òÓ≈ãñÓ˚í SÓ˚y¢yÎ˚ !òÑ¸ / ü_´ ò#ú Óy ¢yîy {°ÏîFäÈ ä%È!Ó˚ñ ¢)â¸ñ !¢!Ó˚Oñ ˆÓœv¸ñ Ñ§¸yâ¸ñ õy£z˜Ïe´yÁ˜Ïî˚¶¸/x˜Ï›¸y˜ÏÑœ¸¶¸ ÓƒyÜ £zì¸ƒy!î îy úúƒ !â¸!Ñ¸¢yÎ˚ ÓƒÓ£*ì¸ £Î˚ ÓƒÓ£yÓ˚ Ñ¸˜ÏÓ˚ V ~ÓÇ =§˜Ïv¸¸y Ñ¸Ó˚y 5 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ5 x≤Ã˜Ïî˚yã#Î˚ Á°Ï%ïí ≠ ¸ô%!v¸¸˜Ïî˚ ˆö¸úy ~ÓÇ Ñ¸y˜Ïúy ≤'y!fi›¸˜ÏÑ¸Ó˚ ÓƒyÜ ˆõÎ˚ì v¸z_#í≈ ~ÓÇ Ñ¸ú%!°ì¸ £˜Ïî˚ !òÓ˚y¸ôî Ü˜Ïì≈¸ !ò˜Ï«¸¸ô îyÁÎ˚y Ë°Ï%ïï ¢õ)£ Ñ¸Ó˚y 6 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ6 Ñ¸!‡¸ò Óã≈ƒ ≠ x˜Ï›¸y˜ÏÑœ¸¶¸ ~ÓÇ £ú%î / úyú ≤'y!fi›¸Ñ¸ ÓƒyÜ ÷Ñ¸˜Ïìy ¸ô%§ãÓ˚_´ñ Ó˚_´y_´ ì%¸˜Ïúyñ õyÎ˚z˜Ïe´yÁ˜Ïî˚¶¸ ÓƒÓ£yÓ˚ ≤'yfi›¸yÓ˚ Ñ¸yfi›¸ñ Üã £zì¸ƒy!î Ñ¸Ó˚y £Î˚ 7 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ7 Ñ¸!‡¸ò Óã≈ƒ ≠ ïyÓ˚y˜Ïúy Óã≈ƒ ÓƒÓ£#ì¸ ˆÓ˚y¢yÎ˚ !òÑ¸ ÓƒÓ£yÓ˚ Ñ¸˜ÏÓ˚ úyú ≤'y!fi›¸Ñ¸ ÓƒyÜ / ü_´ xòƒyòƒ Óã≈ƒñ ˆîõòÈÙÈ ¸ôyÑ¸ñ !òÓ≈ã Ñ¸Ó˚í / x˜Ï›¸y˜ÏÑœ¸¶¸ñ ò#ú Óy ¢yîy {°ÏîFäÈ ÓƒyÜ Ñ¸ƒy˜Ïì¸yÓ˚ñ !üÓ˚y Óy v¸z¸ô!üÓ˚y Ñ¸Ó˚y/=§˜Ïv¸¸y Ñ¸Ó˚y ¢õ)˜ÏìÓ˚ õ˜Ïïƒ !î˜Ïî˚ â¸y!úì¸ Ñ¸Ó˚yÓ˚ Îfl¸ƒ!î S˜ü!Ó˚ 8 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ8 ì¸Ó˚ú Óã≈ƒ ≠ Ó˚y¢yÎ˚!òÑ¸ ÓƒÓ£yÓ˚ Ñ¸˜ÏÓ˚ úƒy˜ÏÓy˜ÏÓ˚›¸!Ó˚ ˆì˜ÏÑ¸ ˆÓÓ˚˜Ïòy òyòy !òÓ≈ãñÓ˚í ~ÓÇ ˆv»¸˜Ïò ì¸Ó˚ú ¸ôîyì≈ñ ˜ïyÎ˚yÓ˚ äòƒ ~ÓÇ !ò˜Ï«¸¸ô Ñ¸Ó˚y !òÓ≈ãñÓ˚˜ÏíÓ˚ äòƒ v¸zí¸ôß¨ ì¸Ó˚ú 9 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ9 ¶¸fl¸ø#Ñ¸¸ì¸ Óìfl¸ ¢õ)£ ≠ !òÓ˚y¸ôî Ü˜Ïì≈¸ !ò˜Ï«¸¸ô Ñ¸y˜Ïúy¸ ≤'y!fi›¸˜ÏÑ¸Ó˚ ÓƒyÜ Óy˜ÏîyÈÙÈ˜õ!v¸Ñ¸ƒyú Óã≈ƒ ˆ¸ôyv¸¸y˜ÏòyÓ˚ Ñ¸Ó˚y ¸ôÓ˚ v¸zí¸ôß¨ äÈy£z 10 Ñ¸ƒy˜Ï›¸Ü!Ó˚ÈÙÈ10 Ó˚y¢yÎ˚!òÑ¸ Óã≈ƒ ≠ Ó˚y¢yÎ˚!òÑ¸ ÓƒÓ£yÓ˚ Ñ¸˜ÏÓ˚ Ñ¸y˜Ïúy ≤'y!fi›¸˜ÏÑ¸Ó˚ ÓƒyÜ ˜ãÓ ¸ôîyì≈ÈÙÈ˜ì¸!Ó˚ ˜Ïì¸ ÓƒÓ£*ì¸ !òÓ≈ãñÓ˚í ~ÓÇ ˆv»¸˜Ïò Ó˚y¢yÎ˚!òÑ¸ ~ÓÇ ˆÓ˚yÜÓ#ã òyüÑ¸ Óy !òÓ˚y¸ôî Ü˜Ïì≈¸ !ò˜Ï«¸¸ô Ó˚y¢yÎ˚!òÑ¸ ¸ôîyì≈ Ñ¸Ó˚y NSOU ? AE-ES-21 ? 103 5.9 ¸ô!Ó˚˜ÏÓü !Ó¸ôî≈Î˚ (Environmental Disaster) !Ó¸ô≈î˚ ~õò ~Ñ¸!›¸ á›¸òy Óy á›¸òyÓ˚ ¸ôî≈yÎ˚ e˜õ îy fl¸∫y¶¸y!ÓÑ¸ ã#ÓòÎ˚ey ! Óò‹T Ñ¸˜ÏÓ˚ñ ≤ÃyíÎ˚!ò á›¸yÎ˚ – Óv¸¸ Óv¸¸ !òõ≈yí˜ÏÑ¸ ïπÇ¢ Ñ¸˜ÏÓ˚ñ ~ÓÇ ~£z ¢õhfl¸ !Ñ¸ä%È˜ÏÑ¸ ¢!‡¸Ñ¸ xÓfl¸iyÎ˚ xyò˜Ïì¸ !Ó˚˜Ïü°Ï xy¸ôîÑ¸¸ú#ò ÓƒÓfl¸iy¸òyÓ˚ ≤Ã˜Ïî˚yãò £˜Ïî˚ ¸ô˜Ïv¸¸ – ¸ô!Ó˚˜ÏÓü !Ó¸ô≈î˚ ≤ÃyÑ¸,!ì¸Ñ¸ Ñ¸Ó˚Ó˚ ˜Ïì¸ xyÓ˚ò ¢Ç‹T Ñ¸yÓ˚ò ˜ÏíÁ¸ô ˆìÁ˚ £˜Ïî˚ – S1V ≤ÃyÑ¸,!ì¸Ñ¸ !Ó¸ô≈î˚ (Natural Disaster) ≠ ¸ô!Ó˚˜ÏÓ˚˜ÏüÓ˚ ¢Ç!Ÿ'‹T v¸z¸ôyÎò≈!ú Îòò õyò%˜Ï°ÏÓ˚ ¸ô˜Ï«¸ ≤Ã!ì¸Ñ¸)ú £Î˚ ì¸Öò ì¸y˜ÏÑ¸ ≤ÃyÑ¸,!ì¸Ñ¸ !Ó¸ô≈î˚ Óúy £Î˚ – ≤ÃyÑ¸,!ì¸Ñ¸ !Ó¸ô≈î˚ ˆ¶¸Ô˜ÏÜy!úÑ¸ £˜Ïì¸ ¸ôy˜ÏÓ˚ñ ˆÎõòÈÙÙÈ Óòƒyñ ÖÓ˚yñ ¶)¸!õÑ¸¸ôñ ¢%ÓyÎ!õ ¢yÜ˜Ïî˚Ó˚ã¸òñ x@¿%Ï¸ôyì¸ £zì¸ƒy!î– xyÓyÓ˚ ˜ã!ÓÑ¸ £˜Ïì¸ ¸ôy˜ÏÓ˚ ˆîõòÈÙÙÈ ¢Çe´yõÑ¸ Óƒy!ï S˜≤'Üñ £z˜ÏÓyúñ xƒyò%Ï y: ≤Ã¶¸y!ÓV– S2V õò%°Ïƒ ¢‹T !Ó¸ô≈î˚ (Man-made Disaster) ≠ ~£z !Ó¸ô≈î˚ á›¸yÓ˚ ˆ«¸˜Ïe ¢yïyÓ˚í¶¸y˜ÏÓ ≤

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Ãì¸ƒ«¸ Óy ¸ô˜ÏÓ˚y«¸¶¸y˜ÏÓ õyò%˜Ï°ÏÓ˚ ¶)¸!õÑ¸y

xy˜ÏäÈ ~ÓÇ ~Ó˚ ≤Ã¶¸y˜ÏÓ ≤ÃyíÓyü Á ¢¡ô!_Ó˚ !Óòyü á˜Ï›¸ ìy˜ÏÑ¸ –

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v¸zîy£Ó˚í !£¢y˜ÏÓ Óúy ˆÎˆÌ¸ ¸ôy˜ÏÓ˚

ñ ¸ôyÓ˚õyí!ÓÑ¸ !Ó˜Ïfl¸≥¸yÓ˚íñ ¶)¸!õ«¸Î˚ Üƒy¢ !òÉ¢Ó˚í ~äÈyv¸ ¸y ¸òl î%á≈›¸òyñ ˆÓ˚ú î%á≈›¸òy £zì¸ƒy!î ~ÓÇ òyüÑ¸ì¸y õ)úÑ¸ £yõúyÁ !Ó¸ôî≈Î˚ ˆv¸ˆÏÑ¸ xyò˜Ìì¸ ¸ôy˜ÏÓ˚ – 5.9.1 !Ó¸ôî≈˜ÏÎ˚Ó˚ ÓƒÓfl¸iy¸òòy (Disaster Management) !Ó¸ôî≈˜ÏÎ˚Ó˚ ¸ò)Ó≈y¶¸y¢ ãò¢yïyÓ˚í˜ÏÑ¸ !Ó¸ôî≈Î˚ ˆõyÑ¸y!Óúy Ñ¸Ó˚yÓ˚ K¸yò îyòñ !Ó¸ôî≈Î˚ xy¢yÓ˚ xy˜ÏÜ ˆÌ˜ÏÑ¸ ¢!‡¸Ñ¸ ¸ôî˜Ï«¸¸ô ˆòÁÎ˚yñ !Ó¸ôî≈˜ÏÎ˚Ó˚ ¢õÎ˚ ˆõyÑ¸y!Óúy ~ÓÇ ãò¢yïyÓ˚í˜ÏÑ¸ v¸zk¸yÓ˚ Ñ¸Ó˚y !Ó¸ôî≈Î˚ ÓƒÓfl¸iy¸òòyÓ˚ ≤Ãïyò Ñ¸yã– !Ó¸ôî≈Î˚ ÓƒÓfl¸iy¸òòy ≤Ãïyò 3!›¸ xÇ˜Ïü !Ó¶¸_´ÈÙÙÙÈ S1V !Ó¸ôî≈˜ÏÎ˚Ó˚ ≤ÃyE¸yú S2V !Ó¸ôî≈˜ÏÎ˚Ó˚ ¢õÎ˚ S3V !Ó¸ôî≈˜ÏÎ˚Ó˚ ¸òÓ˚ S1V !Ó¸ôî≈˜ÏÎ˚Ó˚ ≤ÃyÑ¸ Ñ¸yú (Pri-Disaster) ≠ G%ß¸!Ñ¸Ó˚ õ)úƒyÎ˚òñ ≤Ã!ì¸ˆÏÓ˚yï Óy ≤Ãüõòñ ¸ò)Ó≈ ≤Ãlfl¸!ì¸ – S2V !Ó¸ôî≈˜ÏÎ˚Ó˚ ¢õÎ˚ (During Disaster) ≠ xyÜyõ ¢ì¸Ñ≈¸Óyì≈¸yñ äòõyòÓ˚ˆÏÑ¸ ¢!Ó˚˜ÏÎ˚ !ò˜ÏÎ˚ ÎyÁÎ˚y ~ÓÇ Óßyâ¸yˆÏòyñ xy¸òyì¸Ñ¸y!úò ¢y£yÎ˚fñ ïÇ˜Ï¢Ó˚ ¸ô!Ó˚õy¸ô Ñ¸Ó˚yñ xòƒyòƒ «¸!ì¸Ó˚ ¸ô!Ó˚õy¸ô Ñ¸Ó˚y– S3V !Ó¸ôî≈˜ÏÎ˚Ó˚ ¸òÓ˚ (Post-Disaster) ≠ ¸ô%òÓ≈y¢ò Á ¸ô%òÉ!òõ≈yíñ xì≈˜Ïò!ì¸Ñ¸ Á ¢ÿy!ãÑ¸ ¸ô%òÓ˚&k¸yÓ˚ñ !òõ≈yíõ)úÑ¸ !e´Î˚yÑ¸úy¸òñ G%ß¸!Ñ¸Ó˚ õ)úƒyÎ˚ò ~ÓÇ ≤Ã!ì¸ˆÏÓ˚yï– !â¸e 5.2 ≠ !Ó¸ôî≈˜ÏÎ˚Ó˚ ÓƒÓfl¸iy¸òòy â¸e´ (Disaster management cycle) 104 ? NSOU ? AE-ES-21

5.9.2 Óòƒy (Flood) ≤ÃyÑ¸!ì¸Ñ¸ !Ó¸ôî≈˜ÏÎ˚Ó˚ á›¸òy=!úÓ˚ õ˜Ïïƒ xòƒì¸õ £ú Óòƒy– ≤Ã!ì¸ÓäÈÓ˚ ≤ÃyÎ˚ 75 úyÖ ˆ£QÓ˚ ¶)¸!õ ÓòƒyÓ˚ Ñ¸Ó˚˜Ïú xy˜Ï¢ ~ÓÇ ≤ÃyÎ˚ 1500 äò õyÓ˚y Îyˆ – õ)úì¸ Óv¸ ¸ òî#=!úˆÌ¸ ã˜ÏúÓ˚ ¸ô!Ó˚õyí Óyv¸ ¸yÓ˚ ö¸˜Ïú ¢õì¸ú ¶)¸!õ ~úyÑ¸yÎ˚ òî#Ó˚ v¸z¸ôÑ)¸úÓì≈¸# xM¸Èú ≤'y!Óì¸ £˜ÏÎ˚ Îyˆ – ~Ó˚ ≤Ã¶¸y˜ÏÓ˚ ≤Ãâ%¸Ó˚ â¸yºˆÏÎ˚Üƒ ã!õñ ö¸¢úñ áÓ˚ Óy!v¸ ¸ ¢ÓÉ£ ò‹T £˜ÏÎ˚ ÎyÎ˚ – xyÓyÓ˚ ¢õ%o v¸z¸ôÑ)¸úÓì≈¸# ü£Ó˚yM¸Èúñ ˆâ¸ß¨y£zñ Ó˜ÏÌ¸ xìÑ¸ ãò¢ÇÖƒyÓ˚ ~ÓÇ ãú!òÑ¸y!ü ÓƒÓfl¸iy xò%ß¨ì¸ Óy Óì¸ £˜ÏÎ˚ ÎyÁÎ˚yÓ˚ ãòƒ ≤'y!Óì¸ £˜ÏÎ˚ Îy˜ÏÑ¸– ≤Ã!ì¸˜Ï«¸˜ÏeÉ£ õ%Öƒ Ñ¸yÓ˚í £ú ≤ÃÓú Ó¸!‹T ¸òyì¸– Óòƒy≤ÃÓí xM¸Èú=!ú˜Ïì¸ !òÎ˚õ òy ˆõ˜Ïò !òõ≈y˜ÏíÓ˚ ãòƒ «¸Î˚ «¸!ì¸ x˜ÏòÑ¸ ˆÓü# £˜ÏÎ˚ Îy˜ÏÑ¸– Óòƒy ¢¸!‹TÓ˚ Ñ¸yÓ˚í ≠ Óòƒy ≤ÃyÑ¸!ì¸Ñ¸ ~ÓÇ õò%°Ïƒ¢‹T v¸z¶¸Î˚ Ñ¸yÓ˚˜Ïí £˜ÏÎ˚ Îy˜ÏÑ¸– ?? ≤ÃyÑ¸!ì¸Ñ¸ Ñ¸yÓ˚í ≠ î#á≈!òò x!ÓÓ˚yõ Ó°Ï≈˜ÏíÓ˚ ö¸˜Ïú òî#˜Ïì¸ ãúfl¸≥¸#!ì¸ á˜Ï›¸ ~ÓÇ Óòƒy ¸ô!Ó˚!fl¸i!ì¸ ˜Ìì¸!Ó˚ £Î˚ – ~äÈyv¸ ¸y òî#Ó˚ òyÓƒì¸y Ñ¸˜Ïõ ˆÜ˜Ïú ~ÓÇ òî#Ó˚ Ü!ì¸ ¸ô˜ÏÌ Óßy˜ÏÑ¸Ó˚ ¸

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ô!Ó˚õyí Î!î x˜ÏòÑ¸ ˆÓ!ü Îy˜ÏÑ¸ ì¸˜ÏÓ

Ó°Ï≈yÑ¸y˜Ïú x!ì¸Ó‹T˜Ïì¸ òî#Ó˚ xy˜Ïü¸ôy˜Ïü Óòƒy £Î˚ – xyÓyÓ˚ ÷‹Ò Óy ¸ôy£y!v¸ ¸ xM¸È˜Ïú £‡¸yí Ñ¸˜ÏÓ˚ x!ÑÓ¸ Ó‹T £˜Ïú £v¸ ¸ ¸ôy Óy˜ÏòÓ˚ ¢¸‹T £ˆ – ?? õò%°Ïƒ ¢¸‹T Ñ¸yÓ˚í ≠ òî#Ó˚ xÓÓy!£Ñ¸yÎ˚ õyey!ì¸ !Ó˚_´ Ó¸«¸ ˆäÈÎ˚ÒòÓ˚ myÓ˚y ≤Ãì¸ƒ«¸ Óy ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ Óòƒy Ó˚ õyey˜ÏÑ¸ cÓ˚y!ßì¸ Ñ¸˜ÏÓ˚ – òî#Ó˚ Á¸òÓ˚ !òõ≈yíÑ¸yÎ≈ ˆÏòò ˆ¢ì%¸ !òõ≈yíñ ãúyïyÓ˚ !òõ≈yí òî#Ó˚ ÓƒÓ Á ãúïyÓ˚í «¸õì¸y˜ÏÑ¸ Ñ¸!õ˜ÏÎ˚Î˚ ˆÎ˚ ö¸˜Ïú x!ì¸ Ó°Ï≈˜ÏíÓ˚ ¢õÎ˚ ≤'yÓ˚˜ÏòÓ˚ ¢‹T Ñ¸˜ÏÓ˚ – ¢˜ÏÓ≈y¸ô!Ó˚ òÜÓ˚yÎ˚òñ Îy ãú˜ÏÑ¸ õy!›¸Ó˚ ò#˜Ïâ¸ ˆÎ˚ˆÌ¸ ˆ˜Îˆ òy– ¢õhfl¸ ãú ¸ôyÑ¸y Ó ÓyhflyÁ ˆv»¸˜ÏòÓ˚ õyïƒ˜Ïõ òî#˜Ì¸ ¸ô˜Ïv¸ ¸ ~ÓÇ ¶¸!Ó˚ƒ˜Ì¸ ˆv»¸ò=!ú xyÓ≈≈òy myÓ˚y Óì¸ £˜ÏÎ˚ ˆÜ˜Ïú ö¸úfl¸ÍÓ˚*¸ô x!ì¸ Ó!‹T¸ôy˜Ì¸ Óòƒy ¸ô!Ó˚!fl¸i!ì¸ îßyv¸ ¸yÎ˚ – v¸zîyÉÓ˚íÈÙÙÙÈ ˆâ¸ß¨y£zñ õ%¡ƒ£z £zì¸ƒy!î– Óòƒy ! òÎ˚s¸fˆÏí ≤ÃˆÏÎ˚yã#Î˚ ÓƒÓfl¸iy¸òòy ≠ Óòƒy !òÎ˚s¸fí ~ÓÇ Óòƒy ¸ô!Ó˚!fl¸i!ì¸ ˆõyÑ¸y!ÓúyÓ˚ ãòƒ ¢ÓÑ¸yÓ˚ òyòy ¸ôî˜Ï«¸¸ô @˜ÃÉí Ñ¸˜ÏÓ˚ˆÏäÈ– ì¸˜ÏÓ Óì≈¸õyò ¸ô!Ó˚!fl¸i!ì¸˜ÏÑ¸ õyÌyÎ˚ ˆÓ˚˜ÏÜ Óòƒy ¢¸‹TÓ˚ ≤Ãì¸ƒ«¸ Á ¸ôˆÏÓ˚y«¸ Ñ¸yÓ˚í=!ú Îyâ¸yyz Ñ¸˜ÏÓ˚ ì¸yÓ˚ ¢õyïy˜Ïò xy˜ÏÓ˚y õ˜Ïòy˜ÏÎ˚Ü# £˜Ìì¸ £˜ÏÓ– ~£ Ü¸£#ì¸ xyï%!òÑ¸ ¢%¢Çÿì¸ ¸ôî˜Ï«¸¸ô=!ú Óòƒy≤ÃyÎ˚î%¶≈¸yÓ ~ÓÇ ¶¸Î˚yÓ£ì¸y˜ÏÑ¸ £…y¢ Ñ¸Ó˚˜Ìì¸ ¢y£yÎ˚ƒ Ñ¸Ó˚˜ÏÓ– !

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Ñ¸ä%È ¸ôî˜Ï«¸¸ô ¢¡ô˜ÏÑ≈¸ xy˜Ïúyâ¸òy Ñ¸Ó˚y £

úÈÙÙÙ S1V Óò¶)¸!õ ïπÇ¢ Á Ó¸«¸ˆÏäÈÎ˚ÒòÓ˚ ãòƒ ¶)¸õ#«¸Î˚ ÈÙÈ~Ó˚ ¸ô!Ó˚õyí Óƒy¸ôÑ¸ £y˜ÏÓ˚ Ó¸!k¸ ˆ¸ôÎ˚˜ÏäÈ ö¸úfl¸ÍÓ˚*¸ô òî#Ü˜Ï¶≈¸Ó˚ òyÓƒì¸y £…y¢ ~äÈyv¸ ¸y v¸zFâ¸ xÓÓy!£Ñ¸y˜Ïì¸ Á ¸ôy£y!v¸ ¸ xM¸È˜Ïú £v¸ ¸ ¸ôy Óy˜ÏòÓ˚ ¢¸!‹T £ˆ – ì¸y£z Ó¸«¸ ˆÓ˚y¸ôî Ñ¸Ó˚y Ö%ÓÓ£z ãÓ˚&Ó˚# – S2V Ó°Ï≈yÓ˚ x!ì¸ !Ó˚_´ ãú Îy˜Ïì¸ ïyÓ˚í Ñ¸Ó˚ˆÌ¸ ¸ôy˜ÏÓ˚ ì¸y£z òî#=!úÓ˚ xÓÓy!£Ñ¸y˜Ïì¸ Óßyï ˜Ìì¸ !Ó˚ Ñ¸Ó˚ˆÏÌ¸ £˜ÏÓ ~ÓÇ ¸ô%Ó˚yì¸ò Óßyï=!ú˜ÏÑ¸ ¢ÇÕfl¸ÒyÓ˚ Ñ¸Ó˚ˆÌ¸ £˜ÏÓ– ~äÈyv¸ ¸y ¢õì¸ú ¶)¸!õ˜Ì¸ òî#=!ú˜Ïì¸ ¸ô!ú ¸ôˆÏv¸ ¸ ì¸yÓ˚ òyÓƒì¸y £…y¢ ¸ôyÎ˚ ì¸y£z Ööò Ñ¸˜ÏÓ˚ ì¸yÓ˚ Ü¶¸#Ó˚ì¸y Ó¸!k¸ Ñ¸Ó˚˜Ïú ãú ¸ô!Ó˚õyíò Ñ¸Ó˚yÓ˚ «¸õì¸y Ó¸!k¸ Ñ¸Ó˚ˆÌ¸ £˜ÏÓ– S3V òî#Ó˚ ¸ôy˜Ïv¸ ¸Ó˚ v¸zFâ¸ì¸y Ó¸!k¸ Ñ¸Ó˚˜Ïú ¸ôyŸª≈Óì≈¸# xM¸Èú ≤'y!Óì¸ £Î˚ òy– NSOU ? AE-ES-21 ? 105

S4V ¸ò)Ó≈Óì≈¸# ÓòƒyÓ˚ õyò!â¸eyÎ˚ ˆÏòÓ˚ õyïƒ˜Ïõ ˆâúy hfl¸Ó˚ñ ÓyãƒhflÓ˚ ~ÓÇ âyì¸#Î˚ hfl˜ÏÓ˚ Óòƒy≤ÃÓí ~úyÑ¸yˆÏÑ¸ !â¸!£ß´ì¸Ñ¸Ó˚í Ñ¸Ó˚y £ˆ – Îyˆ˜Ïì¸ ¶¸!Ó°Ïƒì¸ ÁÉ£ fl¸iy˜Ïò !òõ≈y˜Ïí !ò˜Ï°ïKyÑ¸ ãy!Ó˚ Á Óòƒy!òÎ˚s¸fÑ¸ òyòy ≤ÃÑ¸ı“ ˜Ì¸!Ó˚ Ñ¸Ó˚y Ñ¸Ó˚y Îyˆ – Central Water Commission (CWC), Ganga Flood Control Commission (GFCC) ~ÓÇ ÈSurvey of India (SOI)ÙÈ~Ó˚ ˆÎÔì v¸z˜Ïîƒ˜ÏÜ ~£z õyò!â¸eyÎ˚ò ~ÓÇ !â¸e´ì¸Ñ¸Ó˚ˆÏí Ñ¸yã!›¸ Ñ¸˜ÏÓ˚ ˆÏÓ˚ – S5V xì¸ƒyïì%ò!òÑ¸ ≤ÃÎ%!_´ Á v¸zß¨ì¸ ¢ƒy˜Ï›¸úy£z˜Ï›¸Ó˚ ÓƒÓ£yÓ˚ Ñ¸˜ÏÓ˚ Óòƒy Óy xyÜyõ ¢Ω¸Ó˚– ö¸˜Ïú «¸Î˚«¸!ì¸Ó˚ ¸ô!Ó˚õyí £…y¢ ¸òyÎ˚ – S6V ãò¢˜Ïâ¸ì¸òì¸y ~ÓÇ xy¸ôî¸yú#ò ÓƒÓfl¸iy¸òòyÎ˚ !Óhfl¸yÓ˚ì¸ K¸yò îy˜ÏòÓ˚ õyòƒ˜Ïõ fl¸iyò#Î˚ õyò%°Ï˜ÏÑ¸ Óòƒy xy›¸Ñ¸y˜Ïòy Á ì¸yÓ˚ ˆÌ˜ÏÑ¸ Óßyâ¸yÓ˚ Ó˚yhfl¸y ˆÌyÎ˚ñ ì¸y£z fl¸%Òú Ñ¸˜Ïúã ~ÓÇ ãòõyïƒ˜Ïõ ~£z K¸yò !Óhfl¸yÓ˚ Ñ¸Ó˚˜Ìì¸ £˜ÏÓ– S7V ÓòƒyÎ˚ î%Ü≈ì¸ õyò%°Ï˜ÏíÓ˚ v¸zk¸yÓ˚ Ñ¸˜ÏÓ˚ Ñ¸Ó˚y!Ó˚ S˜ÎõòÉÙÙÙÈ ¸ô%!úüñ x!@¿¸ !òÓ≈y¸ôÑ¸ îÆÓ˚ ñ ¢yõ!Ó˚Ñ¸ Óy!£ò#V ~ÓÇ ˆÓ˚¢Ó˚Ñ¸y!Ó˚ ¢Çfl¸iyÓ˚ SÎ%Ó ¢ÇÜ‡¸òñ ˆfl¸ÍFäÈyˆÏ¢Ó# ¢Çfl¸iyñ ÓƒÓ¢yÎ˚# ¢!õ!ì¸¸V =Ó˚&c x¸ô!Ó˚¢#õ– 5.9.3 ¶)!õÑ¸¡ô (Earthquake) £‡¸yÍ Ñ¸˜ÏÓ˚ !Ó¸ô%ú ¸ô!Ó˚õy˜ÏíÓ˚ ü!_´ ¶)¸ÈÙÈÜ¶≈≈¸ ˆÌ˜ÏÑ¸ ˆÓ!Ó˚˜ÏÎ˚ xy¢yÓ˚ Ñ¸yÓ˚˜Ïí ¶)¸ÈÙÈ¸ô¸ˆÏ¤¸ Ñ¸¡ô˜ÏòÓ˚ ¢¸‹T £ˆ – ~£z Ñ¸¡ô˜ÏòÓ˚ õyey ~ì¸›¸y£z £˜ÏÎ˚ ˆÏÎ˚ Óy!v¸ ¸ áÓ˚ñ Ó¸£í !Ó ã £zì¸ƒy!î !òõ≈yí i)!úÓ¢yÎ˚ £˜Ïì¸ ¸ ¸ôy˜ÏÓ˚ñ ~ÓÇ ¶)¸!õÑ¸¡ô Ó˚˜Ïú– ¶)¸Ü˜Ï¶≈¸Ó˚ ˆÎ fl¸iy˜Ïò

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Ïò ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ v¸zÍ¸ô!_ £Î˚ ì¸yˆÏÑ¸ ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ˆÑ¸w ~

ÓÇ ì¸yÓ˚ v¸zú¡∫¶¸yˆ

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ÏÓ ¶)¸¸ô¸ˆÏ¤¸Ó˚ Á¸ôˆÏÓ˚Ó˚ fl¸iyò!›¸ ˆÏÑ¸ ¶)¸!õÑ¸ ˆÏ¡ôÓ˚

v¸z¸ôˆÏÑ¸w ÓˆÏú– ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ v¸z¸ôˆÏÑ¸ ˆÏw Ñ¸¡ôˆÏòÓ˚ ì¸#Ó ì¸y ¢ˆÏÓ≈yFâ¸ ÌyˆÏÑ¸– ≤Ãïyòì¸ 2 ïÓ˚ˆÏòÓ˚ ì¸Ó˚ˆÏDÓ˚ ¢‚!‹T £Î˚– ≤ÃyÌ!õÑ¸ ì¸Ó˚D Óy 'p' wave Ìy Ólfl¸Ñ¸íyÓ˚ ¢ˆÏB¸yâ¸ò Á ≤Ã¢yÓ˚ˆÏíÓ˚ õyïƒˆÏõ ¢‚!‹T £Î˚ñ £z£y ¢Ó≈≤ÃÌõ v¸z¸ôˆÏÑ¸ ˆÏw ˆ¸ôÔßäEyÎ˚ ~ÓÇ !mì¸#Î˚ ì¸Ó˚D Óy 's' wave, ~£z ì¸Ó˚D ¸ôîyˆÏÌ≈Ó˚ ¸ôyüy¸ôy!ü ïyE¸yÓ˚ ãòƒ ì¸Ó˚ˆÏDÓ˚ òƒyÎ˚ ¸ô!Ó˚Óy!£ì¸ £Î˚– ~!›¸ ì%¸úòyÎ˚ Ñ¸õ Ü!ì¸ü#úñ ì¸y£z ≤ÃyÌ!õÑ¸ ì¸Ó˚ˆÏDÓ˚ ¸ôˆÏÓ˚ ˆ¸ôÔßäEÎ˚ !Ñ¸ls¸ «¸!ì¸Ó˚ ¸ô!Ó˚õyí ˆÓ!ü– !â¸e 5.2 ≠ S1V ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ˆÑ¸w Á v¸z¸ôˆÏÑ¸wó S2V ≤ÃyÌ!õÑ¸ ì¸Ó˚D Óy 'p' waveó S3V !mì¸#Î˚ ì¸Ó˚D Óy 's' wave. 106 ? NSOU ? AE-ES-21 !¢¢ˆÏõy@˘Ãyö¸ myÓ˚y ¶)¸!õÑ¸¡ô ¢¡ô!Ñ≈¸ì¸ ì¸Ìƒ ãyòˆÏì¸ ¸ôyÓ˚y ÎyÎ˚ ~ÓÇ !Ó˚Ö›¸yÓ˚ 'Richter' ˆfl¸Òú myÓ˚y ¶)¸!

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õÑ¸ ˆÏ¡ôÓ˚ ì¸#Ó ì¸y õy¸ôy £Î˚– ¸

ô)ˆÏÓ≈ áˆÏ›¸ ÌyÑ¸y v¸zˆÏÕ'ÖˆÏÎyÜƒ !Ñ¸ä%È ¶)¸!õÑ¸¡ôÈÙÙÙÈ ì¸y!Ó˚Ö fl¸iyò ì¸#Ó ì¸y õ¸ˆÏì¸Ó˚ ¢ÇÖƒy 03ÈÙÈ01ÈÙÈ2017 ¶¸yÓ˚ì¸ñ ÓyÇúyˆÏìü 5.7 3 26ÈÙÈ10ÈÙÈ2015 xyö¸Üy!òhfl¸yòñ ¶¸yÓ˚ì¸ ¸ôy!Ñ¸hfl¸yò 7.7 399 25ÈÙÈ04ÈÙÈ2015 ˆò¸ôyúñ ¶¸yÓ˚ì¸ 7.8 8ñ864 08ÈÙÈ10ÈÙÈ2005 Ñ¸yŸ¬#Ó˚ 7.6 86ñ000ÈÙÈ87ñ351 26ÈÙÈ12ÈÙÈ2014 ¢%õyey 9.1ÈÙÈ9.3 227ñ898 26ÈÙÈ01ÈÙÈ2001 =ãÓ˚yì¸ S¶)¸ãV 7.7 13ñ805ÈÙÈ20ñ023 ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ Ñ¸yÓ˚í ≠ ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ Ñ¸yÓ˚í=!ú £úÈÙÙÙÈ ??≤ÃyÑ‚¸!ì¸Ñ¸ Ñ¸yÓ˚í ≠ x@¿%ƒÍ¸ôyˆÏì¸Ó˚ ¢õÎ˚ ¶)¸ÈÙÈÜˆÏ¶≈¸Ó˚ Ü!úì¸ õƒyÜõy Á xyÓk¸ Üƒy¢ ¶)¸¸ô¸ˆÏ¤¸Ó˚ ˆÑ¸yò ö¸y›¸ú Óy òÓ˚õ xÇü !îˆÏÎ˚ !Ó¸ô%ú ü!_´ ≤ÃˆÏÎ˚yÜ Ñ¸ˆÏÓ˚ ˆÓ!Ó˚ˆÏÎ˚ xyˆÏ¢ ö¸ˆÏú ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ¢‚!‹T £ˆÏÎ˚ ÌyˆÏÑ¸– !Ó¸ô%ú ¢!M¸Èì¸ â¸yˆÏ¸ôÓ˚ ≤Ã¶¸yˆÏÓ ¶)¸ÈÙÈx¶¸ƒhs¸Ó˚ !üúy ÖÍ¸ ì¸yÓ˚ !fl¸i!ì¸fl¸iy¸ôÑ¸ì¸y ÓãyÎ˚ Ó˚yÖˆÏì¸ òy ˆ¸ôˆÏÓ˚ â%¸ƒ!ì¸Ó˚ ¢‚!‹T £Î˚ Á ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ¢‚!‹T £ˆÏÎ˚ ÌyˆÏÑ¸– ~¶¸yˆÏÓ ¢‚!‹T ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ì¸#Ó ì¸y xˆÏòÑ¸ ˆÓü# £ˆÏÎ˚ ÌyˆÏÑ¸– ¸ôyì¸ ¢M¸Èyúò ì¸_¥ xò%ÎyÎ˚# ~Ñ¸!›¸ ¸ôyì¸ xòƒ ¸ôyˆÏì¸Ó˚ Á¸ôÓ˚ v¸zˆÏ‡¸ ˆÜˆÏú Óy ~Ñ¸!›¸Ó˚ ˆÌˆÏÑ¸ ˆòˆÏõ ˆÜˆÏú ¶)¸!Ñ¸õˆÏ¡ôÓ˚ ¢‚!‹T £ˆÏÎ˚ ÌyˆÏÑ¸– ¢õ%ˆÏoÓ˚ õˆÏïƒ £ˆÏú ~Ó˚ myÓ˚y ¢%òy!õÁ £ˆÏÎ˚ ÌyˆÏÑ¸– ? õò%°ÏƒÏ ¢‹T Ñ¸yÓ˚í ≠ ¢yïyÓ˚îì¸ ≤ÃyÑ‚¸!ì¸Ñ¸ Ñ¸yÓ˚ˆÏíÓ˚ ãˆÏòƒ£z ¶)¸!õÑ¸¡ô áˆÏ›¸ ÌyˆÏÑ¸ ì¸ˆÏÓ !Ñ¸ä%È õò%°Ïƒ ¢‹T Ñ¸yÓ˚íÁ xyˆÏäÈ– ˆÎõòÈÙÙÙÈ Ó‚£Í ãúyïyÓ˚ Óy òî# Óßyï !òõ≈yí Ñ¸Ó˚yÓ˚ ö¸ˆÏú ¢!M¸Èì¸ ãˆÏúÓ˚ â¸yˆÏ¸ô ¶)¸!õÑ¸¡ô ¢‚!‹T £Î˚– õy!›¸Ó˚ !òˆÏâ¸ ¸ôyÓ˚õyí!ÓÑ¸ ü!_´Ó˚ ¸ôÓ˚#«¸y Ñ¸Ó˚yÓ˚ ö¸ˆÏúÁ ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ¢‚!‹T Ñ¸ˆÏÓ˚– ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ !Ó¸ôÎ≈Î˚ !òÎ˚s¸ƒˆÏí ¸ô!Ó˚â¸yúò ÓƒÓfl¸iy ≠ ? òì%¸ò !Ó!”¸Ç ˜ì¸!Ó˚ Ñ¸Ó˚yÓ˚ ˆ«¸ˆÏe ¶)¸!õÑ¸¡ô ¢£ƒ Ñ¸Ó˚yÓ˚ «¸õì¸y¢¡ôß¨ ¸ô!Ó˚Ñ¸y‡¸yˆÏõy Óy ≤'ƒyò ˜ì¸!Ó˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ~ÓÇ ì¸y !ò!î≈‹T îÆÓ˚ myÓ˚y Îyâ¸y£z Ñ¸Ó˚yÓ˚ ¸ôÓ˚£z xò%ˆÏõyîò ¸ôyˆÏÓ– ? ãò¢ˆÏâ¸ì¸òì¸y Ñ¸yÎ≈e´õ ãÓ˚&!Ó˚– ¸ô!Ó˚ÓyˆÏÓ˚Ó˚ ãˆÏòƒ !Ñ¸¶¸yˆÏÓ ãÓ˚&!Ó˚ ÓƒÓfl¸iyÓ˚ ˆõyÑ¸y!Óúy Ñ¸Ó˚ˆÏÓñ first aid ˆîÁÎ˚yÓ˚ ˆ›¸∆!òÇ îyò ~ÓÇ fl¸iyò#Î˚ ¶¸y°ïyÎ˚ ˆúÖy ≤ÃyÌ!õÑ¸ ÓƒÓ£y!Ó˚Ñ¸ Ó£z ÌyˆÏì¸ ¢£ˆÏã ãòÜˆÏíÓ˚ Ñ¸Ó˚í#Î˚ ¢¡ôˆÏÑ≈¸ ˆúÖy ÌyˆÏÑ¸ ì¸y !Óì¸Ó˚í Ñ¸Ó˚y ãÓ˚&!Ó˚– ? ì¸¸íõ)ú hfl¸Ó˚ ˆÌˆÏÑ¸ !ü«¸yÌ≈#ˆÏîÓ˚ ¶)¸!õÑ¸¡ô ˆõyÑ¸y!Óúy Ñ¸Ó˚yÓ˚ ¢yïyÓ˚í ¸ôk¸!ì¸ ˆüÖyˆÏòyÓ˚ ãˆÏòƒ ¸ôy‡¸e´ˆÏõ xhs¸¶%≈¸_´ Ñ¸Ó˚yÓ˚ îy!Î˚c Ó˚yãƒ ¢Ó˚Ñ¸yÓ˚ˆÏÑ¸ !òˆÏì¸ £ˆÏÓ– NSOU ? AE-ES-21 ? 107 ? ˆõ!v¸Ñ¸ƒyú Ñ¸ˆÏúˆÏã !Ó¸ô≈ˆÏÎ˚ ãÓ˚&!Ó˚ ¸ô!Ó˚ˆÏ°ÏÓy Á ÓƒÓ£*ì¸ Ë°ÏˆÏïÓ˚ !Ó°ÏÎ˚ ¸ôv¸¸yˆÏòy ≤ÃˆÏÎ˚yãò– ? ¶)¸!õÑ¸¡ô á›¸yÓ˚ ¸ôÓ˚ ¢Ó˚Ñ¸y!Ó˚ ¢y£yÌƒ xy¢yÓ˚ ¸ô)ˆÏÓ≈ ˆÓü#Ó˚¶¸yÜ v¸zk¸yÓ˚Ñ¸yÌ≈ ~úyÑ¸yÓy¢#Ó˚y Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸ñ ¢%ì¸Ó˚yÇ fl¸iyò#Î˚ ˆfl¸∫FäEyˆÏ¢Ó#ñ National Disaster Response Force (NDRF), SDRF, ¸ô%!úüñ NGOñ x!@¿!òÓ≈y¸ôÑ¸ îÆÓ˚ñ NSS ¢ÓyÓ£zˆÏÑ¸ ¢õyò¶¸yˆÏÓ ≤Ã!ü«¸í !îˆÏì¸ £ˆÏÓ– 5.9.4 á%í≈yÓì≈¸ (Cyclone) ¶)¸¸ô¸ˆÏ¤¸Ó˚ Á¸ôÓ˚ ì¸yˆÏ¸ôÓ˚ ˜Ó°ÏˆÏõƒÓ˚ ãˆÏòƒ ÓyÎ˚%Ó˚ â¸yˆÏ¸ôÓ˚Á ˜Ó°Ïõƒ ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚– ¢ïyÓ˚îì¸ v¸z°å õ[¸ˆÏúñ

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e´yhs¸#Î˚ Á v¸z¸ôe´yhs¸#Î˚ xM¸Èˆ

Ïú â¸yˆÏ¸ôÓ˚ ˜Óº˚ÏõƒÓ˚ ã˘Ïòƒ â¸y!Ó˚ ¸ôyü ˆÌˆÏÑ¸ v¸zFâ¸ â¸y¸ôÎ%_´ ü#ì¸ú ÓyÎ˚% !¶¸ì¸ ˆÏÓ˚Ó˚ !îˆÏÑ¸ ≤ÃˆÏÓü Ñ¸Ó˚ˆÏì¸ ìyˆÏÑ¸ ~ÓÇ ÜÓ˚õ Óyì¸y¢ v¸z¸ôˆÏÓ˚Ó˚ !îˆÏÑ¸ Îy΢ – ~Ó˚ ö¸ˆÏú Îy á˘Ï›¸ ì¸y !Ó¶¸#!ºÏÑ¸yõÎ˚ñ ÓyÎ˚%Ó˚ Ü!ì¸ˆÏÓÜ ˆÓˆÏv¸¸ ïßyv¸¸yΘ Ñ¸õ¸ôˆÏ«¸ 62 km/h ˆÌˆÏÑ¸ 222 km/h ~ÓÇ ì¸yÓˆÁ ˆÓ!ü £ˆÏì¸ ¸ôyˆÏÓ˚ – ~Ó˚ ö¸ˆÏú !òˆÏõˆÏºÓ˚ õˆÏïƒ áÓ˚Óy!v¸¸ ïÇ¢ Ñ¸ˆÏÓ˚ ˆîˆñ ¸≤ÃyíòyüÁ á˘Ï›¸ – Indian Meteriologocal Department ¢y£zˆÏÑœ¸yò ˆÏÑ¸ 3!›¸ ¶¸yˆÏÜ ¶¸yü Ñ¸ˆÏÓ˚ ˆÏäÈ– 89ÈÙÈ118 km/h ¢y£zˆÏÑœ¸yòó 119ÈÙÈ221 km/h Severe ¢y£zˆÏÑœ¸yòñ 222 km/h Á ì¸yÓ˚ Á¸ôˆÏÓ˚ ¢%¸ôyÓ˚ ¢y£zˆÏÑœ¸yò– á)í≈yÓyì¸ ï%ˆÏî≈yÜ ÓƒÓfl¸iy¸ôòy ≠ 1990 ¢yˆÏú xì¸≤ÃˆÏîˆÏü ≤Ãâ¸[¸ ¢y£zˆÏÑœ¸yò xy¢yÓ˚ ¸ôÓ˚ !ÓŸª Óƒy˘ÏB¸Ó˚ ì¸Í¸ôÓ˚ˆì¸yÎ˚ ¶¸yÓ˚ˆì¸ ≤ÃÌõ Cyclone Emergency Reconstruction Project (CERP) ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ¸ôˆÏÓ˚ National Cyclone Risk Mitigetion Project (NCRMP) Ü¸£ õs¸fˆÏÑ¸Ó˚ ì¸_¥yÓìyˆÏò ˜ì¸!Ó˚ £Î˚ Îy ¸ôÓ˚Óì≈¸#Ñ¸yˆÏú National Disaster Management Authority (NDMA) ˆÑ¸ £hfl¸yhs¸!Óˆì¸ Ñ¸Ó˚y £Î˚ – ~£z ≤ÃÑ¸ˆÏ“Ó˚ ≤Ãìyò v¸z¸ôÑ¸Ó˚í =!ú £úÈÙÙÙÈ ? á)í≈yÓì≈¸ xy¢yÓ˚ xyÜyõ ¢¡¸Ñ≈¸ Óyì≈¸y ÓƒÓfl¸iy ˜ì¸!Ó˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ? xì¸ƒyï%! òÑ¸ Îs¸f¸ôy!ì¸ myÓ˚y ~ÓÇ xyÑ¸yü ˆÌˆÏÑ¸ Óy Remote Sensing myÓ˚y ¢õ%ˆÏòÓ˚ v¸z¸ôˆÏÓ˚ ˜ì¸!Ó˚ £ÁÎ˚y á)í≈yÓˆÏì≈¸Ó˚ xyÜyõ ì¸Ïƒ Á xÓfl¸iy ¢Ç@˘Ã£ Ñ¸Ó˚y– ? ˆÓ˚!v¸Áñ DTH myÓ˚y ï%Ü≈õ ãyÎ˚ÜyˆÏì¸ xyÜyõ ¢¡¸Ñ≈¸Óyì≈¸y ãy!Ó˚ Ñ¸Ó˚y– ? á)í≈yÓˆÏì≈¸Ó˚ G%ß¸! Ñ¸ £…y¢ Ñ¸Ó˚yÓ˚ ã˘Ïòƒ v¸z¸ôÑ)¸úÓì≈¸# á)í≈yÓˆÏì≈¸Ó˚ ≤ÃˆÏÑ¸yˆÏ¸ô ¸ôv¸¸y õyò%ºÏˆÏÓ˚ ìyÑ¸yÓ˚ ãyÎ˚Üyñ ¸ô÷¸ôy!Ö ìyÑ¸yÓ˚ fl¸iyò £zì¸ƒy!î ˜ì¸Ó˚#– ? ãú!òÑ¸yü# ÓƒÓfl¸iy !‡¸Ñ¸ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ? v¸z¸ôÑ)¸úÓì¸≈# xM¸ÈˆÏúÓ˚ õyò!â¸eÑ¸Ó˚íñ ÎyˆÏì¸ «¸Î˚«¸! ì¸Ó˚ ¸ô!Ó˚õyí ~ÓÇ xÓfl¸iyÓ˚ ¸ô)Ó≈ !ÓˆÏŸºí Ñ¸Ó˚y ¢Ω¸Ó¸ôÓ˚ £Î˚ – ? õƒyò˘Ï@˘Ãy¶¸ xÓ˚ïƒ myÓ˚y v¸z¸ôÑ)¸úÓì≈¸# xM¸ÈˆÏú ˜ãÓ ≤Ã!ì¸ˆÏÓ˚yí ˜ì¸!Ó˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ? fl¸iyò#Î˚ ãòÜí ¢y£zˆÏÑœ¸yˆÏòÓ˚ !Ó¸ôî≈ˆÏîˆÓ˚ ≤ÃÌ¸ƒyáyì¸ Á«¸Î˚ «¸!ì¸Ó˚ ˆõyÑ¸y!ÓúyÎ˚ Ñ¸Ó˚yÓ˚ ã˘Ïòƒ ≤Ã!ü«¸íÎ˚ò Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ~ÓÇ ¢y£zˆÏÑœ¸yˆÏòÓ˚ ïπÇ¢ú#úyÓ˚ ¸ôÓ˚ ¸ô%òÈfl¸iy¸ôò Ñ¸Ó˚yÓ˚ ãòƒ ¢Ó˚Ñ¸yÓ˚ Á NGO =!úÓ˚ ¢y£yÎ˚ƒ Ö%Ó£ ãÓ˚&!Ó˚ – 108 ? NSOU ? AE-ES-21

5.9.5 ¶)¸!õï¢ (Landslide) ˆ¶¸Ôõ ã˘ÏúÓ˚ â¸yˆÏ¸ôñ x!ì¸Ó¸!‹TÓ˚ ≤Ã¶¸yˆÏÓñ ¶)¸!õÑ¸¡ôñ !òõ≈yíÑ¸yÎ≈ Óy ÎyòÓy£ò â¸úyâ¸ú Ñ¸Ó˚yÓ˚ ã˘Ïòƒ ¸ôy£yv¸¸ Óy v¸z¸ôÑ)¸úÓì≈¸# xM¸ÈˆÏúÓ˚ ë¸yú ˆÌˆÏÑ¸ fl>!úì¸ ¸ôîyÌ≈ ¢õ)£ õïƒÑ¸ºÏ≈ˆÏíÓ˚ Ñ¸yÓ˚ˆÏí £‡¸yÍ Ñ¸ˆÏÓ˚ ˆòˆÏõ xyˆÏ¢ñ ì¸yˆÏÑ¸ ¶)¸!õïπˆÏ¢Ó˚ ã˘Ïòƒ Ó˚yhfl¸y áy›¸ñ Ó¢ì¸Óy!v¸¸ñ Óò¶)¸!õ ¢Ç ˆÏîyÜ ÓƒÓfl¸iy ò‹T £Î˚ – ¶)¸! õïˆ¢Ó˚ ≤Ã!ì¸ˆÏÓ˚yì¸ õ)úÑ¸ ÓƒÓfl¸iy ≠ ? ¶)¸ÈÙÈ˜ÓK¸y!òÑ¸ Á ≤ÃÎ%!_´Üì¸ ¸ôÓ˚#«¸y !òÓ˚#«¸y myÓ˚y ¢!‡¸Ñ¸ xM¸Èú !òÓ≈yâ¸ò Ñ¸ˆÏÓ˚ ¢!‡¸Ñ¸ ÓƒÓfl¸iy @˘ÃÃ£í Ñ¸ˆÏÓ˚ ~ÓÇ xy£zò ≤ÃíÎ˚ò Ñ¸ˆÏÓ˚ G%ß¸!Ñ¸Ó˚ ≤ÃÓî¸y Ñ¸õyˆÏòy ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – ? ¶)¸ì¸y!_¥Ñ¸ õyò!â¸e ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ ¶)¸!õï¢ ≤ÃÓí ~úyÑ¸y fl¸%Óúñ Óy!v¸¸ñ £y¢¸ ôyì¸yú xòƒ ¢!Óˆî˚ !òˆî˚ ˆîˆÏì¸ £ˆÏÓ– ? ≤ÃÜy¢ò ¶)¸ì¸y!_¥Ñ¸ˆÏÓ˚ ¢yˆÏì¸ ¸ôÓ˚yõü≈ Ñ¸ˆÏÓ˚ ¢!‡¸Ñ¸ !òõ≈yˆÏíÓ˚ ~Ñ¸!›¸ ¸ô!Ó˚Ñ¸y‡¸yˆÏõy ~ÓÇ !òˆÏî≈üyÓú# ˜ì¸!

50%	MATCHING BLOCK 155/200	W

Ó˚ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ~ÓÇ xy£zò myÓ˚y ì¸y Óyïƒì¸yõ)úÑ¸ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ – ?

Öyv¸¸y ¶)¸!õ ë¸yˆÏúÓ˚ !òˆÏâ¸

100%	MATCHING BLOCK 160/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Óy!v¸¸ ˜ì¸!Ó˚Ó˚ xò%õ!ì¸ ˆîÁÎ˚y

v¸z!â¸ì¸ òy– ? Ó¸«¸ˆÏÓ˚y¸ôí Ñ¸ˆÏÓ˚ ¢ÓˆÑ¸yÓ˚ ~ÓÇ fl¸iyò#Î˚ Óy!¢®yÓ˚y õy!›¸Ó˚ î¸ë¸¸ì¸y Ó¸!K¸ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ìyˆÏì¸ ¸ôÓ˚Óì≈¸#Ñ¸yˆÏú õy!›¸ xyúÜy òy £ˆÏî ãyÎ˚ ~ÓÇ ïπ¢ òy á˘Ï›¸ – 5.10 xò%ü#úò# ¢!‡¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚&ò ≠ S1V ¶)¸¸ôyú Üƒy¢ ï%á≈›¸òy Ñ¸ˆÏÓ £Î˚/(i) 3Ó˚y ò˘Ï¶¸¡Ó˚ñ 1981 (ii) 3Ó˚y ò˘Ï¶¸¡Ó˚ñ 1984 (iii) 3Ó˚y !v¸ˆÏ¢¡Ó˚ñ 1984 (iv) 3Ó˚y ˆ¢ˆÏ≤Wz¡Ó˚ñ 1984 S2V !õòyõy›¸y ˆÓ˚yü ˆÑ¸yò ˆÑ¸yò ˆõÔˆÏúÓ˚ ≤Ã¶¸yˆÏÓ £Î˚/(i) As (ii) Pb (iii) Cd (iv) Hg S3V ¸ôyò#Î˚ ã˘Ïú xyˆÏ¢≈!òˆÏÑ¸Ó˚ xò%ˆÏõy!îì¸ ¢ˆÏÓ≈yFâ¸ õyeyÈÙÙÈ (i) 0.01 (ii) 0.5 (iii) 0.05 (iv) 1 S4V ü˘Ï∑Ó˚ ≤ÃyÓˆÏúƒÓ˚ õyey õy¸ôy £Î˚ ÈÙÙÈ (i) ppm (ii) v¸Ó¢ò (iii) ˆv¸!¢ˆÏÓú (iv) nm S5V Üy!v¸¸Ó˚ ˆïßyÎ˚y ˆÌˆÏÑ¸ !Ñ¸ ˆÓˆÏÓ˚yÎ˚/(i) NOx (ii) SOx (iii) SPM (iv) O 3 NSOU ? AE-ES-21 ? 109

x!ì¸ ¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ì)ºÏí Ñ¸yˆÏÑ¸ ÓˆÏú⁄ S2V COD Ñ¸yˆÏÑ¸ ÓˆÏú⁄ S3V xyˆÏ¢≈!òÑ¸ ì)ºÏˆÏíÓ˚ ö¸ˆÏú !Ñ¸ !Ñ¸ ˆÓ˚yü £Î˚/ S4V õò%ºÏƒ ¢‹T !Ó¸ôî≈ˆÏÎ˚Ó˚ v¸zîy£Óí !îò– S5V ¶)¸!õÑ¸ˆÏ¡ôÓ˚ ˆÑ¸wÁ v¸z¸ôˆÏÑ¸w Ñ¸yˆÏÑ¸ ÓˆÏú⁄¢Ç!«¸Æ v¸z_Ó˚ !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ≤Ãì¸ƒ«¸ Á ¸ôˆÏÓ˚y«¸ ÓyÎ˚%ì)ºÏí ¢¡

100%	MATCHING BLOCK 157/200	W

ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S2V

ãú ì)ºÏˆÏíÓ˚ Ñ¸yÓ˚í =!ú ÓƒyÖƒy Ñ¸Ó˚&ò– S3V ˜ãÓ x!:ˆÏäò â¸y!£üy !Ñ¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S4V !Ó¸ôî≈ˆÏÎ˚Ó˚ ÓƒÓfl¸iy¸ôòy ¢¡

100%	MATCHING BLOCK 159/200	W

ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S5V ¶)¸!

õÑ¸¡ô !òÎ˚s¸fˆÏíÓ˚ ÓƒÓfl¸iy¸ôòy =!ú xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S6V ¢ƒy!ò›¸y!Ó˚ úfyu¸!ö¸ˆÏ”Ó˚ Ñ¸yã ≤ÃÎ˚!ú ÓƒyÖƒy Ñ¸Ó˚&ò– v¸z_Ó˚ ¢ÇˆÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (iii) 3Ó˚y !v¸ˆÏ¢¡Ó˚ñ 1984 S2V (iv) Hg S3V (iii) 0.05 S4V (iii) ˆv¸!¢ˆÏÓú S5V (i) NO x 110 ? NSOU ? AE-ES-21

~Ñ¸Ñ¸È 6 ¸ô!Ó˚ˆÏÓüÜì¸ ¢õ¢ƒyñ ò#!ì¸ ~ÓÇ â¸â≈¸y (Environmental Issues, Policies and Practices) Ü‡¸ò 6.0 v¸zˆÏjüƒ 6.1 ≤Ãhfl¸ÏyÓòy 6.2 !ÓŸª v¸z°åyÎ˚ò (Global warming) 6.2.1 Ñ¸yÓ˚y Ñ¸yÓ˚y ˆ@'yÓyú ÁÎ˚y!õ≈ÇÈÙÈ~ îyÎ˚# 6.2.2 !ÓŸª v¸z°åyÎ˚íÈÙÈ~Ó˚ ! â¸£´ Óy ò!ãÓ˚ (Evidence of Global Warming) 6.3 x¡'Ó,!‹T ≠ v¸zÍ¢ Á «¸!ì¸Ñ¸yÓ˚Ñ¸ ≤Ã¶¸yÓ (Acid rain : Causes and Effects) 6.4 Áãò hfl¸ˆÏÓ˚Ó˚ !Óòyü (Ozone layer depilation) 6.4.1 ÓyÎ˚%õ[¸ˆÏúÓ˚ ÁˆÏãyò Üƒyˆ Ï¢Ó˚ v¸zÍ¸ô!_ (Origin of O 3 gas in the atmosphere) 6.4.2 ÓyÎ˚%õ[¸ˆÏúÓ˚ ÁˆÏãyò hfl¸ˆÏÓ˚Ó˚ =Ó˚&c (Importance of ozone layer in the atmosphere) 6.4.3 ÁˆÏãyò Üì≈¸ ¢,!‹TÓ˚ Ñ¸yÓ˚í (Causes of ozone depletion) 6.5 ¸ôyÓ˚õyí!ÓÑ¸ î%á≈›¸òy (Nuclear Accidents) 6.6 õ!r›¸∆Î˚yú ˆ≤ÃyˆÏ›¸yÑ¸ú S1987V 6.7 !Ñ¸ˆÏÎ˚yˆÏ›¸y ˆ≤ÃyˆÏ›¸yÑ¸ú S1997V 6.8 ãú ¢ÇÓ˚«¸í (Water Conservation) 6.8.1 Ó,!‹TÓ˚ ãú ¢ÇÓ˚«¸í (Rain water harvesting) 6.9 ¶¸yÓ˚ˆÏì¸ ¸ô! Ó˚ˆÏÓü xyˆÏ®yúò (Environmental Movements of India) 6.9.1 !â¸¸ôˆÏÑ¸y xyˆÏ®yúò 6.9.2 òõ≈îy Ó§yâ¸yÁ xyˆÏ®yúò 6.9.3 ˆì¸£Ó˚# Ó§yï !ÓˆÏÓ˚yï# xyˆÏ®yúò 6.9.4 ¢y£zˆÏúr›¸ ¶¸ƒy!ú xyˆÏ®yúò 6.10 ¸ô!Ó˚ˆÏÓü Ó˚«¸yÎ˚ ¢yÇ!Óïy!òÑ¸ ÓƒÓfl¸iy ¢õ)£ (Constitutional Provision for Protecting Environment) 6.11 xò%ü#úò#

6.0 v¸zˆÏjüƒ ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ˆÏÓ˚ xy¸õ!l !l¡¨!°!áï¸ !Ó£ÏÎ˚=!° çylˆÏï¸ ¸õyÓ˚ˆÏÓl– ? !ÓŸª í¸z£èyÎ˚l Ü¸yˆÏÜ¸ ÓˆÏ°– ˆÎ §ÙhflÏ àƒy§ ! ÓŸª í¸z£èyÎ˚ˆÏîÓ˚ çlƒ òyÎ˚# ï¸yˆÏòÓ˚ í¸zÍ§ G ≤ÃË¸yÓ– ? x"Ó,!‹T– GˆÏçyl hflÏˆÏÓ˚Ó˚ !Óly¢– ? ¸õyÓ˚Ùyî!ÓÜ¸ ò%â≈ê¸lyñ Ù!^˝ê¸∆Î˚y° G !Ü¸ˆÏÎ˚yˆÏê¸y ˆ≤ÃyˆÏê¸yÜ¸°– ? ç° §ÇÓ˚«¸î– ? xyÙyˆÏòÓ˚ Ë¸yÓ˚ï¸ÓˆÏ£Ï≈Ó˚ ¸õ!Ó˚ˆÏÓ¢ xyˆÏ®y°l ~ÓÇ ¸õ!Ó˚ˆÏÓ¢ Ó˚«¸yÎ˚ !Ó!Ë¸ß¨ §yÇ!Óôy!lÜ¸ ÓƒÓfliy§Ù)•– 6.1 ≤Ãhfl¸ÏyÓòy ¸õ,!ÌÓ#ˆÏï¸ ˆÎ §Ù§ƒy Óï≈¸ÙyˆÏl Ùyl%ˆÏ£ÏÓ˚ fliy!Î˚cÜ¸y°ˆÏÜ¸ !Ó¸õß¨ Ü¸ˆÏÓ˚ ï%¸ˆÏ°ˆÏSÈ Ë)¸¸õ,ˆÏ¤¸Ó˚ ï¸y¸õÙyey Ó,!k¸ ï¸yÓ˚ ÙˆÏôƒ xlï¸ƒÙ– ~!ê¸ Ùyl%ˆÏ£ÏÓ˚ §,‹T ï¸y¸õò)£Ïî §Ù§ƒy– ÓyÎ˚%Ù[¸ˆÏ°Ó˚ !Ó! Ë¸ß¨ àƒyˆÏ§Ó˚ âlc Ó,!k¸Ó˚ òÓ˚&l ¸õ,!ÌÓ#Ó˚ àí¸¸ ï¸y¸õÙyey Ó,!k¸ ¸õyˆÏFSÈ– ~•z ~Ü¸ˆÏÜ¸ ¸õ!Ó˚ˆÏÓ¢àï¸ !Ó!Ë¸ß¨ §Ù§ƒy ˆÎÙl ! ÓŸªí¸z£èyÎ˚îñ x¡'Ó,!‹Tñ Gçl hflÏˆÏÓ˚Ó˚ !Óly¢ ˆÎÙl xyˆÏ°yã¸ly Ü¸Ó˚y •ˆÏÎ˚ˆÏSÈ ˆï¸Ù!l xyÙyˆÏòÓ˚ ¸õ!Ó˚ˆÏÓ¢ ÓÑyã¸yˆÏlyÓ˚ °ˆÏ«¸ƒ !Ó! Ë¸ß¨ ¸õk¸!ï¸ G í¸zˆÏÕ'áˆÏÌyàƒ xyˆÏ®y°ˆÏlÓ˚ Ü¸ly Ó°y •ˆÏÎ˚ˆÏSÈ– ¸õ!Ó˚ˆÏÓ¢ Ó˚«¸yÎ˚ !Ó!Ë¸ß¨ §yÇ!Óôy!lÜ¸ ÓƒÓfliyG ~•z ~Ü¸ˆÏÜ¸ xyˆÏ°yã¸ly Ü¸Ó˚y •°– 6.2 !ÓŸª v¸z°åyÎ˚˚í (Global warming) ¸ô,!ÌÓ#Ó˚ î#á≈ ¶)¸ì¸y!_¥Ñ¸ Á ãúÓyÎ˚%Üì¸ !ÓÓì≈¸ˆÏò ¶)¸¸ô,ˆÏ¤¸Ó˚ Üv¸¸ ì¸y¸ôõyey ~Ñ¸!›¸ !ò!î≈‹T õyˆÏò xy¢yÓ˚ ¸ôÓ˚£z ~ÖyˆÏò ≤ÃyˆÏíÓ˚ fl¸ô®ò !õˆÏúˆÏäÈ– ¸ô,!ÌÓ#Ó˚ Üv¸¸ fl¸∫y¶¸y!ÓÑ¸ ì¸y¸ôõyey 15°C– ¢)Î≈ ¸ô,!ÌÓ#Ó˚ ~£z ì¸y¸ôõyeyÓ˚ ≤Ãïyò ~ÓÇ ~Ñ¸õye v¸zÍ¢– ¸ô,!ÌÓ#Ó˚ ~£z fl¸∫y¶¸y!ÓÑ¸ ì¸y¸ôõyey !òÎ˚!s¸fi¸ £Î˚ ¸ô,! ÌÓ#¸ô,ˆÏ¤¸ xyÜì¸ ˆ¢ÔÓ˚ !Ñ¸Ó˚í (Incoming solar radiation) ~ÓÇ ¸ô,!ÌÓ# ˆÌˆÏÑ¸ !ÓÜì¸ Óy ≤Ã!ì¸ö¸!úì¸ ˆ¢ÔÓ˚ !Ñ¸Ó˚ˆÏíÓ˚ (Outgoing solar radiation) ¶¸yÓ˚¢yõƒ myÓ˚y– ÓyÎ˚%õ[¸ˆÏúÓ˚ fl¸∫y¶¸y!ÓÑ¸ Üƒy¢#Î˚ v¸z¸ôyîyò ~£z ì¸y¸ô#Î˚ ¶¸yÓ˚¢yˆÏõƒ ~ì¸Ñ¸yú ˆÑ¸yˆÏòy ≤ÃÑ¸yÓ˚ !Óá¯ ¢,!‹T Ñ¸ˆÏÓ˚!ò– !Ñ¸ls¸ !ü"!Ó≤'ˆÏÓÓ˚ ¸ôÓ˚ xÌ≈yÍ x‹Tyîü ùì¸y∑#Ó˚ ˆü°Ï ˆÌˆÏÑ¸ ~£z fl¸∫y¶¸y!ÓÑ¸ ¶¸yÓ˚¢yˆÏõƒÓ˚ !Óá¯ì¸y !ÓK¸yò# õ£ˆÏúÓ˚ òãˆÏÓ˚ xy¢ˆÏì¸ ÷Ó˚& Ñ¸ˆÏÓ˚ – ¢yÓ˚y !ÓŸª ã%ˆÏv¸¸ ¶)¸¸ô,ˆÏ¤¸Ó˚ Üv¸¸ v¸z°åì¸y ¢yõyòƒ £yˆÏÓ˚ Óyv¸¸ˆÏì¸ ÷Ó˚& Ñ¸ˆÏÓ˚ – 1880 ˆÌˆÏÑ¸ 1980 ~£z ~Ñ¸ˆÏüy ÓäÈˆÏÓ˚ ¸ô,!ÌÓ#Ó˚ Üv¸¸ ì¸y¸ôõyey ˆÓˆÏv¸¸ˆÏäÈ ≤ÃyÎ˚ 0.6°C– xyüB¸y Ñ¸Ó˚y ÎyˆÏFäÈ 2100 ¢yú òyÜyî ~£z ì¸y¸ôõyey ¢Ó≈!ò¡¨ xyÓ˚Á 1.4°C ~ÓÇ ¢ˆÏÓ≈yFâ¸ xyÓ˚Á 5.8°C Óyv¸¸ˆÏÓ– ì¸yÓ˚ Ñ¸yÓ˚í v¸z°åì¸y Ó,!k¸Ó˚ ~£z £yÓ˚ e´õÓï≈õyò– ¢yÓ˚y ¸ô,!ÌÓ#Ó˚ ~£z Üv¸¸ v¸z°åì¸yÓ˚ e´õÓï≈õyò xÓfl¸iyˆÏÑ¸ !ÓK¸yò#Ó˚y òyõ ! îˆÏÎ˚ˆÏäÈò ÚÚˆ@'yÓyú ÁÎ˚y!õ≈ÇÛÛ (Global Warming)– ˆ@'yÓyú ÁÎ˚y!õ≈Ç Óy v¸z°åyÎ˚ˆÏíÓ˚ ~£z £yÓ˚ !òˆÏÎ˚ !ÓK¸yò#ˆÏîÓ˚ õˆÏïƒ òyòyõì¸ ÌyÑ¸ˆÏúÁ ¸ô,!ÌÓ# ˆÎ e´õü v¸z_Æ £ˆÏFäÈ ~!òˆÏÎ˚ !mõì¸ ˆò£z– ~!Ó°ˆÏÎ˚ £z!ì¸õˆÏïƒ !Ó!¶¸ß¨ ≤Ãyõyíƒ ì¸Ìƒ !ÓK¸yò#ˆÏîÓ˚ £yˆÏì¸ ˆ¸ôÔ§ˆÏäÈˆÏäÈ– 6.2.1 Ñ¸yÓ˚y Ñ¸yÓ˚y ˆ@'yÓyú ÁÎ˚y!õ≈ÇÈÙÈ~ îyÎ˚# ≤ÃÌˆÏõ ãyòy !ÜˆÏÎ˚ !äÈú CO 2 ~Ñ¸õye !@˘Ãò £yv¸z¢ Üƒy¢ñ xÌ≈yÍ CO 2 ÈÙÈ~Ó˚ áòc Ó,!k¸Ó˚ ãòƒ ¸ô,!ÌÓ#Ó˚ ì¸y¸ôõyey e´õü Óyv¸¸ˆÏäÈ– ¸ôˆÏÓ˚ ãyòy ˆÜˆÏäÈ !õˆÏÌòñ òy£z›¸∆y¢ x:y£zv¸ñ ˆÑœ¸yˆÏÓ˚yöœ$¸ÁˆÏÓ˚y Ñ¸yÓ≈ò Á Áãò Üƒy¢Á Ñ¸õ îyÎ˚# òÎ˚ – 112 ? NSOU ? AE-ES-21 ¸ô,!ÌÓ#¸ô,ˆÏ¤¸ ì¸y¸ôõyey Ó,!k¸Ó˚ «¸õì¸y ~ˆÏîÓ˚ õˆÏïƒ ˆÑœ¸yˆÏÓ˚yöœ$¸ÁˆÏÓ˚yÑ¸yÓ≈ˆÏòÓ˚ ˆÓ!üñ ì¸yÓ˚ ¸ôÓ˚ e´õyß∫ˆÏÎ˚ xy¢ˆÏÓ òy£z›¸∆y¢ x:y£zv¸ñ !õˆÏÌòñ ÁˆÏãyò Á ¢ÓˆÏüˆÏ°Ï Ñ¸yÓ≈ò v¸y£zx:£zv¸– «¸õì¸y Ñ¸õ £ˆÏúÁ ¸ô,!ÌÓ#¸ô,ˆÏ¤¸ v¸z°åì¸y Ó,!k¸Ó˚ ãòƒ õ)ú îyÎ˚# CO 2 – v¸z°åì¸y Ó,!k¸Ó˚ 55 üì¸yÇˆÏüÓ˚ ãòƒ îyÎ˚# CO 2 , 15 üì¸yÇˆÏüÓ˚ ãòƒ îyÎ˚# !õˆÏÌòñ 14 üì¸yÇˆÏüÓ˚ ãòƒ îyÎ˚# ˆÑœ¸yˆÏÓ˚yöœ$¸ÁˆÏÓ˚y Ñ¸yÓ≈òñ 6 üì¸yÇˆÏüÓ˚ ãòƒ îyÎ˚# òy£z›¸∆y¢ x:y£zv¸ ~ÓÇ ÁˆÏãyò Á ãú#Î˚ Óy‹ô ≤ÃˆÏì¸ƒˆÏÑ¸ ≤ÃyÎ˚ 4 üì¸yÇü Ñ¸ˆÏÓ˚ îyÎ˚#– ≤Ã!ì¸ÓäÈÓ˚ ~£z Üƒy¢=!úÓ˚ ¸ô!Ó˚õyí ˆÎ¶¸yˆÏÓ Óyv¸¸ˆÏäÈ ì¸y ~£z Ó˚Ñ¸õÈÙÙÙÈ Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ 0.4 üì¸yÇüó !õˆÏÌò 1 üì¸yÇüó òy£z›¸∆y¢ x:y£zv¸ 0.3 üì¸yÇü Á ˆÑœ¸yˆÏÓ˚yöœ$¸ÁˆÏÓ˚yÑ¸yÓ≈ò 5 üì¸yÇü– ~Öò ≤ÃŸ¿ £ú ~£z ì¸y¸ôõyey Ó,!k¸ Ñ¸# £yˆÏÓ˚ £ˆÏFäÈ Óy xyˆÏîÔ £ˆÏFäÈ !Ñ¸òy– !ÓˆÏü°ÏK¸ˆÏîÓ˚ õˆÏì¸ ~Ó˚ v¸z_Ó˚ £§ƒy– xÌ≈yÍ ¶)¸¸ô,ˆÏ¤¸Ó˚ ì¸y¸ôõyey Ó,!k¸Ó˚ ≤Ã¶¸yÓ £z!ì¸õˆÏïƒ xyõÓ˚y ¸ôy!FäÈ– ˆÎ ¢õhfl¸ Üƒy¢=!ú !@˘Ãò £yv¸z¢ ≤Ã¶¸yˆÏÓÓ˚ ãòƒ îy#Î˚ ì¸yˆÏîÓ˚ v¸zÍ¢ Á ≤Ã¶¸yÓ ! òˆÏ¡¨ ¢yÓ˚!íˆÏì¸ ≤ÃÑ¸yü Ñ¸Ó˚y £ú– ÜƒyˆÏ¢Ó˚ òyõ v¸zÍ¢ ≤Ã¶¸yÓ 1– Ñ¸yÓ≈òÈÈÙÈÈv¸y£zÈÙÈx:y£zv¸ ??ã#ÓyŸ¬á!›¸ì¸ ãµyúy!ò SÖ! òãˆÏì¸úñ Ñ¸Î˚úy ??¸ô,!ÌÓ#Ó˚ ÓyÎ˚%õ[¸ˆÏú !£õÎ%ˆÏÜ Ñ¸yÓ≈ò (CO 2) ≤Ã¶¸¸!ì¸V ÓƒÓ£yˆÏÓ˚Ó˚ ö¸ˆÏú– v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ˆÎ ¸ô! Ó˚õyí !äÈú xyã ??!ü" Ñ¸yÓ˚Öyòy Á ˆõy›¸Ó˚ Üy!v¸¸ ÓƒÓ£yˆÏÓ˚Ó˚ ö¸ˆÏú– ì¸y ˆÓˆÏv¸¸ˆÏäÈ ≤ÃyÎ˚ 1800 ˆÑ¸y!›¸ ›¸ˆÏòÓ˚ ??!¢ˆÏõr›¸ v¸zÍ¸ôyîò Ñ¸yÓ˚Öyòy ˆÌˆÏÑ¸– õˆÏì¸yñ 0.5% £yˆÏÓ˚ ~£z Ó,!k¸ áˆÏ›¸ˆÏäÈ– ??xÓ˚íƒ ¢Ç£yÓ˚ Á ¢Ó%ã !òïˆÏòÓ˚ ö¸ˆÏú ??¸ô,!ÌÓ#Ó˚ !Ó! ¶¸ß¨ ãyÎ˚ÜyÎ˚ Ñ¸yÓ≈ò v¸y£zÈÙ È CO 2 ÙÈ~Ó˚ ¸ô!Ó˚õyí Ó,!k¸ ¸ôyÎ˚ x:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí ~£z¶¸yˆÏÓ Ó,!k¸ ˆ¸ôˆÏú

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xyÜyõ# üì¸y∑#ˆÏì¸ ¸ô,!ÌÓ#Ó˚ ì¸y¸ôõyey ≤ÃyÎ˚ 36° ˆ¢ú!¢Î˚y¢ ˆÓ˚

Ïv¸¸ ÎyˆÏÓ–– 2– !õ˜Ïlò (CH 4) ??ãúy¶)¸!õ Á Ñ¸¸!ºÏ«¸ ˆÏe ÜyäÈ¸ôyúy ≤Ã¶¸¸!ì¸Ó˚ ??!õ˜ÏlˆÏòÓ˚ ì¸y¸ôïyÓ˚í «¸õì¸y Ñ¸yÓ≈ò v¸y£zÈÙÈ ¸ôâ¸ ˆÏòÓ˚ ö¸ ˆÏúñ !Ó!¶¸ß¨ ˜ãÓ Ó˜Ïã≈ƒñ !Ñ¸ä%È x:y£z˜Ïv¸Ó˚ ˆÌ˜ÏÑ¸ ≤ÃyÎ˚ 21 =í ˆÓ!ü– ã#Óãls¸Ó˚ ¢y£y˜ÏÎƒ ~ÓÇ ˆì¸úÖ!ò ˆÌ˜ÏÑ¸ ! õ˜ÏlˆÏòÓ˚ ¢¸!‹T £Î˚ – ??¶¸yÓ˚ì¸ñ !â¸ò !Ó!¶¸ß¨ ˆïü=!úÓ˚ âúõ@¿ ïyò˜ÏÖì¸ =!ú !õ˜ÏlˆÏòÓ˚ Ó˜Ïv¸¸y v¸zÎ¢ !£¢y˜ÏÓ !â¸!£´ì¸ £˜Ïl˚ˆÏäÈ– 3– òy£z›¸∆y¢ x:y£zv¸ ??õy!›¸ ˆÏì¸ !Ó!¶¸ß¨ ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚yÓ˚ !Ó!e´Î˚y ??~!›¸ ÓäȈÏÓ˚ 0.25% £y˜ÏÓ˚ Óyv¸¸ˆÏäÈ– Á ÜyäÈ¸ôyúyÓ˚ ãòƒ òy£z˜Ï›¸∆y˜Ïãò á!›¸ì¸ ??~!›¸Ó˚ ì¸y¸ôïyÓ˚í «¸õì¸y Ñ¸yÓ≈ò ¢yÓ˚ ¢¸!‹T £Î˚ – v¸y£zÈÙÈx:y£z˜Ïv¸Ó˚ ˆÌ˜ÏÑ¸ 270 =í ˆÓ!ü– ? Ñ¸úÑ¸yÓ˚Öyòyñ ˆõy›¸Ó˚ Üy!v¸¸ ≤Ã¶¸¸!ì¸ ˆÌ˜ÏÑ¸ î£òã!òì¸ Ñ¸yÓ˚ ˆÏíÁ ~!›¸ ¢¸!‹T £Î˚ – 4– ˆÑœ¸y˜ÏÓ˚yöœ$¸Á˜ÏÓ˚yÑ¸yÓ≈ò ?? ˆÑœ¸y!Ó˚ò Á öœ$¸!Ó˚ˆÏòÓ˚ ¢Ç!õ◊˜Ïí ~Ñ¸!›¸ ??ÓyÎ˚%hfl¸ˆÏÓ˚Ó˚ !Ñ¸ˆÏúy!õ›¸yÓ˚ Á¸ô˜ÏÓ˚ (CFC) !Ó˜ÏüºÏ ïÓ˚ˆÏòÓ˚ Üƒy¢ £ú CFC– !Ó!¶¸ß¨ fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ x˜ÏòÑ¸!ìò ìy˜ÏÑ¸ – [~!›¸Ó˚ õ˜Ïïƒ !ü˜Ï“ñ ˆÎõò ˆÓ˚!ö ¸ãy˜ÏÓ˚›¸yÓ˚ Á ü#ì¸ì¸y¸ô ??ì¸y¸ô ïyÓ˚ˆÏíÓ˚ ˆ«¸ˆÏe ~!›¸ Ñ¸yÓ≈ò v¸z˜ÏÕÖ˜ÏÏyÜƒ [CFC 11] !òÎ˚s¸fÑ¸ Îs¸f ˜ì¸!Ó˚Ó˚ ãòƒñ ~˜ÏÓ˚y¢úñ v¸y£zÈÙÈx:y£z˜Ïv¸Ó˚ ˆÌ˜ÏÑ¸ ~ÓÇ CFC 12] ˆfl¸±Ñ¸ƒyòñ ≤y!fi›¸Ñ¸ñ ≤Ã¶¸¸!ì¸ˆÏì¸ £z£y 7000-14000 =í ˆÓ!ü ü!_´üyú#– ÓƒÓ£*ì¸ £Î˚ – ??Ñ¸úÑ¸yÓ˚Öyòyñ ˆõy›¸Ó˚Üy!v¸¸ ≤Ã¶¸¸!ì¸ ˆÌ˜ÏÑ¸ î£òã!òì¸ Ñ¸yÓ˚ ˆÏíÁ ~!›¸ ¢¸!‹T £Î˚ – 5– !òï¨hfl¸ˆÏÓ˚Ó˚ Á˜Ïãyò ??~!›¸Ó˚ ì¸y¸ôïyÓ˚í «¸õì¸y Ñ¸yÓ≈ò (O 3) v¸y£zÈÙÈx:y£z˜Ïv¸Ó˚ ˆÌ˜ÏÑ¸ 2000 =í ˆÓ!ü– NSOU ? AE-ES-21 ? 113

6.2.2 !ÓŸª v¸z°åyÎ˚íÈÙÈ~Ó˚ !â¸£´ Óy ò!ãÓ˚ (Evidence of Global Warming) ¢yÓ˚y ¸ô¸!lÓ# ˆÏì¸ v¸z°åyÎ˚í Óy ˆ@'yÓyú ÁÎ˚y! õ≈ÇÈÙÈ~Ó˚ ˆò˜ÏÜ!›¸¶¸ ≤Ã¶¸yÓ Ñ¸# Ñ¸# £˜Ïl˚ˆÏäÈ Óy £ˆÏFäÈ ~£z !ò˜Ïl˚ ~Ñ¸ú !ÓK¸yò# Ü˜ÏÓºÏíyÎ˚ Ó˚ì¸– ~˜ÏïÓ˚ Ü˜ÏÓºÏíyÎ˚ £z! ì¸õ˜Ïïƒ xyõÓ˚y ˆÎ ˆÎ ò!ãÓ˚ Óy !â¸£´ ˆ¸ô˜Ïl˚ !äÈ ì¸y ¢Ç˜Ï«¸ˆÏÌ¸ô xy˜Ïúy!â¸ì¸ £ú– ? (1) ÓyÎ˚%õ[¸ˆÏú CO 2 Ó¸!k¸ ≠ xyõÓ˚y xy˜ÏÜ£z ˆã˜Ïò!äÈ ÓyÎ˚%õ[¸ˆÏú ÈCO 2 ÙÈ~Ó˚ õyey !ü¨ !Ó≤´˜ÏÓÓ˚ ¸ôÓ˚ xfl¸ƒy¶!yÓÑ¸ £y˜ÏÓ˚ ˆÓ˚ˆÏv¸¸ˆÏäÈ– !ü“!Ó≤´ˆÏÓÓ˚ xy˜ÏÜ 280 ppm ˆÌ˜ÏÑ¸ Óì≈¸õy˜Ïò ≤ÃyÎ˚ 360 ppm ~ ˆ¸ôÔ§˜ÏäȈÏäÈ ÈÙÙÙÈ xì≈yí ≤ÃyÎ˚ 30% Ó¸!k¸ – ~£z õyey Üì¸ 160,000 ÓäȈÏÓ˚Ó˚ õ˜Ïïƒ ¢Ó≈y! ïÑ¸ – ??(2) ÓyÎ˚%õ[¸ˆÏú !õ˜Ïlò Üƒy˜Ï¢Ó˚ Ó¸!k¸ (Increase of methane gas) ≠ !õ˜Ïlò ÓyÎ˚%õ[¸ˆÏúÓ˚ xòfiì¸õ !@˘Ãò £yv¸z¢ Üƒy¢– ~£z Üƒy¢Á Üì¸ 100 ÓäȈÏÓ˚ 0.7 ppm ˆÌ˜ÏÑ¸ 1.7 ppmÈÙÈ~ ˆì¸ xì≈yí ≤ÃyÎ˚ 145% ˆÓ˚ˆÏv¸¸ˆÏäÈ– Óì≈¸õy˜Ïò ≤Ã!ì¸ ÓäÈÈÓ˚ 540 !õ!úÎ˚ò ›¸ò ! õ˜Ïlò ÓyÎ˚%õ[¸ˆÏú ˆõ˜Ïü– ? (3) xyÓ£yÁÎ˚yÓ˚ áòáò ¸ô!Ó˚Óì≈¸ò (Frequent change weather) ≠ Üì¸ î%˜Ïüy (1800-2000) ÓäȈÏÓ˚Ó˚ õ˜Ïïƒ 1999 !äÈú ¢Ó≈y!ïÑ¸ ì¸y¸ô#Î˚ ÓäÈÈÓ˚ ~ÓÇ ~Ó˚ £z õ˜Ïì¸y â¸Ó˚õ ì¸y¸ô#Î˚ xÓfl¸iy ~£z ¢õ˜Ïl˚ 5 ÓyÓ˚ £˜Ïl˚!äÈú– ö¸ˆÏú ÖÓ˚y Á ÓòƒyÓ˚ ≤ÃˆÏÑ¸y¸ôÁ ˆÓ˚ˆÏv¸¸ˆÏäÈ ú«¸í#Î˚¶¸y˜ÏÓ–

95%	MATCHING BLOCK 162/200	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

xy˜Ïõ!ÓÑ¸y £zv¸z˜ÏÓ˚y˜Ïì¸ô ˆ

îÖy ˆÜ˜ÏäÈ Üì¸ 50 ÓäȈÏÓ˚Ó˚ õ˜Ïïƒ ü#ì¸úì¸õ ü#ì¸Ñ¸yú– ~£z ¢õ˜Ïl˚ ì%¸ºÏyÓ˚ ¸ôyì¸ñ ì%¸ºÏyÓ˚G v¸¸¸ Á ÓòƒyÓ˚ ì¸#Ó ì¸yÁ ˆÓ˚ˆÏv¸¸ˆÏäÈ– Üì¸ 25 ÓäȈÏÓ˚Ó˚ õ˜Ïïƒ ì¸#Ó ì¸õ ì%¸ºÏyÓ˚ G v¸¸¸ £˜Ïl˚ˆÏäÈ ãy¸ôyò Á ˆÑ¸y!Ó˚Î˚yÎ˚ – ~£z ¢õ˜Ïl˚ ìy£zúƒyu¸ ü#ì¸úì¸õ ü#ì¸Ñ¸yú ~˜Ïï¢ˆÏäÈ ì¸#Ó ì¸õ @˘Ã#˜Ï‹øÓ˚ ¸ô˜ÏÓ˚ – úu¸ˆÏò ˆîÖy ˆÜ˜ÏäÈ 300 ÓäȈÏÓ˚Ó˚ õ˜Ïïƒ ÷‹Óì¸õ ÈNOAAÙÈÓ˚ (National Climatic data centre) !v¸ˆÏÓ˚QÓ˚ ÎÏy¢ Ñ¸yú≈ È(Thomas Karl)ÙÈ~Ó˚ õ˜Ïì¸ Üì¸ ÓäȈÏÓ˚ ÓyÎ˚%õ[¸ˆÏúÓ˚ ì¸y¸ôõyey e´õyß˜Ïl˚ ˆÓ˚ˆÏv¸¸ â¸ˆÏúˆÏäÈ– Üì¸ ˆü°Ï üì¸y∑#ˆÏì¸ (1900-2000) ¸ô¸!lÓ#Ó˚ ì¸y¸ôõyey Ó¸!k¸Ó˚ ¸ô!Ó˚õyí 0.6°C– ~ÓÇ ˆü°Ï !£õî%ˆÏÜÓ˚ ¸ôÓ˚ (1800-2000 ÓäÈÓ˚ xy˜ÏÜV ÓyÎ˚%õ[¸ˆÏú ì¸y¸ôõyey ≤ÃyÎ˚ 5°-9°F ˆÓ˚ˆÏv¸¸ˆÏäÈ– ? (4) ! £õÓy˜Ï£Ó˚ xhs¸ï≈yò !Ñ¸ÇÓy ¸ôÿ¸yì¸ô¢Ó˚í (Disappearing or retreat of glacier) ≠ ÓÓ˚ˆÏö¸Ó˚ Üúò !Ñ¸ÇÓy !£õyÓy˜Ï£Ó˚ ¸ôÿ¸yì¸ô¢yÓ˚í £ú ˆ@'yÓyú ÁÎ˚y!õ≈ÇÈÙÈ~Ó˚ ¢Ó˚˜Ïâ¸ˆÏl˚ Ó˚ˆÏv¸¸y ~ÓÇ !ò¶≈¸Ó˚ˆÏÎyÜƒ ≤Ãõyí– ¸ô¸!lÓ#Ó˚ 6!›¸ õ£y˜ÏîˆÏüÓ˚ ~£z áÌ¸òy á˜Ï›¸ â¸ˆÏúˆÏäÈ– (i) v¸z_Ó˚ xy˜Ïõ!ÓÑ¸y õ£y˜ÏîˆÏüÓ˚ ¢Ó˚˜Ïâ¸ˆÏl˚ Ó˚ˆÏv¸¸y !£õÓy£ ˆÓ!Ó˚Ç !£õÓy£ (Bering glacier) Îy ≤ÃyÎ˚ 11 ˜Î˚˜Ïá≈ƒ Ñ¸ˆÏõ ˆÏäÈó xì≈yí £z!ì¸õ˜Ïïƒ ˆ¢ì¸yÓ˚ xyÎ˚ˆì¸ˆÏòÓ˚ 20-25% £y!Ó˚˜Ïl˚ˆÏäÈ– (ii) !‹«¸í ˆ¸ôÓ˚&Ó˚ Ñ%¸!ÓÓ˚ !£õÓy£ (Qori glacier) Üì¸ 14 ÓäȈÏÓ˚ (1983-2000) xy˜ÏÜÓ˚ 100 ÓäȈÏÓ˚Ó˚ ˆâ¸˜Ïl˚ ≤ÃyÎ˚ 3 =í ˆÓ!ü £y˜ÏÓ˚ Üú˜Ïì¸ ÷Ó˚& Ñ¸ˆÏÓ˚ˆÏäÈ– (iii) !@˘Ãòúƒy˜Ïu¸Ó˚ !£õÓy£=˜Ïúy ¢õ%˜ÏòÓ˚ !ì˜ÏÑ¸ ˆÓü# Ü!ì¸ˆÏì¸ ~˜ÏÜy˜Ïì¸ ÷Ó˚& Ñ¸ˆÏÓ˚ˆÏäÈ– ~!›¸ ¢Ω¸Óì¸ !£õÓy£ Üúò ~ÓÇ Üú˜ÏòÓ˚ ö¸ˆÏú v¸zÍ¸ôß¨ âú !£õÓy˜Ï£Ó˚ ò#˜Ïâ¸ !¸ô!FäÈúÑ¸yÓ˚ Ñ¸ ¸ôîy˜Ï≈ÿ !£¢y˜ÏÓ Ñ¸yã Ñ¸Ó˚yÓ˚ ö¸ˆÏú á˜Ï›¸ˆÏäÈ– (iv) xyõy˜ÏîÓ˚ á˜ÏÓ˚Ó˚ Ñ¸y˜ÏäÈ !£õyú˜ÏÎÓ˚ !£õÓy˜Ï£Á ~Ñ¸£z á›¸òy ú«¸ Ñ¸Ó˚y ˆÜ˜ÏäÈ– Óì≈¸õy˜Ïò ÜDyÓ˚ v¸zÍ¸ô!_ Ü˜ÏDye# !£õÓy£ ≤ÃyÎ˚ ≤Ã! ì¸ ÓäȈÏÓ˚ 30 !õ›¸yÓ˚ £y˜ÏÓ˚ ˆ¸ôÔ§˜ÏäÈy˜ÏFäÈ– ~£z £yÓ˚ Üì¸ 1935 ~ÓÇÈ 1990ÙÈ~Ó˚ ≤ÃyÎ˚ Ü˜Ïv¸¸ 18 !õ›¸yÓ˚ ~ÓÇ 1842 Á È1935ÙÈ~Ó˚ õ˜Ïïƒ !äÈú Ü˜Ïv¸¸ ≤ÃyÎ˚ 7 !õ›¸yÓ˚ – 114 ? NSOU ? AE-ES-21

~£z ≤Ã¢ˆÏD ˆò¸ôyú ¸ôÓ≈ì¸yˆÏÓ˚y£í ¢Çfl¸iyÓ˚ (Nepal Mountaineering Association) !v¸ˆÏÓ˚QˆÏÓ˚Ó˚ Ó_´Óƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ– xyã ˆÌˆÏÑ¸ 50 ÓäÈÓ˚ xyˆÏÜ ~v¸õu¸ !£úyÓ˚# Á ˆì¸ò!ãÇ ˆòyÓ˚ˆÏÜ (Edmond Hillary Á Tenzing Norgay) ˆÎ fl¸iyò !îˆÏÎ˚ !£õyúˆÏÎ˚Ó˚ ¢ˆÏÓ≈yFâ¸ !üÖˆÏÓ˚ xyˆÏÓ˚y£í Ñ¸ˆÏÓ˚!äÈˆÏúò ì¸y Óì≈¸õyˆÏò ¢ˆÏÓ˚ˆÏäÈ !Ñ¸!õ xÌ≈yÍ ˆÓˆÏv¸¸ˆÏäÈ x!ì¸!Ó˚_´ ≤ÃyÎ˚ 2 á^˘›¸yÓ˚ ¸ôÌ– ? (5) ¢%ˆÏõÓ˚& Á Ñ%¸ˆÏõÓ˚& ¢yÜˆÏÓ˚ ÓÓ˚ˆÏö¸Ó˚ Üúò (Melting of Arctic and Antartic ice) ≠ ¸ô,!ÌÓ#Ó˚ v¸z_Ó˚ Á î!«¸ˆÏíÓ˚ xyÑ≈¸!›¸Ñ¸ Á xƒyr›¸yÑ≈¸!›¸Ñ¸y !Óhfl+¸ì¸ ÓÓ˚ö¸ Ó˚y!üÁ ÜúˆÏì¸ ÷Ó˚& Ñ¸ˆÏÓ˚ xfl¸∫y¶¸y!ÓÑ¸ £yˆÏÓ˚– !ÓK¸yò#Ó˚y ˆîˆÏÖˆÏäÈò Üì¸ 1958 ˆÌˆÏÑ¸ 1976ÈÙÈˆì¸ ˆÎÖyˆÏò ¢%ˆÏõÓ˚&ˆÏì¸ ÓÓ˚ˆÏö¸Ó˚ Üv¸¸ v¸zFâ¸ì¸y !äÈú 3 !õ›¸yÓ˚ ì¸y 1993 ˆÌˆÏÑ¸ 1997ÈÙÈ~Ó˚ Üv¸¸ !£ ¢yˆÏÓ Ñ¸ˆÏõ îßy!v¸¸ˆÏÎ˚ ˆÏäÈ ≤ÃyÎ˚ 1.8 !õ›¸yˆÏÓ˚– xÌ≈yÍ Üì¸ 30 ÓäÈˆÏÓ˚ ¢%ˆÏõÓ˚&Ó˚ ÓÓ˚ö¸ ≤ÃyÎ˚ 40% xyÎ˚ì¸ˆÏò Ñ¸ˆÏõˆÏäÈÈÙÙÈ ÓäÈˆÏÓ˚ ÜˆÏv¸¸ ¢ÇÑ%¸!â¸ì¸ £ˆÏÎ˚ˆÏäÈ ≤ÃyÎ˚ ÓÜ≈ 38,000 !Ñ¸.!õ.– !ÓK¸yò# xyÓ˚Á ÓˆÏúˆÏäÈò ˆÎ ~¶¸yˆÏÓ â¸úˆÏì¸ ÌyÑ¸ˆÏú xyÜyõ# 50 ÓäÈˆÏÓ˚Ó˚ ¸ôÓ˚ ¢%ˆÏõÓ˚&Ó˚ @˘Ã#ˆÏ‹ø xyÓ˚ ˆÑ¸yˆÏòy ÓÓ˚ö¸ ¸ôyÁÎ˚y ÎyˆÏÓ òy– Ñ%¸ˆÏõÓ˚& xM¸ÈˆÏúÁ ≤ÃyÎ˚ 5°F £yˆÏÓ˚ Üì¸ 50 ÓäÈˆÏÓ˚ ≤ÃyÎ˚ 5°F ì¸y¸ôõyey ˆÓˆÏv¸¸ˆÏäÈ– ö¸ˆÏú !Óüyú !Óüyú !£õ˜Ïüú î!«¸í ˆõÓ˚&Ó˚ õ)ú ¶)¸Ö[¸ ˆÌˆÏÑ¸ !Ó!FäÈß¨ £ˆÏÎ˚ˆÏäÈ– ? (6) e´yhs¸#Î˚ ˆÓ˚yˆÏÜÓ˚ ≤Ãyî%¶≈¸yÓ (Outbreak of Tropical diseases) ≠ e´yhs¸#Î˚ xM¸ÈˆÏú !Ó!¶¸ß¨ !òì¸ƒòì%¸ò ˆÓ˚yˆÏÜÓ˚ ≤Ãyî%¶≈¸yˆÏÓÓ˚ Ñ¸yÓ˚íÁ ~£z ì¸y¸ôõyey Ó,!k¸– !òv¸z!ãúƒyˆÏu¸Ó˚ ÚÚÁˆÏÎ˚!úÇ›¸ò fl¸%Òú xö¸ ˆõ!v¸!¢ˆÏòÓ˚ÛÛ !â¸! Ñ¸Í¢Ñ¸Ó˚y ~ !Ó°ˆÏÎ˚ ÜˆÏÓ°Ïíy Ñ¸ˆÏÓ˚ò– ì¸yˆÏîÓ˚ õˆÏì¸ î!«¸í ≤Ãüyhs¸ õ£y¢yÜÓ˚#Î˚ m#¸ô¸ô%ˆÏO áòáò ˆv¸D% ãµˆÏÓ˚Ó˚ (Dengue fever) ≤Ãyî%¶≈¸yˆÏÓÓ˚ !¸ôäÈˆÏò ˆ@'yÓyú ÁÎ˚y!õ≈Ç£z îyÎ˚#– ~£z ~Ñ¸£z Ñ¸yÓ˚ˆÏí xy!ö ¸Ñ¸yÓ˚ !òì¸ƒ òì%¸ò ˆîˆÏü ¸ô#ì¸ãµˆÏÓ˚Ó˚ (yellow fever) ≤ÃˆÏÑ¸y¸ôÁ ˆîÖy !îˆÏFäÈ– £yÓyv≈¸ fl¸%Òú xÓ‰ ¸ôyÓ!úÑ¸ ˆ£úˆÏÌÓ˚ (Harvard's School of Public Health) !â¸! Ñ¸Í¢Ñ¸ˆÏîÓ˚ õˆÏì¸ ˆ@'yÓyú ÁÎ˚y!õ≈ÇÈÙÈ~Ó˚ ö¸ˆÏú Óì≈¸õyˆÏò ~òˆÏÑ¸ö¸yúy£z!›¸¢ (encephalitis)ñ õƒyˆÏú!ÓˆÎ˚y (malaria) £zì¸ƒy! îÓ˚ õˆÏì¸y ˆÓ˚yÜ¢õ)£ ~!üÎ˚yñ úy!ì¸ò xƒyˆÏõ!ÓˆÑ¸y !Ñ¸ÇÓy xy!ö ¸Ñ¸y õ£yˆÏîˆÏüÓ˚ v¸zFâ¸ xÇˆÏü ˆîÖy !îˆÏFäÈ Îy Üì¸ 50 ÓäÈˆÏÓ˚ ≤ÃyÎ˚ áˆÏ›¸!ò– ? (7) xòƒyòƒ ≤Ã¶¸yÓ (Ohter symptoms) ≠ ˆ@'yÓyú ÁÎ˚y!õ≈ÇÈÙÈ~Ó˚ xòƒyòƒ ≤Ã¶¸yˆÏÓÓ˚ õˆÏïƒ xòƒì¸õ £ú ¢õ%ˆÏoÓ˚ !Ó!¶¸ß¨ m#¸ô¸ô%ˆÏOÓ˚ â¸y!Ó˚!îˆÏÑ¸ ¢õ%o ãúì¸ˆÏúÓ˚ v¸zFâ¸ì¸y Ó,!k¸ (Sea level rise)– õy!Ñ≈¸ò Î%_´Ó˚yˆÏ‹T…Ó˚ ÁÎ˚y”≈¸ ÁÎ˚yâ¸ £zò!fi›¸!›¸v¸zˆÏ›¸Ó˚ !£¢yÓ xò%ÎyÎ˚# ¸ô,!ÌÓ# ã%ˆÏv¸¸ ¢õ%ˆÏoÓ˚ ãúhfl¸Ó˚ Óyv¸¸ˆÏäÈ ≤Ã!ì 20¸ ÓäÈˆÏÓ˚ ~Ñ¸ £z!M¸È Ñ¸ˆÏÓ˚– ¸ô,!ÌÓ#Ó˚ ≤ÃÓyú m#¸ô=!ú ì¸y¸ôõyey Ó,!k¸ˆÏì¸ îyÓ˚&í «¸!ì¸@˘Ãhfl¸ £ˆÏFäÈ– Üì¸ 2000 xˆÏQyÓˆÏÓ˚ £zˆÏ®yˆÏò!üÎ˚yÓ˚ Óy!úˆÏì¸ xò%!¤¸ì¸ ÚÚòy£zs¸i £zr›¸yÓ˚òƒüòyú ˆÑ¸yÓ˚yú Ó˚#ö¸ !¢ˆÏ¡ôy!ãÎ˚yˆÏõÛÛÈÙÈ~Ó˚ ì¸Ìƒ (9th International Coral Reef Symposium) xò%¢yˆÏÓ˚ £z!ì¸õˆÏïƒ ¸ô,!ÌÓ#Ó˚ ≤ÃyÎ˚ 27% ≤ÃÓyú m#¸ô ò‹T £ˆÏÎ˚ ˆÜˆÏäÈ– xyÜyõ# 20 ÓäÈˆÏÓ˚ Óy!Ñ¸ m#¸ô=ˆÏúyÓ˚ ≤ÃyÎ˚ ¢õhfl¸ ≤ÃÓyú õyÓ˚y ÎyˆÏÓ Î!î Óì≈¸õyò £yˆÏÓ˚ ˆ@'yÓyú ÁÎ˚y!õ≈Ç ÌyˆÏÑ¸ xƒyr›≈¸y!›≈¸Ñ¸yÎ˚ xyú!ÜÓ˚ (algae) v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú !e´ˆÏúÓ˚ (Krill) ¢ÇÖƒy e´õü Ñ¸õy ~ÓÇ ¸ôy!ÖˆÏîÓ˚ ¸ô!ÓÓ˚ÎyÎ˚#ì¸yÓ˚ (migratory nature) ¸ô!ÓÓ˚Óì≈¸òÁ ˆ@'yÓyú ÁÎ˚y!õ≈ÇˆÏÑ¸ fl¸øÓ˚í Ñ¸!ÓˆÏÎ˚ ˆîÎ˚– NSOU ? AE-ES-21 ? 115

6.3 x¡'Ó,!‹T ≠ v¸zÍ¢ Á «¸!ì¸Ñ¸yÓ˚Ñ¸ ≤Ã¶¸yÓ (Acid rain : Causes and Effects) x¡' Ó,!‹TÓ˚ v¸zÍ¢ Á «¸!ì¸Ñ¸yÓ˚Ñ¸ ≤Ã¶¸yÓ ¢¡∫ˆÏì¸ ò#ˆÏâ¸ xyˆÏúyâ¸òy Ñ¸Ó˚y £úÈÙÙÈ v¸zÍ¢ «¸!ì¸Ñ¸yÓ˚Ñ¸ ≤Ã¶¸yÓ ? ÓyÎ˚%õ[¸ˆÏú x!:ˆÏãò Á ¶¸y¢õyò ï)!úÑ¸íy=!ú ãˆÏúÓ˚ ? ãüïyÓ˚y=! ú ãú ï)!°ˆÏì¸ £Î˚ ~ÓÇ v¸z!qî Á ≤Ãyí#Ó˚ ¢ˆÏD

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xyˆÏúyÑ¸ Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚y á!›¸ˆÏÎ˚ ¢yúö¸yÓ˚È v¸y£

zÈÙÈ ≤Ããy!ì¸ £…y¢ Ñ¸ˆÏÓ˚– x:y£zv¸ (SO_2) ~ÓÇ ¢yÓ˚!ö¸v¸z!ÓˆÑ¸ xƒy!¢v¸ (H_2SO_4) ? áÓ˚Óy!v¸¸ñ fl¸∫y¸ôì¸ƒ!üˆÏ“ñ õò%ˆÏõr›¸ñ fl¸ø!ì¸ˆÏ¢ÔïÁ ˜ì¸!ÓÑ¸ÓˆÏÓ˚– xRy!úÑ¸yÓ˚ «¸!ì¸ ¢y!ïì¸ £Î˚– ? Ñ¸Î˚úyñ Ö!òãˆÏì¸ú ≤Ã¶,¸!ì¸Ó˚ ≤Ãâ%¸Ó˚ ¸ô!ÓÓ˚õyˆÏí î£ˆÏòÓ˚ ? ãúïyÓ˚y=!úÓ˚ ãúï)!°ˆÏì¸ £Î˚ ~ÓÇ v¸z!qî Á ≤Ãyí#Ó˚ ö¸ˆÏú ÓyÎ˚%õ[¸ˆÏú ¢yúö¸yÓ˚ (S) Á Ñ¸yÓ≈òÈÙÈõˆÏòy:y£zv¸ ≤Ããy!ì¸ £…y¢ Ñ¸ˆÏÓ˚– (CO)

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Á òy£zˆÏ›¸∆yˆÏãˆÏòÓ˚ ¸ô!ÓÓ˚õyí ¢!‡¸

Ñ¸ ¸ô!ÓÓ˚õyˆÏí ? xÓˆÏíƒÓ˚ v¸z!qî ïπÇ¢ Ñ¸ˆÏÓ˚– Ó,!k¸ ˆ¸ôˆÏÎ˚ˆÏäÈ– ~£z òy£zˆÏ›¸∆yˆÏãò Á ¢yúö¸yÓ˚ á!›¸ì¸ ? õ,!_Ñ¸yÓ˚ v¸zÍ¸ôyîò «¸õì¸y £…y¢ Ñ¸ˆÏÓ˚–

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x:y£zv¸=!ú xyˆÏúyÑ¸ Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚yÓ˚

ö¸ˆÏú ? x¡'ïõ≈# õ,!_Ñ¸yÓ˚ !Ó!¶¸ß¨ ïyì%¸ Sì¸yõyñ !ãB¸ñ

82% **MATCHING BLOCK 166/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

òy£z!›¸∆Ñ¸ xƒy!¢v¸ (HNO_3) Á ¢yú!ö¸v¸z!ÓˆÑ¸ xƒy!¢v¸ xƒyú%!õ!

òÎ˚yõ ≤Ã¶‚¸!ì¸V õy!›¸Ó˚ Ü¶¸#ˆÏÓ˚ ë%¸ˆÏÑ¸ ãúˆÏÑ¸ (H_2SO_4) ˜ì¸!ÓˆÑ¸ˆÏÓ˚– ï)!°ˆÏì¸

97% **MATCHING BLOCK 167/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

Ñ¸ˆÏÓ˚ – ? òy£z!›¸ΔÑ¸ xƒy!¢v¸ Á ¢yú!ö¸v¸z!Ó˚ xƒy!¢v¸ Óyî˚%õ[¸ˆÏú ?

v¸z!q˚ÏîÓ˚ fl¸ĺy¶¸y!ÓÑ¸ Ó,!k¸ Óƒy£ì¸ £Î˚ – ã!õÓ˚ v¸zÓ≈Ó˚ì¸y !

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õˆÏü ìyÑ¸y £y£zˆÏv»¸yˆÏÑœ¸y!Ó˚Ñ¸ xƒy!¢

v¸ (HCl)ÈÙÈ~Ó˚ ò‹T £Î˚ – ¢ˆÏD !õˆÏü x¡'Ó,!‹T á›¸yÎ˚ – ? x¡'Ó,!‹TˆÏì¸ î%£z ÓˆÑ¸ˆÏõÓ˚ xƒy!¢v¸ ˜ì¸!Ó˚ £Î˚ – x¡'Ó,!‹T ˜ì¸!Ó˚Ó˚ Ó˚y¢yÎ˚! òÑ¸ ¢õ#Ñ¸Ó˚í £úÈÙÙÙÈ ¢

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yú!ö¸v¸z!Ó˚Ñ¸ xƒy!¢v¸ ~ÓÇ òy£z!›¸ΔÑ¸ xƒy!¢v¸ – ~£

z SÑ¸V ¢yúö¸yÓ˚ÈÙÈv¸y£zÈÙÈx:y£zv¸ (SO 2) + ãú#Î˚ Óy‹ô xƒy!¢v¸=!ú Ÿªy¢òy!úˆÏì¸ Á ö%¸¢ö%¸ˆÏ¢ òyòy ˆÓ˚yˆÏÜ ¢,!‹T (H 2 O) ? ¢yú!ö¸v¸z!Ó˚Ñ¸ xƒy!¢v¸ (HNO 3) Ñ¸ˆÏÓ˚ – ~õò!Ñ¸ ~Ó˚ ≤Ã¶¸yˆÏÓ ö%¸¢ö%¸ˆÏ¢ Ñ¸ƒyò¢yÓ˚ ¸ô΁hs¸ SÖV òy£zˆÏ›¸ΔyˆÏãò v¸y£zÈÙÈx:y£zv¸ (NO 2) + ãú#Î˚ Óy‹ô £ˆÏì¸ ¸ôyˆÏÓ˚ – ~ äÈyv¸ ¸yÁ ¸ô!Ó˚ ¸ôyÑ¸ì¸s¸ƒ Á òy¶≈¸ì¸ˆÏs¸ƒÓ˚Á (H 2 O) ? òy£z!›¸ΔÑ¸ xƒy! ¢v¸ (HNO 3) Á «¸!ì¸ ¢y!ì¸ £Î˚ – òy£z›¸Δy¢ xƒy!¢v¸ (HNO 2) v¸zîy£Ó˚ifl¸ĺÓ˚*¸ô Óúy ÎyÎ˚ñ õì%Ó˚yÓ˚ Ñ¸yˆÏäÈ ˜ì¸ú˚ˆÏüyïòyÜyÓ˚ ˆÌˆÏÑ¸ ¢yúö¸yÓ˚ÈÙÈv¸y£zÈÙÈx:y£zv¸ (SO 2) Á xòƒòyƒ Üƒy¢ !òÜ≈ì¸ £ˆÏÎ˚ â¸ˆÏúˆÏäÈ Îy ãú#Î˚ Óy‹ôÓ˚ ¢yˆÏì !Ó!e˚Î˚y Ñ¸ˆÏÓ˚ xƒy! ¢v¸ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ö¸ˆÏú ì¸yõ£ˆÏúÓ˚ õyˆÏÓ≈ú ¸ôylˆÏÓ˚ òyòyÓ˚Ñ¸õ «¸Î˚ ˆÏÓy ÎyˆÏÏFäÈ– 6.4 Áãò hfl¸ˆÏÓ˚Ó˚ !Óòyü (Ozone layer depilation) ÁˆÏãyò £ú ò#úÓ˚ˆÏàÓ˚ õÎ¢ Üì¸Î%_´ ~Ñ¸ ïÓ˚ˆÏòÓ˚ Üƒy¢ ÈÙÙÙÈ x!:ˆÏãˆÏòÓ˚ ¢ˆÏD ÎyÓ˚ ì¸ö¸yì¸ Ö%Ó ¢yõyòƒ– ÁˆÏãyˆÏÑ¸ x!:ˆÏãò ÜƒyˆÏ¢Ó˚ Ó˚*¸ôˆÏ¶¸îÁ Óúy ÎyÎ˚ – !ì¸ò!›¸ x!:ˆÏãò ¸ôÓ˚õyí ¸ô%ˆÏv¸¸ ˜ì¸!Ó˚ £Î˚ ~Ñ¸!›¸ ÁˆÏãyò xí% (O 3)– 1840 ! Ö É !ÓK¸yò# ˆfl¸Òyò!Ó (Sconbien) ¢Ó≈≤Ãìõ ÁˆÏãyˆÏòÓ˚ x!hfl¸c ≤Ãõyí Ñ¸ˆÏÓ˚ò– ÓyÎ˚%õ[¸ˆÏú fl¸T...yˆÏ›¸y!fl¸≥¸Î˚yˆÏÓ˚Ó˚ v¸zFâ¸ xÇˆÏü ≤ÃyÑ¸,!ì¸Ñ¸ Ñ¸yÓ˚ˆÏí x!:ˆÏãò xí% ~ÓÇ x!:ˆÏãò ¸ôÓ˚õyí%Ó˚ Ó˚y¢yÎ˚!òÑ¸ !Ó!e˚Î˚yÎ˚ ÁˆÏãyò Üƒy¢ v¸zí¸ôß £Î˚ – ¢õ@ˆÃ fl¸T... ƒyˆÏ›¸y!fl¸≥¸Î˚yˆÏÓ˚ ÁˆÏãyò ÜƒyˆÏ¢Ó˚ x!hfl¸c ¸ôyÂÎ˚y ˆÜˆÏúÁ ~Ó˚ áòc ¢Ó≈y!ïÑ¸ ìyˆÏÑ¸ 15-35 !Ñ¸!õ v¸zFâ¸ì¸yÎ˚ – ~£z xÇü ÁˆÏãyòhfl¸Ó˚ (Ozone layer) Óy ÁˆÏãyˆÏòy!fl¸≥¸Î˚yÓ˚ (Ozonosphere) òyˆÏõ ¸ô!Ó˚!â¸ì¸ – ÁˆÏãyˆÏòy!fl¸≥¸Î˚yˆÏÓ˚ ÁˆÏãyˆÏòÓ˚ Üyë¸¸c Ö%Ó£ Ñ¸õÈÙÙÙ õyey 10 ppm– ~ˆÏÑ¸ ¶)¸ô¸ˆÏ¤¸Ó˚ Óyî˚%â¸y¸ô Á ì¸y¸ôõyeyÎ˚ !òˆÏî˚ ~ˆÏú 3 !õ!ú!õ›¸yÓ˚ ¸ô%Ó˚ˆ& Óyì¸yˆÏ¢Ó˚ õˆÏì¸y £ˆÏÓ ~ÓÇ Áãò £ˆÏÓ ≤ÃyÎ˚ 30 ˆÑ¸y!›¸ ›¸ˆÏòÓ˚ 116 ? NSOU ? AE-ES-21 õˆÏì¸y– ÁˆÏãyˆÏòÓ˚ ¢Ó≈y!ïÑ¸ Üyë¸¸c e´yhs¸#Î˚ xM¸ÈˆÏú 25 !Ñ¸!õ | ˆÏïπ≈ñ 21 !Ñ¸!õ | ˆÏïπ≈ õïƒ x«¸yÇˆÏü xyÓ˚ 18 !Ñ¸!õ | ˆÏïπ≈ ˆõÓ˚& xM¸ÈˆÏú– ¢yiyÓ˚ì¸ Óyî˚%õ[¸ˆÏú ÁˆÏãyˆÏòÓ˚ áòcˆÏÑ¸ !¸ô!¸ô~õ È(ppm)ÙÈ~Ó˚ ÓíˆÏú v¸Ó¢ò ~Ñ¸ˆÏÑ¸ (Dobson unit) ≤ÃÑ¸yü Ñ¸Ó˚y £Î˚ – ~Ñ¸ v¸Ó¢ò (DB) ~Ñ¸Ñ¸ ÓúˆÏì¸ ~Ñ¸ Óyî˚%õ[¸ú#Î˚ â¸yˆÏÏ¸ô 0.001 !õ!ú!õ›¸yÓ˚ ¸ô%Ó˚& ÁˆÏãyˆÏòÓ˚ áòcˆÏÑ¸ ˆÓyG¸yÎ˚ – e´yhs¸#Î˚ xM¸Èú ˆÏìˆÏÑ¸ ˆõÓ˚& xM¸ÈˆÏúÓ˚ !ïˆÏÑ¸ ÁˆÏãyˆÏòÓ˚ áòc e´õü Óy˜ÏÏv¸¸– e´yhs¸#Î˚ (0°–30°) xM¸ÈˆÏú ~£z áòc õye 250 DU– òy!ì¸ü#ˆÏì¸y°â xM¸ÈˆÏúÓ˚ (30°–60°) Óyî˚%õ[¸ˆÏú ÁˆÏãyˆÏòÓ˚ fl¸ĺy¶¸y!ÓÑ¸ áòc 350 DU ~ÓÇ ˆõÓ˚& ˆîü#Î˚ xM¸ÈˆÏú SÈ60°ÙÈ~Ó˚ x!ïÑ¸V ≤ÃyÎ˚ 450 DU– !ò¡¨ x«¸yÇü ˆÏìˆÏÑ¸ v¸zFâ¸ x«¸yÇˆÏü ÁˆÏãyˆÏòÓ˚ áòc x!ïÑ¸ £ÂÎ˚yÎ˚ õ)ú Ñ¸yÓ˚í fl¸T... ƒyˆÏ›¸y!fl¸≥¸!ÓˆÑ¸ xM¸ÈˆÏú !òÎ˚!õì¸ v¸zFâ¸ Óyî˚%≤ÃÓyˆÏ£Ó˚ ö¸ˆÏú e´yhs¸#Î˚ xM¸ÈˆÏúÓ˚ ˆÏìˆÏÑ¸ v¸z¸ôˆÏõÓ˚& xM¸ÈˆÏú ÁˆÏãyò ÜƒyˆÏ¢Ó˚ ¸ô!Ó˚ÓÓ£ò Óy fl¸iyòyhs¸Ó˚ – 6.4.1 Óyî˚%õ[¸ˆÏúÓ˚ ÁˆÏãyò ÜƒyˆÏ¢Ó˚ v¸zí¸ô!_ (Origin of O 3 gas in the atmosphere) ¢)Î≈ ˆÏìˆÏÑ¸ xòÓÓ˚ì¸ ˆÎ xy˚ˆÏúy ¸ô,!lÓ#ˆÏì¸ ~ˆÏ¢ ˆ¸ôÕÔ§ˆÏäÈyˆÏFäÈ ì¸yÓ˚ ¢ˆÏD x!ì¸ˆÏÓ=!ò Óy xyú›¸ΔyÎ¶¸yˆÏÏ˚yˆÏúÈ (Ultra violate rays) Ó˚! Ÿ¬Á xy¢ˆÏäÈ– ~£z x!ì¸ˆÓ=!ò Ó˚!Ÿ¬ˆ

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ÏÑ¸ !ì¸ò¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y Îyî ÎlyÈÙÙÙÈ ??(

i) £zv¸z !¶¸ ~ (UV-A) ÈÙÙÙÈ ì¸Ó˚D ˜îâ≈ƒ 315 – 400 nm ??(ii) £zv¸z !¶¸ ~ (UV-B) ÈÙÙÙÈ ì¸Ó˚D ˜îâ≈ƒ 280 – 315 nm ??(iii) £zv¸z !¶¸ ~ (UV-C) ÈÙÙÙÈ ì¸Ó˚D ˜îâ≈ƒ 100 – 280 nm ˆîÓy ˆÜˆÏäÈ ~£z x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬Ó˚ õˆÏïƒ ¢ÓˆÏâ¸ˆÏÎ˚ Ñ¸õ ÎyˆÏÓ˚ ì¸Ó˚D ˜îâ≈ƒ x!≈yÎ˚ £zv¸z !¶¸ !¢ ~ÓÇ Óy!òÑ¸y £zv¸z !¶¸ !Ó Óyî˚%õ[¸ˆÏúÓ˚ x!:ˆÏãòˆÏÑ¸ ˆ¶¸ˆÏà äyÎ˚õyò x!:ˆÏãò ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – xyÓ˚ ~£z äyÎ˚õyò x!:ˆÏãò ¸ôÓ˚õyí% (O) xyÓ˚ ~Ñ¸!›¸ x!:ˆÏãò xí%Ó˚ (O 2) ¢ˆÏD !õˆÏú ÁˆÏãyò ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ – ~£z ˆü˚Ïªy_´ !Ó!e˚Î˚y!›¸ˆÏì¸ ≤Ãâ¸[¸ ì¸y¸ô v¸zí¸ôyîò £ÂÎ˚yÎ˚ fl¸T...ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ hfl¸ˆÏÓ˚ Óyî˚%Ó#Î˚ ì¸y¸ôõyey ›¸Δ¸ˆÏ¸ôy!fl¸≥¸Î˚yˆÏÓ˚Ó˚ ì%¸úòyÎ˚ xˆÏòÑ¸ ˆÓ!ü £Î˚ – ???????? ? 2 O [ ] [ ] O O UV-C+UV-B 2O 2 + 2 [O] → 2O 3 + ì¸y¸ô 6.4.2 Óyî˚%õ[¸ˆÏúÓ˚ ÁˆÏãyò hfl¸ˆÏÓ˚Ó˚ =Ó˚&c (Importance of ozone layer in the atmosphere) ¶)¸ô¸ˆÏ¤¸ ÁˆÏãyò Üƒy¢ ~Ñ¸!›¸ ¸ô!Ó˚ˆÏÓü î)°ÏÑ¸ ¸ôîyÌ≈ !£¢yˆÏÓ Ñ¸yã Ñ¸Ó˚ˆÏúÁ fl¸T... ƒyˆÏ›¸y!fl¸≥¸Î˚yˆÏÓ˚Ó˚ Áãò ¸ô!ÓÓ#Ó˚ ìyÓì¸#Î˚ ≤ÃyˆÏïÓ˚ Ó˚«¸Ñ¸ !£¢yˆÏÓ Ñ¸yã Ñ¸ˆÏÓ˚ – ÁãˆÏòÓ˚ ~Ñ¸!›¸ ¸ôyì¸ úy hfl¸Ó˚ ¢)Î≈! Ñ¸Ó˚í ˆÏìˆÏÑ¸ «¸!ì¸Ñ¸Ó˚ x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬Ó˚ ˆÓ!üÓ˚ ¶¸yÜ xÇüˆÏÑ¸ £z

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Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚yÓ˚ õyïƒˆÏõ

xy›¸ˆÏÑ¸ ˆîÎ˚– xÌ≈yÍ Áˆïãyò hfl¸Ó˚ ¸ô¸!ÌÓ#Ó˚ ã#Ó ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ≤ÃyÑ¸¸!ì¸Ñ¸ ˆ¢ÔÓ˚ ¸ôî≈y Óy äÈyì¸y !£¢yˆÏÓ Ñ¸yã Ñ¸ˆÏÓ˚– ˆÑ¸yˆÏòy Ñ¸yÓ˚ˆÏí Áˆïãyòhfl¸ˆÏÓ˚ !äÈo ˜ì¸!Ó˚ £ˆÏú ¸ô¸!ÌÓ#ˆÏì¸ «¸!ì¸Ñ¸yÓ˚Ñ¸ £zv¸z !¶¸ !Ó Ó˚!Ÿ¬Ó˚ xyÜõò á›¸ˆÏÓ– ö¸ˆÏú ã#ÓãÜˆÏì¸Ó˚ x!hfl¸c !Ó¸ôß¨ £ˆÏÓ– õˆÏò Ó˚yÖy îÓ˚Ñ¸yÓ˚ ¸ô¸!ÌÓ# ¢¸!‹TÓ˚ Ó˝ ˆÑ¸y!›¸ ÓäÈÓ˚ ¸ôÓ˚ ¸ô¸!ÌÓ#ˆÏì¸ ≤Ãyí ~ˆÏ¢!äÈú õ)úì¸ x!:ˆÏãò £#òñ Áˆïãyòhfl¸Ó˚ £#ò ÓyÎ˚%õ[¸ú#Î˚ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ãòƒ– xÜ¶¸#Ó˚ ¢yÜˆÏÓ˚Ó˚ ì¸úˆÏîˆÏü ≤ÃÌõ ≤Ãyí ~ˆÏ¢!äÈúñ Ñ¸yÓ˚í ì¸ú x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬ xy›¸ˆÏÑ¸ ˆîÎ˚– ¸ôÓ˚Óì¸≈#Ñ¸yˆÏú fl¸∫ˆÏ¶¸yã# ¢Ó%ã v¸z!qˆÏîÓ˚ xy!Ó¶≈¸yˆÏÓ Óyì¸yˆÏ¢ x!:ˆÏãò ãˆÏõ Áˆïãyò hfl¸Ó˚ ¢¸!‹T Ñ¸ˆÏÓ˚!äÈú– ì¸yÓ˚ ¸ôÓ˚£z ˜ãÓ!ÓÓì≈¸ˆÏò ¸ô¸!ÌÓ#ˆÏì¸ ≤ÃyˆÏíÓ˚ ¢õyˆÏÓ˚y£ ~ˆÏ¢!äÈú– NSOU ? AE-ES-21 ? 117 ¢%ì¸Ó˚yÇ ¢)ˆÏÎ≈Ó˚ x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬Ó˚ «¸!ì¸Ñ¸Ó˚ «¸õì¸y ¶¸Î˚ÇÑ¸Ó˚– xyÓ˚ ~£z Áˆïãyò hfl¸ˆÏÓ˚Ó˚ ¢yõyòƒ ~Ñ¸ üì¸yÇü «¸Î˚ á›¸ˆÏú ¸ô¸!ÌÓ#¸ô¸ˆÏ¤¸ «¸!ì¸Ñ¸yÓ˚Ñ¸ £zv¸z !¶¸ÈÙÈ!ÓÈÙÈÓ˚ õyey Óy ì¸#Ó ì¸y î%£z üì¸yÇü ˆÓ˚ˆÏv¸¸ îyÎ˚– ~Öò ˆîÖy îyÎ˚ ~£z £zv¸z !¶¸ÈÙÈ!Ó Ó˚!Ÿ¬ ã#ÓãÜˆÏì¸Ó˚ Ñ¸# Ñ¸# «¸!ì¸ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚– ??(1) ã#ÓˆÏîˆÏ£ Ñ¸yÓ≈òÈÙÈÑ¸yÓ≈òñ Ñ¸yÓ≈òÈÙÈ£y£zˆÏv»¸yˆÏãòñ x!:ˆÏãòÈÙÈ£y£zˆÏv»¸yˆÏãò £zì¸ƒy!î Óı¸ò (Bond) Ó˚ˆÏÎ˚ˆÏäÈ– ˆÓ!üÓ˚ ¶¸yÜ Ó˚y¢yÎ˚!òÑ¸ Óı¸ò ¶¸yàˆÏì¸ ü!_´ úyˆÏÜ ˆõy›¸yõ%!›¸ 6.95 × 10 -19 ã%ˆÏúÓ˚ õˆÏì¸y– 200 nm ì¸Ó˚DˆÏîˆÏá≈ƒÓ˚ ì¸!v¸¸Í â%¸¡Ñ¸#Î˚ SˆÎÖyˆÏò ÈUV-BÙÈ~Ó˚ ì¸Ó˚D˜Ïîá≈ƒ ≤ÃyÎ˚ 280–315 nmV Ó˚!Ÿ¬Ó˚ ü!_´õyey ≤ÃyÎ˚ 9.93 × 10 -19 ã%ú ≤Ã!ì¸ ˆö¸y›¸ˆÏò– ¢%ì¸Ó˚yÇ x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬Ó˚ ≤Ã¶¸yˆÏÓ ã#ÓˆÏîˆÏ£Ó˚ ˆÎÈÙÈˆÑ¸yˆÏòy Ó˚y¢yÎ˚!òÑ¸ Óı¸ò ¢Ó˚y¢!Ó˚ ¶¸yàˆÏì¸ ¢«¸õ– ö¸ˆÏú ã#ÓˆÏîˆÏ£ òyòyÓ˚Ñ¸õ !Ó¸ô!_Ó˚ ¢¸!‹T £Î˚– ??(2) x!ì¸ x"ÓÎ˚ˆÏ¢£z ˆâ¸yˆÏÖ äÈy!ò (eye cataract) ¸ôv¸¸ˆÏì¸ ¸ôyˆÏÓ˚– ì¸Ìƒ Ó˚ˆÏú £zv¸z !¶¸ÈÙÈ!Ó Ó˚!Ÿ¬Ó˚ ì¸#Ó ì¸y Î!î 10 üì¸yÇü ÓyˆÏv¸¸ ì¸y£ˆÏú 50 ÓäÈˆÏÓ˚Ó˚ Ñ¸õ ÓÎ˚ˆÏ¢Ó˚ õyò%ˆÏ°ÏÓ˚ ˆâ¸yˆÏÖ äÈy!ò ¸ôv¸¸yÓ˚ ¢Ω¸yÓòy xhs¸ì¸ 6 üì¸yÇü Ó‚!k¸ ¸ôyÎ˚– !‡¸Ñ¸ ¢õˆÏÎ˚ !â¸!Ñ¸Í¢y òy Ñ¸Ó˚yˆÏú xı¸ £ˆÏÎ˚ îyÁÎ˚yÓ˚Á xyüB¸y ÌyˆÏÑ¸– ??(3) cˆÏÑ¸Ó˚ v¸z¸ôÓ˚ òyòyÓ˚*¸ô «¸!ì¸Ñ¸yÓ˚Ñ¸ ≤Ã¶¸yÓ ˆö¸ˆÏú ~£z £zv¸z !¶¸ÈÙÈ!Ó Ó˚!Ÿ¬– x" ÓÎ˚ˆÏ¢£z cÑ¸ Ñ%§¸â¸ˆÏÑ¸ ÓÎ˚fl¸Ò õyò%ˆÏ°ÏÓ˚ õˆÏì¸y £ˆÏì¸ ¸ôyˆÏÓ˚– Ñ¸ÖˆÏòy cÑ¸ ¸ô%ˆÏv¸¸ ì¸yõyˆÏ›¸ Óí≈ ïyÓ˚í Ñ¸ˆÏÓ˚ (Suntan)– ì¸y äÈyv¸¸y £zv¸z !¶¸ÈÙÈ!Ó Ó˚!Ÿ¬ cˆÏÑ¸Ó˚ Ñ¸ƒyò¢yÓ˚ (Cancer) á›¸yˆÏì¸ ¢«¸õ–

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Óì¸≈õyˆÏò xyˆÏõ!Ó˚Ñ¸y Î%_´Ó˚y‹T… Á Ñ¸

yòyv¸yÎ˚ õƒy!úÜˆÏòr›¸ cÑ¸ Ñ¸ƒyò¢yˆÏÓ˚Ó˚ £yÓ˚ Ó‚!k¸ ¸ôyÁÎ˚yÎ˚ !ÓK¸yò#Ó˚y ¢)ˆÏÎ≈Ó˚ x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬ˆÏÑ¸ îyÎ˚# Ñ¸ˆÏÓ˚ˆÏäÈò– ??(4) £zv¸z !¶¸ÈÙÈ!Ó Ó˚!Ÿ¬Ó˚ î#á≈Ñ¸yú#ò ≤Ã¶¸yˆÏÓ õyò%ˆÏ°ÏÓ˚ xòye´õì¸y (immunity) Ñ¸ˆÏõ– ö¸ˆÏú õyò%°Ï Ö%Ó ¢£ˆÏã£z ¢Çe´yõÑ¸ ˆÓ˚yˆÏÜ xye´yhs¸ £Î˚– ??(5) ÜyˆÏäÈÓ˚ ¸ôyì¸yÓ˚ ¢yˆÏúyÑ¸¢ÇˆÏŸ'°Ï «¸õì¸y Ñ¸ˆÏõ îyÎ˚– ö¸ˆÏú Öyîƒ v¸zÍ¸ôyîò Óƒy£ì¸ £ˆÏì¸ ¸ôyˆÏÓ˚– ì¸yäÈyv¸¸y £zv¸z !¶¸ÈÙÈ!Ó Ó˚!Ÿ¬Ó˚ ≤Ã¶¸yˆÏÓ ¢Ó˚y¢!Ó˚ v¸z!qˆÏîÓ˚ ¸ôyì¸yñ ö¸ú ~ÓÇ Ó#ˆÏãÓ˚ Ó‚!k¸ £…y¢ ¸ôyÎ˚– ??(6) ¢õ%ˆÏoÓ˚ ~Ñ¸ˆÏÑ¸yü# v¸z!qî ~ÓÇ õyˆÏäÈÓ˚ ~Ñ¸õye Öyîƒ ö¸y£zˆÏ›¸y≤'ƒyB¸›¸ˆÏòÓ˚ Ó‚!k¸ Ñ¸ˆÏõ îyÎ˚– ö¸ˆÏú ¢yõ%!oÑ¸ Óylfl¸ì¸s¸f ˆÎõò ò‹T £ˆÏÓ ˆì¸õ!ò õyˆÏäÈÓ˚ v¸zÍ¸ôyîòÁ xfl¸ÍyÐ¸y!ÓÑ¸ Ñ¸õ £ˆÏÓ– 6.4.3 Áˆïãyò Üì≈¸ ¢¸!‹TÓ˚ Ñ¸yÓ˚í (Causes of ozone depletion) ÓyÎ˚%õ[¸ˆÏú Áˆïãyò ÜƒyˆÏ¢Ó˚ ¢¸!‹T Á ïπÇ¢ ~Ñ¸!›¸ ≤ÃyÑ¸¸!ì¸Ñ¸ á›¸òy– !Ñ¸ls¸ ˆÑ¸yˆÏòy Ñ¸yÓ˚ˆÏí ÁˆïãyˆÏòÓ˚ ¢¸!‹TÓ˚ ˆâ¸ˆÏÎ˚ ïπÇˆÏ¢Ó˚ £yÓ˚ ˆÓ!ü £ˆÏú fl¸ÍyÐ¸y!ÓÑ¸¶¸yˆÏÓ Áˆïãyòhfl¸Ó˚ e´õü ¸ôyì¸úy £ˆÏÓñ ö¸úfl¸∫Ó˚*¸ô ˜ì¸!Ó˚ £ˆÏÓ ÚÁˆïãyò ˆ£yúÛ (Ozone hole)– !Ñ¸ls¸ ~£z Áˆïãyò e´õü Ñ¸ˆÏõ îyÓyÓ˚ Ñ¸yÓ˚í Ñ¸#/~Ó˚ Ñ¸yÓ˚í !£¢yˆÏÓ Ó˚¢yÎ˚ò!ÓîÓ˚y ˆÎ ¢Ó ì¸Ìƒ !îˆ
ÏÎ˚ˆ

100% **MATCHING BLOCK 173/200** **SA** Koushik Roy_Debasis Mondal_Instrumental Dept_U … (D154556271)

ÏäÈò ì¸yÓ˚ õˆÏïƒ v¸zˆÏÕ'Ö ˆÏÎyÜƒ £ú ˆ

Ñœ¸y!Ó˚ò î‚‹T ¸ôk¸!ì¸– ~£z ¸ôk¸!ì¸Ó˚ ¢ÓˆÏâ¸ ˆÏÎ˚ xyîü≈ ãyÎ˚Üy xƒyr›¸yÑ≈¸!›¸Ñ¸y õ£yˆÏîü– xƒyr›¸yÑ≈¸!›¸Ñ¸yÎ˚ 6 õy¢ ü#ì¸Ñ¸yú ÌyˆÏÑ¸– Á£z ¢õÎ˚ ≤Ãâ¸[¸ ‡¸y[¸yÎ˚ ü#ì¸Ñ¸yú#ò ì¸y¸ôõyey ˆòˆÏõ îyÎ˚ –88°C ¸ôÎ≈hs¸ ~ÓÇ @˘Ã#ˆÏ‹ø ì¸y xyÓyÓ˚ 11°C ¸ôÎ≈hs¸ ÁˆÏ‡¸– ü#ì¸Ñ¸yˆÏú ì¸y£z ~£z !ò¡¨ ì¸y¸ôõyeyÎ˚ ÓyÎ˚%õ[¸ú#Î˚ ¢õhfl¸ î)°ÏÑ¸ Üƒy¢ ãõy›¸ ˆÓ§ˆÏï ˆÑ¸úy¢yÑ¸yˆÏÓ˚ ˆ¸ôyúyÓ˚ fl¸T… ƒyˆÏ›¸y!fl¸≥¸!Ó˚Ñ¸ ˆõˆÏá (Polar stratospheric clouds–PSC) ¸ô!Ó˚îì¸ £Î˚– ~£z ¢õÎ˚ ãõy›¸ Ó§yïy ≤Ãïyò î)°ÏÑ¸ Üƒy¢=!ú £ú £y£zˆÏv»¸yˆÏãò ˆÑœ¸yÓ˚y£zv¸ (HCl)ñ ãú#Î˚ Óy‹ô (H 2 O)ñ òy£zˆÏ›¸∆yˆÏãò x:y£zv¸ (NO 2) ~ÓÇ ˆÑœ¸y!Ó˚ò òy£zˆÏ›¸∆›¸ (ClONO 2)– ~£z xÓfl¸iyÎ˚ HCl-~Ó˚ ¢ˆÏD ClONO 2 ~Ó˚ !Ó!e´Î˚yÎ˚ ˆÑœ¸y!Ó˚ò Üƒy¢ v¸zÍ¸ôß¨ £Î˚ ~ÓÇ ≤Ãâ¸[¸ ü#ˆÏì¸ fl¸T… ƒyˆÏ›¸y!fl¸≥¸Î˚yˆÏÓ˚Ó˚ ò#ˆÏâ¸Ó˚ !îˆÏÑ¸ ¢!M¸Èì¸ £Î˚– 118 ? NSOU ? AE-ES-21

Ó¢ˆÏhs¸Ó˚ ÷Ó˚&ˆÌ¸ S˚¢ˆÏ≤Wz¡ÍÓ˚ xˆÏQyÓˆÏÓ˚V ¢)Î≈ !Ñ¸Ó˚ˆÏíÓ˚ xy!Ó¶≈¸yÓ £Î˚ ~ÓÇ ˆÑœ¸y!Ó˚ò x!ì¸ˆÏÓ=!ò Ó˚!Ÿ¬Ó˚ myÓ˚y ! Ó˚ˆÏÎ˚y!ãì¸ £ˆÏÎ˚ ˆÑœ¸y!Ó˚ò ¸ôÓ˚õyí%ˆÌ¸ ¸ô!Ó˚î¸ £Î˚ (Cl) Îy ≤ÃÓú !Óe´ˆÏõ xò%á›¸Ñ¸#Î˚ !e´Î˚y!Ó!íˆÌ¸ Áˆ Ïãyò hfl¸ˆÏÓ˚Ó˚ «¸Î˚ Ñ¸ˆÏÓ˚ â¸ˆÏú– ˜ì¸!Ó˚ £Î˚ ÚÁˆÏãyò ˆ£yúÛ Óy ÁˆÏãyò Üì≈¸– !Óe´Î˚y ≠ (i) Ó¢ˆÏhs¸Ó˚ ÓyÎ˚%õ[¸ ˆÏú x!:ˆÏÑœ¸yÓ˚y£zv¸ õ)úÑ¸ v¸zÍ¸ôyìò ≠ ? • • 3 2 Cl +O ClO +O (ii) x!:ˆÏÑœ¸yÓ˚y£zv¸ õ)úÑ¸ !ò!‹;¸Î˚Ñ¸Ó˚í ≠ ? ? 2 2 M • Cl +NO ClONO +M SM = xò%á›¸Ñ¸V (iii) ÓyÎ˚%õ[¸ú#Î˚ ãú#Î˚ ÓyˆÏ‹ôÓ˚ ¢ˆÏD !Óe´Î˚yÎ˚ òy£z!›¸∆Ñ¸ xƒy!¢v¸ v¸zÍ¸ôyìò (HNO 3) ≠ ClONO 2 + H 2 O → HOCl + HNO 3 (iv) ≤ÃyÑ‰¸ Ó¢ˆÏhs¸Ó˚ xyˆÏúyÎ˚ ¸ôyÓ˚õyí!ÓÑ¸ ˆÑœ¸y!Ó˚ò v¸zÍ¸ôyìò ≠ ????? • • UV-B HOCl HO +Cl ? ? ????? 2 UV-B Cl Cl + Cl (v) Ó¢ˆÏhs¸Ó˚ ÷Ó˚&ˆÌ¸ ÁˆÏãyò «¸Î˚ ÷Ó˚& ≠ 3 2 ? ? 膠 腈 腈 腍 腈 腈 腒 臓 腈腈 腈 腒 臓 膠腍 腈 膠 (vi) xyÓyÓ˚ ~Ñ¸£z¶¸yˆÏÓ ClO ˆÌˆÏÑ¸ ClONO 2 v¸zÍ¸ôß¨ £Î˚ ~ÓÇ ~¶¸yˆÏÓ£z â¸ˆÏú ~Ñ¸ ü,Cú !Óe´Î˚y (Chain reaction)– 6.5 ¸ôyÓ˚õyí!ÓÑ¸ ì%á≈›¸òy (Nuclear Accidents) ¸ôyÓ˚õyí!ÓÑ¸ ü!_´ !Ó¸ô%ú ü!_´Ó˚ xyìyÓˆñ !ÓˆÏŸªÓ˚ !Óî%ƒÍ ü!_´Ó˚ â¸y!£ÎyÓ˚ 13% ¸ô)Ó˚í £Î˚ ¸ôyÓ˚õyí!ÓÑ¸ ü!_´ myÓ˚yñ ¸ôyÓ˚õyí!ÓÑ¸ ü!_´ ¸ô!Ó˚÷k¸ ~ÓÇ ˆÑ¸yòÓˆÑ¸õ @˘Ã#ò £yv¸z¢ Üƒy¢ !òÉ¢Ó˚í Ñ¸ˆÏÓ˚ òy ~ÓÇ xò£yòƒ ü!_´Ó˚ ì%¸úòyÎ˚ «¸!ì¸Ó˚ ¸ô!Ó˚õyíÁ Ñ¸õ– !Ñ¸ls¸ xì¸ƒyì%!òÑ¸ ¢%Ó˚«¸y ÓƒÓfl¸iy ÌyÑ¸yˆÌ¸Á ˆÎ˚ì%á≈›¸òy=!ú á˚Ì›¸ ˆÏäÈ ì¸yÓ˚ ¶¸Î˚yÓ£ì¸y õyÓ˚ydÑ¸ Ó˚Ñ¸ˆÏõÓ˚– ¸ôyÓ˚õyí!ÓÑ¸ ˆÓyõy !Óˆ Ïfl¸≥¸yÓ˚ˆÏí 1945 ¢yˆÏú ãy¸ôyˆÏòÓ˚ ì%!›¸ õ)ú ü£Ó˚ !£ˆÏÓ˚y!üõy Á òyÜy¢y!Ñ¸ ≤ÃyÎ˚ ì%! ú¢ƒyÍ £ˆÏÎ˚ ÎyÎ˚– õyÓ˚y ÎyÎ˚ £yãyˆÏÓ˚Ó˚Á ˆÓ!ü õyò%ˆÏ ~ÓÇ ú«¸y!ìÑ¸ õyò%ˆÏ xy£ì¸ £Î˚ ~ÓÇ ~£z ¸ôÓ˚õyí% ˆÓyõyÓ˚ ˆì¸ã!fl¸;¸Î˚ì¸y xyãÁ ≤ÃÑ¸!ì¸ˆÌ¸ Óì≈¸õyò– ~äÈyv¸¸y xyã ¸ôÎ≈hs¸ ˆõy›¸ 3!›¸ ¸ôyÓ˚õyí!ÓÑ¸ !Óî%ƒÍ ˆÑ¸ˆÏw ì%á≈›¸òy v¸zˆÏÕ'ÖˆÏÌyÜƒ fl¸iyò x! ïÑ¸yÓ˚ Ñ¸ˆÏÓ˚ xyˆÏäÈ ÎyˆÏíÓ˚ ¶¸Î˚yÓ£ì¸y ¸ôyÓ˚õyí!ÓÑ¸ !Óˆ Ïfl¸≥¸yÓ˚ˆÏíÓ˚ õì¸£zñ !ì¸ò õy£zú xy£zÓ¢úƒyu¸ñ ˆâ¸Ó˚ˆÏòy!Óú ~ÓÇ ö%¸Ñ%¸!¢õyÎ˚ á›¸òy ì%á≈›¸òy– ˆâ¸Ó˚ˆÏòy!Óú ì%á≈›¸òy (Chernobyl disaster) ≠ 1986 ¢yˆÏú 26 ˆü ~!≤ÃÚñ £zv¸zˆÏe´ˆÏò ¢¸‹T î#á≈!ò ïˆÏÓ˚ â¸ú¸ˆÌ¸ ÌyÑ¸y ¢Ó≈Ó¸£Í ¸ôyÓ˚õyí!ÓÑ¸ !Óî%ƒÍ v¸zÍ¸ôyìò ˆÑ¸w ˆâ¸Ó˚ˆÏòy!Ó˚ˆÏú ¢Ñ¸yú¸ˆÏÓúyÎ˚ 4òÇ !Ó˚ˆÏÎ˚Ñ¸›¸yˆÏÓ˚ ! Ó˚ˆÏfl¸≥¸yÓ˚í á˚ˆÌ›¸ Îy !Ó˚ˆÏŸª ¢Ó≈Ó¸£Í ¸ôyÓ˚õyí!ÓÑ¸ ì%á≈›¸òy òyˆÏõ ¸ô!Ó˚!â¸ì¸– ¸ôyÓ˚õyí!ÓÑ¸ ˆÑ¸ˆÏwÓ˚ ¸ô!Ó˚â¸yúÑ¸Ûí ~Ñ¸!›¸ Ü˚ˆÏÓºÏíy õ)úÑ¸ Ñ¸yÓ˚ˆÏí !Ó˚ˆÏÎ˚Ñ¸›¸yˆÏÓ˚Ó˚ fl¸Í˚ˆÇ!e´Î˚ ¶¸yˆÏÓ Óı¸ £ˆÏÎ˚ ÎyÂ˚yÓ˚ ÓƒÓfl¸iy!›¸ Óı¸ Ó˚yˆÏÒò ÎyÓ˚ ö¸ˆÏú ¸ôyÓ˚õyí! ÓÑ¸ !Óe´Î˚y xyÎ˚ˆÏ_Ó˚ Óy£zˆÏÓ˚ â¸ˆÏú ÌyÎ˚ Á !Ó˚ˆÏfl¸≥¸yÓ˚í á˚ˆÌ›¸– ≤ÃyÎ˚ NSOU ? AE-ES-21 ? 119 30!›¸ xy=ò úyˆÏÜ Îy ˆò¶¸yˆÌ¸ 100ÈÙÈÓ˚ ˆÓ!ü x!@¿!òÓ≈y¸õÑ¸ xy!ïÑ¸yÓ˚ˆÏÑ¸Ó˚ 10 !ìò ¢õÎ˚ úyˆÏÜñ 60000 Óy!v¸¸ˆÏÑ¸ î)°Ïí õ%_´ Ñ¸Ó˚ˆÏì¸ £Î˚ ~ÓÇ 10 !ÌˆÏòÓ˚ õˆÏíƒ 1ñ35ñ000 õyò%°Ï ~ÓÇ 80ñ000 ¸ôy!úì¸ ¸ô÷ˆÏÑ¸ ¢!Ó˚ˆÏÎ˚ !òˆÏÎ˚ ÎyÁÎ˚y £Î˚– ì¸ã!fl¸;¸Î˚ î)°Ïí xyˆÏü¸ôyˆÏü ≤ÃyÎ˚ 1000 ÓÜ≈!Ñ¸!õ ¸ôÎ≈hs¸ äÈ!v¸¸ˆÏÎ˚ ¸ôˆÏv¸– ~£z ì%á≈›¸òy á›¸yÓ˚ ¸ôÓ˚Á ¶¸yÓ˚ì¸Ó˚°Ï≈ ¢£ Ó˚ v¸zß¨Î˚òü#ú Á v¸zß¨ì¸ ˆìü ¸ôyÓ˚õyí!ÓÑ¸ !Óî%ƒÍ v¸zÍ¸ôyìò ˆÑ¸w ˜ì¸!Ó˚ Ñ¸Ó˚ˆÏäÈ ~ÓÇ ¶¸!Ó°Ïƒ ˆÌ¸ ~£z ïÓ˚ˆÏòÓ˚ ì%á≈›¸òy á›¸yÓ˚ ¢Ω¸yÓòy xˆÏòÑ¸– ö%¸Ñ%¸!¢õy ì%á≈›¸òy (Fukushima Daiichi nuclear disaster) ≠ 2011 ¢yˆÏú 11£z õyâ≈¸ ãy¸ôyˆÏòÓ˚ ö%¸Ñ%¸!¢õy v¸y£z!â¸Ó˚ ¸ôyÓ˚õyí!ÓÑ¸ !Óî%ƒÍ v¸zÍ¸ôyìò ˆÑ¸w!›¸ ¢%Óòy!õÓ˚ xyáyˆÏì¸ «¸!ì¸@˘Ãhfl¸ £Î˚– ¶)Ñ¸¡ôˆÏòÓ˚ ö¸ˆÏú 3!›¸ !ÓÓ˚ˆÏÎ˚Ñ¸›¸yˆÏÓ˚Ó˚ ‡¸y[¸y Ñ¸Ó˚yÓ˚ ≤ÃíyÎ˚!ú ÓƒyÒì¸ £Î˚ ~ÓÇ !ÓˆÏÎ˚Ñ¸›¸yÓ˚=!ú ÜˆÏú ÎyÎ˚ ~ÓÇ ö¸y›¸ìïÓ˚ˆÏ– ¸ôÓ˚Óì≈¸#Ñ¸yˆÏú xòƒ !›¸∆õyÎ˚¸ ≤Îy ˆÏÎ˚›¸Ó˚ ãú ÓƒÓfl¸iyÓ˚ Ñ¸ˆÏÓ˚ !Ó˚xƒyQyˆÏÓ˚Ó˚ ì¸y¸õyeyÑ¸ Ñ¸!õˆÏÌ 80 !v¸!@˘ÃÓ˚ ò#ˆÏâ¸ !òˆÏÎ˚ xy¢y £Î˚– ˆÑ¸yòÓˆÑ¸õ ≤ÃyíÎ£!òÓ˚ á›¸òy òy á›¸ˆÏúÁ ö¸y›¸ˆÏúÓ˚ õÏíƒ !ì¸ã!‹¸;¸Î˚ ¸ôÎ≈ì≈ ÓyŒ£ˆÏÓ˚ ˆÓ!Ó˚ˆÏÎ˚ xy¢yÓ˚ ¢Ω¸yÓòy ˆÌˆÏÑ¸ £z ÌyˆÏÑ¸– ≤ÃyÎ˚ ú«¸y!ïÑ¸ õyò% °ÏˆÏÑ¸ î)ˆÏÓ˚ ¢!Ó˚ˆÏÎ˚ !òˆÏÎ˚ ÎyÁÎ˚y £Î˚– 6.6 ¸õ!›¸∆Î˚ú ˆ≤Ãy‹˚¸yÑ¸ú S1987V ÁˆÏãyò hfl¸Ó˚ˆÏÑ¸ !Óò‹TÑ¸yÓ˚ # ¸ôyˆÏì≈Ó˚ Á¸ôÓ˚ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ !¶¸ˆÏÎ˚òy ¢ˆÏ¡øú ˆÏò v¸zˆÏÕ'!Óì¸ ~Ñ¸!›¸ Ö¢v¸¸y £ú õ!›¸∆Î˚ú ˆ≤Ãy‹˚¸yÑ¸ú– ~!›¸ ~Ñ¸!›¸ xyhs¸ã≈y!ì¸Ñ¸ â%¸!_´ ¸ôe ÎyÓ˚ ≤ÃÏÎ˚y ú«¸ iy ˆÏì¸ô iy ˆÏì¸ô ÁˆÏãyò hfl¸Ó˚ˆÏÑ¸ !Óò‹TÑ¸Ó˚y ¸ôyì≈≈=!úÓ˚ v¸zÍ¸ôyìò ˆÓ¸Ó˚ y– ~!›¸ 1987 ¢yˆÏú 26 ˆü xyÜfi›¸ ¢ˆÏøúˆÏò ¢π≈¢¡øì¸ £Î˚ ~ÓÇ fl¸yÎ«¸!Ó˚ì¸ £Î˚ Á 1989 ¢yˆÏú 26 ˆü xyÜfi›¸ úy= Ñ¸Ó˚y £Î˚– ì¸yÓ˚ ¸ôÓ˚ ˆÌˆÏÑ¸ ≤ÃˆÏÏ¸ôyãyú!›¸ 9ÓyÓ˚ ¢Çfl¸ÒÓ˚í Ñ¸Ó˚y £Î˚ñ 1990 SúùÓ¸òVñ 1991 SòyÓ£zˆÏÓ˚y!ÓVñ 1992 S˚Ñ¸yˆÏ¸òˆÏ£ˆÏÜòVñ 1993 SÓƒB¸ÑVñ 1995 S!¶¸ˆÏÎ˚òyVñ 1997 Sõ!›¸∆Î˚úVñ 1998 SxˆÏfl¸T…!úÎ˚yVñ 1999 S˚Ó!ãÇVñ 2007 Sõ!›¸∆Î˚úV– õ!›¸∆Î˚ú ˆ≤Ãy‹˚¸yÑ¸ú ˆÏúÓ˚ v¸zˆÏjüƒ=!ú £ú ≠ ?? ïyˆÏ¸ô ïyˆÏ¸ô Áãò hfl¸Ó˚ !Óò‹TÑ¸yÓ˚ # Ó˚y¢yÎ˚!òÑ¸ ˆÑœ¸yˆÏÓ˚yœ$¸ˆÏÓ˚y Ñ¸yÓ≈ò (CFCs) Ñ¸õyˆÏòy– ??ïyˆÏ¸ô ïyˆÏ¸ô ¢%¸ô! Ó˚â¸yúò ÓƒÓfl¸iyÓ˚ õyïƒˆÏõ ÁˆÏãyò hfl¸Ó˚ !Óò‹TÑ¸yÓ˚ # £y£zˆÏv»¸y ˆÑœ¸yˆÏÓ˚yœ$¸ˆÏÓ˚y Ñ¸yÓ≈ò (HCFCs) Ñ¸õyˆÏòy– ?? £y£zˆÏv»¸yœ$¸ˆÏÓ˚y Ñ¸yÓ≈ò !òÜ≈õò £…y¢ Ñ¸Ó˚yñ Î!íÁ ~!›¸ ÁˆÏãyò hfl¸Ó˚ !Óò‹T Ñ¸ˆÏÓ˚ òy ì¸Ó%Á ~!›¸ ~Ñ¸!›¸ !@˘Ãò £yv¸z¢ Üƒy¢ ~ÓÇ !ÓŸª v¸z°ÏäyÎ˚ˆÏò ~!›¸ ~Ñ¸!›¸ =

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ÏÓ≈yÓƒ¸ô# ÁˆÏãyò ïπÇ¢Ñ¸yÓ˚ # ¸ôyˆÏì≈Ó˚ v¸zÍ¸ôyìò Á ÓƒÓ£yÓ˚ Ñ¸õ £ÓyÓ˚ ã˚ˆÏòƒ xƒyÓ›¸y›¸yÑ¸yÓ˚ ÁˆÏãyò Ü£¥Ó˚ ï#ˆÏÓ˚ ï#ˆÏÓ˚ !‡¸Ñ¸ £ˆÏÎ˚ xy¢ˆÏäÈ– !Ó!¶¸ß¨ xyÓ£Ây˚y õˆÏv¸ú myÓ˚y ~!›¸

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xò%õyò Ñ¸Ó˚y ÎyˆÏFäÈ ˆÎ˚ xyÜyõ# 2050 ˆÌˆÏÑ¸ 2070 ¢yˆÏúÓ˚ õˆÏïƒ

ÁˆÏãyò hfl¸Ó˚ !‡¸Ñ¸ £ˆÏÎ˚ ¸ô)ˆÏÓ≈Ó˚ 1980 ¢yˆÏúÓ˚ xÓfl¸iyÎ˚ !ö¸ˆÏÓ˚ ÎyÎ˚– 6.7 !Ñ¸ˆÏÎ˚y›¸y ˆ≤Ãy›¸yÑ¸ú S1997V !Ñ¸ˆÏÎ˚y›¸y ˆ≤Ãy›¸yÑ¸ú ~Ñ¸!›¸ Ó˚Ó˚y¢‹T…#Î˚ xyhs¸ã≈y!ì¸Ñ¸ â%¸!_´ Îy United Nation Framework Convention on Climate Change (UNFCCC) myÓ˚y ≤Ã!ì¸fl¸iy!¸ôì¸– 1997 !Ö fi›¸yˆÏ∑Ó˚ 11£z !v¸ˆÏ¢¡ÍÓ˚ ãy¸ôyˆÏòÓ˚ !Ñ¸ˆÏÎ˚y›¸y ü£ˆÏÓ˚ 120 ? NSOU ? AE-ES-21 ~£z â%¸!_´ ≤ÃÌõ @˘Ã£í¸ £Î˚ ~ÓÇ Ó˚y!ûÎyÓ˚ ¢¡ø!ì¸Ó˚ ¸ôÓ˚ 2005 ¢yˆÏú 16£z ˆö¸Ó˚&Î!Ó˚ ≤ÃÌõ Ñ¸yÎ≈≈Ñ¸Ó˚# £Î˚– Óì≈¸õyˆÏò ~£z â%¸!_´ myÓ˚y 169!›¸ ˆü ìyÎ˚Ók¸– !Ñ¸ˆÏÎ˚y›¸y â%¸!_´ fl¸ƒy«¸!Ó˚ì¸ ˆìü=!ú 1990ÈÙÈ2012 ¢yˆÏúÓ˚ õˆÏïƒñ 6!›¸ =Ó˚&¢¸ô)í≈ !@˘ÃÃò£yv¸z¢ Üƒy¢ Îyñ Ñ¸yÓ≈òÈ v¸

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y£zÈÙÈx:y£zv¸ (CO 2)ñ !õˆÏÌò (CH 4)ñ

òy£zˆÏ›¸∆yˆÏãò
x:y£zv¸ (N 2 O)ñ £y£zˆÏv»¸yöœ$¸ˆÏÓ˚y Ñ¸yÓ≈ò (HFCs)ñ ¸ôyÓ˚öœ$¸ˆÏÓ˚y Ñ¸yÓ≈ò (PFCs) ~ÓÇ ¢yúö¸yÓ˚ ˆ£:y öœ$¸Ó˚y£zv¸È (SF 6)ÙÈ~Ó˚ ¸ô!Ó˚õyí 5.2% Ñ¸õyˆÏòyÓ˚ ãòƒ ≤Ã!ì¸K¸yÓk¸– !â¸ò ~ÓÇ ¶¸yÓ˚ì¸Ó°Ï≈ ~£z â%¸!_´ myÓ˚y îyÎ˚Ók¸ £ˆÏúÁ ˆÎˆÏ£ì%¸ Ö%Ó£z òÜòƒ õyeyÎ˚ !@˘Ãò £yv¸z¢ Üƒy¢ v¸zÍ¸ôyîò Ñ¸ˆÏÓ˚ Ìyˆ ÏÑ¸ ì¸y£z ~Ö%!ò ì¸yÓ˚y !@˘Ãò £yv¸z¢ Üƒy¢ Ñ¸õyˆÏòyÓ˚ ¸ô! Ó˚Ñ¸“òy @˘Ã£í Ñ¸Ó˚ˆÏÓ òy– Î!îÁ 5.2% v¸zÍ¸ôyîò!›¸ ¢õhfl¸ ˆîˆÏüÓ˚ Üv¸¸ õyey ì¸Ó% ˆîü !Ó˚ˆÏüˆÏ°Ï ~Ó˚ õyey Ñ¸õ ˆÓ!üñ ˆÎõòÈÙÙÙÈ £zv¸zˆÏÓ˚y¸ô ãy!ì¸¸ô%OˆÏÑ¸ 8% £...y¢ Ñ¸Ó˚ˆÏì¸ £ˆÏÓñ xyÓyÓ˚ USA ˆÑ¸ 7%ñ xˆÏfl¸T...!úÎ˚y 8%ñ xy£z¢úƒyu¸ 10%ñ Ó˚!üÎ˚y 0% ~ÓÇ ãy¸ôyòˆÏÑ¸ 6% £...y¢ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– 2012 ¢yˆÏú ~£z â%¸!_´ˆÏÑ¸ ¸ôÓ˚Ó!ï≈ì¸ Ñ¸ˆÏÓ˚ ˆ¸ôü Ñ¸Ó˚y £Î˚ñ Ìy ˆîy£y ¢ÇˆÏüyïò# òyˆÏõ ¸ô!Ó˚!â¸ì¸ ~£z ¢ÇˆÏüyïò# xò%¢yˆÏÓ˚ ÷ï%õye 2020 !Ö fi›¸y∑ ¸ôÎ≈hs¸ £zv¸zˆÏÓ˚y¸ô#Î˚ ˆîü=!úˆÏÑ¸ !òÉ¢ÓˆÏíÓ˚ ¸ô!Ó˚õyí Ñ¸!õˆÏÎ˚ xyòyÓ˚ ≤Ãhfl¸yÓ ˆîÁÎ˚y £Î˚– î)°Ïí ¢,!‹TÑ¸yÓ˚#Ó˚ Ó˚y‹T...=!úˆÏÑ¸ «¸!ì¸¸ô)Ó˚í !ïˆÏì¸ Óyïƒ Ñ¸Ó˚yÓ˚ ãòƒ !Ñ¸ˆÏÎ˚yˆÏ›¸y ¸ôÓ˚Óì≈¸# ~Ñ¸!›¸ xy£zò Ñ¸y‡¸yˆÏõy ˜ì¸!Ó˚Ó˚ ˆâ¸‹Ty â¸úˆÏäÈñ Ìy 2015 !Ö fi›¸yˆÏ∑Ó˚ !v¸ˆÏ¢¡Ó˚ õyˆÏ¢ ¸ôƒy!Ó˚¢ ü£ˆÏÓ˚ ˆ¸ôü Ñ¸Ó˚y £Î˚ – ì¸ˆÏÓ Ñ¸yòyv¸y Á xyˆÏõ!Ó˚Ñ¸y Î%_´Ó˚y‹T... ~£z â%¸!_´ fl¸∫y«¸Ó˚ òy Ñ¸Ó˚yÓ˚ ˆâ¸‹Ty â¸y!úˆÏÎ˚ ÌyˆÏFäÈ– 6.8 ãú ¢ÇÓ˚«¸í (Water Conservation) ¸ô¸!ÌÓ#Ó˚ ˆõy›¸ 71 ¶¸yÜ ãú ~ÓÇ 25 ¶¸yÜ fl¸iú £ˆÏúÁ ˆÓ!üÓ˚ ¶¸yÜ›¸y£z úÓíy_´ xÓƒÓ£yÎ≈ ãú– õye 3% ãú fl¸iú¶¸yˆÏÜ ¢!M¸Èì¸ ì¸yÓ˚ õye 0.3% ãúyüÎ˚ ¸ô%Ñ%¸Ó˚ £zì¸ƒy!îˆÏì¸ ¢!M¸Èì¸ ~ÓÇ ≤ÃyÎ˚ 30% ãú ˆ¶¸Ôõhfl¸ˆÏÓ˚ ¢!M¸Èì¸– Óì≈¸õyˆÏò v¸zß¨ì¸ !Óúy¢Ó˝ú ã#ÓòÌ¸ôˆÏòÓ˚ ãˆÏòƒ ~ÓÇ xì¸ƒy!ïÑ¸ ãò¢ÇÖƒyÓ˚ Ó,!k¸ñ ÓƒÓ£yÎ≈ fl¸∫yî% ãˆÏúÓ˚ áy›¸!

100%	**MATCHING BLOCK 174/200**	W

ì¸Ó˚ Ñ¸yÓ˚í £ˆÏÎ˚ î§y!v¸¸ˆÏÎ˚ ˆÏäÈ– ˆ¶¸

Ôõãú hfl¸Ó˚ ˆÌˆÏÑ¸
ãú ¢Ç@˘Ã£ Ñ¸Ó˚yÓ˚ ãˆÏòƒ Ü¶¸#Ó˚ ˆÌˆÏÑ¸ Ü¶¸#Ó˚ì¸Ó˚ !›¸v¸zÓÁˆÏÎ˚ú ˆÖ§yv¸¸y £ˆÏFäÈ– Óì≈¸õyˆÏò Ó˝ ü£Ó˚ ãú ¢ÇÑ¸ˆÏ›¸Ó˚ ! üÑ¸yÓ˚ £ˆÏÎ˚ ˆÏäÈ– ¶)¸!õ¶¸yˆÏÜÓ˚ ãú ¢¡ôˆÏîÓ˚ ¢ÇÓ˚«¸ˆÏíÓ˚ myÓ˚y ~£z ¢ÇÑ¸ˆÏ›¸Ó˚ ˆõyÑ¸y!Óúy Ñ¸Ó˚y ¢Ω¸Ó– ãú ¢ÇÓ˚«¸ˆÏíÓ˚ ≤ÃˆÏÎ˚yãò#Î˚ ¸ôîˆÏ«¸¸ô=!ú £úÈÙÙÙÈ ? òî#=!ú ¸ôÓ˚fl¸ôÓ˚ òyúy myÓ˚y ¢ÇÎ%_´ Ñ¸Ó˚ˆÏì¸ £ˆÏÓñ ~Ó˚ ö¸ˆÏú õïƒÓì≈¸# xM¸Èú=!ú ˆÎõò ãúˆÏ¢â¸ ÓƒÓfl¸iyÓ˚ ¢%!Óïy ¸ôyˆÏÓ x¸ôÓ˚ ¸ôˆÏ«¸ ÓòƒyÓ˚ ¢õÎ˚ x!ì¸!Ó˚_´ ãú xˆÏ¸ô«¸yÑ¸,¸ì¸ ÷‹Ò xM¸ÈˆÏúÓ˚ !îˆÏÑ¸ ¸ôy!‡¸ˆÏÎ˚ Óòƒy !òÎ˚!s¸fì¸ £ˆÏÓ ~ÓÇ ãú¢M¸ÈÎ˚Á £ˆÏÓ– ? ¸ôyÓ≈ì¸ƒ xM¸ÈˆÏúÓ˚ òyúy=!ú Óy ¸ôy£yˆÏv¸¸Ó˚ ë¸yú ÓÓ˚yÓÓ˚ ˆâ¸Ñ¸ v¸ƒyõ ≤Ãlfl¸ì¸ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ Ìyˆ Ïì¸ Ó,!‹TÓ˚ ãú ¢Ó˚y¢!Ó˚ òy ÓˆÏÎ˚ !ÜˆÏÎ˚ õy!›¸Ó˚ x¶¸ƒhs¸Ó˚#í ≤ÃÓy£ Ó,!k¸ ¸ôyÎ˚ – ~£z ÓƒÓfl¸iy ¢õì¸ˆÏúÓ˚ òî#=!úˆÏìÁ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – ? ãúy¶)¸!õ xÌ≈yÍ Ú≤ÃÑ,¸!ì¸Ó˚ Ó,E¸Û Ìy xyã òÜÓ˚yÎ˚ˆÏòÓ˚ ì¸y!ÜˆÏî !Óò‹T £ˆÏÎ˚ â¸ˆÏúˆÏäÈ– !Ñ¸ls¸ ~£z ãúy¶)¸!õ òyòy¶¸yˆÏÓ ≤ÃÑ,¸!ì¸ˆÏÑ¸ ¢y£yÎƒ Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸– ˆÎõòÈÙÙÙÈ ü£ˆÏÓ˚Ó˚ x¸ô!Ó˚fl¸À%ì¸ ãúˆÏÑ¸ ¸ô! Ó˚fl¸À%ì¸ Ñ¸ˆÏÓ˚ñ õy!›¸Ó˚ !òˆÏâ¸Ó˚ ˆ¶¸Ôõ ãúhfl¸Ó˚ Ó,!k¸ Ñ¸ˆÏÓ˚ ~ÓÇ ãúy¶)¸!õ ≤Ãâ%¸Ó˚ ¸ô!Ó˚õyˆÏí !Ó÷k¸ x!:ˆÏãò ¢Ó˚ÓÓ˚y£ Ñ¸ˆÏÓ˚ ÌyˆÏÑ¸– ì¸y£z ãúy¶)¸!õ ¢ÇÓ˚«¸í Ñ¸Ó˚y =Ó˚&c¸ô)í≈– ? ¶)¸¸ô,ˆÏ¤¸Ó˚ Á¸ôÓ˚ ≤ÃÓy£õyò Ó,!‹TÓ˚ ãú ïˆÏÓ˚ ˆÓ˚ˆÏÖ ì¸y Ñ¸¸! °ÏÑ¸yã Á xòƒyòƒ Ñ¸yˆÏã úyÜyˆÏòyÓ˚ ~Ñ¸õye ¢£ã v¸z¸ôyÎ˚ òî#Ó˚ v¸z¸ôÓ˚ Ó§yï !òõ≈yí Î!îÁ Óy ~£z Ó§yï !òõ≈yˆÏíÓ˚ xˆÏòÑ¸ ÖyÓ˚y¸ô !îÑ¸Á xyˆÏäÈ ˆÎõòÈÙÙÙÈ Ó§yï=!ú NSOU ? AE-ES-21 ? 121
≤ÃÌˆÏõ ãú ¢ÇÓ˚«¸í Ñ¸ˆÏÓ˚ Óòƒy !òÎ˚s¸fí Ñ¸ˆÏÓ˚ !Ñ¸ls¸ ¸ôˆÏÓ˚ ì¸y õˆÏã !ÜˆÏÎ˚ Óòƒy ≤ÃˆÏÑ¸y¸ô xyÓ˚Á Óy!v¸¸ˆÏÎ˚ ˆîÎ˚ – òî# xÓÓy!£Ñ¸yÓ˚ Óylfl¸ì¸s¸f !Óò‹T Ñ¸ˆÏÓ˚ – ? ÷‹Ò !òÓ˚«¸#Î˚ xM¸ÈˆÏú ¢yÓ˚y ÓäÈÓ˚ Ó,!‹T £Î˚ òy ì¸y£z ãˆÏúÓ˚ â¸y!£îy ˆõ›¸yˆÏòyÓ˚ ãˆÏòƒ ¸ô%Ñ%¸Ó˚ ~ÓÇ Ó,£Í ãúyüÎ˚ Öòò Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸– õ)úì¸ ˆ¶¸Ôõ ãúhfl¸Ó˚ ÓƒÓ£yÓ˚ òy Ñ¸ˆÏÓ˚ Ó,!‹TÓ˚ ãú ïˆÏÓ˚ ˆÓ˚ˆÏÖ ì¸y ÓƒÓ£yÓ˚ Ñ¸yˆÏã úyÜyˆÏòy£z ãú ¢ÇÑ¸›¸ î)Ó˚ Ñ¸Ó˚yÓ˚ ~Ñ¸õye v¸z¸ôyÎ˚ – ì¸y£z ¢Ó˚Ñ¸yÓ˚ òyòy ≤ÃÑ¸ˆÏ“Ó˚ õyïƒˆÏõ ¸ô%Ñ%¸Ó˚ Öòò Ñ¸Ó˚yˆÏFäÈ– 6.8.1 Ó,!‹TÓ˚ ãú ¢ÇÓ˚«¸í (Rain water harvesting) ≠ ¶)¸¶¸yˆÏÜ ˆÎ fl¸∫“ ¸ô!Ó˚õyí Ó,!‹T¸ôyì¸ £Î˚ ì¸yÓ˚ ≤ÃyÎ˚ 71% ãú òî#ÈÙÈòyúyÓ˚ õyïƒˆÏõ ¸ô%Ñ%¸ˆÏÓ˚ ¸ô!ì¸ì¸ £Î˚ñ !Ñ¸ls¸ Óì≈¸õyò xÓfl¸iyˆÏì¸ Ó,!‹TÓ˚ ≤Ã!ì¸!›¸ ãú!Ó®%ˆÏÑ¸ ¢Ç@˘Ã£ Ñ¸ˆÏÓ˚ Ñ¸yˆÏã úyÜyˆÏì¸ òy ¸ôyÓ˚ˆÏú ãú ¢ÇÑ¸›¸ £...y¢ Ñ¸Ó˚y ¢Ω¸Ó¸ôÓ˚ òÎ˚ – ≤Ãyâ¸#òÑ¸yˆÏú ãúyüÎ˚ ¸ô%Ñ%¸Ó˚ñ ˆv¸yÓy £zì¸ƒy! î Öòò Ñ¸ˆÏÓ˚ Ó,!‹TÓ˚ ãú ïˆÏÓ˚ Ó˚yÖy £ì¸ ~ÓÇ ≤ÃˆÏÎ˚yãˆÏò ì¸y ÓƒÓ£yÓ˚ Ñ¸Ó˚y £ì¸– ì¸ˆÏÓ Óì≈¸õyˆÏò v¸zß¨ì¸ ≤ÃÎ%!_´Ó˚ myÓ˚y ãú ¢ÇÓ˚«¸í Ñ¸Ó˚y £ˆÏFäÈñ ˆÎõòÈÙÙÙÈ ¸ôy£y!v¸¸ Á ÷‹Ò xM¸ÈˆÏú Óy!v¸¸Ó˚ äÈyˆÏî Ó,!‹TÓ˚ ãú¢Ç@˘Ã£ Ñ¸ˆÏÓ˚ Óy!v¸¸Ó˚ !òˆÏâ¸ ›¸ƒyÇÑ¸ Óy!òˆÏÎ˚ ì¸yˆÏì¸ ¢M¸ÈÎ˚ Ñ¸ˆÏÓ˚ Ó˚yÖy £Î˚ – ~ÓÇ Ó°Ï≈yÓ˚ ˆüˆÏ°Ï Á£z ãú Óy!v¸¸Ó˚ Ñ¸yˆÏã Á â¸y°ÏÓyˆÏ¢

95%	**MATCHING BLOCK 179/200**	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – ~äÈyv¸¸y Óy!v¸¸Ó˚

äÈyˆÏî Ó,!‹TÓ˚ ãú ¸ô!Ó˚ˆÏüyïò Ñ¸ˆÏÓ˚ !›¸v¸zÓÁˆÏÎ˚ˆÏúÓ˚ õyïƒˆÏõ õy!›¸Ó˚ !òˆÏâ¸ ¸ôy!‡¸ˆÏÎ˚ ˆ¶¸Ôõ ãúhfl¸ˆÏÓ˚Ó˚ Ó,!k¸ á›¸yˆÏòy £Î˚ Ìy ¶¸!Ó°ÏƒˆÏì¸ Ñ¸yˆÏã úyˆÏÜ– !â¸e ≠ Ó,!‹TÓ˚ ãú ¢Ç@˘Ã£ 6.9 ¶¸yÓ˚ˆÏì¸ ¸ô!Ó˚ˆÏÓü xyˆÏ®yúò (Environmental Movements of India) ¸ô!Ó˚ˆÏÓü ¢¡ô!Ñ≈¸ì¸ ¢õ¢ƒy=!ú x¢ÇÖƒ ~ÓÇ ≤ÃÑ,¸!ì¸ˆÏÑ¸ Ó§yâ¸yˆÏòyÓ˚ ãˆÏòƒ !Ó!¶¸ß¨ ïÓ˚ˆÏòÓ˚ xyˆÏ®yúò ¢yÓ˚y ¸ô,!ÌÓ# ã%ˆÏv¸¸£z !Ó!¶¸ß¨ ¢õˆÏÎ˚ £ˆÏÎ˚ˆÏäÈ– ãyì¸#Î˚ xyˆÏ®yúˆÏòÓ˚ ¢ˆÏD ¢ˆÏD xyM¸È!úÑ¸¶¸yˆÏÓ ¸ô!Ó˚!fl¸i!ì¸ xò%ÎyÎ˚# ~ÓÇ ¢#!õì¸ ˆ«¸ˆÏe ¸ô!Ó˚ˆÏÓü

100%	MATCHING BLOCK 180/200	SA	MA in History SEM II (CBCS Mode).pdf (D142514392)

xy˘Ï®yúò Ü˘Ïv¸¸ v¸z˘Ï‡¸˘ÏäÈ– ì¸

y˘ÏïÓ˚ õ˘Ïïƒ xòƒì¸õ £úÈÙÙÙÈ S1V xÓ˚íƒyM¸Èú !¶¸!_Ñ¸ xy˘Ï®yúò ≠ ~£z ïÓ˚˘ÏòÓ˚ xy˘Ï®yú˘ÏòÓ˚ !Ó°Ïî˚ £ú xÓ˚íƒ ò#!ì¸ñ Óò¢ ¡ô˘ÏïÓ˚ ÓƒÓ£yÓ˚ £zì¸ƒy!î– ˘ÎõòÈÙÙÙÈ !â¸¸ô˘ÏÑ¸yñ xƒy!¸ô˘ÏÑ¸y xy˘Ï®yúò– 122 ? NSOU ? AE-ES-21 6.9.1 !â¸¸ô˘ÏÑ¸y xy˘Ï®yúò 1972 ¢y˘ÏúÓ˚ !v¸˘Ï¢¡ÍÓ˚ õy˘Ï¢ v¸z_Ó˚ ≤Ã˘Ïî˘Ïü ˘ì¸£Ó˚# Üy˘Ïv¸¸yÎ˚yú xM¸È˘Ïú ~£z xy˘Ï®yú˘ÏòÓ˚ ¢)â¸òy £Î˚ – Ú!â¸¸ô˘ÏÑ¸yÛ Ñ¸Ìy!›¸Ó˚ xì≈ Úxy!úDòÛ– !Ó_Óyò !‡¸Ñ¸yîyÓ˚ ~ÓÇ !ü”¸ô!ì¸˘ÏïÓ˚ !ò!Ó≈â¸y˘ÏÓ˚ Óò¶)¸!õ ïπÇ¢ ~ÓÇ Óò¢¡ôî ú%Z¸˘ÏòÓ˚ !ÓÓ˚&˘Ïk¸ ~£z xy˘Ï®yúò ¢ÇÜ!‡¸ì¸ £Î˚ – Ó˚y˘Ïì¸Ó˚ xı¸Ñ¸y˘ÏïÓ˚ !‡¸Ñ¸yîy˘ÏÓ˚Ó˚ ˘úy˘ÏÑ¸Ó˚y ÜyäÈ Ñ¸y›¸˘Ïì¸ ~˘Ïú xy! îÓy¢# ˘õ˘ÏÎ˚Ó˚y ≤Ã!ì¸!›¸ Ó¸«¸˘ÏÑ¸ ¢hs¸y˘ÏòÓ˚ õ˘Ïì¸y ã!v¸¸˘ÏÎ˚ Ìy˘ÏÑ¸ò– Ó˚y˘Ïì¸Ó˚ ¸ôÓ˚ Ó˚yì¸ ˘ã˘ÏÜ ÜyäÈ ¸ôy£yÓ˚y !î˘ÏÎ˚˘ÏäÈò ~£z õ!£úýÓ˚y– xy˘Ï®yú˘ÏòÓ˚ ˘òì¸¸c !î˘ÏÎ˚ !äÈ˘Ïúò ¢Ó˚úy ˘Óòñ õ#Ó˚y ˘Óòñ ¢%®Ó˚úyú Ó˝=íyñ â¸!wÑ¸y≤Ã¢yî ¶¸y›¸ £zì¸ƒy!î ¸ô! Ó˚˘ÏÓüÓyî#Ó˚y– Ó˝=íyÓ˚ ˘òì¸¸˘Ïc ◊#òÜÓ˚ ˘Ì˘ÏÑ¸ !ü!ú=!v¸¸ ¸ôÎ≈hs¸ 300 !Ñ¸!õ ¸ôîÎyey Ñ¸Ó˚y £Î˚ – !ì¸!ò ¸ôÓ˚Óì≈¸#Ñ¸y˘Ïú xòü˘ÏòÁ Ó˚˘Ï¢ò– ~Üy˘ÏÓ˚y !î˘ÏòÓ˚ õyìyÎ˚ Ó˝=íy˘ÏÑ¸ ˘@˘ÃÆyÓ˚ Ñ¸Ó˚y £Î˚ – ÖÓÓ˚ ˘¸ô˘ÏÎ˚ £z £yãyÓ˚ £yãyÓ˚ õyò%°Ï ä%È˘Ï›¸ xy˘Ï¢ ~ÓÇ ì¸yÓ˚ â¸y˘Ïì¸ô ¸ô%!úüÓy!£ò# ¸ôÿ¸yì¸ôÇ¢Ó˚í Ñ¸Ó˚˘Ïì¸ Óyïƒ £Î˚ – ~£z xy˘Ï®yú˘ÏòÓ˚ ì¸#Ó ì¸y ˘Ñ¸w#Î˚ ≤Ãüy¢˘ÏòÓ˚ òäÓ˚Á ˘Ñ¸˘Ïv¸¸!äÈú– ¶¸yÓ˚ ˘Ïì¸Ó˚ xòƒyòƒ ≤Ãy˘Ïhs¸Ó˚ !Ó!¶¸ß¨ x!ïÓy¢#Ó˚y ~£z xy˘Ï®yú˘Ïò xò%≤Ãy!ì¸ £Î˚ – Ó¸«¸˘ÏäÈ˘ÏòÓ˚ ! ÓÓ˚&˘Ïk¸ ¢ßyÁì¸yú ¸ôÓ˚ Üíyñ äÈ!_üÙv¸¸ñ Ìy˘Ïò ~ÓÇ xyÓ˚yÓÕ'# xM¸È˘ÏúÁ xy˘Ï®yúò ÷Ó˚& £Î˚ – Ñ¸ò≈y›¸˘ÏÑ¸ ~£z xy˘Ï®yúò òì%¸ò õyey ˘¸ô˘ÏÎ˚ 1983 ¢y˘Ïú xƒy!Ø˘ÏÑ¸y (Appiko) òyõÑ¸ xy˘Ï®yú˘Ïò ¸ô!Ó˚˘Ïì¸ £Î˚ – Ó˝ õyò%°Ï ¸ôîÎyey Ñ¸˘ÏÓ˚ ˘Ñ¸ú¢# (Kelase) xÓ˚˘ÏîíƒÜyäÈ˘ÏÑ¸ ã!v¸¸˘ÏÎ˚ ï˘ÏÓ˚ !‡¸Ñ¸yîy˘ÏÓ˚Ó˚ Ñ%‡¸yÓ˚yáyì¸ ˘Ì˘ÏÑ¸ ì¸y˘ÏïÓ˚ Ó˚«¸y Ñ¸˘ÏÓ˚ – ~˘Ïì¸ !‡¸Ñ¸yîyÓ˚Ó˚y ¶¸#ì¸ £˘ÏÎ˚ ¸ô˘Ïv¸¸ ~ÓÇ â¸ì%¸!î≈Ñ¸ ˘Ì˘ÏÑ¸ ~£z xy˘Ï®yúò ¢õ˘ì≈òÁ ¸ôyÎ˚ – !â¸¸ô˘ÏÑ¸y xy˘Ï®yú˘ÏòÓ˚ ≤Ãïyò v¸z˘Ïjüƒ !äÈú õ¸!_Ñ¸y Á ãú ¢ÇÓ˚«¸˘ÏíÓ˚ äòƒ !£õyúî˚ xM¸È˘ÏúÓ˚ v¸z!qî !òïò !ò!°Ïk¸ Ñ¸Ó˚y– Ñ¸yÓ˚í ¸ôÓ≈˘Ïì¸ xÓ!fl¸ïì¸ ≤Ã!ì¸!›¸ v¸z!qî !£õyÓ£ Á ï¢ òy £˘Ïì¸ !ï˘ÏÎ˚ õ¸!_Ñ¸y Á ¢!M¸Èì¸ ãú˘ÏÑ¸ Ó˚«¸y Ñ¸˘ÏÓ˚ – Ó˝=íyÓ˚ õ˘Ïì¸ ÜyäÈ xyõy˘ÏÎ˚˘ÏÓ˚ ãµyúy!ò Óy xy¢ÓyÓ¸ô˘ÏeÓ˚ Ñ¸y‡¸ ˘ãyÜyò ˘îÓyÓ˚ ãòƒ ãß√yÎ˚!ò– õ¸!_Ñ¸yñ ãú ¢ÇÓ˚«¸í ~ÓÇ õyò%°Ï˘ÏÑ¸ ì¸yÓ˚ Óßyâ¸yÓ˚ xÓ˚íƒ¢¡ôî £ú ¶¸ÜÓyò ≤Ã_ v¸z¸ô£yÓ˚ fl¸ÍÓ˚*¸ô– xyÓ˚ ~Ñ¸!›¸ îy!ÓÁ ~£z xy˘Ï®yú˘ÏòÓ˚ !¶¸ì¸Ó˚ ˘Ì˘ÏÑ¸ ˘ãyÓ˚îyÓ˚ £˘Ïî˚ Á˘Ï‡¸ÈÙÙÙÈ xÓ˚˘ÏíƒÓ˚ õ)ú ≤Ããy!ì¸ ˜Ó!â¸eƒ x«%¸] Ó˚yÖ˘Ïì¸ £˘ÏÓ– ¸ô÷Öyîƒ ¢Ç@˘ÃÆ Á £yúÑ¸y ãµyúy!ò ¢Ç@˘ÃÆ˘ÏÆ õy˘ÏÎ˚˘ÏïÓ˚ x!ïÑ¸yÓ˚ ÌyÑ¸˘ÏÓ– ì¸ÌyÑ¸!ì¸ x!ü!«¸ì¸ xy!îÓy¢# õ!£úy˘ÏïÓ˚ ¸ô!Ó˚˘ÏÓü Ó˚«¸yÓ˚ ¢˘Ïâ¸ì¸ì¸yì¸y ì¸y¸ôyÓ˚ ¢˘ÏÆ ¸ò!ï˘Ïì¸ì¸yÓ˚ ˚ìyÓ¸ô¸õ,y˘Ïü©Ó˚ü£ ÎÇ£õyì¸ õyÓ˚ yî˘Ï¢ yØy!ì¸y˘ÏÓ˚ ¸ôyÜyÓ˚ ì˘ÏÓ˚ – xÓ˚íƒ Ó˚«¸yÓ˚ ¸ôyüy ¸ôy!üñ xÓ˚íƒ ≤Ãäy!ì¸Ó˚ fl¸Íy¶¸y! ÓÑ¸ !ÓÑ¸yü Á ¢ÇÓ˚«¸˘ÏíÓ˚ xy˘Ï®yú˘ÏòÓ˚ v¸z˘Ïjüƒ !äÈú– S2V Ó,£Î˚ ãúyîyÓ˚ !¶¸!_Ñ¸ xy˘Ï®yúò (Big dam movements) ≠ ãúyîyÓ˚ !òõ≈yíñ Óylfl¸â%¸ƒì¸ äòÜ˘ÏïÓ˚ ¸ô%òÓ≈y¢òñ Óylfl¸ì¸s¸ƒÁ ÓòyM¸Èú ïπÇ˘Ï¢Ó˚ !ÓÓ˚&˘Ïk¸ ~£z xy˘Ï®yúò ¢ÇÜ!‡¸ì¸ £Î˚ – ˘ÎõòÈÙÙÙÈ òõ≈îy Óßyâ¸yÁ xy˘Ï®yúòñ ¢yÉzúƒyò›¸¶¸ƒyú# xy˘Ï®yúòñ ˘ì¸£!Ó˚ Óßyî !Ó˚˘ÏÓ˚yî# xy˘Ï®yúò £zì¸ƒy!î– 6.9.2 òõ≈îy Óßyâ¸yÁ xy˘Ï®yúò ¸ô!ÿ¸õ ¶¸yÓ˚˘Ïì¸ ≤Ãîyò òî# £ú òõ≈îy– ˜îâ≈ƒ ≤ÃyÎ˚ 1450 !Ñ¸!õ– õïƒ≤Ã˘Ïî˚˘ÏüÓ˚ xõÓ˚Ñ¸^˘›¸Ñ¸ ˘Ì˘ÏÑ¸ ¸ô! ÿ¸õÓy!£ò# £˘ÏÎ˚ î#á≈¸ôì ˘¸ô!Ó˚˘ÏÎ˚ xyÓ˚ÓÓ ¢yÜ˘ÏÓ˚ !Ü˘ÏÎ˚ ¸ô˘Ïv¸¸˘ÏäÈ– òõ≈îyÓ˚ v¸z¸ôì¸ƒÑ¸yÎ˚ ¶¸yÓ˚ì¸#Î˚ ¢¶¸ƒì¸yÓ˚ ≤Ãyâ¸#òì¸õ xì#ìÓ˚¢# !¶¸ úñ Ü[¸˘ÏïÓ˚ £yãyÓ˚ ÓäÈ˘ÏÓ˚Ó˚ ≤Ãyâ¸#ò ¢¶¸ƒì¸yÓ˚ ¢Çfl¸Ö!ì¸ Ü˘Ïv¸¸ v¸z˘Ï‡¸˘ÏäÈ– ~£z òî#Ó˚ ˘fl¸Ìyì¸ ˘¸ô˘ÏÎ˚ ì¸yÓ˚ v¸z¸ôòî#˘ÏÓ˚ 30!›¸ Ó˚˘Ïv¸¸ ˘ÓÓyïñ 135!›¸ õyG¸y!Ó˚ ÓÓyÁ 3000!›¸ ˘äÉy›¸ Óßyî ˜ì¸!Ó˚Ó˚ v¸z˘Ïjüƒ 1985 ¢y˘Ïú !ÓŸªÓƒÇÑ¸ 45 ˘Ñ¸y!›¸ v¸úyÓ˚ ¦í õO%Ó˚ Ñ¸˘ÏÓ˚ ~ÓÇ 1988 ¢y˘Ïú ¸ô)Ó≈íõyey£ÃÎ˚ Ñ¸yã ÷Ó˚& £Î˚ – ~£z ≤ÃÑ¸˘Ï“Ó˚ v¸z˘Ïjüƒ £ú Óòƒy ≤Ã!ì¸˘ÏÓ˚yïñ ì¸˘ÏÑ¸Ó˚ yãyÓ˚ ≤Ãy!ì¸ ˘Ó˚ yÑ¸y ÓóÎ˚ Ñ¸˘ÏÓ˚ – Ó˝=íyÓ˚ õ˘Ïì¸ ÜyäÈ ÓƒÓfl¸iy Ñ¸Ó˚y Á âú¢ôî ˘Ïì¸Ñ¸ 2700 ˘õÜyÁÎ˚y›¸ ! Óî%ƒî v¸zí¸ôß¨ Ñ¸Ó˚y– ≤ÃÑ¸˘Ï“Ó˚ ¢Ó˚˘Ïâ¸ ˘Ïî˚ Ó˚v¸¸y˘Ïì¸y˘Ïì¸ ÓyîÓ˚y ~Ñ¸!›¸ =ãÓ˚y˘Ï›¸ xÓ!fl¸ïì¸ Ú¢î≈yÓ˚ ¢˘ÏÓ˚yÓÓ˚Û ~ÓÇ xòƒ!›¸ õïƒ≤Ã˘Ïî˚˘ÏüÓ˚ Úòõ≈îy ¢yÜÓ˚Û Óßyî– NSOU ? AE-ES-21 ? 123 ~£z ≤ÃÑ¸˘Ï“Ó˚ !ÓÓ˚&˘Ïk¸ ˘¢yFâ¸yÓ˚ £˘ÏÎ˚ v¸z˘Ï‡¸˘ÏäÈò !ÓÓ˚˘ÏÓü!Óî ˘õîy ¸ôy˘Ï›¸Ñ¸Ó˚ ~ÓÇ ÓyÓy xyõ˘Ïì¸Ó˚ ˘òì¸¸˘Ïc £yãyÓ˚ £yãyÓ˚ xy˘Ï®yúòÑ¸yÓ˚#– ì¸y˘ÏïÓ˚ õ˘Ïì¸ ≤ÃÑ¸˘Ï“Ó˚ ¸ô!Ó˚Ñ¸“òyÓ˚ ¢˘ÏÎ˚ÐÓyhfl¸Ó!ì¸yÓ˚ x˘ÏòÑ¸ x¢D!ì¸ xy˘ÏäÈ– Óßyî ˜ì¸! Ó˚Ó˚ ö˘Ïú ¢y˘Ïv¸¸ !ì¸ò ú«¸ ˘£QÓ˚ Óò¶)¸!õ äúõ@¿ £˘ÏÓ ~ÓÇ 56 £yãyÓ˚ ˘£QÓ˚ v¸zÓ≈Ó˚ Ñ¸!°Ïã!õ ïπÇ¢ £˘ÏÓ– ~Ñ¸!î˘ÏÑ¸Ó˚ Óòƒy ≤Ã!ì¸˘ÏÓ˚yï £˘Ïú xòƒ!î˘ÏÑ¸ Óòƒy ˘îÓy ˘î˘ÏÓ– ˘õy˘Ï›¸Ñ¸ ˘Ó˚˘ÏÓ˚ õ˘Ïì¸ñ ≤ÃÑ¸“!›¸ ˘Ïì¸ 50 ˘õÜyÁÎ˚y˘Ï›¸Ó˚ ˘Ó!ü ãú!Óì%ƒí v¸zí¸ôß¨ Ñ¸Ó˚y ¢Ω¸Ó òy– ≤ÃÑ¸“!›¸ Ó˚*¸ôy!Î˚˘Ïì¸ £˘Ïú ~Ñ¸ !õ!úÎ˚˘Ïò õyò%°Ï Ü,££#ò £˘ÏÓ Ìy˘ÏïÓ˚ ˘Ó!üÓ˚¶¸yÜ£z ÜÓ˚#Ó ~ÓÇ xy! îÓy¢# ˘◊!íÓ˚– ¢õ¸k¸ xÓ˚íƒ˜ÓÓ!â¸eƒ ú%Æ £˘ÏÓ– ≤ÃyÎ˚ 25!›¸ ≤Ããy!ì¸Ó˚ ¸ôy!ÖÓ˚ Óy¢fl¸iyò ïπÇ¢ £˘ÏÎ˚ !Óú%Æ £ÓyÓ˚ xyüB¸y xy˘ÏäÈ– ì¸y äÈyv¸¸y ¸y ≤ÃyÌ!õÑ¸ ÓƒÎ˚ ïÓ˚y ˘Ó˚˘ÏÓ˚ ¸ô˘ÏÓ˚ Úy ¢z ˘ô˘ÏÓ˚ ~Ñ¸ £Î˚ £z £!¢ yÑ¸yÓ˚ ¸ôyÒÓ£ ¢˘ÏÑ¸ Óyò Üyì¸˘Ï¢ ÒÓ˚!Ó îÑ¸ !Ó˚˘Ïõâ¸ Óyñ ˘Ó˚˘ÏÓ˚ ˘Ó!üÓ˚ ¸ô!ì¸ ¸ò≈yì˘Ï¢Ó˚ ¸ô˘Ïì¸ ¸ôÓ˚ ÖyäÈ ¸ôÒÓ!ÿ¸õ˘Ïì¸ ¸ô!Ó˚Ó˚ – 1987 ¢y˘Ïú ÓyÓy xyõ˘Ïì¸ ~£z ≤ÃÑ¸˘Ï“Ó˚ ¢Ó Ñ¸yÌ ¢yïyÓ˚í õyò%°Ï°ÏÓ˚ ãyòyÓyÓ˚ !Ó!Ó ˘ì¸y˘Ïúò– ÓyhflÏ˘Ó˚ ì¸yÓ˚ õyòy £Î˚ !ò– 1989 ¢y˘ÏúÓ˚ ˘ö˘Ó&Î˚!Ó˚ õy˘Ï¢ =ãÓ˚y˘Ï›¸Ó˚ õïƒ≤Ã˘Ïî˚˘ÏüÓ˚ Á õ£yÓ˚y˘ÏáT…Ó˚ ˘Î@˘Ãyõ=!ú v%¸˘ÏÓ ÌyÓyÓ˚ xyüB¸y ì¸y˘ÏïÓ˚ ≤ÃyÎ˚ ïü £yãyÓ˚ õyò%°Ï ãõy £˘ÏÎ˚ !äÈ˘Ïúò ≤ÃÑ¸“!›¸ Ó˚*¸ôyÎ˚˘ÏïÓ˚ ≤Ã!ì¸Óyî ÓyÎ˚˘Ïì¸ ~ÓÇ ˘¢£z x!ÉÇ¢ !õ!ú˘Ïú˘Ïò ¸ô%òÿ≈yü xye´õ Ñ¸˘ÏÓ˚ – õò≈îy ÓßyâüyÁ xy˘Ï®yúò Óì≈¸õy˘Ïò ~Ñ¸ !Óü!Ó!ì¸ò ˘õyv¸¸ !ò˘ÏÎ˚˘Ïú xyhs¸ãyî!ì¸Ñ¸ ì%ú!Ó˚ ~£z ÷Ó˚& ˘Ï¸ô˘Ïü ∆ô˘ì¸ 2000 ¢y˘ÏúÓ˚ 18 x˘ÏQy ÓÓ˚ ¶¸yÓ˚˘Ïì¸Ó˚ ¢%!≤Ãõ ˘Ñ¸y˘Ï›≈¸ !ì¸ò ¢Î˚˘ÏîÎ˚ Óyöå¨ ˘Ó˚˘ÏÓ˚ Óßyî ˘ì¸!Ó˚Ó˚ ¸ô˘Ï«¸ £z õì¸ yõì¸ ≤Ãîy˘Ï ò Ñ¸˘ÏÓ˚ ˘¸ô˘ÏÓ˚ ˘Ó˚˘ÏÓ˚ £˘ÏÓ˚ ˘ÏäÈ– Óßyî ˘ì¸!Ó˚Ó˚ ˘ã˘ÏÓ˚ ˘Î£yãyÓ˚ £yãyÓ˚ õyò%°Ï˘ÏÓ˚Ó˚ Ñ¸˘ÏÓ˚Ñ¸ ≤Ãã˘ÏÜ√Ó˚ ÓyÓfl¸iyò Á Ñ¸õ≈fl¸iú ~ÓÇ ì¸y˘ÏÑ¸ !á˘ÏÓ˚ Ü˘Ïv¸¸ Á‡¸y ¢Çfl¸Ò!ì¸ !òõÎõò £˘ÏÓñ ì¸y˘ÏïÓ˚ ¸ô%òÓ≈y¢˘ÏòÓ˚ ≤ÃŸ¿!›¸

100%	MATCHING BLOCK 178/200	W

˘ÏÑ¸Á v¸z˘Ï¸ô«¸y Ñ¸Ó˚y £˘

ÏÎ˚ˆÏäÈ– ¢Ó≈ˆÏü°Ï Ó˚y˜ÏÎ˚ ¢%!≤Ãõˆ ÏÑ¸y›≈¸ Óßy˜ÏïÓ˚ v¸zFâ¸ì¸y Ó‚!k¸Ó˚ ≤Ãhfl¸yÓ ˆõˆÏò !ò˜ÏÎ˚ Ñ¸ˆÏÎ˚Ñ¸!›¸ üì≈¸¢y˜Ï¸ô˜Ï«¸ ≤ÃÑ¸ˆÏ“Ó˚ Ñ¸yã â¸y!ú˜ÏÎ˚ ÌyÓyÓ˚ !ò˜Ïì≈ü ˆîÁÎ˚yÎ˚ xyÓyÓ˚ òì%¸ò Ñ¸ˆÏÓ˚ !ÓˆÏ«¸y¶¸ ì¸#Ó ì¸Ó˚ xyÑ¸yÓ˚ ïyÓ˚í Ñ¸ˆÏÓ˚ˆÏäÈ– ˆî˜ÏüÓ˚ !Ó!ü‹T !â¸hs¸y!Óîñ Ó%!k¸ã#Ó#Ó˚y fl¸Ì¸Éfl¸≥)¸ì≈¸¶¸y˜ÏÓ ~£z xy˜Ï®yú˜Ïò ¢y!õú £˜ÏFäÈò– 6.9.3 ˆì¸£Ó˚# Óßyï !ÓˆÏÓ˚yï# xy˜Ï®yúò v¸z_Ó˚≤Ã˜ÏìˆÏüÓ˚ v¸z_Ó˚ÈÙÈ¸ô!ÿ¸õ !£õyú˜ÏÎ˚Ó˚ ¸ôyî˜Ïì˜Ïü ¶¸yÜ#Ó˚Ï# Á !¶¸úÜDy òî#m˜ÏÎ˚Ó˚ ¢Ç˜ÏÏyÜfl¸ì˜Ïú 260.5 !õ. v¸zFâ¸ ˆì¸£Ó˚# Óßyï !òõ≈yí ≤ÃÑ¸“!›¸ @˘Ã£í Ñ¸Ó˚y £Î˚ ˆ¢y!¶¸ˆÏÎ˚ì¸ xy!Ì≈Ñ¸ ¢£˜ÏÏy!Üì¸yÎ˚ – ~Ó˚ ö¸˜Ïú 270000 ˆ£QÓ˚ ã!õˆÏì¸ òì%¸ò Ñ¸ˆÏÓ˚ ˆ¢˜Ïâ¸Ó˚ ÓƒÓfl¸iy £˜ÏÓñ 640000 ˆ£QÓ˚ ã!õÓ˚ Óì≈¸õyò ˆ¢â¸ÓƒÓfl¸iy˜ÏÑ¸ v¸zß¨ì¸ Ñ¸Ó˚ˆÏÓ ~ÓÇ 1000 ˆõÜyÁÎ˚y›¸ ! Óî%ƒÍ v¸zÍ¸ôß¨ £ˆÏÓ– 1977 ¢y˜Ïú ~£z Óßy˜ÏïÓ˚ Ñ¸yã ÷Ó˚&£˜Ïú ≤ÃÑ¸“!›¸Ó˚ !ÓˆÏÓ˚y!ïì¸yÎ˚ Ú˜ì¸£Ó˚# Óßyï !ÓˆÏÓ˚yï# ¢Ç@˘Ãyõ ¢! õ!ì¸Û Ü!‡¸ì¸ £Î˚ – ì¸y˜ÏïÓ˚ õˆÏì¸ ~£z Óßyï !õõ≈y˜ÏïÓ˚ ¢%ö¸ú x!ì¸Ó˚!Óì¸ Ñ¸ˆÏÓ˚ ˆîÒy˜Ïòy £˜ÏFäÈ– ≤ÃÑ¸“!›¸Ó˚ ö¸˜Ïú 85000 õyò%°Ï Ü‚£#ò £ˆÏÓ ~ÓÇ ˆì¸£Ó˚# ü£Ó˚ Á ¸ôyŸª≈Óì≈¸# 100!›¸ @˘Ãyõ âüõ@¿ £ˆÏÓ– âüyïy˜ÏÓ˚Ó˚ !Ó¸ô%ú ¸ô!Ó˚Óyí ã˜ÏüÓ˚ â¸y˜Ï¸ô ≤ÃÓú ¶¸)!õÑ¸ ¸ô£ÃÎ˚Ó˚ xyüB¸y Ó˚ˆÏÎ˚ˆÏäÈ– ì¸yäÈyv¸¸y £!Ó˚myÓ˚ñ £*°Ï#ˆÏÑ¸üñ ˆîÓ≤ÃÎ˚ü ≤ÃÑ¸!ì¸ ïö≈#Î˚ ü£Ó˚ ïπÇ¢ £ˆÏÓ ~ÓÇ !Óhfl¸#í≈ v¸zÓ≈Ó˚ Ñ¸¸!°Ïä!õ ã˜Ïú !òõ!ì¸ £ÁÎ˚yÓ˚ ¢Ω¸yÓòy Ó˚˜ÏÎ˚ˆÏä – ¢%®Ó˚úyú Ó˝=íy ~£z Óßy˜ÏïÓ˚ !ÓˆÏÓ˚y!ïì¸yÎ˚ ˆÓü Ñ¸ˆÏÎ˚Ñ¸ÓyÓ˚ xòüò Ñ¸ˆÏÓ˚ò– 6.9.4 ¢y£z˜Ïúr› ¶¸ƒy!ú xy˜Ï®yúò ~£z xy˜Ï®yúò ¶¸yÓ˚ˆÏì¸Ó˚ xòƒì¸õ ¸ô!Ó˚ˆÏÓ˚ˆÏú xy˜Ï®yúò– v¸z_Ó˚ ˆÑ¸Ó˚yúyÓ˚ ¸ôyúyáy›¸ ˆâúyÓ˚ ¸ôy£y!v¸¸ xM¸Èú Ó°ÏÓ≈íyÓ˚íƒ xyFäÈy!ï¸ Ú¢y£z˜Ïúr›¸ ¶¸ƒy!úÛ– î%!ˆÏÑ¸ ˆÑ¸Ó˚yúyÓ˚ î%£z üÓ˚ˆ ˆÑ¸y!ã ˆÏÑ¸ yv¸¸ ~ÓÇ ¸ôyúáy›¸ !òˆÏÎ˚ ~£z v¸z¸z¸ôì¸ƒÑ¸yÓ˚ ˆâ¸£Óy˜Ïy x˜ÏòÑ¸›¸y !e¶%¸ ˆÏãÓ˚ õˆÏì¸y– ~õò Ü¶¸#Ó˚ ãD˜Ïú !G•¸!G¸ ˆ¸ôyÑ¸yÓ˚ v¸yÑ¸ ¸ôî≈hs¸ ˆüyòy ÌyÎ˚ òy– ì¸y£z ~Ó˚ òyõ Ú¢y£z˜ÏúrÛ ¶¸ƒy!úÛ Óy ÚòÜ#Ó˚Ó v¸z¸ôì¸ƒÑ¸yÛ– ~£z v¸z¸ôì¸ƒÑ¸yÓ˚ õyG¸Öyò !î˜ÏÎ˚ v¸z_Ó˚ÈÙÈ!«¸˜Ïì Ó˚˜ÏÎ˚ â¸˜Ïúˆ˜ÏäÈ Ñ¸%¸hs¸# òî#ñ ~£z 124 ? NSOU ? AE-ES-21 òî#ˆÏì¸ 1973 ¢y˜Ïú ¶¸yÓ˚ì¸#Î˚ ¸ô!Ó˚Ñ¸“òy Ñ¸!õüò ~Ñ¸!›¸ Óßyï ˆîÁÎ˚yÓ˚ ≤ÃÑ¸“ ˆáy°Ïíy Ñ¸ˆÏÓ˚ – ÷Ó˚&˜Ïì¸ 120 ˆõÜyÁÎ˚y›¸ Á ¸ôˆÏÓ˚ 240 ˆõÜyÁÎ˚y›¸ !Óî%ƒÍ v¸zÍ¸ôyî˜ÏòÓ˚ !¢k¸yhs¸ £Î˚ – Ó˝ ¸ô!Ó˚ˆÏÓü!Óî xy¸ô!_ äyòyò ~£z ≤ÃÑ¸“ Ó˚*¸ôyÎ˚˜ˆÏí– WWF, IndiaÈÙÈÓ˚ ~Ñ¸!›¸ ›¸yfl¸Ò ˆö¸y˜Ï¢≈Ó˚ ¢õ#«¸yÎ˚ Óúy £Î˚ñ ≤ÃÑ¸“!›¸ Ó˚*¸ôy!Î˚ì¸ £˜Ïú 'the richest expression of life that has evolved on this planet' ïπÇ¢ £ˆÏÎ˚ Ìy˜ÏÓñ ~äÈyv¸¸y ˆÑ¸Ó˚yúyÓ˚ Ó‚£_õ äò!ÓK¸yò ¢ÇÜ‡¸ò ˆÑ¸Ó˚yúy üyfl¸ƒ ¢y!£ì¸ƒ ¸ô!Ó˚°Ïî (KSSP) Ü¡¢y«¸Ó˚ ¢Ç@˘Ãƒ x!¶¸Ìyò ÷Ó˚&Ñ¸ˆÏÓ˚ – ãyì¸#Î˚ ~ÓÇ xyhs¸ã≈y!ì¸Ñ¸ hfl¸ˆÏÓ˚ ~Ó˚ !ÓˆÏÓ˚y!ïì¸y ≤ÃÓú £ˆÏÎ˚ Á‡¸yÎ˚ 1980 ¢y˜ÏúÓ˚ !v¸ˆÏ¢¡ÓˆÏÓ˚ õy˜Ï¢ ˆÑ¸Ó˚yúy ¢Ó˚Ñ¸yÓ˚ ~£z ¸ô!Ó˚Ñ¸“òy ¸ô!Ó˚ì¸ƒ_´ Ó˚˜Ïú ˆáy°Ïíy Ñ¸ˆÏÓ˚ñ ~ÓÇ Ú¢y£z˜Ïúr›¸ ¶¸ƒy!ú˜ÏÑ¸Û Úãyì¸#Î˚ v¸zîƒyòÛ ! £¢y˜ÏÓ ˆáy°Ïíy Ñ¸Ó˚y £Î˚ – 6.10 ¸ô!Ó˚ˆÏÓˆÏü Ó˚«¸yÎ˚ ¢yÇ!Óïy!òÑ¸ ÓƒÓfl¸iy ¢õ)£ (Constitutional Provision for Protecting Environment) ¶¸yÓ˚ˆÏì¸ ¸ô!Ó˚ˆÏÓü ¢Ç˜Ïˆyhs¸ xy£zò ÓÑ¸yò òì%¸ò á›¸òy òÎ˚ – 1865 ¢y˜Ïú ¶¸yÓ˚ì¸ ≤Ãˆõ xÓ˚íƒ xy£zò ≤Ãâ¸!úì¸ £Î˚ ~ÓÇ ¸ôˆÏÓ˚ xyˆÏÓ˚y !Ó!¶¸ß¨ ïÓ˚ˆÏÓ˚Ó˚ xy£zò ≤Ãâ¸!úì¸ Á ¢Ç˜Ïüy!ïì¸ £Î˚ – 1972 ¢y˜Ïú õyòÓ ¸ô!Ó˚ˆÏÓ˚ˆÏüÓ˚ v¸z¸ôÓ˚ Ó˚y‹T... ¢Ç˜ÏäÓ˚ ˆáy°Ïíy¸ôe Ü‚£#ì¸ £Î˚ – fl¸Íy«¸Ó˚Ñ¸yÓ˚# ˆîü !£¢y˜ÏÓ ¶¸yÓ˚ì¸ 1976 ¢y˜Ïú ¸ô!Ó˚ˆÏÓˆÏüÓ˚

100%	**MATCHING BLOCK 182/200**	SA	MA in Geography SEM II (CBCS Mode).pdf (D142514677)

v¸z¸ôÓ˚ =Ó˚&c xyˆÏÓ˚y¸ô Ñ¸ˆÏÓ˚ ¶¸

yÓ˚ì¸#Î˚ ¢Ç!Óïy

ˆÏò 2!›¸ xò%˜ÏFäÈî ¢Ç˜ÏÏy!ãì¸ Ñ¸ˆÏÓ˚ Ìy xò%˜ÏFäÈî 48A ~ÓÇ 51A(g) òy˜Ïõ ¸ô!Ó˚!â¸ì¸ – 48A xò%˜ÏFäÈî xò%¢yˆÏÓ˚ñ ˆî˜ÏüÓ˚ ¸

52%	**MATCHING BLOCK 181/200**	W

ô!Ó˚ˆÏÓü Ó˚«¸y Á v¸zß¨!ì¸ !Óïy˜Ïò ~ÓÇ Óòƒ Á ¸Óòƒ≤Ãyí# Ó˚«¸yÎ˚ Ó˚

y˜ÏäƒÓ˚ ≤ÃÎ˚y¢ ÌyÑ¸ˆÏÓ– Ó˚yãƒ Óú˜Ïì¸ ˆÓyG¸yÎ˚ ¶¸yÓ˚ì¸ ¢Ó˚Ñ¸yÓ˚ñ ¶¸yÓ˚ì¸ ¢Ó˚Ñ¸yÓ˚yï#ò î¸ÆÓ˚ñ fl¸iyò#Î˚ Á xòƒyòƒ ≤Ãy! ïÑ¸y!Ó˚Ñ¸ – "The State shall endeavor to protect and improve the environment and to safeguard the forest and wildlife of the country". 51A(g) xò%˜ÏFäÈî xò%Î˚yÎ˚# ˆî˜ÏüÓ˚ ≤Ã˜Ïì¸ƒÑ¸ òyÜ!Ó˚ÑˆÏÑ¸Ó˚ ˆõÔ!úÑ¸ Ñ¸ì≈¸Óƒ âüñ Óòñ £…î Á Óòƒ≤Ãyí# ¢ˆÏõì¸ ≤ÃyÑ¸!ì¸Ñ¸ ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü ¢¡ô!Ñ≈¸ì¸ ¢õƒÑ¸ K¸yò ÌyÑ¸y ≤Ã˜ÏÎ˚yãò ì¸y£z ¢ˆÏÓ≈yFâ¸ xyîyú˜Ïì¸Ó˚ !òˆÏî≈ü˜Ïú ¢yÓ˚y ˆî˜Ïü ≤Ãy!õÑ¸ ˆÏÎ˚ˆÏÑ¸ v¸zFâ¸!üÑ¸yÎ˚ ¸ô!Ó˚ˆÏÓü ¢Ç˜Ïyhs¸ !ü«¸yÎ˚ò Óy!íƒõ)úÑ¸ Ñ¸Ó˚y £ˆÏÎ˚ˆÏäÈ– "It shall be duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures." ¶¸yÓ˚ˆÏì¸ ¸ô!Ó˚ˆÏÓü ¢Ç˜Ïyhs¸ !ÓˆÏü°Ï xy£zò=!ú £ÚÈÙÙÈ S1V 1986 ¢y˜ÏúÓ˚ ¸ô!Ó˚ˆÏÓü S¢%ÓÓ˚«¸yV xy£zò (The Forest Protection Act, 1986) ¶¸)¸¸ôyú Ü‚£ƒ¢ î%á≈›¸òyÓ˚ ¸ôÓ˚ ¢yÇ!Óïy!òÑ¸ v¸z¸ô˜ÏÏy!Üì¸yÓ˚ !ò!Ó˚ˆÏÎ 1986 ¢y˜Ïú 19 ò˜Ï¶¸¡ÓˆÏÓ˚ ~£z

87%	**MATCHING BLOCK 186/200**	SA	MA in History SEM II (CBCS Mode).pdf (D142514392)

xy£zò!›¸ Ñ¸yÎ≈Ñ¸Ó˚ Ñ¸Ó˚y £Î˚ – ¸ô!Ó˚ˆ

ˆÏÓü Ó˚«¸yñ ¸ô!Ó˚ˆÏÓ˚ˆÏüÓ˚ v¸zß¨!ì¸ Á ¸ô!Ó˚ˆÏÓü î)°Ïí ≤ÃÃ!ì¸ˆÏÓ˚yï Ñ¸Ó˚y£z ~£z xy£zò!›¸Ó˚ õ%Öƒ v¸zˆÏj˜ÏüƒÏ– ~£z xy£zò xò%Î˚yÎ˚# ¢õhfl¸ ¢yïyÓ˚í «¸

62%	**MATCHING BLOCK 183/200**	W

õì¸y ˆÑ¸w¢Ó˚Ñ¸yˆÏÓ˚Ó˚ £y˜Ïì¸ ˆîÁÎ˚y £ˆÏÎ˚ˆÏäÈ– ? ˆÑ¸w¢Ó˚Ñ¸yÓ˚ ¸

ô!Ó˚ˆÏÓˆÏüÓ˚ ¢%Ó˚«¸y ~ÓÇ v¸zß¨!ì¸Ó˚ ì¸y!Üˆ Ïî ¢õhfl¸ ¸ôÎˆÏ«¸¸ô !òˆÏì¸ ¢«¸õ– ? ãúñ Óyì¸y¢ñ õy!›¸Ó˚ =íÜì¸ õyò !òí≈Î˚ ~ÓÇ î) °ÏˆÏíÓ˚ õyey !òï≈yÓ˚í Ñ¸Ó˚y £ˆÏÓ– ? !ü“ ¢Çfl¸iy=!úˆÏÑ¸ î)°Ïí ¢Çe´yhs¸ !Ó!ï ˆõˆÏò â¸úˆÏì¸ £ˆÏÓ– 1993 ¢yˆÏúÓ˚ ¸ôÓ˚ ì¸yˆÏîÓ˚ ¸ô! Ó˚ˆÏÓü !òÓ˚#«¸y Ñ¸Ó˚yˆÏì¸ £ˆÏÓ ~ÓÇ ˆ¢£z ì¸Ìƒ Ó˚yãƒ î)°Ïí !òÎ˚s¸fÑ¸ îÆˆÏÓ˚Ó˚ Ñ¸yˆÏäÈ ˆ¸ôü Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– NSOU ? AE-ES-21 ? 125

? «¸!ì¸Ñ¸yÓ˚Ñ¸ ¸ôîyˆÏÌ≈Ó˚ ≤Ãhfl¸y!Óì¸ !òÎ˚õ Óy !Ó!ï¢¡øì¸ ¶¸yˆÏÓ òyv¸¸yâ¸yv¸¸y òy Ñ¸Ó˚yÓ˚ Á¸ôÓ˚ !òˆÏ°ÏïyK¸y ãy!Ó˚ – ? î)°Ïí ¢Çe´yhs¸ !òˆÏî≈ü xõyòƒ Ñ¸Ó˚ˆÏúñ ~£z xy£zò xò%ÎyÎ˚# Óƒ!_´Ó˚ 7 ÓäÈˆÏÓ˚Ó˚ ˆãú Óy 1 ú«¸ ›¸yÑ¸y ã!Ó˚õyòy £ˆÏì¸ ¸ôyˆÏÓ˚ – S2V 1981 ¢yˆÏú ÓyÎ˚%î)°Ïí S≤Ã!ì¸ˆÏÓ˚yï Á !òÎ˚s¸fíV xy£zò [The Air (Prevention and Control of Pollution) Act, 1981] 1981 ¢yˆÏú 29ˆü õyâ≈¸ñ ¢Ó˚Ñ¸yÓ˚ ~£z ÓyÎ˚%î)°Ïí ≤Ã!ì¸ˆÏÓ˚yï Á !òÎ˚s¸fí xy£zò!›¸ ≤Ãí!Î˚ì¸ Ñ¸ˆÏÓ˚ – õ%Öƒ v¸zˆÏjüƒ !äÈú ÓyÎ˚%î)°Ïí ≤Ã!ì¸ˆÏÓ˚yïñ ! òÎ˚s¸fí Á v¸z¸ôüõ Ñ¸Ó˚y £Î˚ – ~£z xy£zò xò%ÎyÎ˚# Óyì¸yˆÏ¢ v¸z¸ô!fl¸iì¸ ˆÑ¸yò Ñ¸!‡¸òñ ì¸Ó˚ú Óy Üƒy¢#Î˚ ¸ôîyÌ≈ ~ÓÇ ì¸yˆÏîÓ˚ v¸z¸ô!fl¸i!ì¸Ó˚ õyey Îy õyò%°Ï ¢£ xòƒyòƒ ã#Óñ ¢¡ôˆÏîÓ˚ ~ÓÇ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ «¸!ì¸¢yïò Ñ¸ˆÏÓ˚ ì¸yˆÏîÓ˚ ÓyÎ˚%î)°Ïí Óˆ Ïú– ? ~£z xy£zò!›¸Ó˚ ≤ÃˆÏíyîˆÏòÓ˚ ãòƒ ˆ

100% MATCHING BLOCK 184/200 W

Ñ¸w#Î˚ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈

î (CPCB) ~ÓÇ Ó˚yãƒ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈î (SPCB) Ü‡¸ò ~ÓÇ ì¸yˆÏîÓ˚ «¸õì¸y Á îy!Î˚c !òï≈yÓ˚í Ñ¸Ó˚y £Î˚ – ? !òï≈y!Ó˚ì¸ õyeyÓ˚ Á¸ôÓ˚ ¢#¢yñ ¢yúö¸yÓ˚ v¸y£zÈÙÈx:y£zv¸ñ òy£zˆÏ›¸∆yˆÏãò x:y£zv¸ñ VOC, Particulate Matter (PM) ~ÓÇ ~ÓÇ xòƒyòƒ î)!°Ïì¸ ¸ôîyÌ≈ Óyì¸yˆÏ¢ äÈyv¸¸yÓ˚ Á¸ôÓ˚ !òˆÏ°ÏïyK¸y ãy!Ó˚ Ñ¸ˆÏÓ˚ – ? xy£zˆÏòÓ˚ !òˆÏî≈üyÓú# xõyòƒ Ñ¸Ó˚ˆÏú Ñ¸õ¸ôˆÏ«¸ 5 õyˆÏ¢Ó˚ ˆãú ˆ£ö¸yãì¸ ~ÓÇ ¢ˆÏÓ≈yFâ¸ 7 ÓäÈÓ˚ ˆãú £ˆÏì¸ ¸ôyˆÏÓ˚ – S3V 1974 ¢yˆÏúÓ˚ ãú î)°Ïí S≤Ã!ì¸ˆÏÓ˚yï Á !òÎ˚s¸fíV xy£zò [The Water (Prevention and Control of Pollution) Act, 1974] !ü“yM¸Èúñ Ü‚£fl¸iy!ú ~ÓÇ Ñ¸‚!°ÏÑ¸yã ˆÌˆÏÑ¸ v¸zÍ¸ôß¨ î)!°Ïì¸ ãú xyõyˆÏîÓ˚ ãú¢¡ôîˆÏÑ¸ î)!°Ïì¸ Ñ¸Ó˚ˆÏäÈ– ~£z î)°Ïí ≤Ã!ì¸ˆÏÓ˚yï ~ÓÇ !òÎ˚s¸fí Ñ¸Ó˚yÓ˚ ì¸y!Üˆ Ïî ¢Ó˚Ñ¸yÓ˚ 1974 ¢yˆÏú ~£z xy£zò!›¸Ó˚ ≤ÃÓì≈¸ò Ñ¸ˆÏÓ˚ – ? ~£z xy£zò myÓ˚y CPCB Á SPCB Ü‡¸ò ~ÓÇ ì¸yˆÏîÓ˚ îy!Î˚c Ñ¸ì≈¸Óƒ !òï≈yÓ˚í Ñ¸Ó˚y £Î˚ – ? ~£z xy£zò myÓ˚y ˆÑ¸yòÓ˚Ñ¸õ î)!°Ïì¸ Óã≈ƒ ¸ôîyÌ≈ Á ì¸Ó˚ú ˆÑ¸yòÓ˚Ñ¸õ fl¸iyÎ˚# Óy ≤ÃÓ£õyò ãˆÏú ˆö¸úyÓ˚ Á¸ôÓ˚ !òˆÏ°ÏïyK¸y xyòy £Î˚ – ? Ñ¸yÓ˚Öyòy=!ú ˆÌˆÏÑ¸ ˆÑ¸yòÓ˚Ñ¸õ ì¸Ó˚ú Óy Óã≈ƒ ¸ôîyÌ≈ ãˆÏú ˆö¸úyÓ˚ xyˆÏÜ ÈSPCBÙÈÓ˚ Ñ¸yäÈ ˆÌˆÏÑ¸ xò%ˆÏõyîò @˘Ã£í Ñ¸Ó˚ˆÏì¸ £ˆÏÓ ~ÓÇ SPCB Ñ¸yÓ˚Öyòy=!úÓ˚ ˜Ó!üˆÏ‹TÓ˚ Á¸ôÓ˚ !¶¸!_ Ñ¸ˆÏÓ˚ ì¸yˆÏîÓ˚ Óã≈ƒ ¸ôîyîˆÏòÓ˚ õyey !‡¸Ñ¸ Ñ¸ˆÏÓ˚ ˆîˆÏÓ– ? ≤Ã!ì¸!›¸ ˆÑ¸w#Î˚ Á Ó˚yãƒ î)°Ïí !òÎ˚s¸fí îÆˆÏÓ˚ !òãfl¸∫ ¸ôÓ˚#«¸yÜyÓ˚ ÌyÑ¸ˆÏì¸ £ˆÏÓñ Îyˆ Ïì¸ ãú ¢Ç@˘Ã£ Á ¸ôÓ˚#«¸y Ñ¸Ó˚y ¢Ω¸Ó– v¸z_´ ¸ôÓ˚#«¸yÓ˚ ãòƒ ì¸yÓ˚ !Ó!òõˆÏÎ˚ ¢Çfl¸iyÓ˚ Ñ¸yäÈ ˆÌˆÏÑ¸ ≤ÃˆÏÎ˚yãò#Î˚ ›¸yÑ¸y ïyÌ≈ Ñ¸Ó˚y £ˆÏÓ– ? ˆÑ¸yòÓ˚Ñ¸õ !òÎ˚õ úAáˆÏòÓ˚ Ñ¸yÓ˚ˆÏí 3 õyˆÏ¢Ó˚ ˆãú Á 10ñ000 ›¸yÑ¸y ã!Ó˚õyòy £ˆÏì¸ ¸ôyˆÏÓ˚ ~ÓÇ ì¸yÓ˚ ¢yˆÏÌ ì¸_¥yÓïyˆÏòÓ˚ ãòƒ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈ˆÏîÓ˚ ¢õhfl¸ ÖÓ˚â¸ !ìˆÏì¸ £ˆÏÓ– Î!î ¢Çfl¸iyÓ˚ ˆÑ¸yò xy!ïÑ¸y!Ó˚Ñ¸ x¢£ˆÏÎy!Üì¸y ˆîÖyÎ˚ ì¸y£ˆÏú !ì¸!ò îyÎ˚# ÓˆÏú Üíƒ £ˆÏÓò– 126 ? NSOU ? AE-ES-21

S4V 1972 ¢yˆÏúÓ˚ Óòƒ≤Ãyí# S¢%Ó˚«¸yV xy£zò [The Wildlife (Protection) Act, 1972] ¸ô!Ó˚ˆÏÓü Á Óylfl¸ì¸ˆÏs¸fÓ˚ ¢%Ó˚«¸y ¢%!ò!ÿ¸ì¸ Ñ¸Ó˚yÓ˚ úˆÏ«¸ƒ ~£z xy£zò!›¸ 1972 ¢yˆÏú ~Ñ¸!›¸ ã!›¸ú ≤Ãüy¢!òÑ¸ ¸ô!Ó˚Ñ¸y‡¸yˆÏõyÓ˚ ¢!£ì¸ ˜ì¸!Ó˚ Ñ¸Ó˚y £Î˚ – ~£z xy£zò xò%ÎyÎ˚# ≤Ãyí# ≠ ≤Ãyí#Ó˚ xhs¸¶%≈¸_´ñ v¸z¶¸Î˚â¸Ó˚ñ ¸ôy!Öñ hfl¸òƒ¸ôyÎ˚# ≤Ãyí#ñ ¢!Ó˚¢¸¸ô Á ì¸yˆÏîÓ˚ ÓyFâ¸y ~ÓÇ ¸ôy!Ö Á ¢! Ó˚¢¸ˆÏ¸ôÓ˚ ˆ«¸ˆÏe ì¸yˆÏîÓ˚ !v¸õ– Óòƒ≤Ãyí ≠ Óòƒ≤ÃyˆÏíÓ˚ xhs¸¶%≈¸_´ ˆÎ ˆÑ¸yò ≤Ãyí#ñ ãúâ¸Ó˚ xÌÓy ˆÑ¸yò !ò!î≈‹T fl¸iyˆÏòÓ˚ v¸z!qîÑ%¸ú– xyÓk¸ ≤Ãyí# ≠ I, II, III, IV ì¸¸ôü#ˆÏú Ó!í≈ì¸ ≤Ãyí# ÎyˆÏîÓ˚ˆÏÑ¸ xyÓk¸ xÓfl¸iyÎ˚ Ó˚yÖy £ˆÏÎ˚ˆÏäÈ ≤Ããòò Óy xòƒ ˆÑ¸yò Ñ¸yÓ˚ˆÏí– !üÑ¸yÓ˚ ≠ ~£z xy£zò xò%ÎyÎ˚# !üÑ¸yÓ˚ ÓúˆÏì¸ ˆÓyG¸yÎ˚ – ? ˆÑ¸yò Óòƒ Óy xyÓk¸ ≤Ãyí#ˆÏÑ¸ ïÓ˚yñ ˆäÈy›¸yòñ ö§¸yˆÏî xy›¸Ñ¸yˆÏòyñ !Ó°Ï ˆîÁÎ˚y Óy ~£z ¢Çe´yhs¸ ≤ÃˆÏâ¸‹Ty Ñ¸Ó˚y– ? v¸zˆÏÕ'!Öì¸ ≤Ãyí#ˆÏîÓ˚ xy£ì¸ñ !ÓòyüñüÓ˚#ˆÏÓ˚Ó˚ ˆÑ¸yò xÇü ¢Ç@˘Ã£ Ñ¸Ó˚y xÌÓy ¢!Ó˚¢¸¸ô Óy Óòƒ ¸ôy!ÖˆÏîÓ˚ Óy¢y Á !v¸õ ò‹T Ñ¸Ó˚y– !üÑ¸yˆÏÓ˚Ó˚ !Ó!ï !òˆÏ°Ïï ≠ I, II, III, IV ì¸¸ôü#ˆÏú Ó!í≈ì¸ ≤Ãyí#ˆÏÑ¸ !üÑ¸yÓ˚ Ñ¸Ó˚y ÎyˆÏÓ òy xÓüƒ Chief Wildlife Warden ¢ls¸‹T £ˆÏú !ÓˆÏü°Ï Ñ¸yÓ˚ˆÏí !üÑ¸yˆÏÓ˚Ó˚ xò%õ!ì¸ îyò Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ò ˆ¢=!ú £úÈÙÙÈ ? Óòƒ≤Ãyí# õyò%ˆÏ°ÏÓ˚ ãòƒ «¸!ì¸Ñ¸Ó˚ ≤Ãõy!íì¸ £ˆÏú Á ö¸¢ú ò‹T Ñ¸Ó˚ˆÏú– ? ˆÑ¸yò ≤Ãyí# î)Ó˚yˆÏÓ˚yÜƒ ˆÓ˚yˆÏÜÓ˚ !üÑ¸yÓ˚ £ˆÏú ì¸yˆÏÑ¸ !üÑ¸yˆÏÓ˚Ó˚ xò%õ!ì¸ !îˆÏì¸ ¸ôyˆÏÓ˚ò– ? !ü«¸yñ ˜ÓK¸y!òÑ¸ ÜˆÏÓ°Ïíyñ ã#ÓòîyÎ˚# Ë°Ïî ˜ì¸!Ó˚ £zì¸ƒy!î Ñ¸yˆÏã !üÑ¸yˆÏÓ˚Ó˚ xò%õ!ì¸ îyò Ñ¸ˆÏÓ˚ò– ~£z xy£zˆÏò x¶¸Î˚yÓ˚íƒ Á ãyì¸#Î˚ v¸zîƒyˆÏòÓ˚ Ü‡¸ò Á ˜Ó!ü‹Tƒ ! òï≈yÓ˚í Ñ¸Ó˚y £Î˚ – xò%õ!ì¸ äÈyv¸¸y Óòƒ≤Ãyí# ~ÓÇ Óòã ¢¡ôî ¸ô!Ó˚Ó£ò Ñ¸Ó˚y !ò!°Ïk¸ Ñ¸Ó˚y £Î˚ – xòƒÌyÎ˚ ˆãú ˆ£ö¸yãì¸ Á ã! Ó˚õyòy Ñ¸Ó˚y £ˆÏì¸ ¸ôyˆÏÓ˚ – S5V 1980 ¢yˆÏúÓ˚ Óò ¢ÇÓ˚«¸í xy£zò [The Forest Conservation Act, 1980] ¶¸yÓ˚ˆÏì¸ ÓòîÆÓ˚ ≤Ã! ì¸!¤¸ì¸ £Î˚ 1864 !Ö fi›¸yˆÏ∑ñ ì¸yÓ˚ ¸ôÓ˚ !Ó!¶¸ß¨ xy£zò ˜ì¸!Ó˚ £Î˚ñ

100% MATCHING BLOCK 185/200 W

ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ 1927 ¢

yˆÏúÓ˚ ¶¸yÓ˚ì¸#Î˚ xÓ˚íƒ xy£zò– ~£z xy£zò ¸ô)ˆÏÓ≈ ˜ì¸!Ó˚ £ÁÎ˚y ¢Ñ¸ú Óò ¢¡ô!Ñ≈¸ì¸ xy£zòˆÏÑ¸ ~Ñ¸!eì¸ Ñ¸ˆÏÓ˚ – ~£z xy£zò ¢Ó˚Ñ¸yÓ˚ Á ÓòîÆÓ˚ˆÏÑ¸ òì%¸ò ¢ÇÓ˚!«¸ì¸ Óò ˜ì¸!Ó˚Ó˚ ~ÓÇ ì¸yÓ˚ ¢%Ó˚«¸yÓ˚ ¢õhfl¸ «¸õì¸y xyˆÏÓ˚y¸ô Ñ¸ˆÏÓ˚ ~ÓÇ Á£z Ó˚ˆÏòÓ˚ Á¸ôÓ˚ ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ ~Ñ¸õye x!ïÑ¸yÓ˚ fl¸iy!¸ôì¸ Ñ¸Ó˚y £Î˚ – ~äÈyv¸¸y ÓòˆÏÑ¸ ¢ÇÓ˚!«¸ì¸ Óòñ ¢%Ó˚!«¸ì¸ Óò Á xyM¸È! úÑ¸ Óy @˘ÃyˆÏõÓ˚ Ó˚ˆÏò ¶¸yÜ Ñ¸ˆÏÓ˚ – ~£z xy£zò ≤Ãâ¸!úì¸ !äÈú 1980 ¢yú ¸ôÎ≈hs¸ Îì¸«¸í òy ÷ï%õye Ñ¸yˆÏ‡¸Ó˚ ¢ÇÓ˚«¸í òy Ñ¸ˆÏÓ˚ Óò ˆÌˆÏÑ¸ ≤ÃyÆ xòƒyòƒ ˆ¢Óy ˆÎõòÈÙÙÈ ã#Ó˜ÏÓ!â¸ˆÏeƒÓ˚ ¢ÇÓ˚«¸í ~Ó˚ Á¸ôÓ˚ =Ó˚&c xyˆÏ¢– ~Ó˚ ¸ôÓ˚ òì%¸ò xy£zò ≤ÃˆÏÎ˚yãò !äÈú ÓˆÏòÓ˚ ¢y!Ó≈Ñ¸ ¢%Ó˚«¸yÓ˚ ì¸y!Üˆ Ïî ì¸y£z 1980 ¢yˆÏú Óò ¢ÇÓ˚«¸í xy£zò ≤Ãâ¸úò £Î˚ – NSOU ? AE-ES-21 ? 127 ÓòyM¸Èú ïπÇ¢ Óı¸ Ñ¸Ó˚yÓ˚ ãòƒ !ÓˆÏü°Ï ¶¸yˆÏÓ ~£z xy£zò!›¸ ≤Ãâ¸úò Ñ¸Ó˚y £Î˚ – ~£z xy£zò xò%ÎyÎ˚#ÈÙÙÈ ? ˆÑ¸w ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ xò%õ!ì¸ äÈyv¸¸y ˆÑ¸yò ÓòyM¸ÈúˆÏÑ¸ ¢ÇÓ˚«¸ˆÏíÓ˚ xyÁì¸yÓ˚

100% **MATCHING BLOCK 188/200** **SA** B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

Óy£zˆÏÓ˚ !òˆÏÎ˚ ÎyÁÎ˚y ÎyˆÏÓ òy– ? ¢

ÇÓ˚!«¸ì¸ ÓòyM¸ÈˆÏúÓ˚ õˆÏïƒ ˆÑ¸yòÓ˚Ñ¸õ xy=ò úyÜyˆÏòyñ ¸ô÷â¸yÓ˚íñ ÜyäÈ Ñ¸y›¸y Á Óòã ¢¡ôî ¢Ç@˘Ã£ Ñ¸Ó˚y ÎyˆÏÓ òy– Ñ¸Ó˚ˆÏú üy!hfl¸ !£ˆÏ¢ˆÏÓ 6 õyˆÏ¢Ó˚ ˆãú £ˆÏì¸ ¸ôyˆÏÓ˚ – ?

91% **MATCHING BLOCK 189/200** **SA** MA in History SEM II (CBCS Mode).pdf (D142514392)

Ó˚yãƒ ¢Ó˚Ñ¸yÓ˚ ˆÑ¸w ¢Ó˚Ñ¸yˆÏÓ˚Ó˚

xò%õ!ì¸ äÈyv¸¸y v¸zîƒyò ¸ôyúòñ Ë°Ï!ï Üyˆ ÏäÈÓ˚ â¸y°Ï £zì¸ƒy!îÓ˚ ãòƒ ÓˆÏò ã!õ !îˆÏì¸ ¸ôyÓ˚ˆÏÓ òy– S6V 2002 ¢yˆÏúÓ˚ ã#Ó˜ÏÓ!â¸e xy£zò [The Biological Diversity Act, 2002] 1992 ¢yˆÏú ãy!ì¸¢Çá myÓ˚y ˜ãÓ !Ó!â¸eƒ ¢ˆÏ¡øúò xò%!¤¸ì¸ £Î˚ ÎyÓ˚ õ%Öƒ v¸zˆÏjüƒ !äÈú ã#Ó ˜Ó!â¸ˆÏeƒÓ˚ ¢ÇÓ˚«¸í Ñ¸Ó˚y ~ÓÇ xyõyˆÏïÓ˚ ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ôˆÏïÓ˚ ïyÓ˚íˆÏÎyÜƒ (Sustainable use) ÓƒÓ£yÓ˚ – ¶¸yÓ˚ì¸Á ~£z ¢ˆÏ¡øúˆÏò fl¸Ïy«¸Ó˚Ñ¸yÓ˚# ˆîˆÏüÓ˚ õˆÏïƒ ~Ñ¸!›¸ ~ÓÇ ~£z ÓyïƒÓyïÑ¸ì¸y ¸ô)Ó˚í Ñ¸Ó˚yÓ˚ ãòƒ 2002 ¢yˆÏú ¶¸yÓ˚ì¸ ¢Ó˚Ñ¸yÓ˚ xy£zò!›¸ â¸yú% Ñ¸ˆÏÓ˚ñ ~Ó˚ ≤Ãïyò Á ~Ñ¸õye ú«¸ƒ !äÈú ¶¸yÓ˚ˆÏì¸Ó˚ ã#Ó ˜Ó!â¸ˆÏeƒÓ˚ ¢ÇÓ˚«¸í– ã#Ó ˜Ó!â¸eƒ ≠ ã#ˆÏÓÓ˚ v¸zí¢ ~ÓÇ ˆÎ Óylfl¸ì¸ˆÏs¸fÓ˚ xÇü ì¸yÓ˚ !Ó!¶¸ß¨ì¸y ~ÓÇ 2!›¸ ≤Ããy!ì¸Ó˚ õˆÏïƒ Óy ~Ñ¸£z ≤Ããy!ì¸Ó˚ õˆÏïƒ xÌÓy Óylfl¸ì¸ˆÏs¸fÓ˚ õˆÏïƒ ˆÎ !Ó! ¶¸ß¨ì¸y ˆîÓy ÎyÎ˚ ì¸yˆÏÑ¸ ˆÓyG¸yÎ˚ – ˜ã!ÓÑ¸ ¢¡ôî ≠ ≤Ãyí#ñ v¸z!qîñ xí%ã#Ó xÌÓy ì¸yˆÏïÓ˚ xÓ!ü‹T xÇüñ ì¸yˆÏïÓ˚ ã#òÜì¸ ¸ôîyÌ≈ Óy Óy£zˆÏ≤Ãyv¸yQ ÎyÓ˚ ÓƒÓ£yÎ≈ õ)úƒ xyˆÏäÈ ì¸yˆÏÑ¸ ˆÓyG¸yÎ˚ñ !Ñ¸ls¸ õyòÓ !ãòÜì¸ ¸ôîyÌ≈È ~Ó˚ õˆÏïƒ xhs¸¶%≈¸_´ òÎ˚ – ïyÓ˚íˆÏÎyÜƒ ÓƒÓ£yÓ˚ ≠ ã#Ó˜ÏÓ!â¸eƒ ~ÓÇ ≤ÃyÑ,¸!ì¸Ñ¸ ¢¡ôîˆÏÑ¸ ~õò¶¸yˆÏÓ ÓƒÓ£yÓ˚ Ñ¸Ó˚y ÎyˆÏì¸ ¶¸!Ó°ÏƒÍ ≤ÃãˆÏß√Ó˚ ÓƒÓ£yÓ˚ ~ÓÇ ì¸yˆÏïÓ˚ â¸y!£îy ˆõ›¸yˆÏòyÓ˚ ãòƒ xÓ!ü‹T ÌyˆÏÑ¸ – ~£z xy£zò xò%ÎyÎ˚# ÈMoEFCCÙÈ~Ó˚ ì¸_¥yÓïyˆÏò òƒyüyòyú ÓyˆÏÎ˚yv¸y£z¶¸y! ¢≈!›¸ xÌ!Ó˚!›¸ (NBA) ˜ì¸!Ó˚ Ñ¸Ó˚y £Î˚ – ~Ó˚ ¢îÓ˚ îÆÓ˚ ˆâ¸ß¨y£zñ ~Ó˚ Ñ¸yã £úÈÙÙÈ ? ~£z xy£zˆÏò !ÓÓ,ì¸ xy£zò ¢õ)ˆÏ£Ó˚ ! òÎ˚s¸fí– ? ã#Ó˜ÏÓ!â¸eƒ ¢ÇÓ˚«¸í !Ó°ÏˆÏÎ˚ ¢Ó˚Ñ¸yÓ˚ˆÏÑ¸ ¸ôÓ˚yõü≈ îyò– ? ˜ã!ÓÑ¸ ˙!ì¸£ƒ¸ô)í≈ fl¸iyò !òÓ≈yâ¸ˆÏò ¢Ó˚Ñ¸yÓ˚ˆÏÑ¸ ¸ôÓ˚yõü≈ îyò ~£z xy£zò xò%ÎyÎ˚# ? fl¸iyò#Î˚ x!ïÓy¢#ñ â¸y!°Ïñ £y!Ñ¸õ ~ÓÇ ˜ÓïƒÎyÓ˚y ã#Ó˜ÏÓ!â¸eƒˆÏÑ¸ Ñ¸yˆÏã úy!ÜˆÏÎ˚ Ë°Ï%ï ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ ì¸yÓ˚y ~£z xy£zˆÏòÓ˚ xyÁì¸yÓ˚ Óy£zˆÏÓ˚ ÌyÑ¸ˆÏÓ– ? fl¸iyò#Î˚ Óy!¢®yˆÏïÓ˚ ¢ÇÓ˚«¸ˆÏíÓ˚ Á¸ôÓ˚ ~Ñ¸!›¸ x!¶¸õì¸ ÌyÑ¸ˆÏÓ ~ÓÇ ì¸y @˘Ã£íˆÏÎyÜƒ– ? ãyì¸#Î˚ñ Ó˚yãƒñ xyM¸È!úÑ¸ hfl¸ˆÏÓ˚ ÓyˆÏÎ˚yv¸y£z¶¸y!¢≈!›¸ ö¸yu¸ ˜ì¸!Ó˚ Ñ¸Ó˚y £ˆÏÓ– ? Óƒ!_´ !Ó!ï!òˆÏ°Ïï úAáò Ñ¸Ó˚ˆÏú ì¸yÓ˚ 5 ÓäÈˆÏÓ˚Ó˚ Ñ¸yÓ˚yÓy¢ Óy 10 ú«¸ ›¸yÑ¸y¸ ôÎ≈hs¸ ã!Ó˚õyòy !îˆÏì¸ £ˆÏì¸ ¸ôyˆÏÓ˚ – 128 ? NSOU ? AE-ES-21

6.11 xò%ü#úò# ¢!‡¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚&ò ≠ S1V ˆÑ¸yò!›¸ !@˘Ãò £yv¸z¢ Üƒy¢ òÎ˚ (i) CO 2 (ii) CH 4 (iii) N 2 (iv) CFC S2V x¡´ Ó,!‹TÓ˚ ãòƒ îyÎ˚# Üƒy¢ ˆÑ¸yò‰!›¸/(i) N 2 (ii) CO 2 (iii) CO 2 (iv) O 2 S3V òõ≈îy ÓßyâyÁ xyˆÏ®yúòÑ¸yÓ˚# ˆòì,¸c £úÈÙÙÈ (i) ¢î≈yÓ˚ ¸ôy!›¸ú (ii) ˆõïy ¸ôyˆÏ›¸Ñ¸Ó˚ (iii) õ#Ó˚yˆÏÓò (iv) â¸!wÑ¸y ≤Ã¢yî S4V CFC-Ó˚ 'Global warming potential' Ñ¸ì¸/(i) 1 (ii) 23 (iii) 12.000 (iv) 270 S5V UV-C ~Ó˚ ì¸Ó˚D ˜îá≈ƒÈÙÙÈ (i) 100-280 nm (ii) 280-310 nm (iii) 100-180 nm (iv) 315-400 nm x!ì¸ ¢Ç!«¸Æ v¸z_Ó˚!¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V !Ñ¸ˆÏÎ˚yˆÏ›¸y ˆ≤ÃyˆÏ›¸yÑ¸ú Ñ¸ˆÏÓ fl¸Ïy«¸!Ó˚ì¸ £Î˚/S2V !â¸¸ôˆÏÑ¸y xyˆÏ®yúò Ñ¸ˆÏÓ £Î˚ ~ÓÇ ~Ó˚ õ%Öƒ ˆòì¸y ˆÑ¸ !äÈˆÏúò/S3V 51A (g) !Ñ¸/S4V Óòƒ≤Ãyí# ¢ÇÓ˚«¸í xy£zò 1972 xò%ÎyÎ˚# Ú≤Ãyí#Ó˚Û ¢ÇK¸y !îò– S5V CFC !Ñ¸/¢Ç!«¸Æ v¸z_Ó˚!¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ˆâ¸Ó˚ˆÏòy!Óú î%á≈›¸òy xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S2V õ!r›¸∆Î˚yú ˆ≤ÃyˆÏ›¸yÑ¸ú Ñ¸ˆÏÓ fl¸Ïy«¸!Ó˚ì¸ £Î˚ ~ÓÇ ~Ó˚ v¸zˆÏjüƒ=!ú xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S3V ãú ¢ÇÓ˚«¸ˆÏíÓ˚ ¸ôk¸!ì¸=!ú xyˆÏúyòy Ñ¸Ó˚&ò– S4V Ó,£í ãúyïyÓ˚ !¶¸!_Ñ¸ xyˆÏ®yúò ¢ ¡∫ˆÏì¸ ¢

ÇˆÏ«¸ˆÏ¸

44% **MATCHING BLOCK 187/200** **W**

ô xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S5V ÁˆÏãyò hfl¸Ó˚ !ÓòyˆÏüÓ˚ Ñ¸yÓ˚í=!ú xyˆÏúyâ¸òy Ñ¸Ó˚&ò– v¸z_Ó˚ ¢

ÇˆÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (iii) 2 S2V (ii) CO 2 S3V (ii) ˆõïy ¸ôyˆÏ›¸Ñ¸Ó˚ S4V (iiiV 12–000 S5V (i) 100-280 nm NSOU ? AE-ES-21 ? 129

~Ñ¸Ñ¸È 7 ãò¢ÇÖƒy Á ¸ô!ÓˆÏÓü (Human Population and Environment) Ü‡¸ò 7.0 v¸zˆÏjüƒ 7.1 ≤Ãhfl¸ÏyÓòy 7.2 ãò¢ÇÖƒy (Human population) 7.2.1 ãò¢ÇÖƒy ˜Ó!ü‹Tƒ 7.3 ãò!ÓˆÏfl¸≥¸yÓ˚í Á ¸ô!Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)!â¸ (Population explosion and Family welfare programme) 7.3.1 ãò¢ÇÖƒy Ó,!k¸Ó˚ Ñ¸yÓ˚í 7.3.2 ãò!ÓˆÏfl¸≥¸yÓ˚ˆÏïÓ˚ ≤Ã¶¸yÓ 7.3.3 ¸ô!Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)â¸# (Family Welfare Program) 7.4 ¸ô!Ó˚ˆÏÓü Á õyòÓ fl¸Ïyfl¸iƒ (Environment and Human Health) 7.4.1 õyòÓ fl¸ÏyˆÏfl¸iƒÓ˚ Á¸ôÓ˚ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ≤Ã¶¸yÓ 7.5 ¢Çe´yõÑ¸ Óƒy!ï (Communicable Disease) 7.5.1 Î"y ˆÓ˚yÜ (Tuberculosis) 7.5.2 õƒyˆÏú!Ó˚Î˚y (Malaria) 7.5.3 ˆv¸D% (Dengue) 7.5.4 v¸y£z!Ó˚Î˚y Óy ¸ôyì¸úy ¸ôyÎ˚Öyòy (Diarrhea Diseases) 7.5.5 ~£zv¸¢ (AIDS) 7.6 x¢Çe´yõÑ¸ Óƒy!ï (Non-Communicable Diseases) 7.6.1 £*îˆÏÓ˚yÜ (Cardiovascular Disease) 7.6.2 Ñ¸Ñ≈¸›¸ ˆÓ˚yÜ (Cancer) 7.6.3 õï%ˆÏõ£ ˆÓ˚yÜ (Diabetes Mellitus) 7.7 xò%ü#úò# 7.8 ¢£yÎ˚Ñ¸ @˘Ãs¸iyÓú#

7.0 v¸z˚Ïjüƒ ~•z ~Ü¸Ü¸!ê¸ ¸õyë¸ Ü¸ ˆÏÓ˚ xy¸õ!! !l¡¨!°!aï¸ !Ó£Ïˆ˚=!° çyl˚Ïï¸ ¸õyÓ˚ ˆÏÓl– ? çlßÇáƒy G ï¸yÓ˚ ˜Ó!¢‹Tƒ§Ù)•– ? çl! Ó˚Ïfl≥¸yÓ˚î G ¸õ!Ó˚ÓyÓ˚ Ü¸°ƒy˚Ïî Ü¸Ù≈§)ã¸#– ? ¸õ!Ó˚ˆÏÓ¢ G ÙyìÓ flÏyflíƒ– ? !Ó!Ë¸ß¨ ≤ÃÜ¸yÓ˚ ß Çe´yÙÜ¸ Óƒy!ôÓ˚ °«¸î G !ã¸! Ü¸Íßy– ? !Ó!Ë¸ß¨ ≤ÃÜ¸yÓ˚ x§Çe´yÙÜ¸ Óƒy!ôÓ˚ Ü¸yÓ˚î G ≤Ã!ï¸ˆÏÓ˚yô ÓƒÓfliy– 7.1 ≤Ãhfl¸ÏyÓòy ãò¢ÇÖƒy Á ¸õ!Ó˚ˆÏÓü Áì¸ˆÏ≤Ãyì¸¶¸y˚ÏÓ ~ˆÏÑ¸ x¸ô˚ÏÓ˚Ó˚ ¢y˚Ïì ¢¡ôÑ≈¸ Î%_´– õyò%˚Ï°ÏÓ˚ ˆÓ§˚Ïâ¸ ÌyÑ¸yÓ˚ ãòƒ ˆÏõò î)°Ïiõ%_´ ¸¢%fl¸i ¸õ!Ó˚ˆÏÓü ≤Ã˚Ïî˚yãòñ ˆì¸õòÊz ¸ô¸!lÓ# Óy¢˚ÏÎyÜƒ £˚Ïî˚ v¸z˚Ï‡¸ ˆÏäÈ õyò%˚Ï°ÏÓ˚ Ñ¸õ≈Ñ¸y[¸ Á òyòy ≤ÃÏ˚y˚Ï¢Ó˚ õyïƒ˚Ïõ– õyò%°Ïì¸yÓ˚ Ó%!k¸õ_y˚ÏÑ¸ Ñ¸y˚Ïã úy!Ü˚Ïî˚ xRy!úÑ¸yñ òÜÓ˚ñ Óy!ïãƒñ !â¸!Ñ¸Í¢yüyfl¸ƒ £zì¸ƒy!î ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ˆÏäÈ– ~£z ¢õhfl¸ Ñ¸yÓ˚ˆÏî£z ãò¢ÇÖƒy xyã ˆÎ ˆÑ¸yò Óy˚Ï‹T…Ó˚ Ñ¸y˚ÏäÈ ¢¡ôî Sõyòó ¢¡ôîV !£¢y˚ÏÓ ¸ô!Ó˚â¸ì¸– xyÓyÓ˚ xì¸ƒy!Ñ¸ ãò!Ó˚Ïfl≥¸yÓ˚í ¢#!õì¸ ≤ÃyÑ¸!ì¸Ñ¸ ¢¡ô˚ÏÎ˚Ó˚ xì¸ƒy!ïÑ¸ ÓƒÓ£yÓ˚ ~ÓÇ ¸õ!Ó˚ˆÏÓü î)°Ïˆ˚ÏÓ˚ Ñ¸yÓ˚˚Ïí ¸õ!Ó˚î¸ £˚Ïì¸ ¸õy˚ÏÓ˚ – ãò¢ÇÖƒy Á ¸õ!Ó˚ˆÏÓüÓ˚ xyhs¸É¢¡ôÑ≈¸ ˆÏÑ¸ xò%ïyÓò Ñ¸Ó˚yÓ˚ úˆÏ«¸ƒñ ~£z xïƒy˚Ïî˚ ãò¢ÇÖƒyÓ˚ ˜Ó!ü‹Tƒ Á Ó¸!k¸– ¢¡ô!Ñ≈¸ì¸ !Ó!¶¸ß¨ ïyÓ˚íyñ ≤Ã!e´ˆÏy ~ÓÇ ¸õ!Ó˚ˆÏÓü Á fl¸Íyˆ˚Ïfl¸iƒÓ˚ Á¸ôÓ˚ ãò¢ÇÖƒyÓ¸!k¸Ó˚ ≤Ã¶¸yÓ ¢¡ôˆÏÑ≈¸ ¸ô!î≈y˚Ïúyâ¸òy Ñ¸Ó˚y £˚Ïî˚ˆÏäÈ– 7.2 ãò¢ÇÖƒy (Human population) ãò¢ÇÖƒy Óy Ú¸ô¸õ%˚ÏüüòÛ üΣ!›¸ úƒy!›¸ò üΣ Ú¸ô¸õ%úy¢‰%Û (Pupulas) ˆÏ˚ÏÑ¸ ~ˆÏ¢ˆÏäÈ ÎyÓ˚ xÏ≈ £ú ãòÜÏí– ~Ñ¸!›¸ !õ! î≈‹T ˆ¶¸ˆÔˆÏÜy!úÑ¸ xM¸È˚Ïú ÓÇÓy¢Ñ¸yÓ˚# ~ÓÇ ≤ÃÃãòò «¸õì¸y ¢¡ôß¨ ~Ñ¸ £z ˆÜy¤¸# Óy ≤Ãäy!ì¸Ó˚ ã#Óˆ˚ÏÑ¸ ãò¢ÇÖƒy Óúy £Î˚ – ! ÓK¸y˚ÏòÓ˚ ˆÎ üyÖy ãò¢ÇÖƒy !ò˚Ïî˚ xïƒÎ˚ò Ñ¸ˆÏÓ˚ ì¸y˚ÏÑ¸ ãò¢ÇÖƒyÓ˚ Óylfl¸!Óîƒy (Population Ecology) Óúy £Î˚ – ãò¢ÇÖƒyÓ˚ xyÑ¸yÓ˚ ñ xyÑ¸!ì¸ ñ £…y¢ñ Ó¸!k¸ £zì¸ƒy!î ¢Ó£z ãò¢ÇÖƒyÓ˚ ˜Ó!ü‹Tƒ– 7.2.1 ãò¢ÇÖƒy ˜Ó!ü‹Tƒ S1V xyÑ¸yÓ˚ Á àòc (Size and Density) ≠ ãò¢ÇÖƒyÓ˚ xyÑ¸yÓ˚ Óú˚Ïì¸ Îì¸ ¢ÇÖƒ ≤Ãyí# xÓfl¸iyò Ñ¸Ó˚ˆÏäÈ ì¸y˚ÏÑ¸ ˆÓyG¸yÎ˚ – ≤Ãäy!ì¸Ó˚ ãò¢ÇÖƒyÓ˚ xyÑ¸yÓ˚ ã#ˆÏÓÓ˚ ãß√ñ õ¸i%¸ƒÓ˚ v¸z¸ôÓ˚ !ò¶≈Ó˚ Ñ¸˚Ïü#ú– ãò¢ÇÖƒyÓ˚ xyÑ¸yÓ˚ È=È ì¸=!ú ≤Ãyí# Óì≈¸õy˚Ïò xÓfl¸iyò Ñ¸Ó˚ˆÏäÈ + ãß√ ÈÙÈ õ¸i%¸ƒ– ≤Ã!ì¸ ÓÜ≈ !Ñ¸˚Ïúy!›¸y˚ÏÓ˚ ÓÓy¢Ñ¸yÓ˚# õyò%˚Ï°ÏÓ˚ ¢ÇÖƒ myÓ˚y ãòáòc ¸õ!Ó˚õy¸ô Ñ¸Ó˚y £Î˚ – ãòáòc ¸õ!Ó˚õy¸ô myÓ˚y õylÌy!¸ôä%È Ñ¸ì¸›¸y Ñ¸ ˆÏÓ˚ ≤ÃyÑ¸!ì¸Ñ¸ ¢¡ôî õyò%°Ï ÓƒÓ£yÓ˚ Ñ¸Ó˚˚Ïì¸ ¸õyÓ˚ˆÏÓ˚ Óy ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏäÈ ì¸y !£ˆÏ¢Ó Ñ¸Ó˚y ¢Ω¸Ó £Î˚ – NSOU ? AE-ES-21 ? 131
S2V ãß√£yÓ˚ (Birth Rate) ≠ ≤Ã!ì¸ ~Ñ¸ £yãyÓ˚ õyò%°Ï !¸ôä%È ÓäÈˆÏÓ˚ !ü÷Ó˚ ã˚Ïß√Ó˚ ¢ÇÖƒy˚ÏÑ¸ ãß√£yÓ˚ Óy fl¸i(ú ãß√£yÓ˚ Óúy £Î˚ – ãß√£yÓ˚ = x 1000 v¸zß¨ì¸ ˆïü ~ÓÇ v¸zß¨ˆÎ˚òü#ú ˆî˚ÏüÓ˚ õ˚Ïïƒ ãß√£yˆÏÓ˚Ó˚ !ÓˆÏü°Ï ¸

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ô!Ó˚Óì≈¸ò ú«¸ƒ Ñ¸Ó˚y Îy˚Ï – ˆÏõòÈÙÙÈ 2011 ¢y˚Ïú

v¸zß¨ì¸ ˆïü=!úÓ˚ ãß√£yÓ˚ 12 xyÓyÓ˚ v¸zß¨ˆÎ˚òü#ú ˆïü=!úÓ˚ ˆ«¸˚Ïe 22 !äÈú– S3V õ¸i%¸ƒ£yÓ˚ (Death Rate/Mortality) ≠ ≤Ã!ì¸ ~Ñ¸ £yãyÓ˚ õyò%°Ï !¸ôä%È ÓäÈˆÏÓ˚ õ¸ì¸ ˆúy˚ÏÑ¸Ó˚ ¢ÇÖƒy˚ÏÑ¸ Á£z ÓäÈˆÏÓ˚Ó˚ õ¸i%¸ƒ£yÓ˚ Óúy £Î˚ – õ¸i%¸ƒ£yÓ˚ = x 1000 v¸zß¨ì¸ ˆî˚Ïü õ¸i%¸ƒ £yÓ˚ v¸zß¨ˆÎ˚òü#ú Á xò%ßß¨ì¸ ˆî˚ÏüÓ˚ î%¸úòyÎ˚ Ñ¸õ ~ÓÇ ÷î%õye Ó¸Ñ¸ ˆÏÎÓ˚ õ¸i%¸ƒÓ˚ ¸õ!Ó˚õyí ˆÓ!ü– v¸zß¨ˆÎ˚òü#ú Á xò%ßß¨ì¸ ˆïü=!úÓ˚ ˆ«¸˚Ïe Î%ÓÑ¸ Á !Ñ¸˚ÏÜyÓ˚ˆÏÓ˚ õ¸i%¸ƒÓ˚ ¸õ!Ó˚õyí ˆÓ!ü– S4V ÓÎ˚¢ !ÓòƒÜ¢ (Age Distribution) ≠ ãò¢ÇÖƒyÓ˚ ~Ñ¸!›¸ =Ó˚&c¸ô)í≈ ˜Ó!ü‹Tƒ £ú ãò˚ÏÜy¤¸#Ó˚ õ˚Ïïƒ ÓÎ˚¢ !ÓòƒÜ¢– ˆÑ¸yò ˆÜy¤¸#Ó˚ õ˚Ïïƒ xÓfl¸iyòÑ¸yÓ˚# !Ó!¶¸ß¨ ÓÎ˚ˆÏ¢Ó˚ ãòÜˆÏí˚ £yÓ˚ˆÏÑ¸ ˆÓyG¸yÎ˚ – ¸ô)Ó≈ ≤Ããß√«¸õ ÓÎ˚¢ S0ÈÙÈ18 ÓäÈÓ˚V ñ ≤Ããß√«¸õ ÓÎ˚¢ S18ÈÙÈ50 ÓäÈÓ˚V ñ ≤ÃyÑ¸ ≤Ããß√«¸õ ÓÎ˚¢ S50ÈÙÈ80 ÓäÈÓ˚V ~£z !ì¸ò!›¸ ¶¸y˚ÏÜ ÓÎ˚¢ !ÓòƒÜ¢˚ÏÑ¸ ¶¸yÜ Ñ¸Ó˚y £Î˚ – ÓÎ˚¢ !ÓòƒÜ˚Ï¢Ó˚ Á¸ôÓ˚ ˆÑ¸yò ãy!ì¸ˆÏÜy¤¸#Ó˚ ãß√£yÓ˚ Á õ¸i%¸ƒ£yÓ˚ !ò¶≈Ó˚ Ñ¸ˆÏÓ˚ – S5V ãò¢ÇÖƒy Ó¸!k¸Ó˚ £yÓ˚ (Rate of Polulation Growth) ≠ ˆî˚ÏüÓ˚ ãò¢ÇÖƒy Ó¸!k¸ Óy £…y˚Ï¢Ó˚ ¸õ!Ó˚õy¸ô Ñ¸Ó˚yÓ˚ ˆ«¸˚Ïe ~Ñ¸!›¸ Ñ¸yî≈Ñ¸Ó˚# ïyÓ˚í Óy £ú Úãò¢ÇÖƒy Ó¸!k¸Ó˚ £yÓ˚Û– Óy˚Ï‹T…Ó˚ õ˚Ïïƒ ãß√£yÓ˚

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Á õ¸i%¸ƒ£y˚ÏÓ˚Ó˚ õ˚Ïïƒ ¸õyÌ≈Ñ¸ƒ

ÏÑ¸ ãò¢ÇÖƒy Ó¸!k¸Ó˚ £yÓ˚ Óúy £˚Ïî˚ Ìy˚ÏÑ¸– ãò¢ÇÖƒy Ó¸!k¸Ó˚ £yÓ˚ = x 1000 S6V !úD xò%¸ôyì¸ (Sex Ratio) ≠ ≤Ã!ì¸ £yãyÓ˚ ãò ¸ô%Ó%Ó˚&˚Ï°ÏÓ˚ !ò!Ó˚ˆÏÜ òyÓ˚#Ó˚ ¢ÇÖƒy˚ÏÑ¸ !úD xò%¸ôyì¸ Óúy £Î˚ – ˆÑ¸yò ¢¡±îy˚ÏÎ˚Ó˚ !ú˚ÏDÓ˚ xò%¸ôyì¸ Á£z ¢õy˚ÏãÓ˚ ¢y¶y! ãÑ¸ v¸zß¨ˆÎ˚òÓ˚ ~Ñ¸!›¸ ¢)â¸Ñ¸ Îy !úD ˜Ó°Ïõƒ ˆÓ˚yï Ñ¸ˆÏÓ˚ – ¶¸yÓ˚ì¸ ~Ñ¸!›¸ ¸õ%Ó%Ó˚&°Ïì¸y!s¸fÑ¸ ¢õyã £ÃÎ˚ŷ ¸õ%Ó%Ó˚&°Ï !ü÷Ó˚ Ñ¸yõƒì¸y x!ïÑ¸ ì¸y£z xyã ¶¸yÓ˚ˆÏì¸ 1000 ãò ¸õ%Ó%Ó˚&˚Ï°ÏÓ˚ !ò!Ó˚ˆÏÜ 940 ãò õ!£úy v¸z¸ô!fl¸ii – S7V ãò!Ó˚Ïfl≥¸yÓ˚í (Polulation Explosion) ≠ ãò!Ó˚Ïfl≥¸yÓ˚í Óú˚Ïì¸ ˆÓyG¸yÎ˚ ãò¢ÇÖƒyÓ˚ x!ì¸Ó¸!k¸ – ˆÑ¸yò Óy˚Ï‹T…Ó˚ õ¸i%¸ƒ£yˆÏÓ˚Ó˚ î%¸úòyÎ˚ o&!ì¸ ãß√£yÓ˚ £˚Ïú ãò!Ó˚Ïfl≥¸yÓ˚í á˚Ï›¸ Îy˚ÏÑ¸ – ãò!Ó˚Ïfl≥¸yÓ˚í á›˚Ïú ≤ÃyÑ¸!ì¸Ñ¸ ¢¡ôˆÏÎ˚Ó˚ o&!ì¸ £…y¢ñ îy!Ó˚ˆÏofiñ ˆÓÑ¸yÓ˚ñ ˆÓ˚yÜÓÎƒy!ïÓ˚ !üÑ¸yÓ˚ £zì¸ƒy!î ˆÏÓy Îy˚Ï – ãò!Ó˚Ïfl≥¸yÓ˚ˆÏÓ˚ !üÑ¸yÓ˚ xyõy˚ÏÓ˚ ˆïü ¶¸yÓ˚ì¸ Á !â¸ò Îy xyã ~ì¸ v¸zß¨ˆÎ˚òÓ˚ ¸ôÌ Á v¸zß¨ˆÎ˚òü#ú ˆî˚ÏüÓ˚ ì¸Ñ¸õy ˆáyâ¸y˚Ïì¸ x«¸õ– ãò!Ó˚Ïfl≥¸yÓ˚í ì¸y£z ¢õhfl¸ ˆî˚ÏüÓ˚ xò@ˆÃ¢Ó˚ ì¸yÓ˚ ≤Ãìyò Ñ¸yÓ˚í– ÓäÈ˚ÏÓ˚ õ¸i%¸ ˆúy˚ÏÑ¸Ó˚ ¢ÇÖƒy ˆõy›¸ Óì≈¸õyò ãò¢ÇÖƒy ÓäÈ˚ÏÓ˚ ã#!Ó¸ì¸ òÓãyì¸ ˆÏÑ¸Ó˚ ¢ÇÖƒy ˆõy›¸ Óì≈¸õyò ãò¢ÇÖƒy ÓäÈ˚ÏÓ˚ ã#!Ó¸ì¸ òÓãyì¸ ˆÏÑ¸Ó˚ ¢ÇÖƒy ˆõy›¸ Óì≈¸õyò ãò¢ÇÖƒy 132 ? NSOU ? AE-ES-21
S8V ïyÓ˚í«¸õì¸y (Carrying Capacity) : ãò!Ó˚Ïfl≥¸yÓ˚í ~ÓÇ ≤ÃyÑ¸!ì¸Ñ¸ ¢¡ôˆÏÎ˚Ó˚ x!ì¸!Ó˚_´ ÓƒÓ£yˆÏÓ˚Ó˚ ≤Ã¢ˆÏD ¸ô¸!lÓ#Ó˚ ïyÓ˚í«¸õì¸yÓ˚ !Ó°Ïˆ˚Ï !›¸ xyã x!ì¸ =Ó˚&c¸ô)í≈ !Ó°Ïˆ˚ £Ïˆ˚ î§y!v¸¸ ˆÏˆ˚ ˆÏäÈ– ˆÑ¸yò !ò!î≈‹T xM¸È˚ÏúÓ˚ ≤ÃyÆ ¢¡ôî ˆÎ ¢ÇÖƒyÑ¸ õyò%˚Ï°ÏÓ˚ â¸y!£Ïy ˆô›¸y˚Ïì¸ ¸ôy˚ÏÓ˚ ì¸y˚ÏÑ¸ ì¸yÓ˚ ïyÓ˚í«¸õì¸y Óúy £Î˚ – ïyÓ˚í«¸õì¸y x!ì¸¸e´õ Ñ¸Ó˚yÓ˚ ¸ôÓ˚ ¸ô¸îÆ≈yÆ v¸z¸ôÎ%Îò òy ¸ôyÓyÓ˚ ãòƒ v¸z_´ ≤Ãäy!ì¸Ó˚ ãò¢ÇÖƒy £…y¢ ¸õyÎ˚ – !â¸e ≠ 7.1 ïyÓ˚í«¸õì¸y (Carrying Capacity) 7.3 ãò!Ó˚Ïfl≥¸yÓ˚í Á ¸õ! Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)â¸!ã¸ (Population explosion and Family welfare programme) ¶¸yÓ˚ì¸ xyã !ÓˆÏ‡ŸÓ˚ !õì¸#ˆÏ Ó¸£_õ ãòÓ˚ˆú ˆïüñ ! Ó˚ˆÏ‡ŸÓ˚ ˆõy›¸ ãò¢ÇÖƒyÓ˚ 13% õyò%°Ï ¶¸yÓ˚ˆÏì¸ Ó¢Óy¢ Ñ¸ˆÏÓ˚ – Óì≈¸õyò £yÓ˚ ˆÏì¸ ãò¢ÇÖƒy Ó¸!k¸ ˆ¶¸y£z ¸ôyÓ˚Ó˚ ˆÑ¸ ÌyÑ¸ˆÏú ¶¸yÓ˚ì¸ ¢õ#«¸y myÓ˚y ~Ñ¸!›¸ xò%õyò Ñ¸Ó˚y £Î˚ ˆÎ 2028 ¢y˚Ïú ¶¸yÓ˚ì¸ ã¸#ˆÏòÓ˚ ãò¢ÇÖƒy˚ÏÑ¸ äEy!¸ôˆÏÎ˚ Îy˚ÏÓ– ì¸yÓ˚ ~Ñ¸õye Ñ¸yÓ˚í ã¸#ò !ÓÜì¸ î%£z îüÑ¸ ïˆÏÓ˚ ì¸yÓ˚ ãò¢ÇÖƒy Ó¸!k¸Ó˚ £yÓ˚ˆÏÑ¸ xˆÏòÑ¸ Ñ¸!õˆÏÎ˚ ~ˆÏòˆÏäÈñ ¶¸yÓ˚ì¸ Îy ¸ôyˆÏÓ˚!ò v¸z¸ôÓ˚ls¸ 2011 ¢y˚ÏúÓ˚ ¸¢õ#«¸yÓ˚ ¸ôÓ˚ ˆïy˚ÏÎ˚ î%£z îü˚ÏÑ¸ 1990 ˆ

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Ì˘ÏÑ¸ 2011 ¢y˘ÏúÓ˚ õ˘Ïiƒ ãò¢ÇÖƒy Ó,!k¸ ˘¸ô˘

ÏÎ˚˘ÏäÈ â¸yÓ˚ =í– ¢yÓ˚!í 7.1 ≠ ¶¸yÓ˚˘Ïì¸ ãò¢ÇÖƒyÓ˚ Ó,!k¸ Sv¸zÍ¢ ≠ ¶¸yÓ˚ì¸#Î˚ ãòÜíòyV ãòÜíòyÓ˚ ÓäÈÓ˚ ãò¢ÇÖƒy S˘Ñ¸y!›¸˘Ïì¸V ãòÜíòyÓ˚ îü˘ÏÑ¸ Ó,!k¸ S˘Ñ¸y!›¸˘Ïì¸V ãò¢ÇÖƒyÓ˚ Ó,!k¸Ó˚ üì¸yÇü 1901 23.83 ÈÙÙÙÈ ÈÙÙÙÈ 1911 25.20 1.37 5.35 1921 25.13 0.07 0.32 1931 27.89 2.76 11.00 1941 31.86 3.79 14.22 1951 36.10 4.24 13.30 1961 43.92 7.82 21.50 1971 54.81 10.89 24.80 1981 68.59 13.78 24.70 1991 84.63 16.04 23.80 2001 102.87 18.24 21.30 2011 121.01 18.14 17.64 NSOU ? AE-ES-21 ? 133 ¢yÓ˚!í˘Ïì¸ S7.1V ˘îÖy ÎyÎ˚ 1971 ˘Ì˘ÏÑ¸ ãò¢ÇÖƒy Ó,!k¸Ó˚ üì¸yÇü £...y¢ ˘¸ô˘ÏúÁ ãòÜíòy îü˘ÏÑ¸ Ó,!k¸Ó˚ ¸ô!Ó˚õyí ˘Ó˘Ïv¸¸£z â¸˘Ïú˘ÏäÈ– ì¸yÓ˚ Ñ¸yÓ˚í £úñ ¶¸yÓ˚˘Ïì¸Ó˚ xyÎ˚% Ñ¸y‡¸y˘ÏõyÓ˚ !î˘ÏÑ¸ ì¸yÑ¸y˘Ïú ˘îÖy ÎyÎ˚ 2011 ¢y˘Ïú 33 üì¸yÇü õyò%˘Ï°ÏÓ˚ ÓÎ˚¢ 15 ÓäÈÓ˚ Óy ì¸yÓ˚ Ñ¸õ– ¢%ì¸Ó˚yÇ ÓÎ˚¢ Ó,!k¸Ó˚ ¢y˘Ïì ¢y˘Ïì xyÜyõ# !î˘Ïò ì¸yÓ˚y ãò¢ÇÖƒy Ó,!k¸˘Ïì¸ xÇü@˘Ã£í Ñ¸Ó˚˘ÏÓ– ö¸˘Ïú !fl¸i!ì¸ü#ú xÓfl¸iyÎ˚ ˘¸ôÔ§äÈ˘Ïì¸ xyÓ˚Á 35 ÓäÈÓ˚ x˘Ï¸ô«¸y Ñ¸Ó˚˘Ïì¸ £˘ÏÓ ~ÓÇ ¶¸yÓ˚˘Ïì¸Ó˚ ãò¢ÇÖƒy 2050 ¢yú òyÜyî 175 ˘Ñ¸y!›¸˘Ïì¸ ˘¸ôÔ§äÈ˘ÏÓ– ~£z !Ó¸ô%ú ãò¢ÇÖƒyÓ˚ Ó,!k¸Ó˚ îyÎ˚ xyõy˘ÏîÓ˚ õ˘Ïì¸y ˘î˘ÏüÓ˚ ¸ô˘Ï«¸ ˘òÁÎ˚y x¢Ω¸Ó– ì¸y£z ãò! Ó˘Ïfl¸≥¸yÓ˚í xyõy˘ÏîÓ˚ ~Ñ¸!›¸ xòƒì¸õ ¢yõy!ãÑ¸ Á xì≈˘Ïò!ì¸Ñ¸ ¢õ¢ƒy– 7.3.1 ãò¢ÇÖƒy Ó,!k¸Ó˚ Ñ¸yÓ˚í ãß√£yÓ˚ Á õ,ì%¸ƒ £y˘ÏÓ˚Ó˚ õ˘Ïiƒ ÓƒyôÑ¸ ÓƒÓïyòÈ£z ¶¸yÓ˚˘Ïì¸Ó˚ ãò¢ÇÖƒy Ó,!k¸Ó˚ xòƒì¸õ Ñ¸yÓ˚í– xòƒyòƒ ˘î˘ÏüÓ˚ õ˘Ïì¸y !â¸!Ñ¸Í¢y üy˘Ïfl¸ƒ v¸zß¨!ì¸Ó˚ õyiƒ˘Ïõ ¶¸yÓ˚˘Ïì¸ õ,ì%¸ƒ £yÓ˚ x˘ÏòÑ¸ £...y¢ £˘ÏÎ˚˘ÏäÈ !Ñ¸ls¸ ãß√£yÓ˚ !òÎ˚s¸fí Ñ¸Ó˚y ¢Ω¸Ó £Î˚!ò– ¢õ#«¸y myÓ˚y ãyòy ˘Ü˘ÏäÈ ¶¸yÓ˚˘Ïì¸Ó˚ 41% õ!£úy !òÓ˚«¸Ó˚ ~ÓÇ ì¸yÓ˚y ˘Ñ¸yòÓ˚Ñ¸õ ãß√ !òÎ˚s¸fí Ñ¸Ó˚yÓ˚ ¸ôk¸!ì¸ ãy˘Ïòò òy– ~äÈyv¸¸y ¸ô%e ¢hs¸yò Ñ¸yõòyñ ïõ≈#Î˚ x¸ôÓƒyÖƒyñ !òi¨ ã#Óò ÎyeyÓ˚ õyòñ Ó˝ !ÓÓy£ £zì¸ƒy!îÁ ãò¢ÇÖƒyÓ˚

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Ó,!k¸˘ÏÑ¸ cÓ˚y!ß∫ì¸ Ñ¸˘ÏÓ˚˘ÏäÈ– ¢˘ÏÓ≈

y¸ô!Ó˚ ¢Ó˚Ñ¸yÓ˚ Ñ¸ì≈¸Ñ¸ Ü,£#ì¸ ¸ô!Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)!â¸Ó˚ Óyhfl¸ÓyÎ˚˘ÏòÓ˚ v¸z¸ôÎ%_´ ¸ô!Ó˚Ñ¸y‡¸y˘ÏõyÓ˚ x¶¸y˘ÏÓ ãß√ !òÎ˚s¸fí Ñ¸yÎ≈Ñ¸Ó˚ £Î˚!ò– 7.3.2 ãò!Ó˘Ïfl¸≥¸yÓ˚˘ÏíÓ˚ ≤Ã¶¸yÓ ãò!Ó˘Ïfl¸≥¸yÓ˚í ¶¸yÓ˚˘Ïì¸ !Ó!¶¸ß¨ ïÓ˚˘ÏòÓ˚ xy!Ì≈Ñ¸ ¢yõy!ãÑ¸ Á Ó˚yã˘Ïò!ì¸Ñ¸ ¢õ¢ƒyÓ˚ ãß√ !î˘ÏÎ˚˘ÏäÈ– õyÌy!¸ôä%È xyÎ˚ Á ¢¡ô˘ÏîÓ˚ ¢%Ó^˘›¸˘Ïò ¢

100% **MATCHING BLOCK 194/200** **SA** Indrani-Bhattacharya_AsishKumarDas_History_Swa ... (D129738480)

Ó˚Ñ¸y!Ó˚ Á ˘Ó¢Ó˚Ñ¸y!Ó˚ ¢

Çfl¸iy=!ú Ó˝ ≤ÃÎ˚y¢ Ñ¸˘ÏÓ˚Á x¢ö¸ú– x!ïÑ¸ ãò!Ó˘Ïfl¸≥¸yÓ˚˘ÏíÓ˚ ãòƒ ¶¸yÓ˚ì¸Ó°Ï≈ xyã òyòy ¢õ¢ƒyÓ˚ ¢¡ø%Ö#ò £˘ÏÎ˚˘ÏäÈ– ¢õ¢ƒy=!ú £úÈÙÙÙÈ ˘ÓÑ¸yÓ˚cñ îy!Ó˚oñ x!ü«¸yñ x¸ô%!‹Tñ Öyîƒ ¢B¸›¸ñ ¸ôyò#Î˚ ãú ¢B¸›¸ñ fl¸%Òú Á £y¢¸ôyì¸y˘ÏúÓ˚ ¢%! Óïyúy˘Ï¶¸ x¢õÌ≈ñ x¸ôÎ≈yÆ ¸ô!Ó˚Ó£ò ÓƒÓfl¸iyñ ¢Çe´yõÑ¸ ˘Ó˚y˘ÏÜÓ˚ !Óhfl¸yÓ˚ñ !ü÷◊!õÑ¸ñ x¢yõy!ãÑ¸ !e´Î˚yÑ¸úy¸ô Ó,!k¸ñ ¸ô! Ó˚˘ÏÓü î)°Ïí £zì¸ƒy!î– ~£z ïÓ˚˘ÏòÓ˚ ≤Ãâ%¸Ó˚ ¢õ¢ƒyÎ˚ ¶¸yÓ˚ì¸Ó°Ï≈ xyã ãã≈!Ó˚ì¸ñ ì¸yÓ˚ ~Ñ¸õye xòƒì¸õ Ñ¸yÓ˚í ãò!Ó˘Ïfl¸≥¸yÓ˚í– ì¸y£z xyãÁ ¶¸yÓ˚ì¸ v¸zß¨Î˚òü#ú ˘îü=!úÓ˚ ~Ñ¸!›¸– 7.3.3 ¸ô!Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)â¸# (Family Welfare Program) ˘Ñ¸w ¢Ó˚Ñ¸y˘ÏÓ˚Ó˚ xï#˘Ïò 1951 ¢y˘Ïú ¶¸yÓ˚˘Ïì¸ ãyì¸#Î˚ ¸ô!Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)â¸# â¸yú% Ñ¸Ó˚y £Î˚– ≤Ãîyò ú«¸ƒ £ú ãß√ ! òÎ˚s¸fí– ≤ÃÌõ Á !mì¸#Î˚ ¸ôM¸ÈÓy!°Ï≈Ñ¸# Ñ¸õ≈¢)â¸#!›¸ ¸ô%˘ÏÓ˚y›¸y£z !Ñœ¸!òÑ¸ƒyú !¶¸!_Ñ¸ !äÈú– !Ñ¸ls¸ 1961 ¢y˘ÏúÓ˚ ãò¢ %õy!Ó˚Ó˚ ¸ôÓ˚ ì¸y ¸ô%˘ÏÓ˚y¸ô%!Ó˚ !ü«¸yîò Á !Ñœ¸!òÑ¸ƒyú !¶¸!_Ñ¸ £Î˚ – ¸ôÓ˚Óì≈¸#Ñ¸y˘Ïú â¸ì%¸Ì≈ Á ¸ôM¸Èõ ¸

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ôMÈ¸Óy!°Ï≈Ñ¸# ¸ô!Ó˚Ñ¸“òy˘Ïì¸ ãß√£yÓ˚ 35 ˘Ì˘ÏÑ¸ 32˘ì¸ òy!õ˘ÏÎ˚ xyòyÓ˚ ¸ô!Ó˚Ñ¸“òy ˘òÁÎ˚y £Î˚ –

x‹Tõ ¸ô!Ó˚Ñ¸“òy˘Ïì¸ S1992ÈÙÈ97V NGO =!ú˘ÏÑ¸ Ñ¸y˘Ïã úyÜy˘ÏòyÓ˚ ¸ô!Ó˚Ñ¸“òy ˘òÁÎ˚y £Î˚ – ¶¸yÓ˚˘Ïì¸Ó˚ ãyì¸#Î˚ Ñ¸úƒyí Ñ¸õ≈¢)â¸# ãß√!òÎ˚s¸f˘ÏíÓ˚ ãòƒ òyòyÓ˚Ñ¸˘ÏõÓ˚ ãß√ !ò˘ÏÓ˚yïÑ¸ ¢yõ@˘Ã#Ó˚ ≤Ãhfl¸yÓ ˘îÎ˚ñ ˘ÎõòÈÙÙÙÈ Ñ¸˘Ïu¸yõñ Ü¶≈¸! ò˘ÏÓ˚yïÑ¸ Ó!v¸¸ñ £zr›¸∆y £zv¸zÓ˚y£zò !v¸¶¸y£z¢ (IUD) ˘ÎõòÈÙÙÙÈ Ñ¸¸ôyÓ˚ÈÙÈ!›¸– ~äÈyv¸¸y Ü¶≈¸!ò˘ÏÓ˚yïÑ¸ñ ãß√!òÎ˚s¸fí ¢ ¡ô˘ÏÑ≈¸ ãò¢˘Ïâ¸ì¸òì¸y õ)úÑ¸ Ñ¸õ≈¢)â¸# @˘Ã£í ~ÓÇ ì¸y ¢ö¸ú Ñ¸Ó˚yÓ˚ ãòƒ ¢

100% **MATCHING BLOCK 196/200** **SA** Indrani-Bhattacharya_AsishKumarDas_History_Swa ... (D129738480)

Ó˚Ñ¸y!Ó˚ Á ˘Ó¢Ó˚Ñ¸y!Ó˚ ¢

Çfl¸iy=!ú˘ÏÑ¸ Ñ¸y˘Ïã úyÜy˘Ïòy £Î˚ – 2002ÈÙÈ2003 ¢y˘Ïú x!òÎ˚!s¸fì¸ ˘ÎÔò ¢Ç˘ÏÎyÜ Óy xÎy!â¸ì¸ Ü¶≈¸yÓfl¸iy˘ÏÑ¸ ˘Ó˚yï Ñ¸Ó˚yÓ˚ ãòƒ xy¸ôì¸Ñ¸yú#ò Ü¶≈¸!ò˘ÏÓ˚yïÑ¸ Ó!v¸¸Ó˚ ≤Ãâ¸úò Ñ¸Ó˚y £Î˚ –

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v¸z¸ô!Ó˚v¸z_´ ¸ôk¸!ì¸ äÈyv¸¸y xyÓ˚Á ~Ñ¸!›¸ Ó˝ú ≤

Ãâ¸!úì¸ ¸ôk¸!ì¸ £ú Óı¸ycÑ¸Ó˚í– ãyì¸#Î˚ ¸ô!Ó˚ÓyÓ˚ Ñ¸úƒyí Ñ¸õ≈¢)â¸#Ó˚ xhs¸Ü≈ì¸ Óı¸ycÑ¸Ó˚í ¸ôk¸!ì¸=!ú £úÈÙÙÙÈ ??!›¸v¸z˚ÏÓƒQ!õ ≠ ~!›¸ õ!£úy˚ÏîÓ˚ Óı¸ycÑ¸Ó˚í ¸ôk¸!ì¸ Îy ö¸ƒy˚Ïúy!¸ôÎ˚yò òy!ú˚ÏÑ¸ ˆÑ¸˚Ï›¸ Ñ¸Ó˚y £Î˚ – ??¶¸ƒy!¢Q!õ ≠ ~!›¸ ¸ô%Ó˚&°Ï˚ÏîÓ˚ Óı¸ycÑ¸Ó˚í ¸ôk¸!ì¸ Îy ¶¸ƒy¢ !v¸ö¸y˚ÏÓ˚™˚ÏÑ¸ ˆÑ¸˚Ï›¸ Ñ¸Ó˚y £Î˚ – 134 ? NSOU ? AE-ES-21 7.4 ¸ô!Ó˚˚ÏÓü Á õyòÓ fl¸ſyfl¸iƒ (Environment and Human Health) õyòÓ fl¸ſyfl¸iƒ Óú˚Ïì¸ ˆÑ¸Óú ˆÓ˚yÜñ Ë°Ï%ïñ v¸y_´yÓ˚ñ £y¢¸ôyì¸yú˚ÏÑ¸ ˆÓyG¸yÎ˚ òyñ fl¸ſyfl¸iƒ Óú˚Ïì¸ ˆÓyG¸yÎ˚ ò#˚ÏÓ˚yÜ ˆî£– ¸ô!Ó˚˚ÏÓü!Óî˚ÏîÓ˚ õ˚Ïì¸ fl¸ſyfl¸iƒ £ú õyò%°Ï ~ÓÇ ì¸yÓ˚ ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ õ˚Ïiƒ ¸≤ÃyíÓhs¸ ¢£yÓfl¸iyò– xÌ≈yí x¢¡ô)í≈ õyò%°Ï Á x¢¡ô)í≈ ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ xyd¢¡ôÑ≈¸ ˆÓ˚y˚ÏÜÓ˚ ¢‚!‹T Ñ¸˚ÏÓ˚ – fl¸ſyfl¸iƒñ !ò¶≈¸Ó˚ Ñ¸˚ÏÓ˚ õyò%˚Ï°ÏÓ˚ ˜î!£Ñ¸ñ ¢yõy!ãÑ¸ñ õyò!¢Ñ¸ ñ ¢Çfl¸‚Ò!

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ì¸Ñ¸ñ xÌ≈˜Ïò!ì¸Ñ¸ Á Ó˚yã˜Ïò!ì¸Ñ¸ ¸

ô!Ó˚˚
ÏÓ˚ÏüÓ˚ v¸z¸ôÓ˚ – !ÓŸª fl¸ſyfl¸iƒ ¢Çfl¸iy (WHO) ~Ó˚ õ˚Ïì¸ fl¸ſyfl¸iƒ £ú ˜î!£Ñ¸ñ õyò!¢Ñ¸ Á ¢yõy!ãÑ¸ ¸ô!Ó˚ ¸ô)í≈ì¸yÓ˚ ¢y!Ó≈Ñ¸ ≤ÃÑ¸yü– xÌ≈yí !Ó˚Ïü°Ï ˆ¶¸Ô˚ÏÜy!úÑ¸ ~ÓÇ ¢yõy!ãÑ¸ xÓfl¸iy˚Ïò ~Ñ¸ãò ÓÎ˚¢ Á !úD ¢y˚Ï¸ô˚Ï«¸ fl¸ſy¶¸y!ÓÑ¸¶¸y˚ÏÓ ¢õhfl¸ xD ≤Ãì¸ƒ˚ÏDÓ˚ ¸ô!Ó˚â¸yúòyÎ˚ Ñ¸yÎ≈ ¢¡ôyîò Ñ%¸üúì¸y £ú ¢%fl¸ſy˚Ïfl¸iƒÓ˚ ú«¸í– fl¸ſy˚Ïfl¸iƒÓ˚ =íÜì¸ xÓfl¸iyÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸˚ÏÓ˚ fl¸ſyfl¸iƒ˚ÏÑ¸ Ñ¸ì¸=!ú ¶¸y˚ÏÜ ¶¸yÜ Ñ¸Ó˚y £˚ÏÎ˚ ˚ÏäÈ– ÎlyÈÙÙÙÈ ïòydÑ¸ fl¸ſyfl¸iƒ ↔ v¸zß¨ì¸Ó˚ fl¸ſyfl¸iƒ ↔ ˆÓ˚y˚ÏÜÓ˚ xò%¸ô!fl¸i!ì¸ // x¸ô!Ó˚Ñ¸!"ì¸ x¢%Ö ↔ x¢%fl¸iì¸y ↔ x!ïÑ¸ x¢%fl¸iì¸y ↔ õ‚ì%¸ƒ 7.4.1 õyòÓ fl¸ſy˚Ïfl¸iƒÓ˚ Á¸ôÓ˚ ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ ≤Ã¶¸yÓ ¸ô!Ó˚˚ÏÓü õyòÓ fl¸ſyfl¸iƒˆ

100% **MATCHING BLOCK 200/200** **SA** MA in Geography SEM II (CBCS Mode).pdf (D142514677)

ÏÑ¸ ≤Ãì¸ƒ«¸ Á ¸ô˚ÏÓ˚y«¸¶¸y˚ÏÓ ≤Ã¶¸y!Óì¸ Ñ¸˚ÏÓ˚ – ¸

ô!Ó˚˚ÏÓü˚ÏÑ¸ î%!›¸ ¶¸y˚ÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ÈÙÙÙÈ xy¶¸ƒhs¸Ó˚# ò Á Óy!£ƒÑ¸ ¸ô!Ó˚˚ÏÓü– xy¶¸ƒhs¸Ó˚#ò ¸ô!Ó˚˚ÏÓü Îy xy¢˚Ïú õyò%˚Ï°ÏÓ˚ xy¶¸ƒhs¸Ó˚#ò xDñ ≤Ãì¸ƒDñ ˆÑ¸y°Ï Ñ¸úy £zì¸ƒy!îÓ˚ ¢ £yÓfl¸iy˚ÏòÓ˚ õyïƒ˚Ïõ ˆî£ ¢%‡¸yõ Á ¢Óú £˚ÏÎ˚ Á˚Ï‡¸ – xòƒ!î˚ÏÑ¸ õyòÓ !ü÷ ¶)¸!õ¤¸ £ÁÎ˚yÓ˚ ¸ôÓ˚ ˆÌ˚ÏÑ¸£z ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ ¢õß∫˚ÏÎ˚ õyò!¢Ñ¸ Á ¢yõy!ãÑ¸ ¶¸y˚ÏÓ˚ õyò%˚Ï°ÏÓ˚ ˜î!£Ñ¸ñ ≤ÃyÑ¸‚!ì¸Ñ¸ Á õyò!¢Ñ¸ !ÓÑ¸yü ¢¡ô)í≈ £Î˚ – ¸ô!Ó˚˚ÏÓü Î!î ˆÓ˚yÜ ã#Óyí%Ó˚ ÓÇü !Óhfl¸yÓ˚ ¢£yÎ˚Ñ¸ £Î˚ Óy äÈv¸¸y˚Ïì¸ ¢y£yÎƒ Ñ¸˚ÏÓ˚ ì¸Öò õyò%°Ï ˆÓ˚y˚ÏÜÓ˚ Ñ¸Ó˚˚Ïú ¸ô˚Ïv¸¸– xyÓyÓ˚ ¸ô!Ó˚˚ÏÓü Î!î õyòÓ ˆî˚Ï£Ó˚ ¢£yÎ˚Ñ¸ £˚ÏÎ˚ Á˚Ï‡¸ ì¸˚ÏÓ˚ ì¸yÓ˚ ˆÓ˚yÜ ã#Óyí%Ó˚ !ÓÓ˚&˚Ïk¸ ¢%Ó˚«¸y Óú˚ ˜ì¸!Ó˚ Ñ¸˚ÏÓ˚ – ¢£ã Ñ¸ÌyÎ˚ ÓúyÎ˚ ¸ô! Ó˚˚ÏÓü !fl¸i!ì¸ü#ú î˚Ï[¸Ó˚ òƒyÎ˚ Ñ¸yã Ñ¸˚ÏÓ˚ñ !Ñ¸ä%Èõye ¸ô!Ó˚Óì≈¸ò ˆÓ˚yÜ ¢‚!‹TÓ˚ Ñ¸yÓ˚í £˚Ïì¸ ¸ôy˚ÏÓ˚ – ã#Óyí%ñ õyòÓ˚Ïî£ Á ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ xyd ¢¡ôÑ≈¸˚ÏÑ¸ ~!¸ô˚Ïv¸!õÁú!ãÑ¸ƒyú ›¸∆y˚ÏÎ˚v¸ (Epidemiological Triad) Óúy ÎyÎ˚ – !â¸e 7.2 ≠ ˆÓ˚yÜã#Óyí%ñ õyòÓ˚Ïî£ Á ¸ô!Ó˚˚ÏÓ˚ÏüÓ˚ xyd¢¡ôÑ≈¸ Sv¸zÍ¢ ≠ Text Book of Preventive and Social Medicine, -K, ParkV NSOU ? AE-ES-21 ? 135 7.5 ¢Çe´yõÑ¸ Óƒy!ï (Communicable Disease) Ñ¸˚ÏÎ˚Ñ¸!›¸ ¢Çe´yõÑ¸ Óƒy!ï ¢¡ô˚ÏÑ≈¸ xy˚Ïúyâ¸òy Ñ¸Ó˚y £úÈÙÙÙÈ 7.5.1 Î"y ˆÓ˚yÜ (Tuberculosis) Î"y Óy !›¸!Óñ M. tuberculosis òyõÑ¸ ã#Óyí%á!›¸ì¸ ˆÓ˚yÜñ ¢yïyÓ˚îì¸ ö%¸¢ö%¸¢ñ x!fl¸iñ !ú¡≥¸ñ @'ƒyu¸¢ Á x!fl¸iÓ˚ ¢Ç˚ÏÎyÜ fl¸i˚Ïú !›¸!ÓÓ˚ ¢Çe´õí á˚Ï›¸ Ìy˚ÏÑ¸– !Ó˚ÏŸª !›¸!Ó xye´yhs¸ ˆîü=!úÓ˚ õ˚Ïiƒ ¶¸yÓ˚ì¸ ≤ÃÌõ fl¸iyò x!ïÑ¸yÓ˚ Ñ¸˚ÏÓ˚ xy˚ÏäÈ– ≤Ã!ì¸ ÓäÈÓ˚ ≤ÃyÎ˚ 18 ú«¸ ˆúyÑ¸ !›¸!Ó myÓ˚y xye´yhs¸ £˚ÏÎ˚ Ìy˚ÏÑ¸ ~ÓÇ ì¸y˚ÏîÓ˚ õ˚Ïiƒ 4 ú«¸ ˆúyÑ¸ õyÓ˚yÁ ÎyÎ˚ – ¢Çe´õí ≠ ~!›¸ ~Ñ¸!›¸ ÓyÎ˚% Óy!£ì¸ ˆÓ˚yÜ– xye´yhs¸ Î"y ˆÓ˚yÜ#Ó˚ Ñ¸y!üñ Ì%ì%¸ñ Ñ¸ö¸ñ ˆŸ'‹øyÓ˚ õyïƒ˚Ïõ ˆÓ˚y˚ÏÜÓ˚ ã#Óyí% Óyì¸y˚Ï¢ äÈv¸¸yÎ˚ ~ÓÇ ¢%fl¸i õyò%°Ï˚ÏÑ¸ xye´yhs¸ Ñ¸˚ÏÓ˚ – ã#Óyí% ¢Çe´õ˚ÏíÓ˚ ¢yïyÓ˚îì¸ 3ÈÙÈ6 ¢Æy˚Ï£Ó˚ ¸ôÓ˚ Î"y ˆÓ˚yÜ ≤ÃÑ¸yü ¸ôyÎ˚ – ú«¸í ≠ Î"y ˆÓ˚y˚ÏÜÓ˚ ¢Çe´yõ˚ÏíÓ˚ ú«¸í=!ú £úÈÙÙÙÈ ??~Ñ¸ õy¢ Óy ì¸yÓ˚ ˆÓ!ü !îò ï˚ÏÓ˚ Ñ¸y!ü ~ÓÇ ãµÓ˚ ??Ó%˚ÏÑ¸ Óƒyì ??Ñ¸y!üÓ˚ ¢y˚Ïì Ó˚_´ ??e´õyß∫˚ÏÎ˚ Á˚Ïãyò £…y¢ Á «%¸îyõ®y ~äÈyv¸¸y Ñ¸ö¸ñ Ì%ì%¸ñ ¸ôÓ˚#«¸yñ ~:ÈÙÈ˚Ó˚ Á !›¸v¸zÓyÓ˚!Ñ¸v¸z! úò ¸ôÓ˚#«¸y myÓ˚y ¢Çe´õí ãyò˚Ïì¸ ¸ôyÓ˚y ÎyÎ˚ – !â¸Ñ¸Í¢y ≠ ¢!‡¸Ñ¸ ¢õ˚ÏÎ˚ ¢!‡¸Ñ¸ !â¸!Ñ¸Í¢y myÓ˚y ~£z ˆÓ˚yÜ !òÓ˚yõÎ˚ Ñ¸Ó˚y ¢Ω¸Ó– Óì≈¸õy˚Ïò DOT (Directly Observed Treatment) ≤ÃÑ¸˚Ï" !òÖÓ˚â¸yÎ˚ ¢Ó˚Ñ¸y!Ó˚ fl¸ſyfl¸iƒ˚ÏÑ¸˚Ïw ~£z ˆÓ˚y˚ÏÜÓ˚ !â¸!Ñ¸Í¢y Ñ¸Ó˚y £Î˚ – !òÎ˚!õì¸ fl¸ſyfl¸iƒÑ¸õ≈#Ó˚ ì¸_¥yÓïy˚Ïò ≤ÃyÎ˚ òÎ˚ õy¢ Ë°Ï%ï ˆ¢Óò Ñ¸Ó˚˚Ïú ~£z ˆÓ˚yÜ ¢¡ô)í≈ !òÓ˚yõÎ˚ £Î˚ – !òÎ˚!õì¸ Ë°Ï%ï òy ˆÖ˚Ïú ã#Óyí%=!ú ÈTBÙÈË°Ï%˚ÏîÓ˚ ≤Ã!ì¸˚ÏÓ˚yï «¸õì¸y xã≈ò Ñ¸˚ÏÓ˚ ˆö¸˚Ïú ˆ¢£z¢Ó ˆÓ˚yÜ#˚ÏÑ¸ ¢%fl¸i Ñ¸˚ÏÓ˚ ˆì¸yúy ÓƒÎ˚Ó˚˝ú Á î%‹ÒÓ˚ £˚ÏÎ˚ ¸ô˚Ïv¸¸– ~äÈyv¸¸y !ü÷Ó˚ ã˚Ïß√Ó˚ ¸ôÓ˚ BCG (Bacilli Chalmette Guerin) !›¸Ñ¸y ¢yÓ˚yã#Óò !›¸!Ó ˆÓ˚yÜ ˆÌ˚ÏÑ¸ Ó˚«¸y Ñ¸˚ÏÓ˚ – 7.5.2 õƒy˚Ïú!Ó˚Î˚y (Malaria) õƒy˚Ïú!Ó˚Î˚y ~Ñ¸!›¸ ˆ≤Ãy˚Ï›¸y˚ÏãyÎ˚y á!›¸ì¸ ˆÓ˚yÜ ~ÓÇ fl¸f#ÈÙÈ≤Ããy!ì¸Ó˚ xƒy˚Ïòy!ö¸!ú¢ õüy ~£z ˆÓ˚yÜ Ó£ò Ñ¸˚ÏÓ˚ – ÈWHOÙÈ~Ó˚ ì¸Ìƒ S2009V xò%ÎyÎ˚# !Ó˚ÏŸª ÓäÈ˚ÏÓ˚ ≤ÃyÎ˚ 20 ˆÑ¸y!›¸ õyò%°Ï õƒy˚Ïú! Ó˚Î˚yÎ˚ xye´yhs¸ ~ÓÇ ~Ñ¸ ú«¸ ˆúyÑ¸ õyÓ˚y Îyò– ≤Ãiyòì¸ 4 ≤ÃÑ¸y˚ÏÓ˚Ó˚ õƒy˚Ïú!Ó˚yÓ˚ ¸ôƒyÓ˚y¢y£z›¸ ¢Çe´õí á›¸yÎ˚ñ ˆÎõò P. vivax, P. falciparum, P. malariae, P. ovale– ~£z ≤Ããy!ì¸=!úÓ˚ õ˚Ïiƒ ¶¸yÓ˚˚Ïì¸ ≤ÃyÎ˚ 70% ¢Çe´õí P. vivax myÓ˚y ~ÓÇ ≤ÃyÎ˚ 25% ¢Çe´õí P. falciparum myÓ˚y £˚ÏÎ˚ Ìy˚ÏÑ¸ Á õ‚ì%¸ƒÁ £Î˚ – !Ó˚ÏŸªÓ˚ v¸zß¨ì¸ ˆîü=!ú ˆÌ˚ÏÑ¸ õƒy˚Ïú!Ó˚Î˚y !ÓîyÎ˚ !ò˚ÏÎ˚˚ÏäÈ !Ñ¸ls¸ ¶¸yÓ˚ì¸ ¢ £ xòƒyòƒ v¸zß¨Î˚òü#ú ˆîü=!ú ˆÌ˚ÏÑ¸ ì¸y ¢Ω¸Ó¸ ¸ôÓ˚ £Î˚!ò ~Ñ¸õye áòÓ¢!ì¸ Á î)°Ï˚ÏíÓ˚ Ñ¸yÓ˚˚Ïíñ Îy õüyÑ%¸˚ÏúÓ˚ Ó¢Óy˚Ï¢Ó˚ v¸z¸ôÎ%_´ Ñ¸˚ÏÓ˚ ì%¸˚Ïú˚ÏäÈ– 136 ? NSOU ? AE-ES-21

¢Çe´õí ≠ õƒy˜Ïú!Ó˚Î˚y ¢Ó ÓÎ˚ˆÏ¢Ó˚ õyò%°ÏˆÏÑ¸ xye´õí Ñ¸ˆÏÓ˚ñ ì¸ˆÏÓ õ!£úy x˜Ï¸ô«¸y ¸ô%Ó˚&°ÏˆÏíÓ˚ xye´õˆÏíÓ˚ £yÓ˚ ˆÓ!ü– Ü¶≈¸yÓfl¸iyÎ˚ õ!£úyˆÏíÓ˚ ¢Çe´õˆÏíÓ˚ ≤ÃÓî¸y ˆÓ!ü lyˆÏÑ¸ ~õò!Ñ¸ Ü¶≈¸fl¸i ¢hs¸y˜ÏòÓ˚ õ‚ì%¸ƒÓ˚ xyüB¸yÁ lyˆÏÑ¸ – ¢yïyÓ˚î¸ õüy! Ó˚ òy ›¸y!à˜ÏÎ˚ ˆüyÁÎ˚y õƒy˜Ïú!Ó˚Î˚y ¢Çe´õˆÏíÓ˚ ≤Ãïyò Ñ¸yÓ˚í– ì¸yäÈyv¸¸y £z˜ÏOÑ¸ü˜ÏòÓ˚ õyïƒˆÏõ ~ÓÇ ¢Çe´y!õì¸ ˆÓ˚yÜ#Ó˚ Ñ¸yäÈ ˆÌˆÏÑ¸ Ó˚_´@˘Ã£ˆÏíÓ˚ õyïƒˆÏõÁ ˆÓ˚yÜ äÈv¸¸y˜Ïì¸ ¸ôy˜ÏÓ˚ – ú«¸í ≠ õƒy˜Ïú!Ó˚Î˚yÎ˚ ¢Çe´y!õì¸ õüy Ñ¸yõv¸¸y˜ÏòyÓ˚ 9ÈÙÈ10 !î˜ÏòÓ˚ ¸ôÓ˚ õƒy˜Ïú!Ó˚Î˚yÓ˚ ú«¸í ˆîÖy !î˜Ïì¸ ¸ôy˜ÏÓ˚ !Ñ¸ls¸ ì¸y !Ó!¶¸ß¨ ≤Ãäy!ì¸Ó˚ Á¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚ – õƒy˜Ïú!Ó˚Î˚yÓ˚ ú«¸í=!ú £úÈÙÙÙÈ xì¸ƒ!ïÑ¸ ì¸y¸õöyeyñ õyÌyÓƒyÌyñ Ó!õ¶¸yÓñ ¢yÓ˚y üÓ˚#ˆÏÓ˚ Óƒyìyñ î%Ó≈úì¸yñ ~äÈyv¸¸y â¸yõv¸¸yÎ˚ Ó˚ ƒyü‰ ˆÓ˚ˆÏÓ˚yÎ˚ ñ ~Ñ¸òyÜy˜Ïv¸¸ ãµÓ˚ â¸ú˜Ïì¸£z lyˆÏÑ¸ Á õyò%°Ï ¶%¸ú Ó˜ÏÑ¸ – ~£z ˆÓ˚y˜ÏÜ ˆÓ˚yÜ#Ó˚ õ‚ì%¸ƒÓ˚ £yÓ˚ xì¸ƒ!ïÑ¸ lyˆÏÑ¸ – !â¸!Ñ¸Í¢y ≠ õƒy˜Ïú!Ó˚Î˚yÓ˚ ú«¸í=!ú ˆîÖy ˆÜˆÏú ˆÓ˚yÜ#Ó˚ Ó˚_´ ¸ôÓ˚#«¸y Ñ¸Ó˚y˜Ïì¸ £ˆÏÓ ~ÓÇ Ó˚ˆÏ_´ ¸ôƒyÓ˚y¢y£zˆÏ›¸Ó˚ v¸z¸ô!fl¸ìì¸ lyÑ¸ ˆÏú !òÑ¸›¸Óì≈¸# fl¸Íyfl¸iƒˆÏÑ¸ˆÏw !â¸!Ñ¸Í¢y Ñ¸Ó˚y˜Ïì¸ £ˆÏÓ– õƒy˜Ïú!Ó˚Î˚y ≤Ã!ì¸ˆÏÓ˚yï ≠ ? Óy!v¸¸Ó˚ xyü¸ôyü ¸ô! Ó˚‹ÓyÓ˚ Ó˚yÖ˜Ïì¸ £ˆÏÓñ Ó°Ï≈yÑ¸y˜Ïú ãú ãõ˜Ïì¸ ˆîÁÎ˚y â¸úˆÏÓ òy– Ñ¸yÓ˚í ¸ô!Ó˚‹ÓyÓ˚ ãõy ã˜Ïú õƒy˜Ïú!Ó˚Î˚yÓ˚ õüy !v¸õ ¸ôy˜Ïv¸¸ – ? õüy!Ó˚ Óy›¸y˜Ïì¸ £ˆÏÓ Óy õüy õyÓ˚yÓ˚ Ë°Ïì

100% **MATCHING BLOCK 198/200** **W**

ÓƒÓ£yÓ˚ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – ? ˆv¸

yÓyñ õãy ¸ô%Ñ%¸Ó˚ Óy òîõ≈y˜Ïì¸ ˆì¸úy!¸ôÎ˚ Á Üƒyj%!¢Î˚y õy˜ÏäÈÓ˚ â¸y°Ï Ñ¸Ó˚ˆÏú ì¸yÓ˚y õüyÓ˚ úy¶≈¸y ˆÖˆÏÎ˚ ˆö¸ˆÏú ö¸ˆÏú õüyÓ˚ v¸z¸ôÓ Ñ¸ˆÏõ– 7.5.3 ˆv¸D% (Dengue) ~!›¸ ~Ñ¸!›¸ ¶¸y£zÓ˚y¢ á!›¸ì¸ ˆÓ˚yÜ lyÓ˚ Óy£Ñ¸ Aedes aegypti Á Aedes albopictus ≤Ãäy!ì¸Ó˚ õüy– Ó°Ï≈yÑ¸y˜Ïú õüy ˆÓ!ü £ÁÎ˚yÓ˚ Ñ¸yÓ˚ˆÏí ˆv¸D%Ó˚ ≤Ã¶¸yÓÁ ˆÓ!ü ú«¸ƒ Ñ¸Ó˚y lyÎ˚ – ¢Ó ÓÎ˚ˆÏ¢Ó˚ òyÓ˚# Á ¸ô%Ó˚&°Ï xye´yhs¸ £Î˚ – ˆv¸D%Ó˚ î%!›¸ ¶¸yÜ xy˜ÏäÈ Dengue Haemorrhagic Feaver (DHF) Á Dengue Shock Syndrome (DSS)– ú«¸í ≠ ¢yïyÓ˚î¸ ÷Ó˚&Ó˚ !îˆÏÑ¸ Ñß¸y¸ô%!ò !î˜ÏÎ˚ ãµÓ˚ñ x¢£ƒ õyÌyÓƒÌyñ «%¸ïyõ®yñ ˆâ¸yˆÏÖÓ˚ Ís¸fíyñ Üßy˜Ï›¸ ÓƒÌy ˆîÖy ˆîÎ˚ñ ãµÓ˚ £Î˚ S103ÈÙÈ104°CVñ õ%ˆÏÖ ÜúyÎ˚ Ó˚ ƒyü‰ ˆÓ˚ˆÏÓ˚yÎ˚ – 5 !îò ¸ôÓ˚ ãµÓ˚ ˆäÈˆÏv¸¸ ˆîÎ˚ – DHFÈÙÈ~Ó˚ ˆ«¸ˆÏe 4ÈÙÈ6 !îò ãµÓ˚ñ ˆ¸ô›¸ Óƒly Á õ%Ö !î˜ÏÎ˚ Ó˚_´ Ó!õ Á ≤'yõy ˆÓ˚ˆÏÓ˚y˜Ïì¸ lyˆÏÑ¸ – Ó˚_´ ¸ôÓ˚#«¸y myÓ˚y üòy_´Ñ¸Ó˚í Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôy˜ÏÓ˚ – DSS ú«¸í=! ú ÈDHFÈÙÈ~Ó˚ õì¸£z lyˆÏÑ¸ñ ÷î%õye ÚüÑ¸Û ˆîÖy lyÎ˚ ~Ó˚ õyïƒˆÏõ õ‚ì%¸ƒ £yÓ˚ ˆÓ!ü £Î˚ – NSOU ? AE-ES-21 ? 137 ≤Ã!ì¸ˆÏÓ˚yï ÓƒÓfl¸iy ≠ õƒy˜Ïú!Ó˚Î˚yÓ˚ õì¸£z v¸z¸ôî%_´ ›¸#Ñ¸yÓ˚ ÓƒÓfl¸iy òy lyÑ¸yÓ˚ Ñ¸yÓ˚ˆÏí õüyÓ˚ Ñ¸yõv¸¸ ˆÌˆÏÑ¸ Óßyâ¸y£z v¸z¸ôî%_´ ≤Ã!ì¸ˆÏ°ÏïÑ¸ ÓƒÓfl¸iyñ õüyÓ˚ !Óòyü Ñ¸Ó˚y£z ~Ñ¸õye v¸z¸ôyÎ˚ Á õüy!Ó˚ ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– 7.5.4 v¸y£z!Ó˚Î˚y Óy ¸ôyì¸úy ¸ôyÎ˚Öyòy (Diarrhea Diseases) !î˜Ïò !ì¸òÓy˜ÏÓ˚ Ó˚ ˆÓ!ü ¸ôyì¸úy ¸ôyÎ˚Öyòy £ˆÏú ì¸y˜ÏÑ¸ v¸y£z!Ó˚Î˚y Óúy ˆÎˆÏì¸ ¸ôy˜ÏÓ˚ñ ~!›¸ !Ó!¶¸ß¨ ¶¸y£zÓ˚y¢ Á ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚yÓ˚ äòƒ £ˆÏÎ˚ lyˆÏÑ¸ – v¸y£z!Ó˚Î˚yÓ˚ äòƒ £yäyÓ˚ £yäyÓ˚ ˆúyÑ¸ ≤Ã!ì¸ÓäÈÓ˚ õyÓ˚y lyÎ˚ – ¢Çe´õí ≠ ¢yïyÓ˚î¸ ì)!°Ïì¸ ãúñ ì)!°Ïì¸ Öyïƒ @˘Ãí Ñ¸Ó˚yÓ˚ ö¸ˆÏú ~£z ˆÓ˚yÜ £ˆÏÎ˚ lyˆÏÑ¸ – xye´yhs¸ ˆÓ˚yÜ#Ó˚ õ)ú õ)e ˆÌˆÏÑ¸ ã#Óyí%ñ õy!äÈñ xyÓ˚ ˆÏüyúy myÓ˚y Öyïƒ Á ãú ì)!°Ïì¸ Ñ¸ˆÏÓ˚ lyˆÏÑ¸ – ~äÈyv¸¸y ¶¸y˜Ïúy Ñ¸ˆÏÓ˚ £yì¸ òy ï%ˆÏÎ˚ Öyïƒ @˘Ãí Ñ¸Ó˚ˆÏúÁ ~£z ˆÓ˚yÜ äÈv¸¸yÎ˚ñ ì¸y£z ÓyFâ¸yÓ˚y ˆÓ!ü xye´yhs¸ £ˆÏÎ˚ lyˆÏÑ¸ – ~äÈyv¸¸y Óy!¢ñ ¸ôâ¸y ÖyÓyÓ˚ñ x¸ô! Ó˚ˆÏüy!ïì¸ ã˜Ïú ˜ì¸!Ó˚ xy£zÓ¢e´#õ ¢Çe´õˆÏíÑ¸ Óy!v¸¸˜ÏÎ˚ ˆîÎ˚ – ≤Ã!ì¸Ñ¸yÓ˚ ≠ xì¸ƒ!ïÑ¸ ÓyÓ˚ ¸ôyÎ˚Öyòy Ñ¸Ó˚yÓ˚ ö¸ˆÏú üÓ˚#ˆÏÓ˚ ˆ¢y!v¸Î˚yõñ ¸ô›¸y!ü˜Ïõ ~Ó˚ x¶¸yÓ £Î˚ – ˆÓ˚yÜ# î%Ó≈ú £ˆÏÎ˚ ¸ôˆÏv¸¸ Á õyÓ˚y lyÎ˚ – ì¸y£z ˆÓ˚yÜ#Ó˚ üÓ˚#ˆÏÓ˚ £zÕÒˆÏ›¸∆yúy£z›¸ Óƒyúy™ Ñ¸ˆÏÓ˚ ˆÓ˚yÜ#ˆÏÑ¸ !fl¸i!ì¸ü#ú Ñ¸Ó˚y ≤ÃˆÏÎ˚yãò– ì¸yÓ˚ ãòƒ ˆÓ˚yÜ#ˆÏÑ¸ Oral Rehydration Salt (ORS) 1 !ú›¸yÓ˚ ãˆÏú =ˆÏú Óy˜ÏÓ˚ Óy˜ÏÓ˚ ÖyÁÎ˚y˜Ïì¸ £ˆÏÓ ì¸yäÈyv¸¸y Óy!v¸¸ì¸ õ%!v¸¸ ˆ¶¸ãy ãúñ v¸y˜ÏúÓ˚ ãúñ ò%ÓÈÙÈ!â¸!òÓ˚ ¢ÓÓ˚ì¸ £zì¸ƒy!î ÖyÁÎ˚y˜Ïú ¢yïyÓ˚í¶¸y˜ÏÓ v¸y£z!Ó˚Î˚yÓ˚ v¸z¸ôüõ £Î˚ – !Ñ¸ls¸ ˆÓ!ü Óyv¸¸ yÓy!v¸¸ £ˆÏú £y¢¸ôyì¸y˜Ïú ¶¸!ì≈ ¸ Ñ¸Ó˚y›¸y£z v¸z!â¸ì¸ – v¸y£z!Ó˚Î˚yÓ˚ ≤ÃˆÏÑ¸y¸ô Ñ¸õy˜Ïì¸ ˆÜˆÏú !Ó÷¸k ãú ˆÖˆÏì¸ £ˆÏÓñ ÖyÓyÓ˚ ÖyÁÎ˚y ÓyÓyÓ˚ ˆîyÓ˚ ¢õÎ˚ £yì¸ ¢yÓyò !î˜ÏÎ˚ ¸ô!Ó˚‹ÓyÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– ÖyÓyÓ˚ îyÓyÓ˚ ¢Ó¢õÎ˚ ë¸yÑ¸y !î˜ÏÎ˚ Ó˚yÖ˜Ïì¸ £ˆÏÓ– Îeì¸e õú õ)e ì¸ƒyÜ Ñ¸Ó˚y â¸úˆÏÓ òy Óy!v¸¸ áÓ˚ ¸ô!Ó˚‹ÓyÓ˚ ¸ô!Ó˚FäÈß¨ Ó˚yÖ˜Ïì¸ £ˆÏÓñ õy!äÈÓ˚ v¸z¸ôÓ Ñ¸õy˜Ïì¸ £ˆÏÓ– ¢ˆÏÓ≈y¸ô! Ó˚ ãòÜí ˆÏÑ¸ !Ó˚ˆÏü°Ï Ñ¸ˆÏÓ˚ Óy!v¸¸Ó˚ õ!£úyˆÏîÓ˚ K¸yò îyò Á ¢˜Ïâ¸ì¸ò Ñ¸Ó˚ˆÏì¸ £ˆÏÓ– 7.5.5 ~£zv¸¸¢ (AIDS) HIV (Human Immuno Deficiency Virus) ¶¸y£zÓ˚y¢ á!›¸ì¸ ˆÓ˚yÜ £ú ~£zv¸¸¢ (AIDS- Acquired Immuno Deficiency Syndrome)– ~£zv¸¸¢ ¢Çe´õˆÏíÓ˚ ö¸ˆÏú ˆÎˆÏ£Ó˚ ≤Ã!ì¸ˆÏÓ˚yï ÓƒÓfl¸iy £…y¢ ¸ôyÎ˚ ~ÓÇ ì¸yÓ˚ ö¸ˆÏú xòƒyòƒ ˆÓ˚yÜ ˆÎˆÏ£ Óy¢y Ößy˜ÏÎ– HIV ¶¸y£zÓ˚y¢ ˆÎˆÏ£ Ó˚ˆÏ_´Ó˚ õyïƒˆÏõ Óy ˆÎÒò ¢ÇÎˆÏõÓ˚ õyïƒˆÏõ ≤ÃˆÏÓü Ñ¸ˆÏÓ˚ ~ÓÇ T-helper cell ˆÑ¸ xye´yhs˘ ¸ Ñ¸ˆÏÓ˚ ˆŸªì¸ Ó˚_´Ñ¸!íÑ¸y =!ú ˆÑ¸ òœT Ñ¸ˆÏÓ˚ – ö¸ˆÏú ˆÓ˚yÜ# ï#ˆÏÓ˚ ï#ˆÏÓ˚ î%Ó≈ú Á ≤Ã!ì¸ˆÏÓ˚yï «¸õì¸y£#ò £ˆÏÎ˚ ¸ôˆÏv¸¸ – xÓˆÏüˆÏ°Ï AIDS ˆÓ˚yˆÏÜ xye´yhs¸ ˆÓ˚yÜ# ~Ñ¸!›¸ õyÓ˚ydÑ¸ ˆÓ˚yˆÏÜ ˆÎõòÈÙÙÙÈ Î"yñ Ñ¸ƒyò¢yÓ˚ñ v¸y£z!Ó˚Î˚yñ !òv¸z˜Ïüy!òÎ˚y £zì¸ƒy!î˜Ïì¸ xye´yhs¸ £Î˚ ~ÓÇ xÓˆÏü˜Ï°Ï ì¸y˜Ïì¸£z õyÓ˚y Óy lyÎ˚ – 1986 ¢y˜Ïú ¶¸yÓ˚ˆÏì¸ Ó˚ ì¸y!õúòyv¸¸ Y˜Ïì¸ ≤ÃÌõ ÈAIDSÙÈ~Ó˚ ˆÓ˚yÜ#Ó˚ ¢¡¸yò ¸ôyÁÎ˚y lyÎ˚ – ¢Çe´õí ≠ AIDS ! Ó!¶¸ß¨ ¶¸yˆÏÓ õyòÓ˚˜ÏîˆÏ£ äÈv¸¸y˜Ïì¸ ¸ôy˜ÏÓ˚ñ ??ˆÎÒò¢DõÈÙÈ~Ó˚ õyïƒˆÏõ ??xye´yhs¸ ˆÓ˚yÜ#Ó˚ Ó˚_´ @˘Ã£ˆÏíÓ˚ õyïƒˆÏõ 138 ? NSOU ? AE-ES-21

??¢Çe´y!õì¸ £zòˆÏãÑ¸¢ò !¢!Ó˚O Á !â¸!Ñ¸Í¢yÓ˚ Îs¸f¸ôy!ì¸ myÓ˚y ??~£zv¸¢ xye´yhs¸ Ü¶≈¸Óì¸# õy ˆÌˆÏÑ¸ !ü÷Ó˚ ˆîˆÏ£ ¢Çe´õí £Î˚ – ú«¸í ≠ ? õy˚Ï¢ 10% Óy ì¸yÓ˚ ˆÓ!ü ˆîˆÏ£Ó˚ Áãò £...y¢ ? áò áò ˆÓ˚y˚ÏÜ xye´yhs¸ £ÁÎ˚y ? ãµÓ˚ ¢!î≈ Ñ¸y!ü ˆú˚ÏÜ£z ÌyÑ¸y ¢yïyÓ˚ îì¸ ELISA (Enzyme Linked Immunosorbent Assay) Á Western Blot Test myÓ˚y ~£z ˆÓ˚yÜ üòy_´ Ñ¸Ó˚y £Î˚ – ≤Ã!ì¸Ñ¸yÓ˚ ≠ ? xye´yhs¸ ˆÓ˚yÜ#Ó˚ Ñ¸yäÈ ˆÌˆÏÑ¸ Ó˚_´ñ ≤'yãõy Óy xD ≤Ã!ì¸fl¸iy¸ôò Ñ¸Ó˚y â¸ú˚ÏÓ òy– ? ˆÎÔò ¢D˚ÏõÓ˚ ˆ«¸˚Ïe ¢%Ó˚«¸y xÓú¡Ìò Ñ¸Ó˚y ãÓ˚&!Ó˚ Îy˚Ïì¸ ˆî£ Ó˚ˆÏ¢Ó˚ ˆÑ¸yò ¢Ç˚ÏÏyÜ òy á˚Ï›¸– ? x˚ÏòƒÓ˚ ÓƒÓ£*ì¸ ä%È§â¸ñ ˆÓœv¸ £zì¸ƒy!î ÓƒÓ£yÓ˚ Ñ¸Ó˚y â¸ú˚ÏÓ òy– ? HIV + £˚Ïú fl¸f# ˆúy˚ÏÑ¸Ó˚ Ü¶≈¸ ¢M¸ÈyÓ˚ òy £ÁÎ˚yÎ˚ ÓyN¸ò#Î˚ – 7.6 x¢Çe´yõÑ¸ Óƒy!ï (Non-Communicable Diseases) ˆÎ ˆÓ˚yÜ ˆÑ¸yò¶¸y˚ÏÓ ~Ñ¸ õyò%°Ï ˆÌˆÏÑ¸ xòƒ õyò%°Ï Óy ¸ô÷ ˆÌˆÏÑ¸ õyò%˚Ï°ÏÓ˚ ˆîˆÏ£ äÈv¸¸yÎ˚ òy ì¸y˚ÏîÓ˚ x¢Çe´yõÑ¸ Óƒy!ï Ó˚Ïú– ¢yïyÓ˚îì¸ x!ì¸!Ó˚_´ ï)õ¸ôyòñ õîƒ¸ôyòñ Öyîƒy¶¸y¢ñ õyò!¢Ñ¸ î%!ÿ¸hs¸yñ G%§¸!Ñ¸¸ô)í≈ ˆ¸ôüy £zì¸ƒy!î– ¢yïyÓ˚îì¸ ˆÎ ˆÓ˚yÜ=!ú £˚ÏÎ˚ Ìy˚ÏÑ¸ ì¸y £úÈÙÙÙÈ 7.6.1 £*î˚ÏÓ˚yÜ (Cardiovascular Disease) õyò%˚Ï°ÏÓ˚ Üv¸¸ xyÎ˚% Óyv¸¸yÓ˚ ¢y˚Ïì ¢y˚Ïì Óyv¸¸˚ÏäÈ £*î˚ÏÓ˚yÜ– @˘Ãy˚ÏõÓ˚ õyò%°Ï˚ÏîÓ˚ ˆÌˆÏÑ¸ ü£˚ÏÓ˚Ó˚ õyò%˚Ï°ÏÓ˚ xye´yhs¸ £ÁÎ˚yÓ˚ ≤ÃÓîì¸y x˚ÏòÑ¸ ˆÓ!üñ ~Ó˚ ˜î!£Ñ¸ Ñ¸yÓ˚í=!ú £úÈÙÙÙÈ ˆõî Ó¸!k¸ñ v¸zFâ¸ Ó˚_´â¸y¸ôñ v¸yÎ˚y˚ÏÓ!›¸¢ñ x!ì¸!Ó˚_´ ï)õ¸ôyòñ ˜ì¸úy_´ ÖyÓyÓ˚ ˆÓ!ü ÖyÁÎ˚yñ Ñ¸y!Î˚Ñ¸ ¸ô!Ó˚◊˚ÏõÓ˚ x¶¸yÓ £*î˚ÏÓ˚y˚ÏÜÓ˚ äòƒ xòƒì¸õ Ñ¸yÓ˚í– üÓ˚#˚ÏÓ˚ ≤'yãõyÈÙ˚Ñ¸y˚Ïú˚Ïfi›¸Ó˚úÈÙÈ~Ó˚ áòc 200 mg/dl ~Ó˚ Á¸ô˚ÏÓ˚ ˆÜ˚Ïú £*î˚ÏÓ˚y˚ÏÜÓ˚ ¢Ω¸yÓòy Ó¸!k¸ ¸ôyÎ˚ – ≤Ã!ì¸˚ÏÓ˚yï ≠ £*îÍs¸f˚ÏÑ¸ !ł¸Ñ¸ Ó˚yÖ˚Ïì¸ ˆÜ˚ÏúÈÙÙÙÈ ? ˆî˚Ï£ Ó˚_´â¸y¸ô Á ˆÑ¸y˚Ïú˚Ïfi›¸Ó˚úÈÙÈ~Ó˚ õyey ÓãyÎ˚ Ó˚yÖ˚Ïì¸ £˚ÏÓ– ? Ñ¸y!Î˚Ñ¸ ¸ô!Ó˚◊õ Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– ? õyò!¢Ñ¸ î%!ÿ¸hs¸y î)Ó˚ Ñ¸Ó˚˚Ïì¸ £˚ÏÓ Á ¶¸y˚Ïúy á%õ ãÓ˚&!Ó˚ñ ˆÓ˚yã ≤ÃyÎ˚ 8 á^˘›¸y– ? ¢˚ÏÓ≈y¸ô!Ó˚ ¢Ó˚ú Á ¢!ł¸Ñ¸ ¢õÎ˚ xy£yÓ˚ @˘Ã£í Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– NSOU ? AE-ES-21 ? 139

7.6.2 Ñ¸Ñ≈¸›¸ ˆÓ˚yÜ (Cancer) Ñ¸ƒy™yÓ˚ Óú˚Ïì¸ ˆÑ¸yò ˆÑ¸y˚Ï°ÏÓ˚ xfl¸∫y¶¸y!ÓÑ¸ Ó¸!k¸ñ !›¸v¸zõy˚ÏÓ˚Ó˚ xfl¸∫y¶¸y!ÓÑ¸ Ó¸!k¸ Á xye´yhs¸ xÇ˚ÏüÓ˚ ï)˚ÏÓ˚Ó˚ xD≤Ãì¸ƒD˚ÏÑ¸ xye´õ˚ÏíÓ˚ «¸õì¸yÓ˚ ö¸˚Ïú ˆÓ˚yÜ#Ó˚ õ¸ì%¸ƒ˚ÏÑ¸ ˆÓyG¸yÎ˚ – ¢yÓ˚y !Ó˚ÏŸª 60 ú˚Ï«¸Ó˚Á ˆÓ!ü ˆúyÑ¸ xye´yhs¸ ~ÓÇ ¶¸yÓ˚˚Ïì¸Ó˚ ≤ÃyÎ˚ 3.5 ú«¸ ˆúyÑ¸ õyÓ˚y Îy˚ÏFäÈ ≤Ã!ì¸ÓäÈÓ˚ – ˆõ˚ÏÎ˚˚ÏìÓ˚ õ˚Ïìƒ hfl¸ò Á ãÓ˚yÎ˚%Ó˚ Ñ¸ƒy™yÓ˚ ~ÓÇ ¸ô%Ó˚&°Ï˚ÏîÓ˚ ˆ«¸˚Ïe ö%¸¢ö%¸¢ Á õ%˚ÏÖÓ˚ Ñ¸ƒy™yÓ˚ ˆÓ!ü £Î˚ – Ñ¸ƒy™y˚ÏÓ˚Ó˚ Ñ¸yÓ˚í ≠ ? ï)õ¸ôyòñ î_´yñ ¸ôyòõüúy £zì¸ƒy!î @˘Ã£í õ%Ö Á ö%¸¢ö%¸¢ˆÏ¢Ó˚ Ñ¸ƒy™y˚ÏÓ˚Ó˚ xòƒì¸õ Ñ¸yÓ˚í– ? x!ì¸!Ó˚_´ õîƒ¸ôyò !ú¶¸y˚ÏÓ˚ Ñ¸ƒy™y˚ÏÓ˚Ó˚ ¢¸!‹T Ñ¸˚ÏÓ˚ – ? ¸ô!Ó˚˚ÏÓü ï)!°ì¸ xy˚Ï¢≈!òÑ¸ñ ˆe´y!õÎ˚yõñ Ñ¸ƒyv¸!õÎ˚yõñ ~¢˚ÏÓfi›¸¢ñ ˆÓ!Oò £zì¸ƒy!îÁ Ñ¸ƒy™y˚ÏÓ˚Ó˚ ¢Ω¸yÓòy Óyv¸¸yÎ˚ – ? ˆ£¸ôy›¸y£z!›¸¢ÈÙÈ B, C Ñ¸ƒy™y˚ÏÓ˚Ó˚ ¸ôyŸª≈ ¶¸y˚ÏÓ ¢£yÎ˚Ñ¸ – ? ¢)˚Ïî≈Ó˚ x!ì¸ ˆÓ=ò# Ó˚!Ÿ¬ñ ~:˚ÏÓ˚ £zì¸ƒy!î c˚ÏÑ¸ Ñ¸ƒy™yÓ˚ á›¸yÎ˚ – ? ÓÇüyò%e´˚Ïõ !ãò myÓ˚y !Ñ¸ä%È !Ñ¸ä%È Ñ¸ƒy™yÓ˚ £Î˚ – ≤Ã!ì¸˚ÏÓ˚yï ≠ ? ï)õ¸ôyòñ ì¸yõyÑ¸ ˆ¢Óò ~ÓÇ õîƒ¸ôyò Óã≈ò Ñ¸Ó˚˚Ïì¸ £˚ÏÓ– ? ~:˚ÏÓ˚ñ ¢)˚Ïî≈Ó˚ !Ó!Ñ¸Ó˚í ~!v¸˚Ïv¸¸ ˆÎ˚Ï˚ â¸ú˚Ïì¸ £˚ÏÓ– ? ˆ£¸ôy›¸y£z!›¸¢ÈÙÈ!Ó ˆÓ˚y˚ÏÜÓ˚ ›¸#Ñ¸y Ñ¸Ó˚í Ñ¸Ó˚y îÓ˚Ñ¸yÓ˚ – ? Ñ¸ƒy™y˚ÏÓ˚Ó˚ ú«¸í xy˚ÏÜ ˆÌˆÏÑ¸ Ó%G¸˚Ïì¸ ¸ôyÓ˚˚Ïú v¸y_´y˚ÏÓ˚Ó˚ ¸ôÓ˚yõü≈ Á üòy_´Ñ¸Ó˚í Ñ¸Ó˚y ãÓ˚&!Ó˚ – Î!îÁ õye ~Ñ¸ ì¸¸ì¸#Î˚yÇü ˆÓ˚yÜ ≤Ã!ì¸˚ÏÓ˚yï Á !òÎ˚s¸fí ¢Ω¸Ó– 7.6.3 õï%˚Ïõ£ ˆÓ˚yÜ (Diabetes Mellitus) ~!›¸ ~Ñ¸!›¸ ã!›¸ú Óƒy!ïñ î#á≈fl¸iyÎ˚# hyperglycemia £ú ~Ó˚ ú«¸í– ˆî£ î%Ó≈ú £˚ÏÎ˚ ¸ô˚Ïv¸¸ñ üÑ≈¸Ó˚y ãyì¸#Î˚ Öyîƒ ˆÑ¸y˚Ï°Ï ˆ¸ô§ÔãÈyÎ˚ òy ~ÓÇ Ó˚˚Ïì_´ !Óîƒõyò Ìy˚ÏÑ¸ – ~Ó˚ ≤Ãïyò Ñ¸yÓ˚í ˆî£ £zò¢%!úò v¸zÍ¸ôß¨ Ñ¸Ó˚˚Ïì¸ ¸ôy˚ÏÓ˚ òy– £zò¢%!úò üÑ≈¸Ó˚y˚ÏÑ¸ !Ó¸ôy˚ÏÑ¸ ¢y£yÎƒ Ñ¸˚ÏÓ˚ – ˆî£ î%Ó≈ú Á ˆÑ¸y˚Ï°Ï ¢!ł¸Ñ¸ ¸ô%!‹T òy ¸ôyÓyÓ˚ ö¸˚Ïú !Ó!¶¸ß¨ x¢ %Ö˚ÏÑ¸ cÓ˚y!ßÌì¸ Ñ¸˚ÏÓ˚ Óy ¢¸!‹T˚Ïì¸ ¢y£yÎƒ Ñ¸˚ÏÓ˚ñ ˆÎõòÈÙÙÙÈ £*î˚ÏÓ˚yÜñ v¸zFâ¸ Ó˚_´â¸y¸ôñ ˆâ¸y˚ÏÖÓ˚ î¸!‹T ü!_´ £...y¢ñ ! Ñ¸v¸¸!ò ò‹T £ÁÎ˚y £zì¸ƒy!î– ≤Ã!ì¸˚ÏÓ˚yï ÓƒÓfl¸iy ≠ ? ˆî£˚ÏÓ˚ fl¸∫y¶¸y!ÓÑ¸ Áãòñ !òÎ˚s¸fí Óƒy!Î˚yõ Ñ¸Ó˚y– ? Ó˚ ˆ˚Ïì_´ üÑ≈¸Ó˚yÓ˚ õyey !ł¸Ñ¸ Ó˚yÖy– ? õyò!¢Ñ¸ !â¸hs¸y Ñ¸õ Ñ¸Ó˚yñ Ó˚_´ â¸y¸ô Ñ¸õ Ó˚yÖy– ? ¸ô!Ó˚Óy˚ÏÓ˚Ó˚ £z!ì¸£y˚Ï¢ ~£z ˆÓ˚yÜ ÌyÑ¸˚Ïú ì¸y˚ÏîÓ˚ ¢yõ˚Ïú â¸ú˚Ïì¸ £˚ÏÓ ~ÓÇ !õ!‹T Ñ¸õ ˆÖ˚Ïì¸ £˚ÏÓ– 140 ? NSOU ? AE-ES-21

? v¸yÎ˚y˚ÏÓ!›¸¢ ˆÓ˚yÜ#˚ÏîÓ˚ !òÎ˚!õì¸ v¸y_´y˚ÏÓ˚Ó˚ ¸ôÓ˚yõü≈ !ò˚Ïì¸ £˚ÏÓ Á Ä°î%˚Ïï ˆÖ˚Ïì¸ £˚ÏÓ– ? xòƒyòƒ xD ˆÎõòÈÙÙÙÈ ˆâ¸yÖñ £*îÍs¸f £zì¸ƒy!îÁ õy˚ÏG¸ õ˚Ïìƒ ¸ôÓ˚#«¸y Ñ¸Ó˚y˚Ïì¸ £˚ÏÓ– 7.7 xò%ü#úò# ¢!ł¸Ñ¸ v¸z_Ó˚!›¸ !òÓ≈yâ¸ò Ñ¸Ó˚&ò ≠ S1V 2011 ¢yú xò%ÎyÎ˚# ¶¸yÓ˚˚Ïì¸Ó˚ ãò ¢ÇÖƒyÈÙÙÙÈ (i) 102 ˆÑ¸y!›¸ (ii) 112 ˆÑ¸y!›¸ (iii) 121 ˆÑ¸y!›¸ (iv) 125 ˆÑ¸y!›¸ S2V Natality Ó¸!k¸ ˆ¸ô˚Ïú ãò¢ÇÖƒyÈÙÙÙÈ (i) Ñ¸˚Ïõ Îy˚ÏÓ (ii) Óyv¸¸˚ÏÓ (iii) ~Ñ¸£z ÌyÑ¸˚ÏÓ (iv) ˆÑ¸yò!›¸ òÎ˚ S3V ÈDOTsÙÈ~Ó˚ ˆÑ¸yò ˆÓ˚y˚ÏÜÓ˚ v¸z¸ôüõ ÓƒÓfl¸iyÈÙÙÙÈ (i) AIDSs (ii) Hepatatis (iii) Î"y (iv) õƒy˚Ïú!Ó˚Î˚y S4V AIDs ˆÑ¸yò ˆÓ˚yÜ üòy_´Ñ¸Ó˚˚ÏíÓ˚ v¸z¸ôyÎ˚ÈÙÙÙÈ (i) ~: ˆÓ˚ (ii) !›¸v¸zÓyÓ˚ !Ñ¸v¸z!úò (iii) !fl¸øÎ˚yÓ˚ ˆ›¸fi›¸ (iv) ELISA S5V Ñ¸Ñ≈¸›¸ ˆÓ˚y˚ÏÜÓ˚ Ñ¸yÓ˚íÈÙÙÙÈ (i) ï)õ¸ôyò (ii) x!ì¸Ó˚!_´ õîƒ¸ôyò (iii) ÈUVÙÈÓ˚!Ÿ¬Ó˚ Ñ¸yÓ˚˚Ïí (iv) ¢ÓÑ¸!›¸ x!ì¸ ¢Ç!«¸Æ v¸z_Ó˚!¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ãò¢ÇÖƒy !Ñ¸⁄S2V !úD xò%¸ôyì¸ !Ñ¸⁄S3V fl¸∫yfl¸iƒ Óú˚Ïì¸ !Ñ¸ ˆÓy˚ÏG¸ò⁄S4V ORS !Ñ¸⁄S5V AIDS ˆÓ˚yÜ ˆÑ¸yò ¶¸y£zÓ˚y˚Ï¢Ó˚ ãòƒ £˚ÏÎ˚ Ìy˚ÏÑ¸⁄¢Ç!«¸Æ v¸z_Ó˚!¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V ãß√£yÓ˚ Á õ¸ì%¸ƒ£yÓ˚ Ñ¸y˚ÏÑ¸ Ó˚Ïú ÓƒyÖƒy Ñ¸Ó˚&ò– S2V ïyÓ˚í«¸õì¸y Ñ¸y˚ÏÑ¸ Ó˚Ïú⁄S3V õyòÓfl¸∫yfl¸iƒ Á ¸ô! Ó˚˚ÏÓ˚ÏüÓ˚ ¢¡ôÑ≈¸ ÓƒyÖƒy Ñ¸Ó˚&ò– S4V AIDS ¢Çe´õí !Ñ¸¶¸y˚ÏÓ £Î˚ Á ì¸yÓ˚ ≤Ã!ì¸Ñ¸yÓ˚ ¢¡ô˚ÏÑ≈¸ !úÐ%ò– S5V õï%˚Ïõ£ ˆÓ˚y˚ÏÜÓ˚ ≤Ã!ì¸˚ÏÓ˚yï ÓƒÓfl¸iy=!ú xy˚ÏúyâÈòy Ñ¸Ó˚ – NSOU ? AE-ES-21 ? 141

v¸z_Ó˚ ¢Ç˚ÏÑ¸ì¸ !òÓ≈yâ¸ò !¶¸!_Ñ¸ ≤ÃŸ¿ ≠ S1V (iii) 121 ˆÑ¸y!›¸ S2V (i) Ñ¸˚Ïõ Îy˚ÏÓ S3V (iii) Î"y S4V (iv) ELISA S5V (iv) ¢ÓÑ¸!›¸ 7.8 ¢ £yÎ˚Ñ¸ @˘Ãs¸iyÓú# Agrawal, K. M., Sikdar, P. K. & Deb, S. C. (2002). A Textbook of Environment (1st ed.). Macmillan India Limited. Barrick, M., Barrett, G. W. & Odum, E. P. (2005) Fundamentals of Ecology (5th ed.) Cengage. Basu, M., Xavier, S. (2016). Fundamentals of Environmental Studies. Cambridge University Press. Bharucha, E. (2003). Textbook of Environmental Studies for UG Courses (2nd ed.). Unisersities press (India) Private Limited. Bhattacharya, K., Ghosh, A. K., Hati, G. (2017). A Textbook of Botany (1st ed.). New Central Book Agency (NCBA) Government of India (2011). Census of India (Provisional). New Delhi, Ministry of Information and Broadcasting. Park, K. (2005). Park's Textbook of Priventive and Social Medicine (18th ed.). M/s. banarasidas Bhanot. Rajagopalan, R. (2011), Environmental Studies from Crisis to Cure (2nd ed.). Oxford University Press. Tripathi, A. K. (2018). Environmental Studies Multiple Choice Questions. TERI Press. Study Material (2019). NSOU, Environmental Studies (BDP), 33th, Reprint. ———————— 142 ? NSOU ? AE-ES-21

NOTES NSOU ? AE-ES-21 ? 143

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Submitted text As student entered the text in the submitted document.

Matching text As the text appears in the source.

1/200 **SUBMITTED TEXT** 7 WORDS **100%** **MATCHING TEXT** 7 WORDS

ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ÇK¸y [Definition of Environment] 1.3 ¸ô!
Ó˚ˆÏÓˆÏüÓ˚ ˆ◊!

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2/200 **SUBMITTED TEXT** 6 WORDS **100%** **MATCHING TEXT** 6 WORDS

ÏÓ– 1.2 ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¢ÇK¸y (Definition of Environment) ¸ô!
Ó˚ˆ

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3/200 **SUBMITTED TEXT** 8 WORDS **85%** **MATCHING TEXT** 8 WORDS

Ñ¸ˆÏÓ˚ ¸ô!Ó˚ˆÏÓüˆÏÑ¸ î%!›¸ ≤Ãïyò ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y

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4/200 **SUBMITTED TEXT** 6 WORDS **78%** **MATCHING TEXT** 6 WORDS

Ó!¶¸ß¨ v¸z¸ôyîyò=!úÓ˚ õˆÏïƒ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡ôÑ≈¸

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5/200 **SUBMITTED TEXT** 6 WORDS **64%** **MATCHING TEXT** 6 WORDS

ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ¸ô!Ó˚Óì≈¸ò £Î˚ – ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!
Ó˚ˆ

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6/200 **SUBMITTED TEXT** 11 WORDS **39%** **MATCHING TEXT** 11 WORDS

Ó!¶¸ß¨ xM¸ÈˆÏúÓ˚ ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓü !Ó!¶¸ß¨– ≤ÃyÑ,¸!
ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ ì¸yÓ˚ì¸õƒ ãúÓyÎ˚%ñ õy!›¸ñ

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7/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí ˆÓˆ

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8/200 **SUBMITTED TEXT** 10 WORDS **52%** **MATCHING TEXT** 10 WORDS

ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚ v¸z¸ôyîyò¢õ)£ 12 ? NSOU ? AE-ES-21 ≤ÃyÑ,¸!ì¸Ñ¸ ¸ô!Ó˚ˆÏÓˆÏüÓ˚

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9/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

Î˚ ¢Ó v¸z¸ôÑ¸Ó˚í ¸ôyÁÎ˚y ÎyÎ˚ ~£

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10/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

Ïò!ì¸Ñ¸ Ñ¸yÎ≈Ñ¸úy¸ôˆÏÑ¸ Ó˝

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

11/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

v¸z¸ô!fl¸i!ì¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú–

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12/200 **SUBMITTED TEXT** 4 WORDS **83%** **MATCHING TEXT** 4 WORDS

ƒhs¸Ó˚#í Á xyhs¸ã≈y!ì¸Ñ¸ ãú¸ô!Ó˚

ƒhs¸Ó˚#í Á xyhs¸ã≈y!ì¸Ñ¸ òì%¸ò ¸ô!Ó˚!

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

13/200 **SUBMITTED TEXT** 7 WORDS **88%** **MATCHING TEXT** 7 WORDS

ô,¤¸ ˆÌˆÏÑ¸ ≤ÃyÎ˚ 10ñ000 !Ñ¸ˆÏúy!õ›¸yÓ˚ ¸ôÎ≈hs¸ !Óhfl+¸ì¸ ˆ

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14/200 **SUBMITTED TEXT** 7 WORDS **78%** **MATCHING TEXT** 7 WORDS

yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ – ÎÌyÈÙÙÙÈ SÑ¸V Ó˚y¢yÎ˚!òÑ¸

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15/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

â¸yÓ˚!›¸ v¸z¸ô!Ó¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y

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16/200 **SUBMITTED TEXT** 3 WORDS **79%** **MATCHING TEXT** 3 WORDS

ΔˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ñ fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ñ
ˆõˆÏ¢y!fl¸≥¸Î˚yÓ˚

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17/200 **SUBMITTED TEXT** 6 WORDS **88%** **MATCHING TEXT** 6 WORDS

ÌyˆÏõ≈y!fl¸≥¸Î˚yÓ˚ Óy xyÎ˚ ˆÏòy!fl¸≥¸Î˚yÓ˚ñ ~ˆÏ:y!fl¸≥¸Î˚yÓ˚ Á
õƒyÜˆÏòˆÏ›¸y!fl¸≥¸Î˚yÓ˚

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18/200 **SUBMITTED TEXT** 4 WORDS **70%** **MATCHING TEXT** 4 WORDS

ΔˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ Á fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ ~

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19/200 **SUBMITTED TEXT** 3 WORDS **87%** **MATCHING TEXT** 3 WORDS

ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ Á ˆõˆÏ¢y!fl¸≥¸Î˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

20/200 **SUBMITTED TEXT** 5 WORDS **71%** **MATCHING TEXT** 5 WORDS

ÌyˆÏõ≈y!fl¸≥¸Î˚yÓ˚ Óy xyÎ˚ ˆÏòy!fl¸≥¸Î˚yÓ˚ É ˆõˆÏ¢y¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

21/200 **SUBMITTED TEXT** 11 WORDS **50%** **MATCHING TEXT** 11 WORDS

üÑ≈¸Ó˚y ãyì¸#Î˚ Öyîƒ ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚ Îy ≤Ãyí#Ñ%¸ú Öyîƒ !£
¢yˆÏÓ @˘Ã£í Ñ¸ˆÏÓ˚ ~

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

22/200 **SUBMITTED TEXT** 7 WORDS **93%** **MATCHING TEXT** 7 WORDS

õ›¸yÓ˚ v¸zFâ¸ì¸y Ó‚!k¸Ó˚ ¢yˆÏÌ ¢yˆÏÌ ì¸y¸ôõyey £…

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

23/200 **SUBMITTED TEXT** 5 WORDS **68%** **MATCHING TEXT** 5 WORDS

ΔˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ (iv) ˆõˆÏ¢y¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

24/200	**SUBMITTED TEXT** 3 WORDS	**87%** **MATCHING TEXT** 3 WORDS
	ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ Á ˆõˆÏ¢y!fl¸≥¸Î˚	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

25/200	**SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
	ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S4V	ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚%ò– S6V

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

26/200	**SUBMITTED TEXT** 6 WORDS	**100%** **MATCHING TEXT** 6 WORDS
	ì¸ ¢¡ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚y £ˆÏÎ˚ ˆÏäÈ– 2.2 ≤	ì¸ ¢¡ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚y £ ˆÏäÈ–

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

27/200	**SUBMITTED TEXT** 5 WORDS	**54%** **MATCHING TEXT** 5 WORDS
	∆ˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ (iv) ÌyÓ˚ˆÏõy!fl¸≥¸Î˚yÓ˚	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

28/200	**SUBMITTED TEXT** 5 WORDS	**54%** **MATCHING TEXT** 5 WORDS
	∆ˆÏ¸ôy!fl¸≥¸Î˚yÓ˚ (iii) fl¸T…ƒyˆÏ›¸y!fl¸≥¸Î˚yÓ˚ (iv) ÌyÓ˚ˆÏõy!fl¸≥¸Î˚yÓ˚	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

29/200	**SUBMITTED TEXT** 11 WORDS	**78%** **MATCHING TEXT** 11 WORDS
	Ó˚ v¸z¸ôÓ˚ !¶¸!_ Ñ¸ ˆÏÓ˚ ¢¡ôîˆÏÑ¸ 2!›¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ñ ˜	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

30/200	**SUBMITTED TEXT** 12 WORDS	**79%** **MATCHING TEXT** 12 WORDS
	Ó˚ v¸z¸ôÓ˚ !¶¸!_ Ñ¸ ˆÏÓ˚ ¢¡ôîˆÏÑ¸ 2!›¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ñ ÎÌyÈÙÙÙÈ	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

31/200	**SUBMITTED TEXT** 4 WORDS	**87%** **MATCHING TEXT** 4 WORDS
	õ!îò#¸ô%Ó˚ñ Ó§yÑ%¸v¸¸y Á ¸ô%Ó˚&!	

SA Debabrata Roy_Subhashis Halder_Drama_Banglar_Lokonatye_Chhukri.pdf (D129246634)

32/200	SUBMITTED TEXT	5 WORDS	100%	MATCHING TEXT	5 WORDS
	òˆÏ¡¨ xyˆÏúyâ¸òy Ñ¸Ó˚y £úÈÙÙÙÈ S1V ¢				

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

33/200	SUBMITTED TEXT	7 WORDS	54%	MATCHING TEXT	7 WORDS
	ô!Ó˚Ñ¸"òy @˘Ã£í Ñ¸Ó˚y £ˆÏÎ˚ˆÏäÈ ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ £			ô!Ó˚° ÏˆÏîÓ˚ Ñ¸ Ñ ¸Î˚ ¶)¸!õÑ¸òˆÏÎ˚ˆÏäÈò ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ £ˆ	

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

34/200	SUBMITTED TEXT	4 WORDS	95%	MATCHING TEXT	4 WORDS
	ô!Ó˚Ó£ò ÓƒÓfl¸iy v¸zß¨ì¸ Ñ¸Ó˚				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

35/200	SUBMITTED TEXT	7 WORDS	76%	MATCHING TEXT	7 WORDS
	Ó Ñ¸yˆÏã ÓƒÓ£yÓ˚ Ñ¸Ó˚ˆÏì¸ £ˆÏÓñ ˆÎ¢Ó Ñ¸				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

36/200	SUBMITTED TEXT	5 WORDS	96%	MATCHING TEXT	5 WORDS
	ÏÎ˚Ó˚ v¸z¸ôÓ˚ =Ó˚&c xyˆÏÓ˚y¸ô Ñ¸ˆÏÓ˚				

SA Geography-CC-1.1.pdf (D142516024)

37/200	SUBMITTED TEXT	6 WORDS	100%	MATCHING TEXT	6 WORDS
	ÓˆÏâ¸ˆÏÎ˚ Ñ¸õ ÖÓ˚ˆÏâ¸ ¢ÓˆÏâ¸ˆÏÎ˚ ˆÓ!ü				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

38/200	SUBMITTED TEXT	4 WORDS	100%	MATCHING TEXT	4 WORDS
	ú xyˆÏúyâ¸òy Ñ¸Ó˚&ò– v¸z_Ó˚ ¢			ú xyˆÏúyâ¸òy Ñ¸Ó˚%ò– 114 23.10 v¸z_Ó˚	

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

39/200	SUBMITTED TEXT	6 WORDS	80%	MATCHING TEXT	6 WORDS
	äÈyv¸¸y !fl¸i!ì¸ü#ú v¸zß¨Î˚ò ¢Ω¸Ó òÎ˚ – [8]				

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

40/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

ô!Ó˚ˆÏÓˆÏüÓ˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ !e´Î˚

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

41/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸yÓ˚ !¶¸!_ˆÏì¸£

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

42/200 **SUBMITTED TEXT** 4 WORDS **88%** **MATCHING TEXT** 4 WORDS

v¸z¸ôyîyò ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ !e´Î˚yÈÙÈ≤Ã!ì¸!e´Î˚yÓ˚ õyïƒˆÏõ ¢%

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

43/200 **SUBMITTED TEXT** 5 WORDS **85%** **MATCHING TEXT** 5 WORDS

õˆÏïƒ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡ôÑ≈¸ ÜˆÏv¸¸ ÁˆÏ‡¸– 4. Óylfl¸ì¸ˆ

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

44/200 **SUBMITTED TEXT** 6 WORDS **88%** **MATCHING TEXT** 6 WORDS

òˆÏ¡¨ ¢ÇˆÏ«¸ˆÏ¸ô xyˆÏúyâ¸òy Ñ¸Ó˚y £ú– 3.4.1

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

45/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

î%£z ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y £Î˚ÈÙÙÈ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

46/200 **SUBMITTED TEXT** 6 WORDS **65%** **MATCHING TEXT** 6 WORDS

Óylfl¸ì¸ˆÏs¸fÓ˚ Ñ¸yÎ≈Ñ¸y!Ó˚ì¸yÓ˚ v¸z¸ôÓ˚ !¶¸!_ Ñ¸ˆÏÓ˚ !

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

47/200 **SUBMITTED TEXT** 9 WORDS **61%** **MATCHING TEXT** 9 WORDS

v¸z¸ôyîyò ¢ã#Ó v¸z¸ôyîyò x˜ÏãÓ v¸z¸ôyîyò ˜ãÓ v¸z¸ôyîyò
ˆ¶¸Ôì¸ v¸z¸ôyîyò

SA Geography-CC-1.1.pdf (D142516024)

48/200 **SUBMITTED TEXT** 10 WORDS **61%** **MATCHING TEXT** 10 WORDS

Ñ¸yÓ≈ò v¸y£zx:y£zv¸ (CO 2) @˘Ã£í Ñ¸ˆÏÓ˚ ~ÓÇ ¢)Î≈yˆÏúyÑ¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

49/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

ÏÑ¸ !ò¡¨!ú!Öì¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y Îyΰ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

50/200 **SUBMITTED TEXT** 5 WORDS **88%** **MATCHING TEXT** 5 WORDS

ÏÑ¸ !ò¡¨!ú!Öì¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y Îyΰ ÈÙÙÙÈ v¸

SA Geography-CC-1.1.pdf (D142516024)

51/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

v¸zÍ¸ôyîˆÏÑ¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú–

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

52/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

v¸zÍ¸ôyîˆÏÑ¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

53/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

v¸zÍ¸ôyîˆÏÑ¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#ú

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

54/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

Ïì¸ Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ ì¸yˆÏîÓ˚ !

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

55/200 **SUBMITTED TEXT** 6 WORDS **78%** **MATCHING TEXT** 6 WORDS

Ó!¶¸ß¨ v¸z¸ôyîyò=!úÓ˚ õˆÏïƒ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡ôÑ≈¸ !

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

56/200 **SUBMITTED TEXT** 5 WORDS **90%** **MATCHING TEXT** 5 WORDS

v¸z!qî Á ≤Ãyí#Ó˚ ¸ôyÓ˚fl¸ô!Ó˚Ñ¸ ¢¡

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

57/200 **SUBMITTED TEXT** 6 WORDS **68%** **MATCHING TEXT** 6 WORDS

Óylfl¸ì¸ˆÏs¸fÓ˚ v¸zÍ¸ôyîòü#úì¸y (Productivity of Ecosystem)
Óylfl¸ì¸ˆÏs¸fÓ˚ ≤

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

58/200 **SUBMITTED TEXT** 5 WORDS **92%** **MATCHING TEXT** 5 WORDS

ü!_´ˆÏÑ¸ Ó˚y¢yÎ˚!òÑ¸ ü!_´ˆÏì¸ Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ ~

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

59/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ó˚y¢yÎ˚!òÑ¸ ü!_´ˆÏì¸ Ó˚*¸ôyhs¸!Ó˚ì¸ £

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

60/200 **SUBMITTED TEXT** 5 WORDS **80%** **MATCHING TEXT** 5 WORDS

yˆÏúyÑ¸¢ÇˆÏŸ'°Ï ≤Ã!e´Î˚yÎ˚ ˆ¢ÔÓ˚ü!_´ @ˇÃ£í Ñ¸ˆÏÓ˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

61/200 **SUBMITTED TEXT** 6 WORDS **89%** **MATCHING TEXT** 6 WORDS

yˆÏÑ¸ Ó˚y¢yÎ˚!òÑ¸ ü!_´ˆÏì¸ Ó˚*¸ôyhs¸!Ó˚ì¸ Ñ¸ˆÏÓ˚ – ~£

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

62/200 **SUBMITTED TEXT** 5 WORDS **90%** **MATCHING TEXT** 5 WORDS

Ó˚y ≤Ãì¸ƒ«¸ Óy ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ @ˇÃ£

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

63/200 **SUBMITTED TEXT** 5 WORDS **61%** **MATCHING TEXT** 5 WORDS

Ñ¸ˆÏÓ˚ òy– Ñ¸yÓ≈òñ òy£zˆÏ›¸ΔyˆÏãòñ x!:ˆÏãòñ ö¸¢ö¸Ó˚y¢

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

64/200 **SUBMITTED TEXT** 8 WORDS **85%** **MATCHING TEXT** 8 WORDS

Ïãò â¸e´ñ x!:ˆÏãò â¸e´ñ ö¸¢ö¸Ó˚y¢ â¸e´ñ ¢yúö¸yÓ˚ â¸e´ !

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

65/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

Óˆ Ïü°Ï¶¸yˆÏÓ v¸zˆÏÕ'ÖˆÏÎyÜƒ– !

Óˆ Ïü°Ï¶¸yˆÏÓ v¸zˆÏÕ'ÖˆÏÎyÜƒ ≠

W http://yojana.gov.in/Dec-19-PDF.pdf

66/200 **SUBMITTED TEXT** 8 WORDS **67%** **MATCHING TEXT** 8 WORDS

òˆÏ¡¨ Ñ¸yÓ≈ò â¸e´ ~ÓÇ òy£zˆÏ›¸ΔyˆÏãò â¸e´ xyˆÏúyâ¸òy
Ñ¸Ó˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

67/200 **SUBMITTED TEXT** 4 WORDS **84%** **MATCHING TEXT** 4 WORDS

Ñ¸yÓ≈òñ Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zv¸ Ó˚*ˆÏ¸ô

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

68/200 **SUBMITTED TEXT** 5 WORDS **90%** **MATCHING TEXT** 5 WORDS

Ñ¸yÓ≈ò v¸y£zx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí Ó‚!k¸ ¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

69/200 **SUBMITTED TEXT** 6 WORDS **54%** **MATCHING TEXT** 6 WORDS

Ñ¸yÓ≈ò v¸y£zx:y£zv¸ !òÜ≈ì¸ £Î˚– Ñ¸yÓ≈ò v¸y£zx:y£zˆÏv¸Ó˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

70/200 **SUBMITTED TEXT** 6 WORDS **83%** **MATCHING TEXT** 6 WORDS

òy£zˆÏ›¸Δ›¸ ˆÌˆÏÑ¸ òy£zˆÏ›¸ΔyˆÏãò @˘Ã£í Ñ¸ˆÏÓ˚ ˆ≤

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

71/200 **SUBMITTED TEXT** 6 WORDS **58%** **MATCHING TEXT** 6 WORDS

zˆÏ›¸ΔyˆÏ¢yˆÏõyòy¢V ≤Ã¶¸yˆÏÓ ãy!Ó˚ £ˆÏÎ˚ òy£zˆÏ›¸ΔˆÏ›¸ ¸ô!
Ó˚îì¸ £Î˚– òy£zˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

72/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

ÏÑ¸ òy£z!›¸∆!ö¸ ˆÏÑ¸üò (Nitrification) ÓˆÏú–

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

73/200 **SUBMITTED TEXT** 6 WORDS **75%** **MATCHING TEXT** 6 WORDS

Î˚ ì¸yˆÏÑ¸ !v¸ÈÙÈòy£z!›¸∆!ö¸ ˆÏÑ¸üò (Denitrification) ÓˆÏú–

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

74/200 **SUBMITTED TEXT** 13 WORDS **52%** **MATCHING TEXT** 13 WORDS

Ó˚y£zˆÏãy!ÓÎ˚yõ òyõÑ¸ ~Ñ¸≤ÃÑ¸yÓ˚ ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚y
Ó¢Óy¢ Ñ¸ˆÏÓ˚– ~£z ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚y=!ú ≤Ãì¸ƒ«¸¶¸yˆÏÓ
õ,!_Ñ¸y!fl¸ìì¸ òy£zˆÏ›¸∆yˆÏãò @˘Ã£í Ñ¸ˆÏÓ˚ ì¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

75/200 **SUBMITTED TEXT** 6 WORDS **100%** **MATCHING TEXT** 6 WORDS

Î˚ – ≤Ãyí# ~ÓÇ v¸z!qˆÏîÓ˚ õ,ì%¸ƒÓ˚ ¸ôÓ˚ ì¸yˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

76/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S5V	ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚%ò– S6V

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

77/200 **SUBMITTED TEXT** 4 WORDS **91%** **MATCHING TEXT** 4 WORDS

òy£z!›¸∆ö¸y£zÇ ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚yÓ˚ Sòy£zˆÏ›¸∆yˆÏ¢yˆÏõyòy¢

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

78/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

òy£z!›¸∆ö¸y£zÇ ÓƒyÑ¸ˆÏ›¸!Ó˚Î˚y

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

79/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

Ó!¶¸ß¨ì¸y ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚ – ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

80/200	**SUBMITTED TEXT**	5 WORDS	**100%**	**MATCHING TEXT**	5 WORDS
v¸z¸ô!fl¸i!ì¸ ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚ – ˆ					

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

81/200	**SUBMITTED TEXT**	7 WORDS	**100%**	**MATCHING TEXT**	7 WORDS
ã¡ø% Á Ñ¸yŸ¬#Ó˚ñ !£õyâ¸ú ≤Ãˆïîüñ					

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

82/200	**SUBMITTED TEXT**	3 WORDS	**100%**	**MATCHING TEXT**	3 WORDS
Óy!°Ï≈Ñ¸ Ó‚!‹T¸ôyˆÏì¸Ó˚ ¸ô!Ó˚					

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

83/200	**SUBMITTED TEXT**	5 WORDS	**87%**	**MATCHING TEXT**	5 WORDS
y ÎyÎ˚ – ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £			y £Î˚ ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £		

J 85194d5c-26ee-44ef-b2f6-622bc663b182

84/200	**SUBMITTED TEXT**	4 WORDS	**100%**	**MATCHING TEXT**	4 WORDS
ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £			ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £ˆ		

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

85/200	**SUBMITTED TEXT**	3 WORDS	**100%**	**MATCHING TEXT**	3 WORDS
v¸z!qˆÏîÓ˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ü#					

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

86/200	**SUBMITTED TEXT**	7 WORDS	**100%**	**MATCHING TEXT**	7 WORDS
Ñ¸!›¸ =Ó˚&c¸ô)í≈ ¶)¸!õÑ¸y ¸ôyúò Ñ¸ˆÏÓ˚ â¸ˆÏúˆÏäÈ– 4.7					

SA Indrani-Bhattacharya_AsishKumarDas_History_Swadhin Bharater Chaa Shilpo_ PhD Final.pdf (D129738480)

87/200	**SUBMITTED TEXT**	4 WORDS	**100%**	**MATCHING TEXT**	4 WORDS
ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £			ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £ˆ		

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

88/200 **SUBMITTED TEXT** 4 WORDS **76%** **MATCHING TEXT** 4 WORDS

Ãì¸ƒ«¸ ~ÓÇ ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ õyò%ˆÏ°ÏÓ˚ â¸y!£

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

89/200 **SUBMITTED TEXT** 6 WORDS **100%** **MATCHING TEXT** 6 WORDS

õ)úì¸ â¸yÓ˚!›¸ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚

SA Indrani-Bhattacharya_AsishKumarDas_History_Swadhin Bharater Chaa Shilpo_ PhD Final.pdf (D129738480)

90/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

v¸zˆÏÕ'ÖˆÏÎyÜƒ ¶)¸!õÑ¸y @˘Ã£í Ñ¸ˆÏÓ˚ –

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

91/200 **SUBMITTED TEXT** 4 WORDS **76%** **MATCHING TEXT** 4 WORDS

ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸yÎ˚ Ü!‡¸ì¸ ~Ñ¸ ¢%

ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸y !â¸!£´ì¸ Ñ¸

W https://cdn1.byjus.com/wp-content/uploads/2019/10/West-Bengal-Class-4-syllabus_bengali.pdf

92/200 **SUBMITTED TEXT** 2 WORDS **100%** **MATCHING TEXT** 2 WORDS

ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸yÓ˚

ôyÓ˚fl¸ô!Ó˚Ñ¸ !ò¶≈¸Ó˚ü#úì¸yÓ˚

W https://cdn1.byjus.com/wp-content/uploads/2019/10/West-Bengal-Class-4-syllabus_bengali.pdf

93/200 **SUBMITTED TEXT** 6 WORDS **100%** **MATCHING TEXT** 6 WORDS

Ó˚ ≤ÃÑ,¸!ì¸Ó˚ v¸z¸ôÓ˚ !ò¶≈¸Ó˚ Ñ¸ˆÏÓ˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

94/200 **SUBMITTED TEXT** 6 WORDS **83%** **MATCHING TEXT** 6 WORDS

Ó˚ ~Ñ¸!›¸ =Ó˚&c¸ô)í≈ v¸z¸ôyîyòñ Ñ¸yÓ˚í ~!›¸ ≤

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

95/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

Ñ¸yÓ≈òÈÙÈv¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

96/200 **SUBMITTED TEXT** 3 WORDS **95%** **MATCHING TEXT** 3 WORDS

ì¸ã!‹;¸Î˚ ¸ôîyˆÏÌ≈Ó˚ v¸z¸ô!fl¸i!ì¸

SA Geography-CC-1.1.pdf (D142516024)

97/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

xyˆÏúyÑ¸ Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚y

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

98/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

ÇˆÏ«¸ˆÏ¸ô v¸zˆÏÕ'Ö Ñ¸Ó˚y £ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

99/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

v¸zÍ¸ôß¨ Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ £ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

100/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

xyˆÏúyÑ¸ Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚yÓ˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

101/200 **SUBMITTED TEXT** 10 WORDS **100%** **MATCHING TEXT** 10 WORDS

yú!ö¸v¸z!Ó˚Ñ¸ xƒy!¢v¸ (H 2 SO 4) ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

102/200 **SUBMITTED TEXT** 8 WORDS **52%** **MATCHING TEXT** 8 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ £…y¢ Ñ¸ˆÏÓ˚ !Ó÷k¸ x!:ˆÏãò
v¸zÍ¸ôß¨ Ñ¸ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

103/200 **SUBMITTED TEXT** 3 WORDS **90%** **MATCHING TEXT** 3 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí xfl¸∫y¶¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

104/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£z ˆÏv¸Ó˚ ¸ô!Ó˚õyí Ó,!k¸ ¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

105/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

v¸z¸ôÓ˚ «¸!ì¸Ñ¸Ó˚ ¸≤Ã¶¸yÓ ˆö¸ˆÏú

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

106/200 **SUBMITTED TEXT** 7 WORDS **96%** **MATCHING TEXT** 7 WORDS

õy£ze´ò ˆÌˆÏÑ¸ 3 õy£ze´ò ¸ôÎ≈hs¸ £ˆÏì¸ ¸ôyˆÏÓ˚ –

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

107/200 **SUBMITTED TEXT** 7 WORDS **96%** **MATCHING TEXT** 7 WORDS

õy£ze´ò ˆÌˆÏÑ¸ 1 õy£ze´ò ¸ôÎ≈hs¸ £ˆÏì¸ ¸ôyˆÏÓ˚ – 5.2.3

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

108/200 **SUBMITTED TEXT** 10 WORDS **100%** **MATCHING TEXT** 10 WORDS

yú!ö¸v¸z!Ó˚Ñ¸ xƒy!¢v¸ (H 2 SO 3) ˜ì¸!Ó˚ Ñ¸ˆÏÓ˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

109/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ äÈyv¸ ¸y ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

110/200 **SUBMITTED TEXT** 10 WORDS **62%** **MATCHING TEXT** 10 WORDS

Ó˚ ¢y£yˆÏÎƒ ~õò ¸ôk¸!ì¸ xÓú¡∫ò Ñ¸Ó˚y £ˆÏÓ ÎyÓ˚ ö¸ˆÏú

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

111/200 **SUBMITTED TEXT** 4 WORDS **95%** **MATCHING TEXT** 4 WORDS

yÓ˚ v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

112/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí £...y¢ ¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

113/200 **SUBMITTED TEXT** 8 WORDS **70%** **MATCHING TEXT** 8 WORDS

y£zˆÏv»¸yˆÏãò Á ~Ñ¸ ¸ôÓ˚õyí% x!:ˆÏãò myÓ˚y Ü!‡¸ì¸ ~

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

114/200 **SUBMITTED TEXT** 6 WORDS **80%** **MATCHING TEXT** 6 WORDS

ì¸y ~ÖyˆÏò ¢ÇˆÏ«¸ˆÏ¸ô xyˆÏúyâ¸òy Ñ¸Ó˚y £ú–

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

115/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

v¸zˆÏÕ'ÖˆÏÎyÜƒ ¶)¸!õÑ¸y ¸ôyúò Ñ¸ˆÏÓ˚ –

SA Indrani-Bhattacharya_AsishKumarDas_History_Swadhin Bharater Chaa Shilpo_ PhD Final.pdf (D129738480)

116/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

v¸z!qî Á ≤Ãyí#Ó˚ ˆî£yÓˆÏü°Ï–

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

117/200 **SUBMITTED TEXT** 7 WORDS **100%** **MATCHING TEXT** 7 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ Á ãú v¸zÍ¸ôß¨ £Î˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

118/200 **SUBMITTED TEXT** 3 WORDS **100%** **MATCHING TEXT** 3 WORDS

yÓ≈òñ Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

119/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ñ¸w#Î˚ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈

Ñ¸w#Î˚ î)°Ïí !òÎ˚s¸fí ¸ô°Ï≈

W http://yojana.gov.in/Dec-19-PDF.pdf

120/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

ì¸y ¸ô!Ó˚õy¸ô Ñ¸Ó˚y £Î˚ –

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

121/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

y ~ ¢¡∫ˆÏı¸ !Óhfl¸y!Ó˚ì¸ xyˆÏúyâ¸òy Ñ¸

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

122/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

xy£zò Ñ¸yÎ≈Ñ¸Ó˚# Ñ¸Ó˚yÓ˚ ˆ«¸ˆÏe

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

123/200 **SUBMITTED TEXT** 6 WORDS **62%** **MATCHING TEXT** 6 WORDS

ô!Ó˚ˆÏüyïˆÏòÓ˚ Ñ¸ˆÏÎ˚Ñ¸!›¸ ¸ôk¸!ì¸ ~ÖyˆÏò xyˆÏúyâ¸òy Ñ¸Ó˚y
£ú– ¸ô!Ó˚

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

124/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ó¢ÓyˆÏ¢Ó˚ v¸z¸ôÎ%_´ ¸ô!Ó˚ˆÏÓü

SA Indrani-Bhattacharya_AsishKumarDas_History_Swadhin Bharater Chaa Shilpo_ PhD Final.pdf (D129738480)

125/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ v¸zÍ¸ôß¨ £Î˚ –

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

126/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

ñ xyˆÏõ!Ó˚Ñ¸y Î%_´Ó˚y‹T... (21%)

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

127/200 **SUBMITTED TEXT** 6 WORDS **78%** **MATCHING TEXT** 6 WORDS

ôˆÏÓ˚Ó˚ A hfl¸Ó˚ ˆÌˆÏÑ¸ ˆïÔì¸ÈÙÈ≤Ã!e´Î˚yÎ˚ (

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

128/200	**SUBMITTED TEXT**	4 WORDS	**66%** **MATCHING TEXT**	4 WORDS
ô!Ó˚ ˆÏÓˆÏü ˆïÔì¸ÈÙ≤Ã!e´Î˚yÎ˚ x¸ô¢y!Ó˚ì¸ ~				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

129/200	**SUBMITTED TEXT**	3 WORDS	**84%** **MATCHING TEXT**	3 WORDS
ôîyˆÏÌ≈Ó˚ ¸ô!Ó˚õyˆÏíÓ˚ Á¸ôÓ˚ !ò¶≈¸Ó˚ü#ú– ¢				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

130/200	**SUBMITTED TEXT**	6 WORDS	**100%** **MATCHING TEXT**	6 WORDS
Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ ~			Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚	

W https://banglarshiksha.gov.in/readwrite/Online_Teacher_Training/Bridge%20Book/Bridge%20Combined%2 ...

131/200	**SUBMITTED TEXT**	6 WORDS	**87%** **MATCHING TEXT**	6 WORDS
Ó˚ ~›¸y Ö%Ó =Ó˚&c¸ô)í≈ñ Ñ¸yÓ˚í ~				

SA Geography-CC-1.1.pdf (D142516024)

132/200	**SUBMITTED TEXT**	6 WORDS	**100%** **MATCHING TEXT**	6 WORDS
Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ (			Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚	

W https://banglarshiksha.gov.in/readwrite/Online_Teacher_Training/Bridge%20Book/Bridge%20Combined%2 ...

133/200	**SUBMITTED TEXT**	8 WORDS	**88%** **MATCHING TEXT**	8 WORDS
Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ òy Ñ¸ˆÏÓ˚ ˜			Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ Ñ¸ˆÏÓ˚ 5000 ›¸	

W https://banglarshiksha.gov.in/readwrite/Online_Teacher_Training/Bridge%20Book/Bridge%20Combined%2 ...

134/200	**SUBMITTED TEXT**	8 WORDS	**58%** **MATCHING TEXT**	8 WORDS
òy£zˆÏ›¸ΔyˆÏãò ˆÎÔÜ õy!›¸Ó˚ ¸ô%!‹T Ó‚!k¸ˆÏì¸ ¢y£yÎƒ Ñ¸ˆÏÓ˚– !				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

135/200	**SUBMITTED TEXT**	6 WORDS	**100%** **MATCHING TEXT**	6 WORDS
ÏÑ¸ !Ó!¶¸ß¨ ¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y £Î˚				

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

136/200	**SUBMITTED TEXT**	6 WORDS	**100%**	**MATCHING TEXT**	6 WORDS
Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ Ñ¸!			Ó˚y¢yÎ˚!òÑ¸ ¢yÓ˚ Á Ñ¸#›¸òyüÑ¸ ÓƒÓ£yÓ˚ Ñ¸ˆ		

W https://banglarshiksha.gov.in/readwrite/Online_Teacher_Training/Bridge%20Book/Bridge%20Combined%2 ...

137/200	**SUBMITTED TEXT**	4 WORDS	**100%**	**MATCHING TEXT**	4 WORDS
Ñ¸w#Î˚ ï)°Ïí !òÎ˚s¸fí ¸ô°Ï≈			Ñ¸w#Î˚ ï)°Ïí !òÎ˚s¸fí ¸ô°Ï≈		

W http://yojana.gov.in/Dec-19-PDF.pdf

138/200	**SUBMITTED TEXT**	5 WORDS	**100%**	**MATCHING TEXT**	5 WORDS

Ó˚ì¸y Ó‚!k¸Ó˚ ¢yˆÏÌ ¢yˆÏÌ ¶)¸!

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

139/200	**SUBMITTED TEXT**	6 WORDS	**95%**	**MATCHING TEXT**	6 WORDS

ôk¸!ì¸ xò%¢Ó˚í Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ ≠ (

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

140/200	**SUBMITTED TEXT**	4 WORDS	**100%**	**MATCHING TEXT**	4 WORDS

Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – v¸z¸ôˆÏÓ˚y_´

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

141/200	**SUBMITTED TEXT**	5 WORDS	**75%**	**MATCHING TEXT**	5 WORDS

Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – v¸z¸ôÎ%_´ òÜÓ˚ ¸ô!Ó˚Ñ¸“

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

142/200	**SUBMITTED TEXT**	4 WORDS	**100%**	**MATCHING TEXT**	4 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí Ó‚!k¸ £

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

143/200	**SUBMITTED TEXT**	7 WORDS	**57%**	**MATCHING TEXT**	7 WORDS

Ñ¸yÓ≈ò v¸y£zÈÙÈx:y£zv¸ˆÏÑ¸ ãˆÏú oÓ#¶)¸ì¸ Ñ¸ˆÏÓ˚ Îy
Ñ¸yÓ≈!òÑ¸ xƒy!¢ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

144/200 **SUBMITTED TEXT** 6 WORDS **68%** **MATCHING TEXT** 6 WORDS

Ñ¸yÓ≈òÈ v¸y£zÈÙÈx:y£zˆÏv¸Ó˚ ¸ô!Ó˚õyí x!ì¸!Ó˚_´ Ó,!k¸Ó˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

145/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ã!ì¸Ñ¸yˆÏÓ˚Ó˚ ~Ñ¸õye v¸z¸ôyÎ˚ £

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

146/200 **SUBMITTED TEXT** 6 WORDS **76%** **MATCHING TEXT** 6 WORDS

ì¸y¸ôõyey ¢£ƒ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ÷ï% ì¸yÓ˚y£

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

147/200 **SUBMITTED TEXT** 7 WORDS **61%** **MATCHING TEXT** 7 WORDS

SUBMITTED TEXT	MATCHING TEXT
yˆÏÓ Ñ¸Ó˚y £ˆÏÎ˚ ÌyˆÏÑ¸ ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ £	yˆÏã ¢!Ñ ¸Î˚ ¶)¸!õÑ¸y !òˆÏÎ˚ˆÏäÈò ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ £ˆ

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

148/200 **SUBMITTED TEXT** 12 WORDS **55%** **MATCHING TEXT** 12 WORDS

Ó˚ v¸z¸ôÓ˚ !¶¸!_ Ñ¸ ˆÏÓ˚ Ñ¸!‡¸ò Óã≈ƒ ¸ôîyÌ≈ˆÏÑ¸ 3!›¸ ¶¸yˆÏÜ
¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ –

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

149/200 **SUBMITTED TEXT** 6 WORDS **76%** **MATCHING TEXT** 6 WORDS

Ãì¸ƒ«¸ Óy ¸ôˆÏÓ˚y«¸¶¸yˆÏÓ õyò%ˆÏ°ÏÓ˚ ¶)¸!õÑ¸y

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

150/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

v¸zîy£Ó˚í !£¢yˆÏÓ Óúy ˆÎˆÏì¸ ¸ôyˆÏÓ˚

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

151/200 **SUBMITTED TEXT** 7 WORDS **76%** **MATCHING TEXT** 7 WORDS

ô!Ó˚õyí Î!î xˆÏòÑ¸ ˆÓ!ü ÌyˆÏÑ¸ ì¸ˆÏÓ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

152/200

SUBMITTED TEXT 6 WORDS	**78%** **MATCHING TEXT** 6 WORDS
Ñ¸ä%È ¸ôîˆÏ«¸¸ô ¢¡ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚y £	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

153/200

SUBMITTED TEXT 8 WORDS	**96%** **MATCHING TEXT** 8 WORDS
Ïò ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ v¸zÍ¸ô!_ £Î˚ ì¸yˆÏÑ¸ ¶)¸!õÑ¸ ˆÏ¡ôÓ˚ ˆÑ¸w ~	

SA Geography-CC-1.1.pdf (D142516024)

154/200

SUBMITTED TEXT 5 WORDS	**75%** **MATCHING TEXT** 5 WORDS
ÏÓ ¶)¸¸ô,ˆÏ¤¸Ó˚ Á¸ôˆÏÓ˚Ó˚ fl¸iyò!›¸ˆÏÑ¸ ¶)¸!õÑ¸ ˆÏ¡ôÓ˚	

SA Geography-CC-1.1.pdf (D142516024)

155/200

SUBMITTED TEXT 10 WORDS	**50%** **MATCHING TEXT** 10 WORDS
Ó˚ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ~ÓÇ xy£zò myÓ˚y ì¸y Óyïƒì¸yõ)úÑ¸ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ – ?	Ó¶¸yÜ Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ ~ÓÇ xy£zò ≤ÃˆÏÎ˚yˆÏÜÓ˚ ˆ«¸ˆÏe ≤ÃˆÏ¶¸î Ñ¸Ó˚ˆÏì¸ ¸ôyˆÏÓ˚ –

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

156/200

SUBMITTED TEXT 5 WORDS	**100%** **MATCHING TEXT** 5 WORDS
õÑ¸ ˆÏ¡ôÓ˚ ì¸#Ó ì¸y õy¸ôy £Î˚ – ¸	

SA Geography-CC-1.1.pdf (D142516024)

157/200

SUBMITTED TEXT 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S2V	ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚%ò– S6V

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

158/200

SUBMITTED TEXT 3 WORDS	**100%** **MATCHING TEXT** 3 WORDS
e´yhs¸#Î˚ Á v¸z¸ôe´yhs¸#Î˚ xM¸Èˆ	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

159/200

SUBMITTED TEXT 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S5V ¶)¸!	ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚%ò– S6V

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

160/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

Óy!v˛¸ ˜ì˛!Ó˚Ó˚ xò%õ!ì˛ ˆîÁÎ˚y

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

161/200 **SUBMITTED TEXT** 9 WORDS **73%** **MATCHING TEXT** 9 WORDS

xyÜyõ# üì˛y∑#ˆÏì˛ ˛ô,!ÌÓ#Ó˚ ì˛y˛ôõyey ≤ÃyÎ˚ 36° ˆ¢ú!¢Î˚y¢
ˆÓˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

162/200 **SUBMITTED TEXT** 3 WORDS **95%** **MATCHING TEXT** 3 WORDS

xyˆÏõ!Ó˚Ñ˛y £zv˛zˆÏÓ˚yˆÏ˛ô ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

163/200 **SUBMITTED TEXT** 6 WORDS **88%** **MATCHING TEXT** 6 WORDS

xyˆÏúyÑ˛ Ó˚y¢yÎ˚!òÑ˛ !Ó!e´Î˚y á!›˛ˆÏÎ˚ ¢yúö˛yÓ˚È v˛y£

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

164/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Á òy£zˆÏ›˛∆yˆÏãˆÏòÓ˚ ˛ô!Ó˚õyí ¢!‡˛

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

165/200 **SUBMITTED TEXT** 5 WORDS **89%** **MATCHING TEXT** 5 WORDS

x:y£zv˛=!ú xyˆÏúyÑ˛ Ó˚y¢yÎ˚!òÑ˛ !Ó!e´Î˚yÓ˚

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

166/200 **SUBMITTED TEXT** 9 WORDS **82%** **MATCHING TEXT** 9 WORDS

òy£z!›˛∆Ñ˛ xƒy!¢v˛ (HNO 3) Á ¢yú!ö˛v˛z!Ó˚Ñ˛ xƒy!¢v˛
xƒyú%!õ!

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

167/200 **SUBMITTED TEXT** 9 WORDS **97%** **MATCHING TEXT** 9 WORDS

Ñ˛ˆÏÓ˚ – ? òy£z!›˛∆Ñ˛ xƒy!¢v˛ Á ¢yú!ö˛v˛z!Ó˚ xƒy!¢v˛
ÓyÎ˚%õ[˛ˆÏú ?

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

168/200 **SUBMITTED TEXT** 4 WORDS **88%** **MATCHING TEXT** 4 WORDS

õˆÏü ÌyÑ¸y £y£zˆÏv»¸yˆÏÑœ¸y!Ó˚Ñ¸ xƒy!¢

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

169/200 **SUBMITTED TEXT** 6 WORDS **89%** **MATCHING TEXT** 6 WORDS

yú!ö¸v¸z!Ó˚Ñ¸ xƒy!¢v¸ ~ÓÇ òy£z!›¸ΔÑ¸ xƒy!¢v¸– ~£

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

170/200 **SUBMITTED TEXT** 6 WORDS **100%** **MATCHING TEXT** 6 WORDS

ÏÑ¸ !ì¸ò¶¸yˆÏÜ ¶¸yÜ Ñ¸Ó˚y ÎyÎ˚ ÎÌyÈÙÙÙÈ ??(

SA Geography-CC-1.1.pdf (D142516024)

171/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ó˚y¢yÎ˚!òÑ¸ !Ó!e´Î˚yÓ˚ õyïƒˆÏõ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

172/200 **SUBMITTED TEXT** 5 WORDS **82%** **MATCHING TEXT** 5 WORDS

Óì¸≈õyˆÏò xyˆÏõ!Ó˚Ñ¸y Î%_´Ó˚y‹T… Á Ñ¸

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

173/200 **SUBMITTED TEXT** 6 WORDS **100%** **MATCHING TEXT** 6 WORDS

ÏäÈò ì¸yÓ˚ õˆÏïƒ v¸zˆÏÕ‘ÖˆÏÎyÜƒ £ú ˆ

SA Koushik Roy_Debasis Mondal_Instrumental Dept_Uttar Bharatiya Lok....pdf (D154556271)

174/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

ì¸Ó˚ Ñ¸yÓ˚í £ˆÏÎ˚ îßy!v¸¸ˆÏÎ˚ ˆÏäÈ– ˆ¶¸

ì¸Ó˚ Ñ¸yÓ˚í £ˆÏÎ˚ îßy!v¸¸ˆÏÎ˚ ˆÏäÈ

W http://yojana.gov.in/Dec-19-PDF.pdf

175/200 **SUBMITTED TEXT** 5 WORDS **95%** **MATCHING TEXT** 5 WORDS

Ó˚&c¸ô)í≈ ¶)¸!õÑ¸y @˘Ã£í Ñ¸ˆÏÓ˚– ~£z ¢ˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

176/200 **SUBMITTED TEXT** 10 WORDS	**80%** **MATCHING TEXT** 10 WORDS
xò%õyò Ñ¸Ó˚y ÎyˆÏFäÈ ˆÎ xyÜyõ# 2050 ˆÌˆÏÑ¸ 2070 ¢yˆÏúÓ˚ õˆÏïƒ	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

177/200 **SUBMITTED TEXT** 9 WORDS	**100%** **MATCHING TEXT** 9 WORDS
y£zÈÙÈx:y£zv¸ (CO 2)ñ !õˆÏò (CH 4)ñ	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

178/200 **SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
ÏÑ¸Á v¸zˆÏ¸ô«¸y Ñ¸Ó˚y £ˆ	ÏÑ¸Á v¸zˆÏ¸ô«¸y Ñ¸Ó˚y £

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

179/200 **SUBMITTED TEXT** 6 WORDS	**95%** **MATCHING TEXT** 6 WORDS
ÓƒÓ£yÓ˚ Ñ¸Ó˚y £Î˚ – ~äÈyv¸¸y Óy!v¸¸Ó˚	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

180/200 **SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
xyˆÏ®yúò ÜˆÏv¸¸ v¸zˆÏ‡¸ ˆÏäÈ– ì¸	

SA MA in History SEM II (CBCS Mode).pdf (D142514392)

181/200 **SUBMITTED TEXT** 11 WORDS	**52%** **MATCHING TEXT** 11 WORDS
ô!Ó˚ˆÏÓü Ó˚«¸y Á v¸zß¨!ì¸ !Óïyˆ Ïò ~ÓÇ Óòƒ Á ¸Óòƒ≤Ãyí# Ó˚«¸yÎ˚ Ó˚	ô!Ó˚ˆÏÓü ¢ÇÓ˚«¸í Á v¸zß¨!ì¸!Óïyò ~ÓÇ Óò Á Óòƒ≤Ãyí#Ó˚ ÎlyÎÌ Ó˚«¸

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

182/200 **SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
v¸z¸ôÓ˚ =Ó˚&c xyˆÏÓ˚y¸ô Ñ¸ˆÏÓ˚ ¶¸	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

183/200 **SUBMITTED TEXT** 9 WORDS	**62%** **MATCHING TEXT** 9 WORDS
õì¸y ˆÑ¸w ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ £yˆÏì¸ ˆîÁÎ˚y £ˆÏÎ˚ ˆÏäÈ– ? ˆÑ¸w ¢Ó˚Ñ¸yÓ˚ ¸	õì¸y ˆÑ¸w#Î˚ 101 ¢Ó˚Ñ¸yˆÏÓ˚Ó˚ £yˆÏì¸ ì%¸ˆÏú ˆîÎ˚ – ~Öyˆ Ïò ˆÑ¸w#Î˚ ¢Ó˚Ñ¸yÓ˚ ¢

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

184/200 **SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
Ñ¸w#Î˚ ì)°Ïí !òÎ˚s¸fí ¸ô°Ï≈	Ñ¸w#Î˚ ì)°Ïí !òÎ˚s¸fí ¸ô°Ï≈

W http://yojana.gov.in/Dec-19-PDF.pdf

185/200 **SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ 1927 ¢	ì¸yˆÏîÓ˚ õˆÏïƒ v¸zˆÏÕ'ÖˆÏÎyÜƒ £ˆ

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

186/200 **SUBMITTED TEXT** 4 WORDS	**87%** **MATCHING TEXT** 4 WORDS
xy£zò!›¸ Ñ¸yÎ≈Ñ¸Ó˚ Ñ¸Ó˚y £Î˚– ¸ô!Ó˚ˆ	

SA MA in History SEM II (CBCS Mode).pdf (D142514392)

187/200 **SUBMITTED TEXT** 10 WORDS	**44%** **MATCHING TEXT** 10 WORDS
ô xyˆÏúyâ¸òy Ñ¸Ó˚&ò– S5V ÁˆÏãyò hfl¸Ó˚ !ÓòyˆÏüÓ˚ Ñ¸yÓ˚í=!ú xyˆÏúyâ¸òy Ñ¸Ó˚&ò– v¸z_Ó˚ ¢	ôˆÏÑ≈¸ xyˆÏúyâ¸òy Ñ¸Ó˚%ò– SÜV !Ó!¶¸ˆÜyú ˆ›¸!Óú ˜Ó‡¸Ñ¸Ü%!úÓ˚ ≤Ãhfl¸yÓ Ñ¸# !äÈú xyˆÏúyâ¸òy Ñ¸Ó˚%ò– 19.9 v¸z_Ó˚

W http://www.wbnsou.ac.in/online_services/SLM/BDP/EPA-02.pdf

188/200 **SUBMITTED TEXT** 6 WORDS	**100%** **MATCHING TEXT** 6 WORDS
Óy£zˆÏÓ˚ !òˆÏÎ˚ ÎyÁÎ˚y ÎyˆÏÓ òy– ? ¢	

SA B Ed Part I Bengali Total Book 03.09.2016.pdf (D142650100)

189/200 **SUBMITTED TEXT** 5 WORDS	**91%** **MATCHING TEXT** 5 WORDS
Ó˚yãƒ ¢Ó˚Ñ¸yÓ˚ ˆÑ¸w ¢Ó˚Ñ¸yˆÏÓ˚Ó˚	

SA MA in History SEM II (CBCS Mode).pdf (D142514392)

190/200 **SUBMITTED TEXT** 7 WORDS	**88%** **MATCHING TEXT** 7 WORDS
ô!Ó˚Óì≈¸ò ú«¸ƒ Ñ¸Ó˚y ÎyÎ˚– ˆÎõòÈÙÙÙÈ 2011 ¢yˆÏú	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

191/200 **SUBMITTED TEXT** 4 WORDS	**100%** **MATCHING TEXT** 4 WORDS
Á õ,ì%¸ƒ£yˆÏÓ˚Ó˚ õˆÏïƒ ¸ôyì≈Ñ¸ƒˆ	

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

192/200 **SUBMITTED TEXT** 6 WORDS **95%** **MATCHING TEXT** 6 WORDS

ÌˆÏÑ¸ 2011 ¢y˜ÏúÓ˚ õ˜Ïïƒ ãò¢ÇÖƒy Ó‚!k¸ ˆ ¸ôˆ

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

193/200 **SUBMITTED TEXT** 3 WORDS **95%** **MATCHING TEXT** 3 WORDS

Ó‚!k¸ˆÏÑ¸ cÓ˚y!ß∫ì¸ Ñ¸ˆÏÓ˚ˆÏäÈ– ¢ˆÏÓ≈

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

194/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ó˚Ñ¸y!Ó˚ Á ˆÓ¢Ó˚Ñ¸y!Ó˚ ¢

SA Indrani-Bhattacharya_AsishKumarDas_History_Swadhin Bharater Chaa Shilpo_ PhD Final.pdf (D129738480)

195/200 **SUBMITTED TEXT** 11 WORDS **42%** **MATCHING TEXT** 11 WORDS

ôMÈ¸Óy!°Ï≈Ñ¸# ¸ô!Ó˚Ñ¸“òy˜Ïì¸ ãß√£yÓ˚ 35 ˆÌˆÏÑ¸ 32ˆì¸ òy!
õˆÏÎ˚ xyòyÓ˚ ¸ô!Ó˚Ñ¸“òy ˆòÁÎ˚y £Î˚ –

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

196/200 **SUBMITTED TEXT** 4 WORDS **100%** **MATCHING TEXT** 4 WORDS

Ó˚Ñ¸y!Ó˚ Á ˆÓ¢Ó˚Ñ¸y!Ó˚ ¢

SA Indrani-Bhattacharya_AsishKumarDas_History_Swadhin Bharater Chaa Shilpo_ PhD Final.pdf (D129738480)

197/200 **SUBMITTED TEXT** 6 WORDS **73%** **MATCHING TEXT** 6 WORDS

v¸z¸ô!Ó˚v¸z_´ ¸ôk¸!ì¸ äÈyv¸¸y xyÓ˚Á ~Ñ¸!›¸ Ó˝ú ≤

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)

198/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

ÓƒÓ£yÓ˚ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚ – ? ˆv¸

ÓƒÓ£yÓ˚ Ñ¸Ó˚y ˆÎˆÏì¸ ¸ôyˆÏÓ˚V ? !

W https://cdn1.byjus.com/wp-content/uploads/2019/10/West-Bengal-Class-4-syllabus_bengali.pdf

199/200 **SUBMITTED TEXT** 5 WORDS **100%** **MATCHING TEXT** 5 WORDS

ì¸Ñ¸ñ xÌ≈˜Ïò!ì¸Ñ¸ Á Ó˚yã˜Ïò!ì¸Ñ¸ ¸

SA MA in Political Science SEM II (CBCS Mode).pdf (D142514805)

200/200 **SUBMITTED TEXT** 7 WORDS **100%** **MATCHING TEXT** 7 WORDS

ÏÑ˛ ≤Ãì˛ƒ«˛ Á ˛ôˆÏÓ˚y«˛¶˛yˆÏÓ ≤Ã¶˛y!Óì˛ Ñ˛ˆÏÓ˚– ˛

SA MA in Geography SEM II (CBCS Mode).pdf (D142514677)