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Impact of Aila on the Dissolved Oxygen Level in the Indian Sundarbans Region

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Abstract

The Indian Sundarban delta complex is one of the hot spots of biodiversity in the Indian subcontinent sustaining some 34 species of true mangrove flora. The aquatic phase is saturated with dissolved oxygen (DO) and the average values in the present study area, Ajmalmari (considered on the basis of 3 decades; 1984–2014) are 5.81 ppm, 6.43 ppm and 6.13 ppm in premonsoon, monsoon and postmonsoon seasons respectively. These values include the DO levels during Aila, a supercyclone that hit the West Bengal coast on 25th May 2009. We observed a pronounced variation in an exponential regression equation between the data sets with and without considering the DO level during Aila. Almost similar R^2 values of exponential regression equations during monsoon and postmonsoon phases confirm the anomalous behavior of DO due to cyclonic storms (in premonsoon) in the inshore region of Bay of Bengal.

Keywords: *Indian Sundarbans, Dissolved Oxygen (DO), Aila, R^2*

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INTRODUCTION

Dissolved Oxygen (DO) is one of the most important indicators of aquatic health on which the survival and growth of aquatic organisms depend. The DO levels in the coastal and estuarine waters are controlled by phytoplankton standing stock, microbial decomposition rate, wave actions and tidal amplitude.

The recent pace of urbanization, industrialization, aquaculture practices and commercial tourisms has deteriorated the coastal waters to a great extent. The Indian Sundarbans is no exception to this rule [1–5]. The present paper is an approach to evaluate the temporal variations of DO in Ajmalmari (21°49'42.9"N; 88°37'13.7'E), which is located in the central Indian Sundarbans. We approached to our conclusion with two important questions namely:

(1) Whether the trend of DO is uniform in all the seasons?
(2) Whether any natural disasters like cyclonic storm perturb the normal trendline equation of DO in the present geographical locale?

The results of such study may serve as road map to assess the water quality (in terms of DO) during cyclonic storms.

MATERIALS AND METHODS

The entire network of present study consists of seasonal sampling of water at Ajmalmari (a sampling station in central Indian Sundarbans) for estimating the DO during the high tide phase. Estimation of DO was carried out by Winkler's Method as per the standard protocol [6]. Our analytical method did not change since the last three decades and the results are the mean of triplicate analyses in the selected sampling station.

We developed two sets of data; one considering the DO level during Aila, and the other excluding the DO value of Aila (during 2009 pre-monsoon). The polynomial equations of power six were computed with these two types of data sets to critically analyse the perturbations caused by Aila in the saturation of oxygen in the study area.

RESULTS

The temporal variation of DO in Ajmalmari is presented in Figure 1. The three decade results of DO exhibit lowest values of 5.11 (during premonsoon 2003) and highest value of 7.36 (during premonsoon 2009). The aveage seasonal order of DO follows the sequence monsoon (6.43 ppm) > postmonsoon (6.13 ppm) > premonsoon (5.81 ppm).

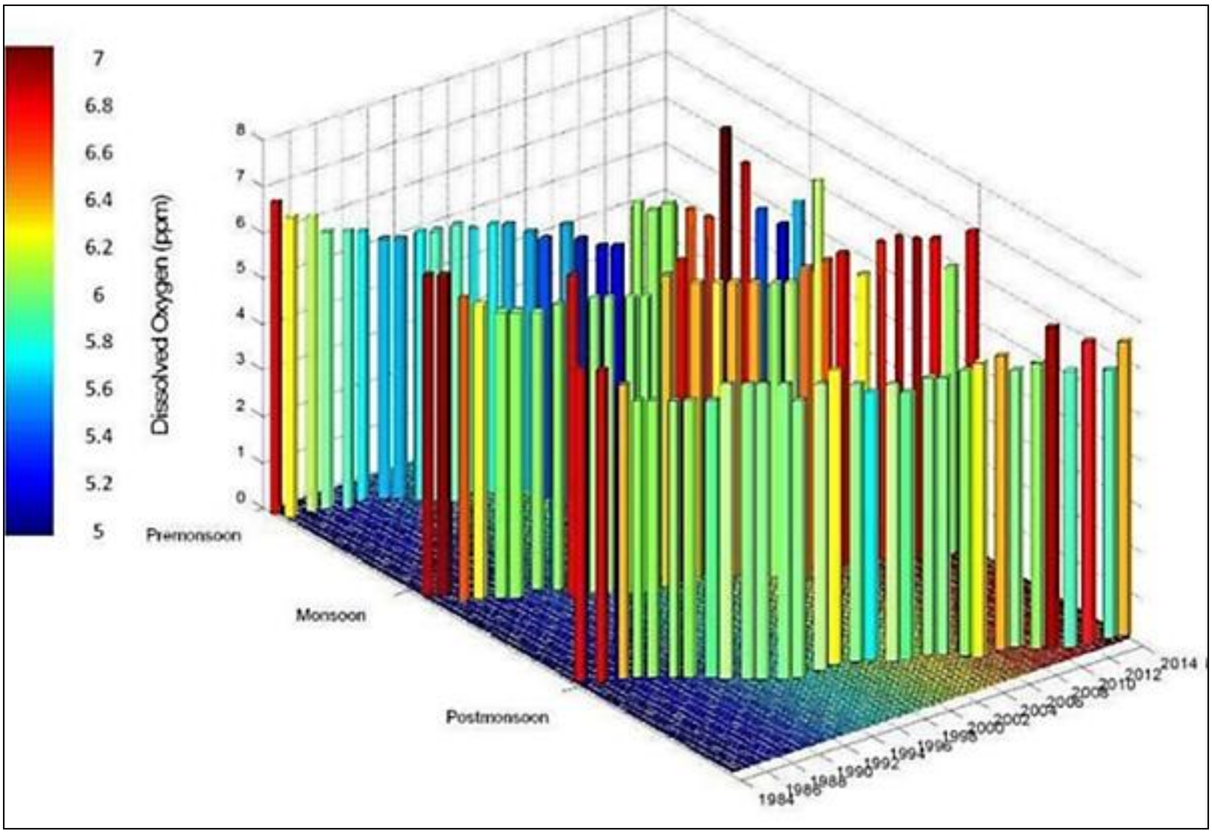

Fig. 1: *Dissolved Oxygen in Ajmalmari During Three Decades.*

Table 1: *Regression Equations Including the Mean DO Value of 2009 Pre-monsoon.*

Season	Equation	R^2
Premonsoon	$y = 4\times10^{-7}x^6 – 0.0045x^5 + 22.603x^4 - 60287x^3 + 9\times10^7x^2 – 7\times10^{10}x + 2\times10^{13}$	0.3917
Monsoon	$y = -3\times10^{-8}x^6 + 0.0003x^5 - 1.676x^4 + 4426.1x^3 - 7\times10^6x^2 + 5\times10^9x - 2\times10^{12}$	0.5385
Postmonsoon	$y = 9\times10^{-8}x^6 - 0.0011x^5 + 5.5374x^4 - 14791x^3 + 2\times10^7x^2 - 2\times10^{10}x + 6\times10^{12}$	0.5199

Table 2: *Regression Equations Excluding the Mean DO Value of 2009 Pre-monsoon.*

Season	Equation	R^2
Premonsoon	$y = 4\times10^{-7}x^6 - 0.0042x^5 + 21.041x^4 - 56107x^3 + 8\times10^7x^2 - 7\times10^{10}x + 2\times10^{13}$	0.5117
Monsoon	$y = -3\times10^{-8}x^6 + 0.0004x^5 - 1.9401x^4 + 5133x^3 - 8\times10^6x^2 + 6\times10^9x - 2\times10^{12}$	0.5219
Postmonsoon	$y = 9\times10^{-8}x^6 - 0.0011x^5 + 5.6756x^4 - 15160x^3 + 2\times10^7x^2 - 2\times10^{10}x + 6\times10^{12}$	0.5156

The sudden rise of DO level during 2009 premonsoon is attributed to Aila, which was a supercyclone that hit the West Bengal coast on 25th May 2009 with a speed of 110 km/hr and the subsequent tidal amplitude hiked up to 8.5 m compared to normal average of 5 m in the study area. This natural disaster is reflected while comparing the exponential regression equations of power six in which the R^2 shows minimum value (R^2= 0.3917) with the inclusion of DO level during Aila indicating the failure of the regression equation to predict the trend of DO in the study area (Tables 1 and 2).

DISCUSSION

The Indian subcontinent is a hotspot of cyclonic depressions through ages [7]. A total of 128 tropical cyclones struck East Coast of India during 1804 to 1999 [8]. In a recent study on numerical simulation of Bay of Bengal circulation from Ocean General Circulation Model, it has been shown that trapping of Kelvin waves in the Central Bay of Bengal may enhance warming of the Central Indian Ocean basin and acts as a potential breeding ground for cyclones [9]. Because of such cyclonic depressions high waves and tidal amplitudes are created which increase the diffusion of atmospheric oxygen in the coastal and esturine waters.

The occurrence of Aila on 25th May 2009 followed this simple route of diffusion because of turbulent wave action. The sudden rise of DO level in the sampling station (Figure 1) during 2009 premonsoon reflects the impact of this super cyclone. Our first order analysis confirms this anomaly in the normal trend of DO when we observe the R^2 values generated from the exponential regression equation analysis considering the data sets of monsoon and postmonsoon. In these two seasons we did not find any pronounced variation in R^2 values considering and without considering the 2009 DO data set.

However, the R^2 value in premonsoon exhibited a sudden fall (R^2= 0.3917) with the inclusion of 2009 DO data confirming the regulatory role of cyclonic depression in altering the water quality. It is thus clear that any model loses its accuracy due to input of non-uniform data of hydrological parameters that are witnessed during tropical cyclones. Such alterations of water quality in terms of DO may have an immediate and long term impact on the biotic community particularly on the fisheries sector. The intrusion of huge quantum of saline water from the adjacent bay (Bay of Bengal in this study) during cyclonic depression has also the possibility of introduction of HAB species in the inshore regions and estuaries that are the extended arms of oceans and seas. Such intrusion may be the cause of mortality of commercial important fishes as reported by several researchers [4, 5].

The present study area is very sensitive in terms of cyclonic depression and any alteration in water quality may have adverse impact on the economic profile in the study area as some 70% of the 4.2 million people in the Indian Sundarbans region depend on the fisheries sector for their livelihood.

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