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Spatio-Temporal Variation of Nitrate in the Lower Gangetic Delta Water

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Abstract: *Nitrate levels in three major stations of Hooghly-Matla estuarine complex have been forecasted on the basis of three decades real time data (1984-2014). The forecast values exhibit enhanced concentrations of nitrate after a period of three decades. The levels of nitrate will be 46.63 µgatm/l, 50.71µgatm/l and 21.68 µgatm/l at Diamond Harbour, Namkhana and Ajmalmari respectively in 2044. The situation seems to be alarming (in context to eutrophication and adverse impact on endemic biodiversity) as the rates of increase are high around 132.98 %, 120.09 % and 97.99 % at Diamond Harbour, Namkhana and Ajmalmari respectively.*

Keywords: *Nitrate, Hooghly-Matla estuarine complex, forecast.*

1. Introduction

Increasing population, extensive agricultural activities and rapid development of urbanization in coastal areas have dramatically increased nitrogen loading to rivers and coastal waters (Seitzinger and Kroeze, 1998; Jennerjahn *et al*., 2004; Umezawa *et al*., 2008). Estuaries play a prominent role for delivery of terrestrially derived nitrogen to coastal water through physical, chemical and biological processes (Mulholland, 1992; Bernhardt *et al*., 2003; Sebilo *et al*., 2006; Hartzell and Jordan, 2012).

The Indian subcontinent has a total population of 1,12,98,66,154 (15% of world's total population) (as per July, 2007) (http://www.the_world_factbook.html), in which 43.3% (approximately 48,94,22,974) is concentrated in the 12 maritime states of India (Table 1). Within 100 km of the coastline 26% of the total maritime's state population (approximately 12,72,49,973) lives (http://country_profiles.pdf), who are directly or indirectly dependent on the coastal and estuarine resources for their livelihood. It has been recorded that about 5,958,744 persons sustain their life through fishery or aquaculture (http://www.coastalpopulation.htm) and the figure of such population in the east coast alone is 9,50,000 (Mitra, 2013).

West Bengal is a maritime state in the north-eastern part of country with a total population of 8,02,21,171, which is 7.1% of the total Indian population (http://census.cenindia.html). The state has mega cities and towns like Kolkata, Howrah and the newly emerging Haldia industrial zone, which are noted for their intense industrialization and urbanization (Mitra, 2013). The huge load of sewage and industrial discharges from these cities and towns reach Bay of Bengal in the southern most part of the state through the conveyer system of rivers and estuaries that are concentrated in the deltaic complex of Indian Sundarbans. This mangrove dominated deltaic complex is noted for its unique genetic diversity and has been declared as the World Heritage Site (1987) and received the status of Biosphere Reserve by UNESCO under Man and Biosphere (MAB) Programme (1989). The anthropogenic load discharged on this mangrove matrix and adjoining water bodies has high probability to create an adverse impact on the positive health of the ecosystem. 'Dead zones' due to low dissoved oxygen triggered by excessive nitrate level may be formed, which may bring mortality to fishes and other aquatic lives. Several workers have pointed out the negative role of unplanned industrialization and urbanization on the aquatic system of Sundarbans particularly on plankton (Banerjee *et al.*, 2000), fishes (Bhattacharyya *et al*., 2000) and molluscan community (Mitra *et al.*, 1993). On this background the main objectives of the present programme are to evaluate the current situation of nitrate and forecast the values of this nutrient considering 1984 as the baseline year.

Table1. *Population of maritime state of India*

Sl. No	Name of State	Population
1.	Gujrat	5,05,96,992
2.	Maharastra	9,67,52,247
3.	Goa	13,43,998
4.	Karnataka	5,27,33,958
5.	Kerala	3,18,38,619
6.	Tamilnadu	6,21,10,839
7.	Andhra Pradesh	7,57,27,541
8.	Orissa	3,67,06,920
9.	West Bengal	8,02,21,171
10.	Pandicherry	9,73,829
11.	Andaman and Nicober Island	3,56,265
12.	Lakshadweep Island	60,595
	Total	48,94,22,974

Source: *http://cyberjournalist.org.in/census_cenindia.html*

2. MATERIALS AND METHODS

The entire prediction on nitrate level in the coming three decades stands on the secondary data collected and compiled since 1984. More than three decades of real time data (1984-2014) were compiled from the archives of the Department of Marine Science, University of Calcutta. A number of studies on different aspects of Indian Sundarbans have been published over the years, which include description of the data (and methods) at different times for more than three decades (Chakraborty and Choudhury, 1985; Mitra *et al*., 1987; Mitra *et al*, 1992; Mitra and Choudhury, 1994; Saha *et al*., 1999; Banerjee *et al*., 2002; Banerjee *et al.*, 2003; Mondal *et al.*, 2006; Mitra *et al.*, 2009; Mitra, 2013; Banerjee *et al.*, 2013; Sengupta *et al.*, 2013; Mitra and Zaman, 2014; Mitra and Zaman, 2015). Finally time series analysis was performed to forecast the trend of nitrate on the basis of the past 30 years' real-time data. Exponential smoothing method produces maximum-likelihood estimates and can reflect the future trend of nitrate, which has been used in this paper to visualize the status in 2044.

3. RESULT

During the tenure of three decades (1984-2014), lowest value of nitrate was 9.44 µgatm/l (during premonsoon 1984 at Ajmalmari) and the highest value was 48.15 µgatm/l (during monsoon 2009 at Namkhana). The nitrate peak observed in 2009 premonsoon, irrespective of sampling stations, is the effect of Aila, which was a super cyclone that passed the study area with a speed of some 110 km/hr. The spatial order of nitrate is Diamond Harbour > Namkhana > Ajmalmari. The forecast method predicts the averge nitrate values to be 46.62 µgatm/l, 50.71 µgatm/l and 21.68 µgatm/l at Diamond Harbour, Namkhana and Ajmalmari respectively during 2044 (Figures 1-9). These forecast values are the average of three seasons.

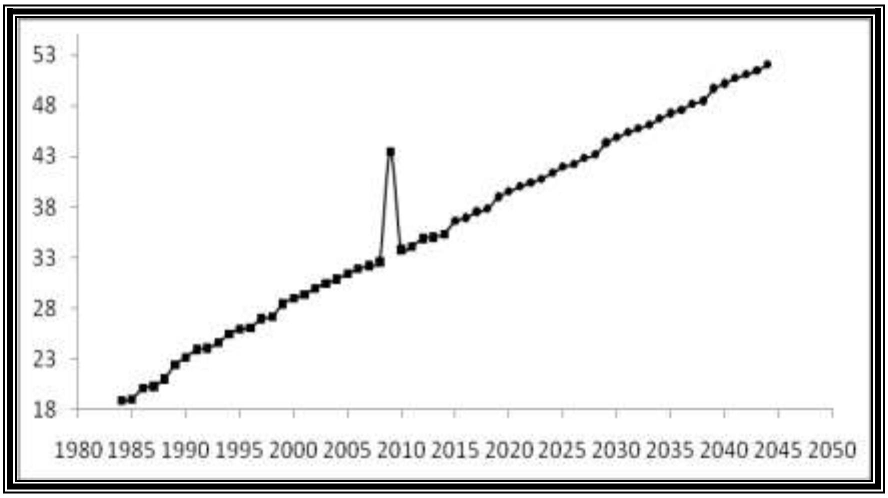

Figure1. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during premonsoon at Diamond Harbour*

Figure2. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during monsoon at Diamond Harbour*

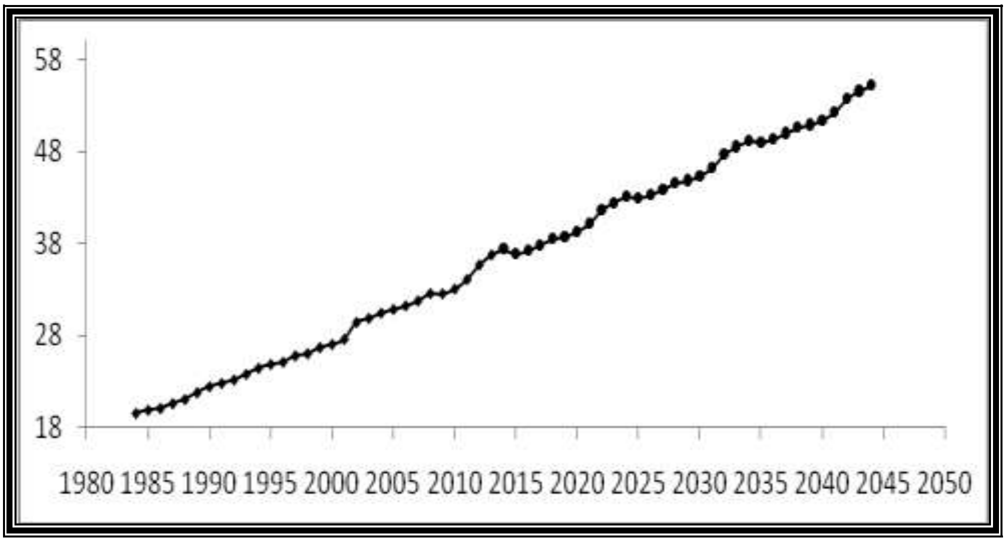

Figure3. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during postmonsoon at Diamond Harbour*

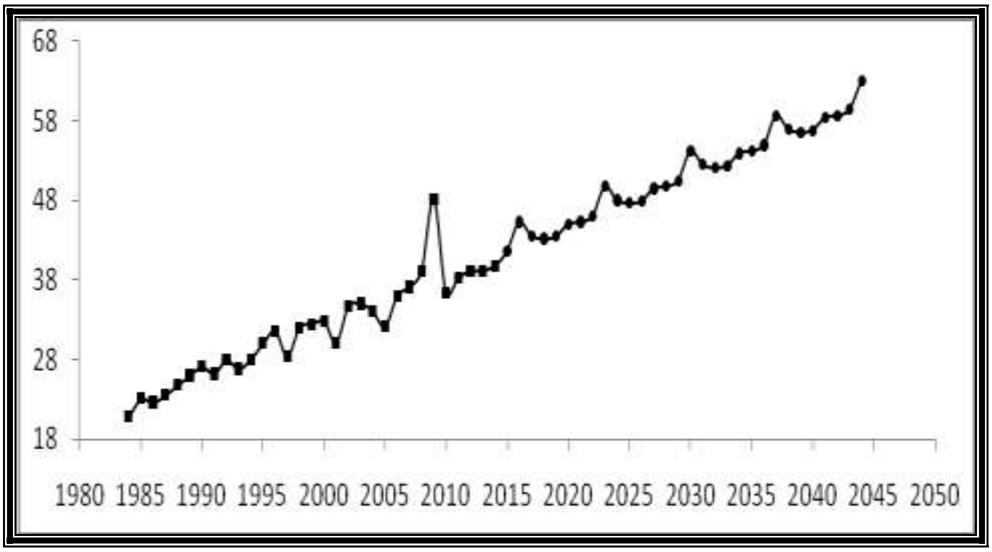

Figure4. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during premonsoon at Namkhana*

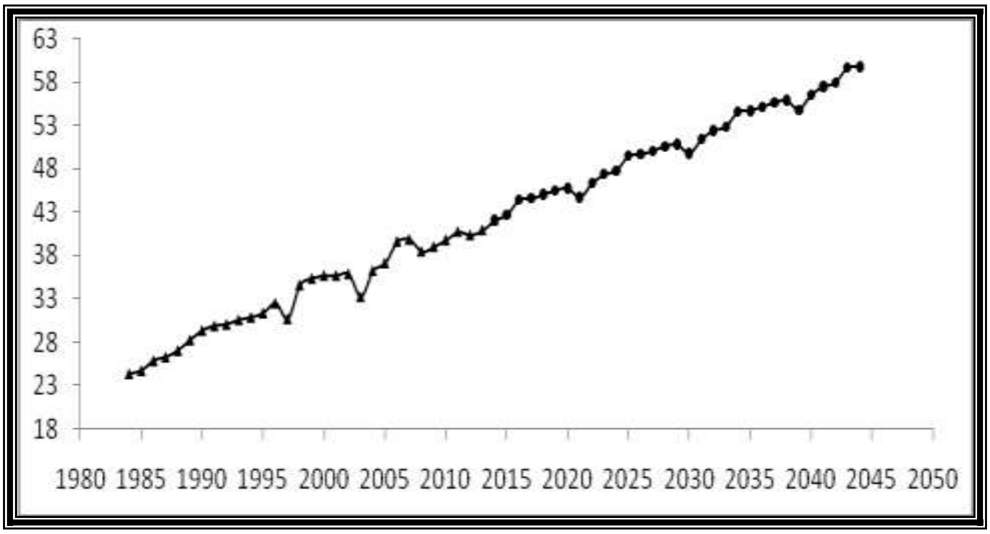

Figure5. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during monsoon at Namkhana*

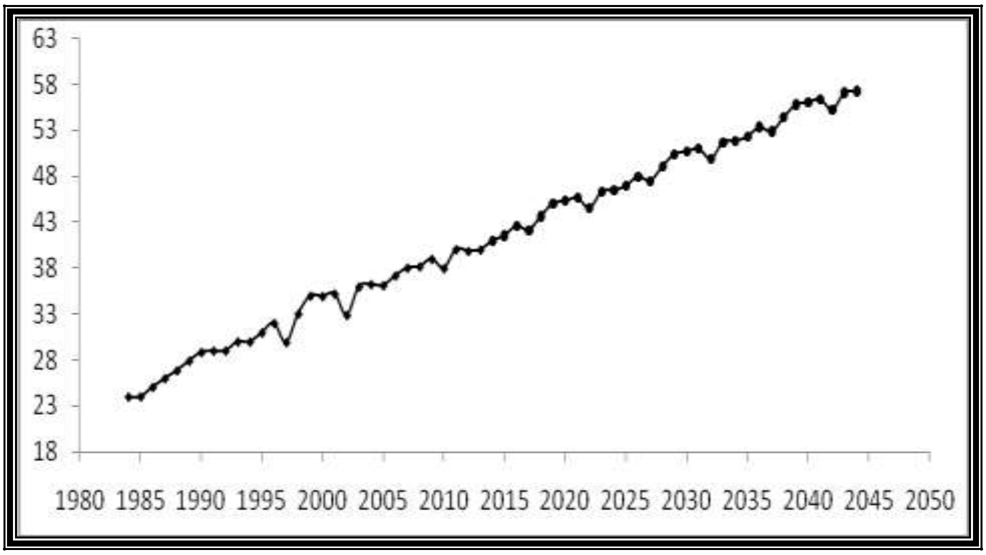

Figure6. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during postmonsoon at Namkhana*

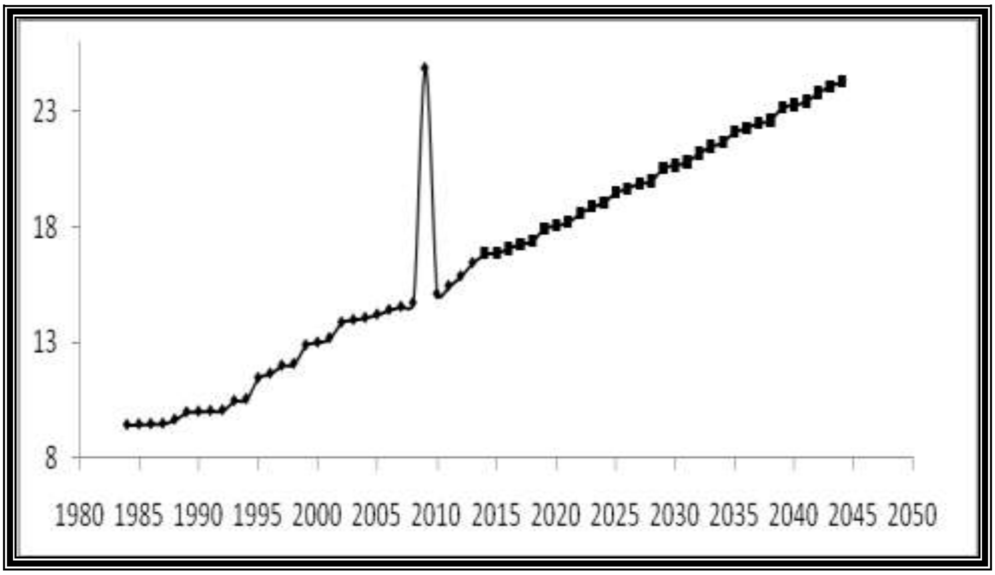

Figure7. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during premonsoon at Ajmalmari*

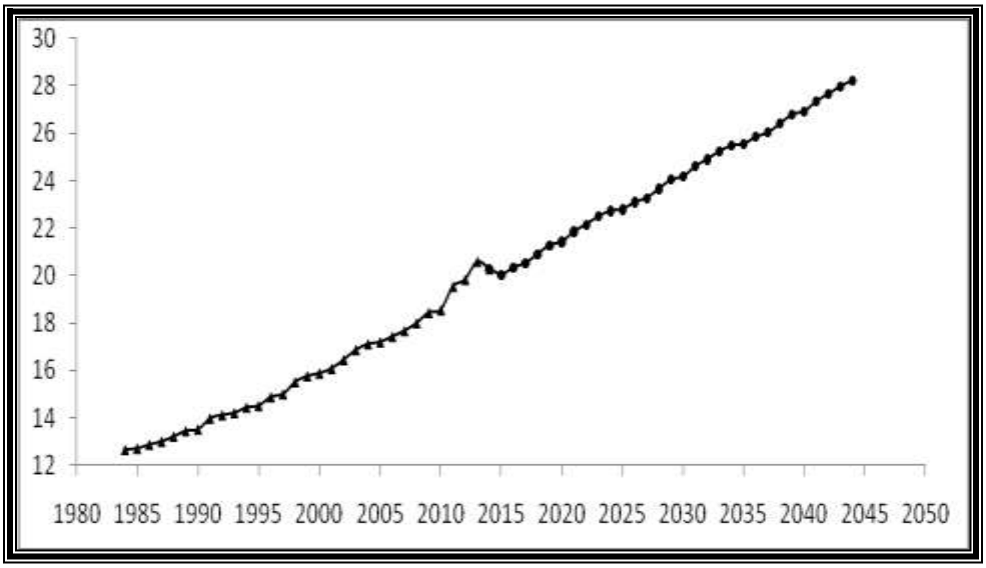

Figure8. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during monsoon at Ajmalmari*

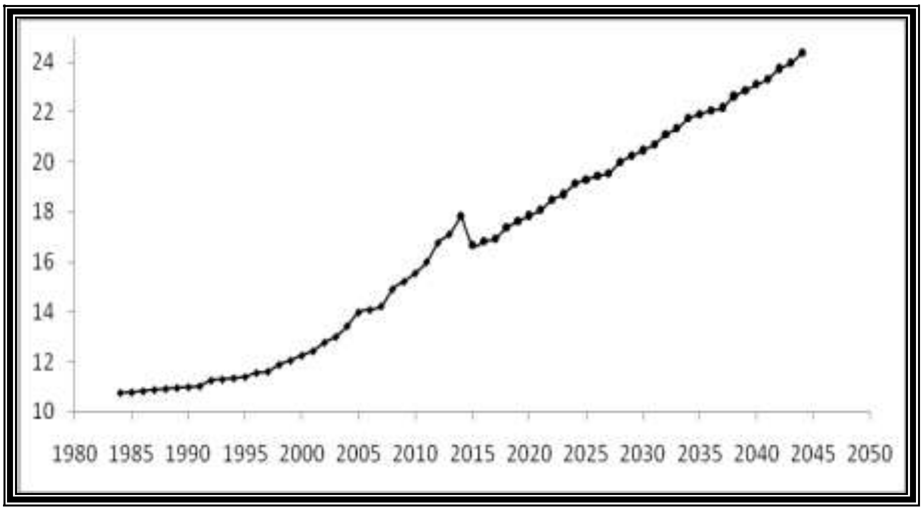

Figure9. *Temporal variation of nitrate real time data (1984-2014) and forecast data (2015-2044) during postmonsoon at Ajmalmari*

4. DISCUSSION

The enhancement of nutrients in the aquatic phase in and around Indian Sundarbans has both natural and anthropogenic origin. The main sources of nutrient input in the present study area are run-off from adjacent landmasses (Mitra, 2013), erosion and leaching (Mitra *et.al*, 2009), sewage from the cities of Kolkata, Howrah and Haldia port-cum-industrial complex (Mitra and Choudhury,1993; Mitra, 1998; Bhattacharya *et.al*, 2013), wastes from shrimp farms (Mitra and Zaman, 2015) etc. Nitrate in the present study area exhibits a significant spatial variation with highest values at Namkhana and lowest at Ajmalmari. The presence of highly urbanized city of Kolkata and Haldia port-cum-industrial complex may be the major contributors of nitrate in the aquatic phase of Diamond Harbour. In the waters of Namkhana, the primary sources of nitrate are shrimp farms and wastes from fish landing stations. Ajmalmari, located adjacent to the reserve forest area is exposed to minimum anthropogenic stress. The presence of nitrate in this station may be sourced from mangrove detritus.

5. CONCLUSION

An influx and abundance of nitrates in estuarine waters cause phytoplankton bloom, which in turn triggers low-oxygen ‘dead zones’ in the aquatic system. There is high probability of occurrence of such ‘dead zone’ in near future as revealed from the forcast values of nitrate in all the selected stations. Along with more optimal use of fertilizer and creation of biological treatment plants for shrimp farms and fish landing stations, strategically reconstructing Combined Effluent Treatment Plants (CETP) in adjacent cities and towns could help reduce the nitrate level in the estuarine waters in and around the World Heritage Site of Indian Sundarbans.

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