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Predominance of cyanobacterial taxa and eutrophication in brackish water fisheries of Sundarbans: Evidence from several sites of North 24 Parganas, West Bengal, India

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Abstract

Sundarbans - the world heritage site is spread over in India and Bangladesh. The Indian part of Sundarbans is located in the districts North 24 Parganas and South 24 Parganas of West Bengal. The brackish water fisheries of North 24 Parganas are integral parts of Sundarbans and its adjoining areas. The development of such fisheries occurred in virtually mangrove reclaimed zone of Sundarbans. The ecological study on the brackish water fisheries of North 24 Parganas reveals that eutrophication has become a significant problem. In these fisheries, nutrients like nitrogen and phosphorus are determinants of such algal bloom. This eutrophication decreases the resource value of such brackish water fisheries which in turn decrease the ecosystem and biodiversity. Anthropogenic activities including use of chemical fertilizers in agriculture is closely tied to such eutrophication. The release of nitrogen and phosphorus to coastal waters has increased significantly due to human activities during the 20th century. Our investigation revealed eutrophication of brackish water fisheries in North 24 Parganas, West Bengal, India. This study also revealed that among different algal groups, cyanobacteria are predominant in these brackish water fisheries. It has also been noticed that abundance of total algal taxa as well as cyanophycean algal taxa is dependent on nitrate concentration as evident from linear regression analysis.

Keywords: *Sundarbans, nitrate, cyanophyceae, linear regression, seasonal variation*

1. Introduction

Eutrophication is a global problem and is the natural aging process of aquatic ecosystems (Meybeck *et al*., 1989). This complex process occurs both in fresh, marine or brackish water (Haslam, 1991; Harper, 1992; Paerl, 1997; Boesch & Brinsfield, 2000; Smith, 2003; Howarth & Marino, 2006; Bianchi, 2007; Naskar & Naskar, 2010). Nutrients of concern are nitrogen (N) and phosphorus (P) which accelerate algal blooms and ultimately lead to fisheries habitat destruction due to development

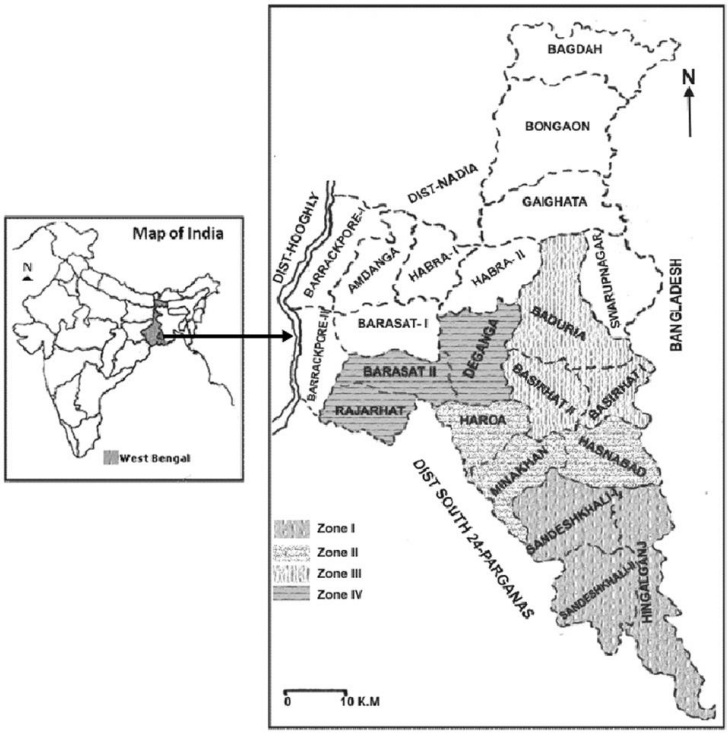
of hypoxic conditions, translating into ecological and economic losses of impacted waters (Nixon, 1995; Boesch *et al*., 2001; Rabalais & Turner, 2001; Diaz & Rosenberg, 2008). Brackish water fisheries of Sundarbans are not an exception of such phenomena and these fisheries are virtually the integral part of coastal fisheries (Naskar & Naskar, 2010). Coastal waters are physically, chemically and biologically distinct from fresh water ecosystems and, as a result, their responses to nutrient inputs and over-enrichment can contrast those observed in fresh water ecosystems (Paerl, 1997; Smith, 2003; Howarth & Marino, 2006; Bianchi, 2007). Brackish waters are biologically more productive than fresh water or even sea water, whether inshore or offshore (Sanjeeva Raj, 2003).

The present work on eutrophication of brackish water fisheries of some areas of the Indian part of Sundarbans was aimed at studying the algal population and its relation to different water parameters as well as nitrate and phosphate concentration.

2. Materials and Methods

The study area: Brackish water fisheries are located in the district north 24 Parganas, West Bengal, India (22°11'6"N and 23°1'2"N and 88°20'E and 89°5'E) are included in the present study. These sampling sites are integral part of Sundarbans. As Indian part of Sundarbans is situated in the districts North and South 24 Parganas, West Bengal, hence, the sampling sites are only in North 24 Parganas *viz.* Hingalganj, Sandeshkhali II and Sandeshkhali I, Hasnabad, Haroa, Minakhan, Basirhat I, Basirhat II, Baduria, Barasat II, Rajarhat and Deganga (figure 1). A total of 39000 ha area (approximately) are used as brackish water fisheries in North 24 Parganas district, W.B., India. Fisheries have been the most important economic activity of such brackish water.

Figure 1. Different zones of brackish water wetlands in the district 24-Parganas (North), West Bengal, India, as studied in this work



Water, soil, and algae were collected during summer, monsoon, post monsoon and winter from 2002 to 2005. The physico-chemical parameters of water *viz.* temperature, transparency, pH, salinity, dissolved oxygen (DO), nitrate and phosphate were analysed following APHA (1992). Soil samples

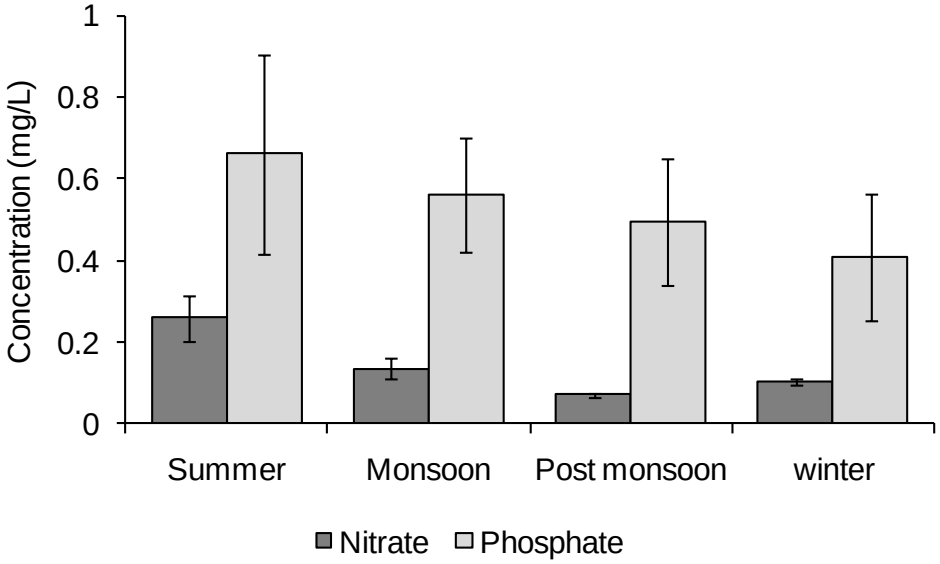
were collected and analyzed for soil texture, pH and organic carbon following Jackson (1974). Algal samples were identified with the help of relevant monographs and literatures (Smith, 1933; Desikachary, 1959; Ramanathan, 1964; Sen & Naskar, 2003).

3. Results and Discussion

The present study is mostly attributed to nutrient status and algal population but the other parameters of water like temperature, transparency, pH, salinity and DO are no less important for aquatic ecosystem where algal growths are abundant. Apart from water characters, soil quality is also pertinent for studying water bodies.

Water temperature plays an important role in controlling chemical and biological phenomena in a fish pond (Moncrief & Jones, 1977). The water temperature in the present brackish water fisheries ranged between 16.3°C and 30.5°C. In aquatic ecosystem, water temperature has a pronounced effect on chemical and biological processes. For example, increased water temperature and nutrient concentrations stimulate algal growth, leading to eutrophication (Nazari-Sharabian *et al.*, 2018). The ratio of chemical and biochemical reactions are doubled with the increase of 10°C temperature (Nath & Misra, 2005). So, the temperature is an important feature for optimum fish production. The pH of brackish water is always alkaline, which ranged from 7.4 to 8.9. Such alkaline water favours algal growth in brackish water (Naskar & Naskar, 2010). In the study area, the transparency observed ranged between 12.1 cm and 52.3 cm. The transparency range relates with other features like water ingress, rainfall, suspended silt and clay particles or allocthonous material through surface run-off (Chakraborty *et al*., 1959; Naskar & Naskar, 2010). The salinity values of brackish water showed a variation during different seasons. These values ranged between 3.4 gl^{-1} and 22.3 gl^{-1}. Whenever the members of Cyanophyceae was abundant than other algal groups, it is an indication of eutrophic condition (Moore, 1979) and the salinity is not a barrier to the presence or proliferation of many N_2 fixing Cyanophyceae in brackish water (Moisander *et al*., 2002). Eutrophication often results in hypoxia in estuarine and coastal systems (Nezlin *et al*., 2009) and thus, it is important to study the dissolved oxygen (DO) in these brackish water fisheries. The DO values ranged between 6.4 mgl^{-1} and 8.1 mgl^{-1}. Eutrophication causes increased phytoplankton production, decrease water clarity, depletion of DO in bottom waters, declines and changes the quality of fish production (Boesch & Brinsfield, 2000). The nitrate-N values fluctuated from a minimum of 0.02 mgl^{-1} to the maximum of 0.49 mgl^{-1} with an average value of 0.18 mgl^{-1}. The soluble phosphate ranged between 0.01 mgl^{-1} and 1.5 mgl^{-1}. Nitrate is an important nutrient which enhances the aquatic productivity. The more nitrate content in estuarine wetlands may be the concern of nitrogen fixation by cyanobacteria (Sakthivel & Haridas, 1974; Devassy *et al*., 1978). Phosphate is also an essential nutrient for enhancing aquatic productivity (Nath *et al*., 1994). In the present study, nitrate values fluctuated during different seasons which was maximum (0.2595 mgl^{-1}) during summer and minimum (0.07 mgl^{-1}) during the post monsoon season (figure 2). The phosphate values also fluctuated during different seasons. The phosphate values were maximum (0.6605 mgl^{-1}) during summer and minimum (0.4073 mgl^{-1}) during winter (figure 2). The N-P ratio was 0.39, 0.24, 0.14 and 0.25 for summer, monsoon, post monsoon and winter, respectively.

Figure 2. Seasonal variation in nitrate and phosphate concentration

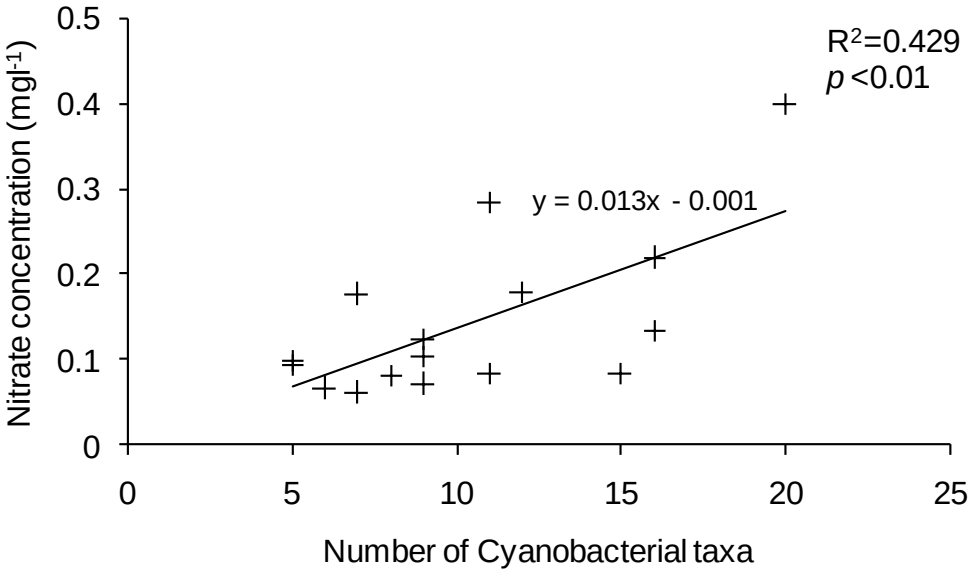


Disposal of waste materials due to rain water incursion adds to the load of phosphate content in these wetland fisheries (Smith & Longmore, 1980). Singbal (1973) opined that sea water intrusion usually serve as the controlling factor of phosphorus in estuaries.

The soil quality is an important factor in aquaculture (Boyd, 1990). The productivity of a pond depends on the quality of soil as it controls pond bottom stability and concentration of plant nutrients necessary for growth of phytoplankton (Kumari, 2015). The proportion of sand, silt and clay in sediment was 69.74 to 89.61%, 10.25 to 29.94% and 0.14 to 0.39%, respectively. The soil pH ranged between 6.9 –7.4. The reason which lowers pH in soil of brackish water fisheries may be attributed to microbial action (Bhaumik *et al*., 2003). Organic carbon content ranged between 0.04 and 7.00% in brackish water.

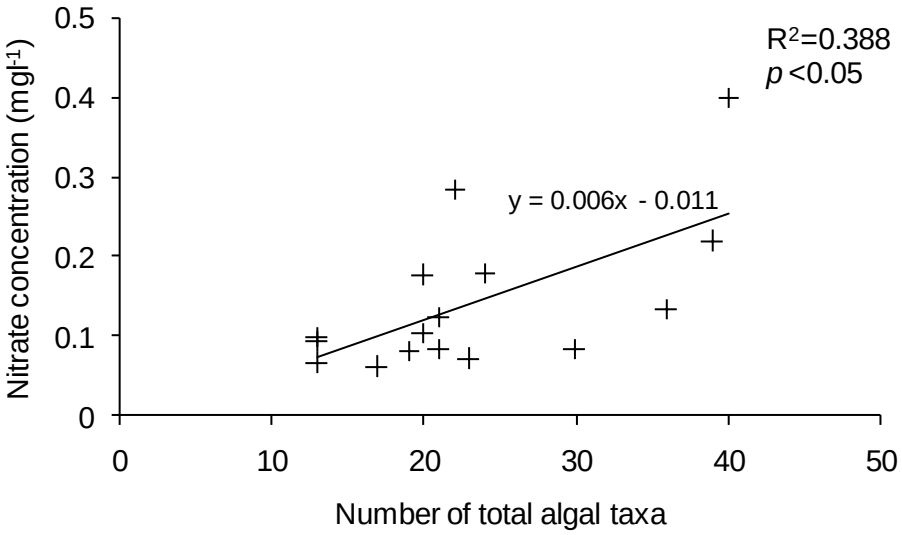
In aquatic ecosystem, the algal population is directly related to physico-chemical parameters of water. The number of cyanobacterian taxa was dependent on nitrate concentration as revealed by linear regression analysis (R^2 = 0.429) in our study (figure 3) which is supported with the observation of Boyd (1990) and Naskar & Naskar (2010).

Figure 3. Linear regression of number of cyanophycean algal taxa with nitrate concentration



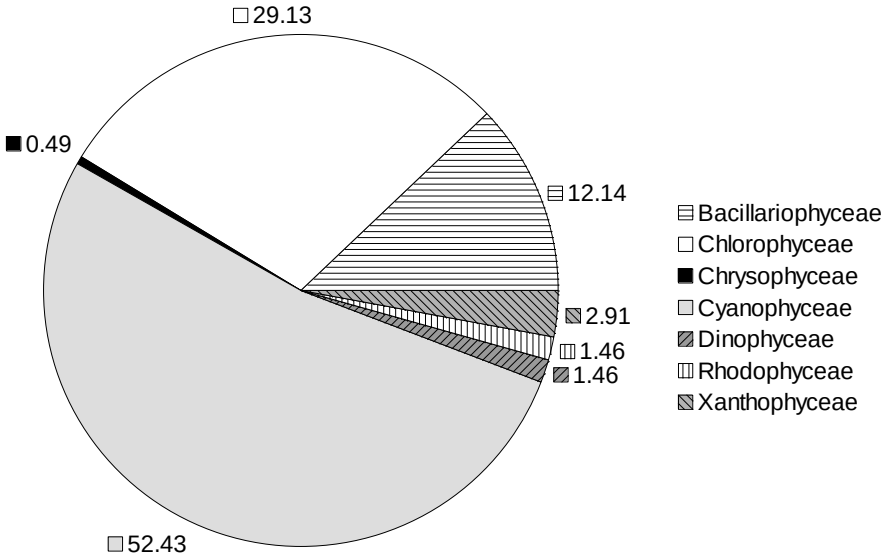
The linear regression (R^2 = 0.388) showed that the total algal taxa were also dependent on nitrate concentration (figure 4). The incidence of algal population is linked with phosphorus (Sze, 1998; Hegde & Sujata, 1997). However, in our study, number of cyanophycean taxa as well as total algal taxa was not dependent on phosphate concentration as evident from linear regression analysis (p>0.05).

Figure 4. Linear regression of total algal taxa with nitrate concentration



The qualitative picture of algae in brackish water fisheries indicates that members of Cyanophyceae are more abundant than other algal groups *viz.* Chlorophyceae, Bacillariophyceae, Xanthophyceae, Dinophyceae, Rhodophyceae and Chrysophyceae (figure 5). The present observation on nitrate and algal population reveals that the abundance of Cyanophycean algae has been related with eutrophication. The fact that the population of Cyanophyceae was more than the population of Chlorophyceae and Bacillariophyceae of these wetlands is an indication of eutrophic condition and corroborates with the studies of Moore (1979) and Holmes & Whitton (1981a, 1981b).

Figure 5. Algal abundance showing percentage composition of different algal groups



The eutrophication of aquatic ecosystems is a major environmental issue that endangers sustainable development of humans and other species. Effective counteraction of the biodiversity crisis requires the identification and protection of the ecological and evolutionary processes that generate and maintain diversity (Douglas *et al*., 1999; Hudson *et al*., 2011).

4. Conclusion

The present study, therefore suggests that brackish water fisheries of Sundarbans are in eutrophic conditions due to the abundant growth of different algae especially Cyanophycean algae and the abundance of Cyanophycean algal taxa as well as total algal taxa is dependent on nitrate concentration. This study will help to combat eutrophication in the brackish water fisheries from North 24 Parganas.

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