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IMPACT OF SUSPENDED SOLIDS ON PHYTOPLANKTON COMMUNITY IN THE LOWER GANGETIC ESTUARIES

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ABSTRACT: The aquatic phase of Indian Sundarbans (between $21^0$13'N and $22^0$40' N latitude and $88^0$03'E and $89^0$07'E longitude) is rich in phytoplankton diversity. We observed 49 phytoplankton species during our study period in 2015-2016, covering three seasons (premonsoon, monsoon, postmonsoon). Being a part of lower Gangetic delta, the aquatic sub-system of Indian Sundarbans has considerable suspended solid that ranged from 102.4 mg/ml (at station 10 during May, 2015) to 193.22 mg/ml (at station 1 during September, 2016). We differentiated the stations on the basis of suspended solid (SS) into two categories. Category S_A = stations with high suspended solid (>140 mg/ml) and Category S_B = stations with low suspended solid (<140 mg/ml). The stations under S_A exhibited low phytoplankton diversity compared to S_B. We observed significant inverse relationship between phytoplankton diversity and suspended solid in all three cases (stations under Category S_A, stations under Category S_B and combination of S_A and S_B stations (S_T). The study depicts that the suspended solids play a crucial role in regulating the phytoplankton diversity in the present geographical locale.

KEYWORDS: Indian Sundarbans, Phytoplankton, Suspended Solid (SS), Shannon Weiner species diversity index.

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1. INTRODUCTION

The distribution of phytoplankton in the aquatic ecosystem is influenced by the availability of nutrients, light and congenial salinity. In a coastal environment, turbidity exerts a further control on phytoplankton, for it restricts the euphotic zone. In these waters, land derived nutrients and suspended solid which in turn are related to the drainage basin's topography and ecobiology

influence the phytoplankton availability [1]. Phytoplankton communities are multispecies communities, which are highly multifaceted in terms of their diversity and dynamics. Successional shifts in phytoplankton community structure are mainly due to changes in environmental variables such as nutrients and other physico-chemical variables which influence the distribution and abundance of plankton communities in estuaries [2-4]. In this study we attempt to assess the influence of suspended solid on phytoplankton species diversity at Indian Sundarbans region. Since suspended solid plays a major role in regulating phytoplankton richness and diversity, therefore we have divided our study area into two major categories: Category S_A = stations with high suspended solid (>140 mg/ml) and Category S_B = stations with low suspended solid (<140 mg/ml) to evaluate the degree of inter-relationship between phytoplankton species and diversity (represented by Shannon Weiner species diversity index in this study) and suspended solid.

2. MATERIALS AND METHODS

2.1. Study site and sampling description

The River Ganga emerges from the Gangotri glacier, about 7010 m above mean sea level in the Himalayas, flows down to the Bay of Bengal and spreads over Bangladesh (which comprises 62% of the total Sundarbans) and India (38% of the total Sundarbans) covering a distance of 2525 km. The Indian part, known as Indian Sundarbans covers a Biosphere Reserve area of 9630 sq. Km and houses 102 islands. The unique biological productivity, taxonomic diversity and aesthetic beauty of the Indian Sundarbans have been recognized with the crowns of World Heritage Site and Biosphere Reserve in 1987 and 1989 respectively by UNESCO [5]. We conducted survey at 12 stations in the Indian Sundarbans region during three seasons viz. premonsoon (May, 2015), monsoon (September, 2015) and postmonsoon (December, 2016). Station selection was primarily based on salinity and anthropogenic activities. Because of rapid industrialization, urbanization, unplanned tourism, navigational and shrimp culture activities, the western Indian Sundarbans is a stressed zone (stations 1 to 6). The discharge of Farakka barrage through Hooghly channel has made the zone relatively low saline [6]. On the contrary stations 7 to 12 are high saline zone due to complete blockage of the fresh water because of Bidyadhari siltation [7-8]. Anthropogenic activities are also low in these stations (except station 7), because of their locations adjacent to the protected mangrove reserve forest. The names and coordinates of the selected stations are highlighted in Table 1.

Table 1: Geographical location of the study sites

Station Name	Station Code	Geographical Location	
		Longitude	Latitude
Kachuberia	Stn. 1	$88^0$08'04.43" E	$21^0$52'26.50" N
Harinbari	Stn. 2	$88^0$04'52.98" E	$21^0$47'01.36" N
Chemaguri	Stn. 3	$88^0$10'07.03" E	$21^0$39'58.15" N
Sagar South	Stn. 4	$88^0$03'06.17" E	$21^0$38'54.37" N
Lothian island	Stn. 5	$88^0$22'13.99" E	$21^0$39'01.58" N
Prentice island	Stn. 6	$88^0$17'10.04" E	$21^0$42'40.97" N
Canning	Stn. 7	$88^0$41'16.20" E	$22^0$18'40.25" N
Sajnekhali	Stn. 8	88° 46'10.8" E	22° 05' 13.4" N
Choto mollakhali	Stn. 9	$88^0$54'26.71"E	22015'40.00" N
Satjelia	Stn. 10	$88^0$52'49.51" E	$22^0$05'17.86" N
Pakhiralaya	Stn. 11	$88^0$48'29.00" E	$22^0$07'07.23" N
Thakuran	Stn. 12	$88^0$38'45.20"E	$21^0$35'33.10" N

2.2. Phytoplankton standing stock estimation

Net samples were collected with a conical nylon net bags (30 cm diameter) made of a 30 No. bolting silk. These samples were preserved in 2 or 4% neutral formaldehyde (final concentration) in glass or polyethylene bottles. Samples were observed with a ZEISS research microscope coupled with an image analyzing system. The total number of phytoplankton (standing crop) present in a liter of water sample was calculated using the formula:

$$N = nv/V$$

Where,

N= total number phytoplankton cells per liter of water filtered.

n = average number of plankton cells in 1ml of plankton sample.

v = volume of plankton concentrate (ml)

V= volume of total water filtered (l)

The units of standing crop are N/l or $N\times10^3$ /m^3

2.3. Diversity Index calculation

The community structure analysis of phytoplankton requires the number of individuals of each species in the community. This was carried out with a ZEISS research microscope coupled with an image analyzing system. The Shannon Weiner Species Diversity Index (H) was computed by using the formula

$$\overline{(H)} = -\sum_{i=1}^{S} \frac{n_i}{N} \log_e \frac{n_i}{N}$$

Where,

n_i = importance probability for each species

N= total of importance values.

2.4. Suspended solid (SS) estimation (in situ)

Suspended solid (in mg/ml) for each of the 12 locations (as fixed with the help of GPS) was gravimetrically measured according to the standard method [9]. Each sample was filtered through a pre-weighed Whatmann GF/F glass fibre filter paper. The filter was washed thrice to remove the salts adhered to that and dried in an oven at 75^{o}C for 48 hours. Then it was reweighed using a digital balance to estimate the suspended solid.

2.5. Statistical approach

We differentiated the selected stations into two categories (1) Category S_A: stations 1 to 6 with high suspended solid (greater than 140 mg/ml) and (2) Category S_B: stations 7 to12 with low suspended solid (less than 140 mg/ml). Pearson correlation (r) values were computed through SYSTAT between phytoplankton species diversity index ($\hat{H}$) and suspended solid data sets separately for (a) Category S_A (b) Category S_B and (c) combining categories S_A and S_B (represented by S_T). This approach was adopted to understand the inter-relationships between suspended solid and phytoplankton diversity in the present geographical locale. Also ANOVA was performed to evaluate the spatial and temporal variations of phytoplankton diversity index and suspended solid.

3. RESULTS AND DISCUSSION

In total, 49 of the encountered phytoplankton taxa were identified to species level. 40 of these were diatoms, 6 were dinoflagellates, 1 was blue green algae, 1 was brown algae and 1 was green algae. Of these 49 species diatom showed the highest abundance (81.63%), followed by dinoflagellates (12.24%). Brown algae, blue green algae and green algae consisted 1 species each (2.04%). In the central and western sectors of our study site dominance of the *Coscinodiscus* species was noticeable. Four species of *Coscinodiscus,* namely, *Coscinodiscus eccentricus, Coscinodiscus jonesianus, Coscinodiscus lineatus,* and *Coscinodiscus radiatus* were recorded in a large number. Other diatom species like *Thalassiosira subtilis* also exhibited high numbers in both sectors. The blue green algae *Trichodesmium erythraea* was also present in large number. Species of *Ceratium* displayed higher densities among the dinoflagellate. The Shannon Weiner diversity indices were graphically presented in Figure 1. We observed relatively low species diversity index value in stations under Category S_A (mean $\hat{H}$ value =3.403095). This may be attributed to high suspended solid in the aquatic phase of stations 1 to 6 compared to Category S_B (where mean $\hat{H}$ value =3.566371) comprising of stations 7 to 12 (Figure 2). The high suspended solid in stations 1

to 6 (under Category S_A) is primarily due to their locations in the western Indian Sundarbans where the possible sources are the mixtures of organic (living or residual) and inorganic suspensions generated from industries, agriculture, urban sewage and shrimp culture units [8, 10-11]. A stressed environment typically has a lower number of species (those adapted to stress) having many more individuals than the other species [12]. The presence of suspended solid has a regulatory influence on the phytoplankton community and primary productivity of the estuarine system. We observed significant negative correlations between the suspended solid and phytoplankton diversity in the stations under category S_A, S_B and also considering all the 12 stations S_T (Table 2). ANOVA revealed significant differences in diversity index values and suspended solids between the two categories ($p < 0.01$). Suspended solid is regulated by anthropogenic activity, eutrophication and in the present geographic locale very much by erosion of Sundarban islands [13], sewage and industrial discharge from the highly urbanized city of Kolkata, Howrah and newly developing Haldia complex [8,10,11]. Hence studying the role of suspended solid on the phytoplankton diversity is of great interest as phytoplankton are currently responsible for approximately 50% of global primary production [14], and in therefore an important biological community to be analysed.

Table 2: Interrelationships between Shannon Weiner species diversity index and suspended solid

Category	Combination	r Value	p Value
S_A (>140 mg/ml)	SS * $\hat{H}$	-0.84891	<0.01
S_B (<140 mg/ml)	SS * $\hat{H}$	-0.57269	<0.01
S_T	SS * $\hat{H}$	-0.66503	<0.01

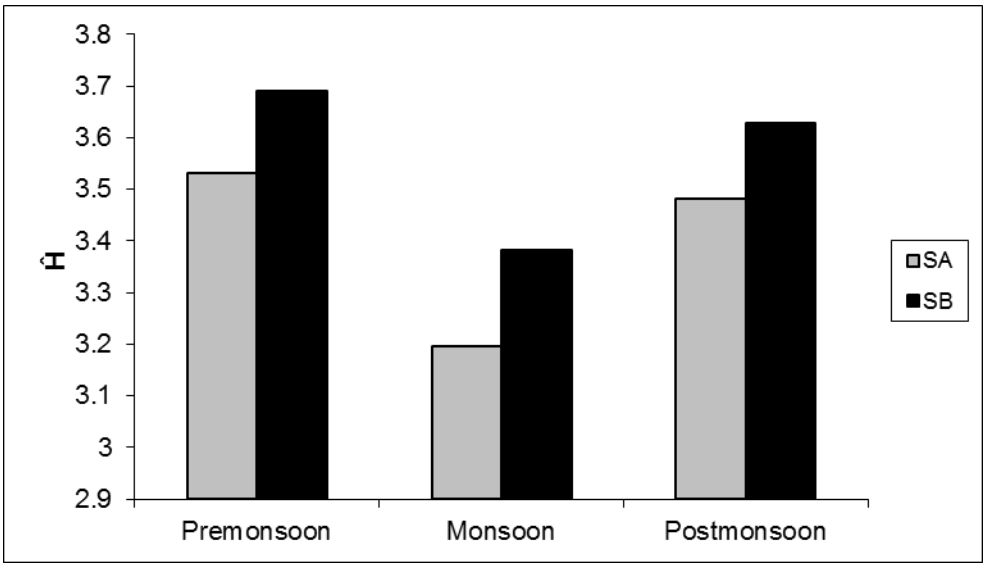

Fig.1. Spatial and temporal variation of Shannon Weiner species diversity index ($\hat{H}$) in the study area

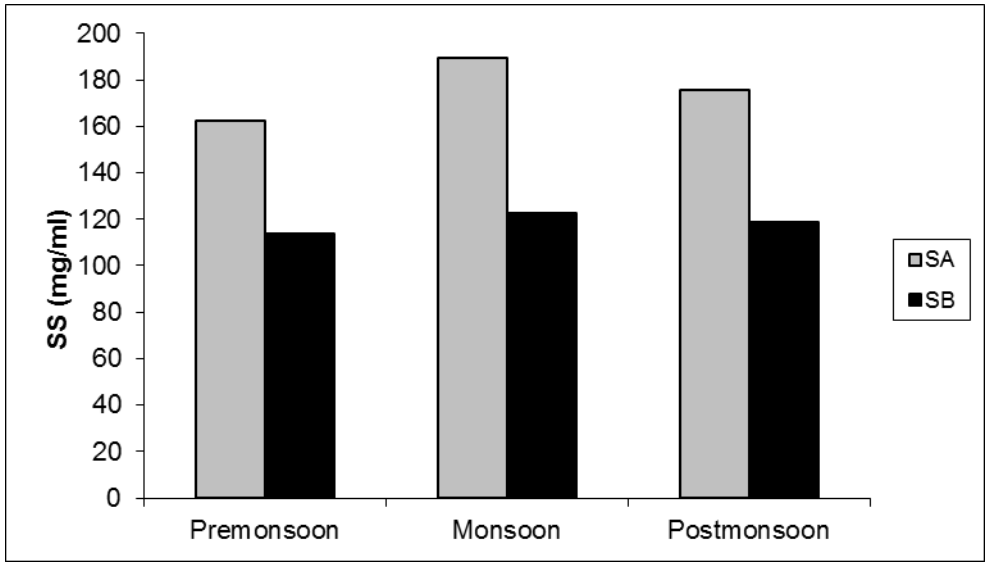

Fig.2. Spatial and temporal variation of suspended solid in the study area

4. CONCLUSION

The Indian Sundarbans, at the apex of Bay of Bengal is noted for its rich taxonomic diversity, primary and secondary productivity [5, 15]. Being a Gangetic delta, the region experiences considerable suspended solid in the aquatic phase in some seasons due to riverine input, erosion of river banks and embankments and run-off from adjacent landmasses. The ultimate aim of ecology is to study the interaction of organisms with their environment and other organisms living in it [16, 17]. According to earlier work [18] phytoplankton abundance and species richness appeared to be influenced by high turbidity, water velocity, fluctuating water level and age of water. The adverse public health, environmental, socio-economic, food quality, security and aesthetic impacts from sewage contamination in coastal areas are well documented [19, 20, 21, 22]. The significant increase of industrial and anthropogenic activities in the upstream zone of the Hooghly-Matla estuarine complex coupled with reduction of sweet water flow in the estuary in recent times have aggravated the problem related to suspended load. Although, a number of studies have been carried out on the ecological conditions of estuarine region, as Bay of Bengal is considered as a low productive zone [23] very limited work has been done. The present study reveals the negative impact of suspended solid on the phytoplankton community of the Indian Sundarbans and suggests a comprehensive remedial measure to lower the suspended solid load through strict monitoring and checking at point sources (like industrial outfall) and controlling embankment erosion through mangrove plantation. Moreover it can be said estuarine regions are subjected to considerable fluctuations and these micro flora were well adapted to such vicissitude environment [24, 25]. Phytoplanktons need a wide variety of chemical elements but the two critical ones are nitrogen and phosphorous [26].

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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