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DIVERSITY, DISTRIBUTION AND DENSITY OF ESTUARINE PHYTOPLANKTON IN THE SUNDARBAN MANGROVE FORESTS, BANGLADESH

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Abstract

Diversity, distribution and density of estuarine phytoplankton from nine sites under four Ranges of the Sundarban Mangrove Forests (SMF), Bangladesh have been studied. The phytoplankton communities represented by 36 species which belonged to Chlorophyceae (3), Euglenophyceae (2), Bacillariophyceae (30) and Xanthophyceae (1). Occurrence of taxa and their densities were highest near the confluence of Hangsha River (R) with the river Murdat at Patcosta. Shannon-Wiener diversity index was also highest (H = 3.494) in this area. Lowest density of phytoplankton and diversity indices (H = 1.661) were found in Bal R., Bisandri Khal and Kalabogi R. *Oocystis pusilla*, *Coscinodiscus excentricus*, *C. lineatus* and *Navicula brekkeansis* occurred abundantly, while *Cyclotella comta, Thalassionema nitzschioides* and *Lioloma delicatula* were common. *Coscinodiscus lineatus* was distributed in all the nine sites including high and low tides indicating its high capacity to tolerate habitat fluctuations. *Chaetoceros socialis* was found only in Passur R. with low salinity, conductivity and total dissolved solids. The total numbers of phytoplankton individuals per liter were generally higher during low tide than those of high one. Principal Component Analysis (PCA) showed the relationship between pH and some species of phytoplankton.

Introduction

The estuary at Sundarban Mangrove Forests (SMF) accounts for a good amount of revenue from fisheries. Phytoplankton, the primary producer in the estuaries and seas, enter into the aquatic food chain and thus help directly or indirectly in the production of fish and other animals living in the sea water (Castro and Huber 2003).

Quantitative aspects on the phytoplankton of the Bay of Bengal, coast of Moheshkali island and the estuary of Karnaphuli, Rupsha and Buragauranga rivers have already been studied (Aziz 2005, Aziz and Islam 1979, Islam and Aziz 1977, 1979, 1980, Ahmed *et al.* 2010). Although Chaudhuri and Choudhury (1994) studied the estuarine pytoplankton from the SMF of Indian territory, no information on this account from Bangladesh part was available until Aziz and Rahman (2011) reported 12 planktonic diatoms taxa as new records. The present research was undertaken to study the diversity, distribution and the density of phytoplankton in relation to the water chemistry in the estuary of different ranges of the SMF.

Materials and Methods

A total of 65 phytoplankton samples from nine sites (five samples from each site and at some sites samples from high and low tide conditions) were collected between 25 and 29 March, 2010 covering four Ranges of the SMF (Fig. 1). Details of the study sites have been provided in Aziz *et al.* (2011). For each sample, 22 liter water was passed through plankton net of 40 µm mesh aperture and the concentrates were preserved in 4% formalin. pH (HANNA HI 98127), conductivity (Aqualitic CD 22), salinity (Hand Refractometer, VEEGEE STX-3), and TDS (HANNA HI 9034) of water were determined in the field immediately with the help of respective instruments. Alkalinity was determined following Wetzel and Likens (1979).

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Identification of phytoplankton taxa were made following Cupp (1943), Subrahmanyan (1946), Islam and Begum (1970), Islam and Aziz (1975, 1977, 1979), Germain (1981), Aziz and Ara (2000), Aziz and Tanbir (2003), Islam and Akhter (2004) and Ahmed *et al.* (2008, 2009). Shannon-Wiener Diversity indices were calculated following Ruggiero and Marchant (1979). Principal Component Analysis (PCA) was done using MINITAB 14 program.

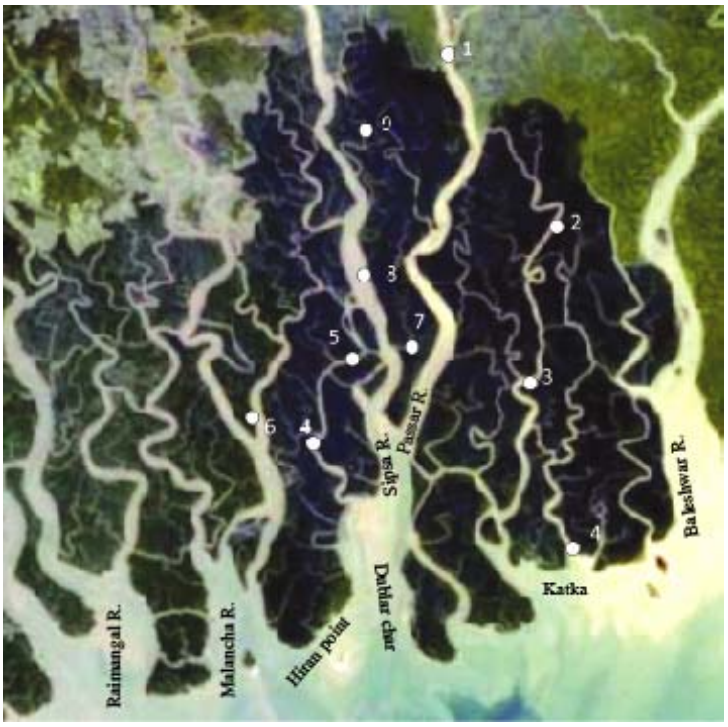


Fig. 1. Sundabrabans Mangrove Forest showing the nine sampling sites: Passur R. (1), Sela R. near Tambulbunia F.S. (2), Harmal R. (3), Betmara R., Kotka F.S. (4), Conjoint of Hansharaj and Mardat R. (5), Near conjoint of Bal and Arpangasia R. (6), Bishandirkhal, east of Shipsa R. (7), Shipsa R. near Chailabogi F.S. (8) and Kalabogi R. near Aila settlement area (9). (R. = River, F.S. = Forest station).

Results and Discussion

A list of taxa, their distribution and concentration in different locations of SMF are given in Table 1. The phytoplankton communities were represented by 36 species. Chlorophyceae and Euglenophyceae were represented by three and two species, respectively. Highest number, 30 species was recorded for Bacillariophyceae. Xanthophyceae was represented by one species, namely *Centritractus belanophorus*. Occurrence of taxa and number of individuals per liter was highest in the Passur R. aside Nalianala (Khulna) Range, near the confluence of Hangsha R. with Murdat R. at Patcosta and in Harmal R. at Tek where the salinity was found to be moderate (14.8 ‰) to high (24.6 ‰). Lowest number of individuals was found in the Bal R., Bisandri Khal and Kalabogi R. sites. Thirty six species were reported from this area.

No published record on the algal flora of brackish water within Bangladesh existed until Islam (1973) reported and described some attached algal species including some new species from the SMF. Recently Aziz (2005) recorded three species of *Biddulphia* from the brackish water of

Rupsha R. near Khulna Launch Ghat, about 6 km north of SMF. Very little information exists on the phytoplankton composition of estuarine water of the country. Islam and Aziz (1977) recorded 23 genera and 42 spp. belonging to Chlorophyceae, Euglenophyceae, Chrysophyceae, Bacillariophyceae (with highest number of genera and species), Dinophyceae and Cyanophyceae from Karnaphuli River estuary. Ahmed *et al.* (2010) recorded ten phytoplankton genera belonging to Chlorophyceae, Bacillariophyceae and Euglenophyceae of which eight belonged to Bacillariophyceae in Buragauranga River estuary having salinity range of 5 to 10‰.

In the Passur R. (between Nalianala and Chandpai Ranges), 13 taxa were recorded during low tide. *Chaetoceros socialis* and *Centritractus belanophorus* (only representative of Xanthophyceae), were found in this area. A filamentous tychoplankton of Chlorophyceae, namely *Uronema* sp. was found in this site and also in the Tambulbunia (Chandpai Range) during low tide condition. It appears that these three members of phytoplankton are low salinity tolerant organisms and are washed down to the north-eastern Ranges of the SMF during low tide.

When the tidal effect on phytoplankton were considered and compared, it was found that the total number of individual per liter was generally higher during the low tide (Table 1). The low density during high tide was most likely due to dilution of water body by huge mass of water.

Except *Oocystis pusilla*, diatoms dominated in the SMF (Table 1). Among diatoms *Coscinodiscus* and *Nitzschia* contributed highest number of taxa. However, *O. pusilla*, *Coscinodiscus excentricus, C. lineatus* and *Navicula brekkeansis* occurred abundantly (considering their presence in 10 or more sites), while *Cyclotella comta, Thalassionema nitzschioides* and *Lioloma delicatula* were common (considering their presence in 5 or more sites) in the SMF. Remaining 29 taxa were rare in occurrence. Studies on phytoplankton in the Indian part of SMF revealed the presence of several taxa of diatom out of which *Coscinodiscus excentricus*, *C. radiatus, Rhizosolania alata, Biddulphia sinensis, Ditylum brightwelli* formed blooms in different months of a year (Chaudhuri and Choudhury1994). In the present study no such blooms were recorded in the study sites in March, 2010.

Shannon-Wiener index of diversity (H) was found to be highest (3.494) during low tide in the Hangsha R. at Patkosta, Nalianala Range (Table 2). During high tide the H value was almost similar to low tide. However, in the Passur R., the diversity index was also very high. The lowest diversity index (H=1.661) was found in Bisandri Khal and Kalabogi R. Ahmed *et al.* (2010) reported the value of H 2.823 in the Buragauranga river estuary of Patuakhali district which was also dominated by the members of Bacillariophyceae (80%).

In the Passur R., *C. lineatus* and *N. brekkaensis* both had the maximum IVI (importance value index) of 0.399 (total data are not shown), whereas in the Sela R., all the species have same number of individuals during high tide, but during low tide *C. lineatus* and *C. excentricus* were dominant (Table 1). *Coscinodiscus lineatus* was the dominant algae in the Harmal River where as *S. fastuosa* var. *recedens* dominate the Betmara River at Kotka during low tide condition (Table 1). At Patcosta, *C. comta* and *C. lineatus* dominate during both the tidal conditions, but *L. delicatula* dominated during the low tide period. *Coscinodiscus granii, Amphiprora alata* and *Bacteriastum delicatulum* were found in this site only, during high tide (Table 1). Among 36 species, *C. lineatus* were found in all the 13 sites and during low and high tide times, indicating tolerance of this species to a large variation of environmental factors (Table 1). In habitat fluctuation, *C. excentricus* was found in 10 samples out of 13 (nine sites including high and low tide collections), second in position to *C. lineatus* (Table 1). *Chaetoceros socialis* was found only in Passur R. between Nalianala and Chandpai Ranges, a zone of low salinity, conductivity and total dissolved solids.

Table 1. Diversity indices, species composition, distribution and density of phytoplankton population (ind/l) in nine study sites of the SMF. Values are mean of five samples.

Name of the taxa	S 1 Passur R		S 2 Sela R.	S 3 Harmal R	S 4 Betmara R.	
	LT	HT	LT	LT	LT	HT
Chlorophyceae						
Oocystis pusilla Hans.	1		0.5			0.5
Staurastrum orbiculare Ralfs						
Uronema sp.	0.5		0.5			
Euglenophyceae						
Astasia cylindrica Pringsh.						
Euglena spathirhyncha Skuja				0.5		
Bacillariophyceae: Centrales						
Bacteriastrum delcatulum Cl.						
Biddulphia dubia Cl.						
Chaetoceros pendulus Karsten	1					1
C. socialis Lauder	1					
Chaetoceros sp.		0.5				
Coscinodiscus excentricus Ehr.	0.5		1		0.5	
C. granii Gough						0.5
C. jonesianus Grev.				0.5		
C. lineatus Ehr.	1.5	0.5	1	2	0.5	0.5
C. marginatus Ehr.	0.5		0.5			
C. oculus-iridis var. *boreales* (Bailey) Cl.						
Cyclotella comta (Her.) Kütz.				1		1
Rhyzosolenia setigera Brightw.						0.5
Skeletonema costatum (Grev.) Cl.	0.5		0.5	1		
Thalassiosira weissflogii Grun.				0.5		
T. rotula Meunier					0.5	0.5
Unknown centric diatom						
Bacillariophyceae: Pennales						
Amphiprora alata Kütz.						
Amphora ovalis Kütz.				0.5		
A. veneta Kütz.				0.5		
Navicula brekkaensis Petersen fa	1.5	0.5	0.5	0.5	0.5	
Nitzschia acicularis Smith	0.5	0.5				
N. closterium (Ehr.) Smith						
N. inconspicua Grun. fa						
N. romana Grun. fa						
N. sigma Kütz.	1		0.5			
Nitzschia sp.						
Surirella fastuosa var. *recedens* (Schm.) Cl.	0.5	0.5	0.5		1.5	
Thalassionema nitzschioides (Grun.) Meresh		0.5		1	0.5	0.5
Lioloma delicatula (Cupp) Hasle		0.5	0.5			
Xanthophyceae						
Centritractus belanophorus Schmidle	0.5					
Total density (ind/l)	10.5	3.5	6	10	4	5
Shannon-Wiener Index of divesity (H)	3.453.	2.75	3.236	3.01	2.046	2.816

(Contd.)

(Contd.)

S 5 Hangsha R.		S 6 Ball R.		S 7 Bisindri Khal	S 8 Sipsah R.	S 9 Kalabogi R.	No. of occur-rence	Total density ind/l
LT	HT	LT	HT	LT	HT	LT		
1	1	0.5	0.5	0.5	1	1	10	0.577
0.5							1	0.038
							2	0.077
0.5							1	0.038
							1	0.038
0.5							1	0.038
0.5							1	0.038
0.5							3	0.192
							1	0.077
	0.5						2	0.077
0.5	0.5	0.5	0.5	0.5	0.5	0.5	10	0.423
							1	0.038
	0.5						2	0.077
1.5	1.5	1	0.5	0.5	0.5	0.5	13	0.923
							2	0.077
	1	1			0.5		3	0.192
1.5	1.5	0.5					5	0.423
	0.5						2	0.077
1							4	0.231
0.5	0.5	0.5					4	0.154
							2	0.077
	0.5						1	0.038
0.5							1	0.038
							1	0.038
							1	0.038
	0.5	0.5	0.5		0.5	0.5	10	0.461
							2	0.077
	0.5						1	0.038
		0.5					1	0.038
		0.5					1	0.038
		0.5					3	0.154
		0.5					1	0.038
							4	0.231
1							5	0.269
1.5	0.5	0.5		0.5			6	0.308
							1	0.038
12	9.5	7	2	2	3	2.5		
3.494	3.359	3.271	2.406	1.661	2.406	1.661		

LT = Low tide, HT = High tide, S = Site, R. = River.

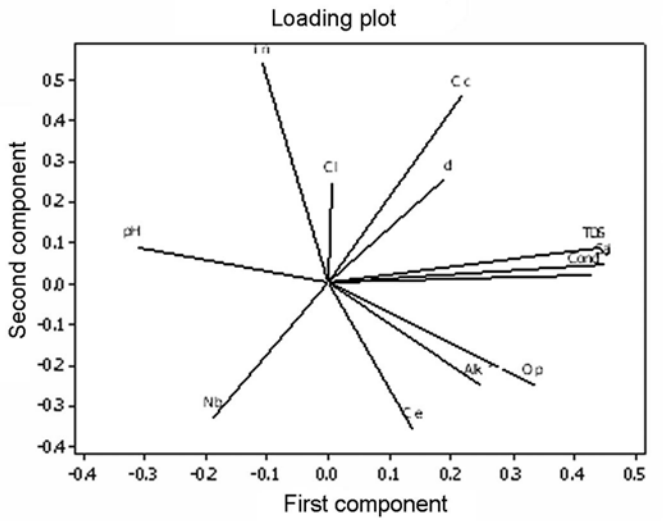
Table 2. Mean values of water quality variables at different sites of the SMF. n = 5; Values in parentheses indicate standard deviations.

Locations	S1	S2		S3	S4		S5		S6		S7	S8	S9
variables	LT	HT	LW	LT	LT	HT	LT	HW	LT	HW	LT	HT	LT
pH	7.64 (0.05)	7.66 (0.05)	7.60 (0.14)	7.64 (0.09)	7.98 (0.04)	7.82 (0.24)	7.44 (0.05)	7.42 (0.08)	7.48 (0.04)	7.46 (0.09)	7.26 (0.05)	7.49 (0.16)	7.66 (0.27)
Conductivity (mS/cm)	16.02 (1.19)	14.34 (0.32)	14.71 (0.28)	22.40 (0.33)	28.18 (0.22)	28.36 (0.09)	30.42 (0.09)	31.60 (0.78)	34.24 (0.15)	34.04 (0.05)	26.66 (0.59)	29.20 (0.44)	36.46 (0.50)
Salinity (‰)	14.80 (0.45)	10.40 (0.54)	10.40 (0.55)	14.80 (1.64)	20.60 (0.54)	20.20 (0.84)	23.40 (0.55)	24.60 (0.89)	26.00 (0.71)	26.20 (0.45)	19.80 (0.45)	21.20 (0.64)	19.00 (0.71)
TDS (g/l)	10.576 (0.77)	8.026 (0.12)	8.038 (0.07)	12.012 (0.17)	15.632 (0.41)	16.23 (0.43)	18.05 (0.44)	18.22 (0.35)	>20.00	>20.00	14.876 (0.01)	17.69 (0.23)	13.15 (0.43)
Alkalinity (meq/l)	0.43 (0.014)	0.372 (0.011)	0.362 (0.015)	0.376 (0.02)	0.372 (0.024)	0.372 (0.004)	0.418 (0.024)	0.404 (0.02)	0.376 (0.02)	0.384 (0.005)	0.426 (0.009)	0.410 (0.01)	0.438 (0.004)

The pH values of the study areas were slight to moderately alkaline (Table 2). There was a sharp difference in conductivity and salinity among the sites which ranged from 14.34 - 36.50. mS/cm and 10.4 - 26.2‰, respectively. The water of Hangsha R. is also characterized by higher value of salinity, conductivity and TDS with low alkalinity, where maximum species diversity was found.

Though the SMF of Bangladesh part had western and southern moderately saline, and northern and north-eastern freshwater zones in 1930's (Curtis 1933), presently it is divided into southern to south western polyhaline (18 - 30‰), median northern mesohaline (≥5 - 18‰) and eastern- northern oligohaline (0.5 - 5‰) zones (Siddiqi 2001). In the present study salinity in the last week of March, was above 18‰ in site 4 to 9 (polyhaline) while site 1 to 3 in Chandpai Range the salinity was less then 18‰ (mesohaline) (Table 2). However, conductivity, TDS and alkalinity in the sites of Chandpai Range were the lowest of all.

Based on the highest number of individuals per liter found in the samples, the following phytoplankton were selected for Principal Component Analysis (PCA), e.g *Coscinodiscus lineatus, C. excentricus, Lioloma delicatula, Cyclotella comta, Ocystis pusilla*, *Navicula brekkaensis* and *Thalassionema nitzschioides.* The PCA analysis showed that all variables except pH have positive correlation with *C. lineatus, C. excentricus, L. delicatula, Cyclotella comta, O. pusilla*. On the other hand, these variables have *negative* correlation with *N. brekkaensis* and *T. nitzschioides*. These two diatom species have positive correlation with pH (Fig. 2). Using PCA, Ahmed *et al.* (2010) reported that *Trachelomonas* sp. showed negative correlation with Mg, K, conductivity, DO, BOD_5 and salinity whereas *Coscinodiscus* sp. had shown positive correlation with these variables and negative correlation with free CO_2 and alkalinity.



Variable	PC1	PC2	PC3
pH	-0.311	0.066	-0.262
Cond	0.425	0.020	-0.309
Sal	0.456	0.047	-0.236
TDS	0.441	0.007	-0.262
Alk	0.246	-0.246	0.262
C l	0.005	0.244	0.505
C e	0.137	-0.356	0.169
O p	0.333	-0.246	0.306
N b	-0.166	-0.331	0.221
C c	0.216	0.459	0.215
T n	-0.109	0.537	0.071
L d	0.166	0.252	0.367

Fig. 2. Principal component analysis of chemical variables and some phytoplankton taxa (Cl = *Coscinodiscus lineatus, Ce = C. excentricus,* Nb = *Navicula brekkaensis* Cc = *Cyclotella comta,* Tn = *Thalassionema nitzschioides* and Ld = *Lioloma delicatula.*

Out of 36 species reported from SMF, a couple of centric and pinnate diatoms and *Oocystis pusilla* (a green alga) were dominant. *Coscindiscus lineatus* was distributed in all the nine sites including high and low tides, indicated its capacity to tolerate high fluctuations of water chemistry

(Table 2). This was followed by *C. excentricus*. *Chaetoceros socialis* was found only in Passur R. between Nalianala and Chandpai Ranges, a zone of low salinity, conductivity and total dissolved solids.

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