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SEASONALITY AND DIVERSITY OF EPIPELIC DIATOMS IN TWO WETLANDS OF BANGLADESH

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Abstract

Seasonality and composition of epipelic diatom community were studied for two years in two wetlands of Bangladesh namely, Joysagar and Sitlai Beel. A total 73 diatom taxa were recorded. The average density of epipelic diatom was higher in Sitlai Beel (52.97×10^4/g sediment) than in the Joysagar (3.92×10^4/g sediment). The epipelic diatom community of Joysagar was dominated by the species of *Melosira, Synedra, Navicula, Pinnularia, Gomphonema,* and *Nitzschia*, whereas *Melosira, Navicula, Pinnularia, Cymbella* and *Gomphonema* dominated in Sitlai Beel. *Melosira granulata, Navicula americana, Pinnularia major,* and *Gomphonema lanceolatum* were dominant and expressed distinct seasonality in both wetlands. The concentration of soluble reactive silicate of water and the average density of epipelic diatom did not express any significant relation in both of the water bodies. The concentration of phytoplankton chl *a* had a positive relationship with epipelic diatoms and was significant in Sitlai Beel.

Introduction

Epipelic diatoms are important primary producers and key food source for benthic organisms (Daume *et al*. 1999, Beltrones and Romero 2001) in shallow aquatic environments. Moreover, they contribute in carbon cycling (Hecky and Hesslein 1995, Barranguet 1997). Several variables such as sediment type (Amspoker and McIntire 1986), nutrient availability (Agatz *et al*. 1999), salinity (Underwood *et al*. 1998) of a water body can affect the distribution and diversity of epipelic diatom communities. Compared to benthic macroinvertebrates, diatoms are considered more sensitive indicator of water chemistry owing to their shorter life cycle and nature as primary producer (Steinberg and Schiefele 1988). They have been found to be useful for river monitoring purposes (Eloranta and Andersson 1998). Seasonality and water quality alterations have been linked to changes in aquatic biota and each species of diatom has a specific distribution range and tolerance for environmental variables.

Bangladesh possesses enormous area of wetlands and those have an ecological, socio-cultural, and economical importance. The *haors, baors, beels* and *jheels* are of fluvial origin and are commonly identified as freshwater wetlands and regarded as valuable fish and wild life habitats. The ecology of epipelic diatoms is less well understood than their pelagic counterparts in various limnological study of Bangladesh. The present study includes spatial and temporal variations in species composition of epipelic diatoms of Joysagar pond and Sitlai Beel

Materials and Methods

Two wetlands, namely Joysagar pond and Sitlai Beel in the district of Sirajganj, Bangladesh were selected for this study. Joysagar pond (24°28′40″- 24°28′50″E and 89°25′24″- 89°25′42″N) is about 0.226 km^2 in area and up to 2.13 m deep during monsoon. On the other hand, Sitlai Beel (24°28′10″E and 89°26′30″N) has an area of 0.04 km^2. Fertilization is done by chemical fertilizer in

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both the water bodies for aquaculture. Besides, the water of Sitlai Beel is also used for domestic purposes by villagers. Samples for the present study were collected bi-monthly for a period from June, 1995 to May, 1997. The average values of some physical and chemical variables of the wetlands are presented at Table 1.

Table 1. Physico-chemical states of the studied wetlands.

Variables	Joysagar	Sitlai Beel
Air temperature (° C)	29.90 ± 9.30	21.70 ± 2.60
Water temperature (° C)	27.40 ± 4.10	28.50 ± 4.30
Maximum depth (Zs) (cm)	14.10 ± 1.70	14.90 ± 2.00
pH	7.40 ± 0.70	7.50 ± 0.70
Alkalinity (meq/l)	0.66 ± 0.10	0.44 ± 0.12
Conductivity (µS/cm)	109.20 ± 27.40	85.60 ± 20.70
Soluble reactive silicate (SRS) (mg/l)	11.43 ± 0.61	21.00 ± 0.80
Soluble reactive phosphorus (SRP) (µg/l)	79.87 ± 9.95	220.18 ± 15.66
Total phosphorus (TP) (µg/l)	254.00 ± 82.20	458.70 ± 278.90
NO_3-N (µg/l)	97.70 ± 52.10	127.20 ± 76.80
Phytoplankton chl *a* (µg/l)	174.10 ± 93.00	97.90 ± 58.30

Duplicate water samples were collected from five stations of each wetland by a Schindlers sampler (5 L capacity) and taken into screw capped 500 ml capacity polystyrene bottles for chemical analysis. A known volume of water was filtered through a Whatman GF/C filter paper by Sartorius vacuum filtration pump (GMBh, Göttingen, Germany). Chl *a* was extracted from the Whatman GF/C filter paper with hot ethanol, described by Marker *et al*. (1980), and the concentration was determined following APHA (1989). The filtered water was used for the analysis of soluble reactive silicate (Golterman *et al.* 1978).

A PVC pipe (length 30 cm and diameter 5 cm) was used to collect the sediment sample for epipelic diatom analysis. The pipe was inserted manually in the soft mud with the help of a diver and made air tight by putting a rubber cork at the other end of the pipe. It made the pipe air tight. It was then pulled out from the sediment and a second rubber cork was put and pushed slowly from the bottom end of the pipe. The water above sediment in the tube was sucked out by using the force of gravity. A 0.5 cm thin section of the top most sediment was then cut with the help of a piece of galvanized metal sheet. The piece of wet sediment was kept in a screw capped wide mouthed plastic jar (100 ml capacity) and preserved with 4% formalin. Diatom frustules were cleaned using 30% hydrogen peroxide and 30% potassium dichromate as described by Van der Werff (1958) and preserved in a screw capped glass vials for quantitative and qualitative analysis. The number of valves of each species was counted for each sample. Diatoms were identified using Hustedt (1930), Germain (1981), Islam and Haroon (1975), Foged (1976), Federovich (1980) and Tolonen *et al*. (1986).

All data were checked for the assumption of normal distributions and homogeneity of the variances before statistical analyses. The regression analysis of SRS and phytoplankton chl *a* with the density of epipelic diatom was performed using MS Excel. One-way ANOVAs were used (STATISTICA, version 5) to determine statistical significance of SRS and chl *a* with density of epipelic diatom as the main factor and to find statistical differences of the density of diatom cells between the wetlands.

Results and Discussion

A total of 73 diatom taxa were recorded from the two studied water bodies, of which solely 12 taxa occurred in Joysagar and 21 taxa occurred in Sitlai Beel. Forty taxa of diatom were common for both the Joysagar and Sitlai Beel (Table 2). Number of total mean diatom frustules in Joysagar and Sitlai Beel are plotted in Fig. 1. The average density of epipelic diatom was significantly higher (one-way ANOVA, $p > 0.001$) in Sitlai Beel (52.97×10^4/g sediment) than in the Joysagar (3.92×10^4/g sediment) (Fig. 1). In the first year (1995-1996) of the observation, lowest diatom cell density (1.6×10^4/g sediment in Joysagar and 32.1×10^4/g sediment in Sitlai Beel) was observed in June´95 whereas the highest density (12×10^4/g sediment in Joysagar and 71.9×10^4/g sediment in Sitlai Beel) was attained in April'96 for both study sites (Fig. 1). In the second year (1996-97), highest density of diatom frustules was recorded in March'97 for both the studied sites (13.2×10^4/g sediment in Joysagar and 70×10^4/g sediment in Sitlai Beel).

Table 2. List of benthic diatom taxa recorded from both Joysagar and Sitlai Beel.

Joysagar	Sitlai Beel
Coscinodiscaceae	**Coscinodiscaceae**
Cyclotella meneghiniana Kütz.	*Cyclotella meneghiniana* Kütz.
Cyclotella stelligera Cleve *et* Grun.	*Cyclotella stelligera* Cleve *et* Grun.
Melosira granulata (Ehr.) Ralfs	*Melosira distans* var. *alpigina* Grun.
Melosira granulata var. *curva* Grun.	*Melosira granulata* (Ehr.) Ralfs
Fragilariaceae	*Melosira granulata* var. *angustissima* Mull.
Asterionella formosa Hasall.	**Fragilariaceae**
Fragilaria intermedia Grun.	*Asterionella formosa* Hasall.
Fragilaria virescens Ralfs	*Fragilaria intermedia* Grun.
Synedra ulna (Nitz.) Ehr.	*Fragilaria virescens* Ralfs
Synedra vaucheriae Kütz.	*Synedra rumpens* var. *familiaris* Kütz.
Synnedra rumpens var. *familiaris* Kütz.	*Synedra ulna* (Nitz.) Ehr.
Naviculaceae	**Naviculaceae**
Amphora comutata Grun.	*Amphora commutata* Grun.
Cymbella turgida (Gregory) Cleve	*Amphora ovalis* var. *libyca* (Ehr.) Cleve
Diploneis ovalis (Hilse) Cleve	*Caloneis silicula* (Ehr.) Cleve
Gomphonema acuminatum Ehr.	*Cymbella tumida* (Bréb.) van Heurek
Gomphonema augur Ehr.	*Cymbella turgida* (Gregory) Cleve
Gomphonema lanceolatum (Greg.) Cleve	*Cymbella ventricosa* Kütz.
Gomphonema longiceps Ehr.	*Diploneis ovalis* (Hilse) Cleve
Gomphonema subtile Ehr.	*Gomphonema acuminatum* Ehr.
Navicula mutica Kütz.	*Gomphonema augur* Ehr.
Navicula americana Ehr.	*Gomphonema helveticum* Brun.
Navicula cuspidata Kütz.	*Gomphonema lanceolatum* (Greg.) Cleve
Navicula cuspidata Kütz. var. *heribaudii* Peragallo	*Gomphonema subtile* Ehr.
Navicula grimmei Krasske	*Navicula muctica* Kütz.
Navicula laevissima Kütz.	*Navicula pupula* Kütz. var. *capitata* Hust.

(Contd.)

(Contd.)

Navicula pupula Kütz.	*Neidium binodis* (Ehr.) Cleve
Neidium iridis (Ehr.) Cleve	*Neidium irridis* (Ehr.) Cleve
Pinnularia krookei (Grun.) Cleve	*Pinnulaira krookei* (Grun.) Cleve
Pinnularia acrosphaeria Bréb.	*Pinnulaira major* (Kütz.) Cleve
Pinnularia acrosphaeria Bréb. var. *laevis* Cleve	*Pinnularia acrosphaeria* Bréb.
Pinnularia braunii (Grun.) Cleve	*Pinnularia braunii* (Grun.) Cleve
Pinnularia major (Kütz.) Cleve	*Pinnularia pulchra* Ostrup
Pinnularia stauroptera (Grun.) Cleve	*Pinnularia stauroptera* (Grun.) Cleve
Pinnularia viridis Ehr.	*Pinnularia viridis* Ehr.
Stauroneis anceps Ehr.	*Pinnularira divergens* W. Smith
Stauroneis schroederi Hust.	*Stauroneis anceps* Ehr.
Eunotiaceae	*Stauroneis schroederi* Hust.
Eunotia exigua var. *bidens* Hust.	**Eunotiaceae**
Eunotia monodon var. *major* fa. *bidens* (Smith) Hust.	*Eunotia exigua* var. *bidens* Hust.
Eunotia pecitnalis var. *undulata* (Ralfs) Rab.	*Eunotia pectinalis* var. *rostrata* (Kütz.) Rab.
Eunotia pectinalis var. *rostrata* (Kütz.) Rab.	*Eunotia pectinalis* var. *tetraedron* (Ehr.) Ralfs
Eunotia pectinalis var. *valvaire* (Kütz.) Rab.	*Eunotia pectinalis* var. *valvaire* (Kütz.) Rab.
Eunotia robusta var. *tetraedron* (Ehr.) Ralfs	*Eunotia veneris* (Kütz.) Muller
Eunotia tenella (Grun.) Hust.	*Neidium irridis* (Ehr.) Cleve
Eunotia veneris (Kütz.) Mull.	**Epithemiaceae**
Neidium binodis (Ehr.) Cleve	*Epithemia zebra* (Ehr.) Kütz.
Nitzschiaceae	*Rhopalodia gibba* Ehr.
Hantzschia amphioxys (Ehr.) Grun.	**Nitzschiaceae**
Nitzschia acicularis Smith	*Hantzschia amphioxys* (Ehr.) Grun.
Nitzschia clausii Hantzsch.	*Nitzschia acicularis* Smith
Nitzschia spectabilis (Ehr.) Ralfs	*Nitzschia clausii* Hantzsch.
Nitzschia subtubicola Smith	*Nitzschia fruticosa* Hust.
Surirellaceae	*Nitzschia linearis* Smith
Surirella ovulum Hust.	*Nitzschia subtubicola* Smith
Surirella tenera Gregory	*Nitzschia tryblionella* var. *levidensis* (W. Smith) Grun.
Surirella var. *splendida* Ehr.	**Surirellaceae**
Navicula americana Ehr.	*Surirella capronii* Brébisson
Navicula anglica Ralfs	*Surirella molleriana* Grun.
Navicula cuspidata Kütz.	*Surirella ovulum* Hust.
Navicula grimmei Krasske	*Surirella robusta* var. *splendida* Ehr.
Navicula laevissima Kütz.	*Surirella tenera* Gregory.

The trend of peak diatom occurrence for both Joysagar and Sitlai Beel were found in March and April (Fig. 1). During these peaks the range of Zs, water temperature, conductivity and SRP for both the water bodies were: 14 - 15 cm, 28.4 - 30.0° C, 85 - 129 µS/cm and 56.9 - 187.7 µg/l, respectively. The overall ranges of the above mentioned parameters for both the water bodies were

Zs: 12 - 19 cm, water temperature: 21.1 - 38.4° C, conductivity: 66.2 - 129.4 µS/cm and SRP : 25.8 - 416.3 µg/l. This indicates that the diatom peaks occur mostly at medium range values of Zs, water temperature, conductivity and SRP. In contrast, the lowest values of diatoms were recorded in August'96 for Joysagar (1.5×10^4/g sediment) and October'96 for Sitlai Beel (30.7×10^4/g sediment) (Fig. 1).

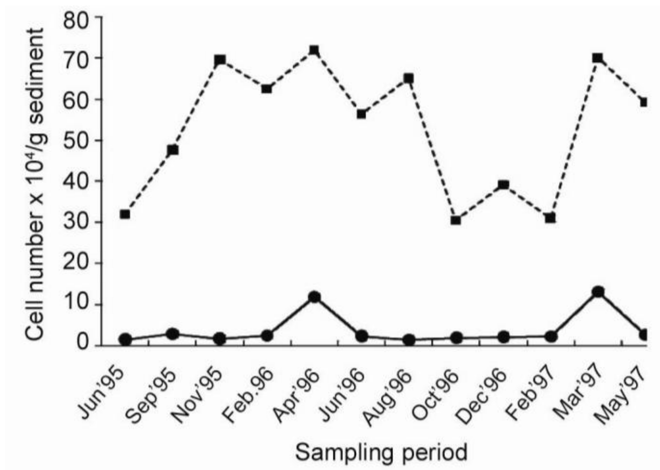

Fig. 1. Seasonal fluctuations of total benthic diatom cells in both of the studied water bodies.
--●-- Joysagar, --■-- Satlai beel

The eutrophication status of Sitlai Beel is much higher than Joysagar (Table 1). SRS and Ptot are double in concentration and SRP is nearly threefold higher in Sitlai Beel than in Joysagar. Nitrate nitrogen concentration is 30% more in Sitlai Beel than in Joysagar. On the other hand, pelagic chl. *a* which is a major limiting factor for the growth of bottom living diatoms is 46% lower in Sitlai Beel than in Joysagar. Because of these reasons the species number and density of bottom living diatoms are higher in Sitlai Beel.

However, no significant correlation was observed between the SRS concentration of water and the average density of epipelic diatom in both of the Joysagar and Sitlai Beel (Fig. 2A-B).This results contradict with the results of Pearsall (1930), who suggested that the fall in silica concentrations coincides with the diatom maxima and it increases while individual numbers of diatoms decrease. Round (1953) observed 153 fold increases in the concentration of epipelic diatom with a fall of 50% silicate concentration in the interstitial water. But Hickman (1978) observed relationship between silicate and epipelic diatom within a concentration 0.6 - 2.8 mg/l. Compared to this range the SRS concentration in both the studied habitats are far more richer (Table 1).

The average concentration of phytoplankton chl. *a* was higher in Joysagar than in the Sitlai Beel (Table 1). It showed a positive, significant correlation with the density of epipelic diatom of Sitlai Beel (Fig. 2) and it was insignificant in Joysagar (Fig. 2).

The two years of study revealed that diatom flora of Joysagar were dominated by the species of *Melosira, Synedra, Navicula, Pinnularia, Gomphonema,* and *Nitzschia,* whereas species of *Melosira, Navicula, Pinnularia, Cymbella* and *Gomphonema* dominated the community of Sitlai Beel. Among the dominant species, 11 and 12 species were present in a year round basis in Joysagar and Sitlai Beel. *Melosira granulata, Navicula americana, Pinnularia major,* and *Gomphonema lanceolatum* were dominated and expressed distinct seasonality in both the wetlands.

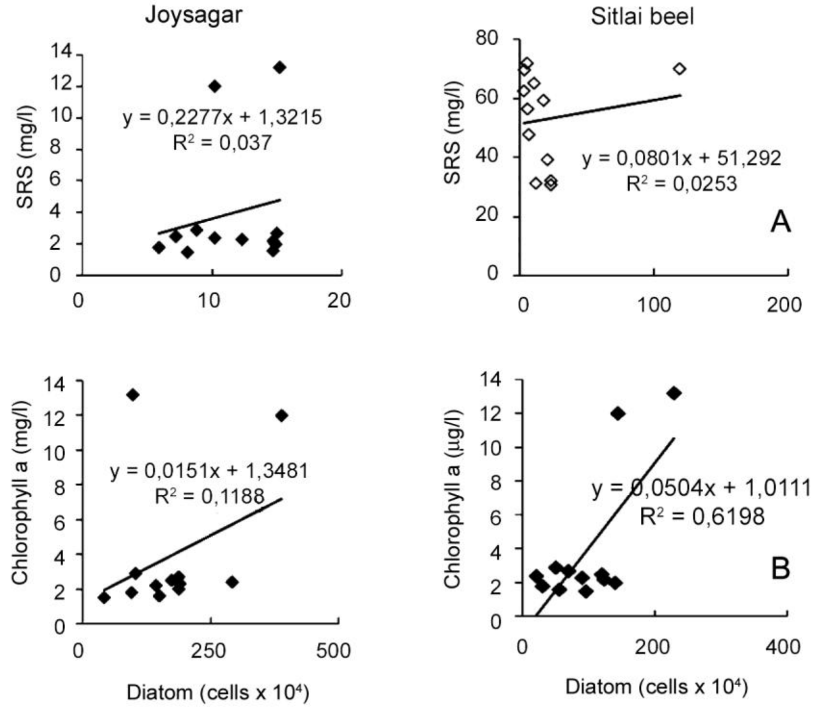

Fig. 2. Relationship of diatom density with chlorophyll *a* (lower row) and with SRS (upper row) of water of the Joysagar and Sitlai Beel.

The seasonal dynamics of these four diatoms is presented in Fig. 3 A-B for Joysagar and Sitlai Beel. This result is supported by the data obtained by Sherman and Phinney (1971) and Khondker and Dokulil (1987). Sherman and Phinney (1971) made a study on epipelic algal communities of the Metolouis River, Central Oregan. They described that 9 out of 60 identified algal species showed a definite seasonal distribution and remaining species found on a year round basis. The community of downstream was dominated by diatom and mostly were *Nitzschia palea* and *Cymbella cistula*. Correspondingly Khondker and Dokulil (1987) observed that the assemblage of epipelic algae was dominated by diatom in a shallow lake, Neusiedlersee, Austria where three species i.e., *Cyclotella meneghiniana* Kütz., *Fragilaria brevistriata* Grun. and *Nitzschia tryblionella* var. *levidensis* (W. Sm.) Grun. were dominated throughout the year.

In the present study, *Melosira granulata* was the most dominating species in the epipelic diatom community in the studied wetlands (Fig. 3 A-B). Their density was much higher than the other species throughout the period of investigation. In the first year of investigation, *M. granulata* showed its highest peak in April 96 (1.4×10^4/g sediment) for Joysagar and in February'96 for Sitlai Beel (41×10^4/g sediment). In the second year, an early summer maxima was observed in March'97 (2.4×10^4/g sediment) which was much higher than the previous year in Joysagar. In Sitlai Beel, it also showed a summer maxima in March'97, but the cell density (32×10^4/g sediment) was lower than the previous year (Fig. 3B). *Melosira* spp. are economically important for Bangladesh. Islam (1974) analysed the stomach contents of the fish Hilsha (*Hilsa hilsa*) and cat fish (*Mystus aor*), and found 98% of the total food content belonged to *Melosira* spp. They mainly identified *Melosira granulata* and some varieties of this species.

Navicula americana showed four peaks in Joysagar, one in each of November'95, April'96, December'96 and March'97 (Fig. 3 A). In Sitlai Beel the species also showed four peaks but in each of February'96, August'96, December'96 and March'97 (Fig. 3B). This characteristic peak formation for Joysagar and Sitlai Beel has also been observed for two other species namely, *P. major* and *G. lanceolatum* (Fig. 3 A-B).

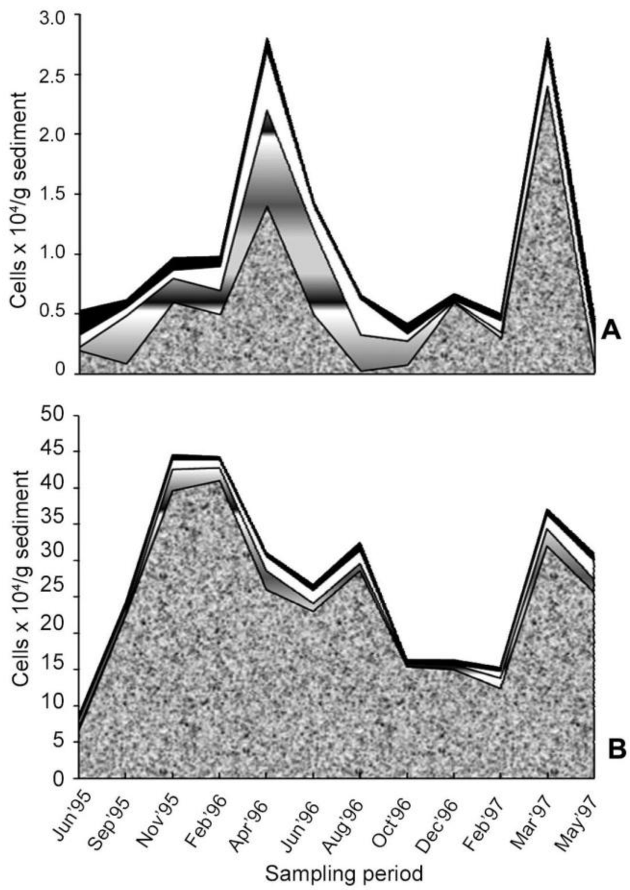

Fig. 3 A,B. Distribution of four major diatom species in Joysagar (A) and Sitlai Beel (B) over the period of investigation. ▩ *M. granulata* ▤ *N. americana* □ *P. major* ■ *G. lanceolatum*

From the observations it could be said that, as because of freshwater bio-monitoring requires considerable effort and resources, epipelic diatom has a leading role in many parts of the world (Pan *et al*. 1999, Leland and Porter 2000). Epipelic diatom assemblages of the studied two wetlands responded to seasonality and environmental gradients; however, different taxa showed different patterns. The diatom population density was much higher in Sitlai Beel than in the Joysagar and the state of SRS concentration of water did not have significant correlation with the diatom density. However, a medium range in the Sechhi disc transparency, water temperature, conductivity and SRP was found suitable for the diatom peaks in the studied wetlands.

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