View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Update Publishing (E-Journals)

Research in Plant Biology, 3(6): 31-41, 2013
ISSN : 2231-5101
www.resplantbiol.com

Regular Article

Studies on brackish water epiphytic algae from Sundarbans in North 24 Parganas district, West Bengal, India

Nurmohammad Naskar[1]*, Ashutosh Mukherjee[2], Kumudranjan Naskar[3], M. A. Hassan[3] and Subhra Mukhopadhyay[4]

[1]Bongaon Ghosh Institution, North 24 Parganas-743235, West Bengal, India
[2]Department of Botany, Dinabandhu Mahavidyalaya, Bongaon, North 24 Parganas - 743235, West Bengal, India
[3]Central Inland Fisheries Research Institute (ICAR), West Bengal, India
[4] Department of Botany, Barasat Govt. College, Barasat, Kolkata-124, West Bengal, India.
*Corresponding author E-mail: nurmohammadnaskar@yahoo.com

This study represents the species diversity and ecology of brackish water epiphytic algae of Sundarbans. Out of 22 taxa, Cyanophyceae represent 50%, Chlorophyceae and Xanthophyceae were 36% and 14%, respectively. These algal taxa were studied in relation to physicochemical characters viz. water temperature, transparency, pH, salinity, phosphate and nitrate. To analyze the data, computerized statistical package was used to calculate correlation co-efficient between the epiphytic algal distribution and physicochemical factors. A dendrogram was also constructed to reveal the relationships among different algae on the basis of their diversity in different seasons. Epiphytic algal taxa showed maximum growth during summer and are more diverse and variable at different stations. These taxa showed a correlation with the habitat.

Key words: Epiphytic algae, brackish water, physicochemical characters, ecosystem, dendrogram, Sundarbans

Sundarbans claims to be one of the wonders of the world for its natural resources having the largest halophytic mangrove forest in the world. Out of 10000 sq. km. area of Sundarbans, 6000 sq. km. are in Bangladesh and the rest of the area is in India. The mangrove forest, biodiversity and ecosystem of Sundarbans form an extraordinary environment of the globe. Sundarbans is also one of the most ecologically threatened areas of the planet. The brackishwater environment is an integral part of Sundarbans which is a consequence of tidal sea water incursion and fresh water discharge from the adjoining creeks and rivers.

Fisheries of Sundarbans are largely associated with brackish water and provide favourable substratum for algae. The algal communities associated with brackish water fisheries of Sundarbans influence the aquatic ecosystem and fish production (Naskar and Naskar, 2010). In brackish water of Sundarbans, epiphytic algal populations grow along with phytoplaktons and benthic forms. Epiphytic algal species

Received : 29.6.13; Revised : 20.11.13; Accepted : 2.12.13

abundantly found in the brackish water fish guts (shell and fin fishes) are no less than phytoplanktons and benthic algal species (Chung and Lee, 2008; Naskar and Naskar, 2010).

Brackish water epiphytic algae are more diverse in species and numbers and are called as dependent algae (Reid *et al*., 1995) which relate productive ecosystem of brackish water fisheries (Naskar and Naskar, 2010). Apart from that, epiphytic algae support nutrition in fisheries species in Sundarbans (Conolly *et al*, 2005; Naskar and Naskar, 2010). Fisheries species also rely on epiphytic algae as their ultimate source of nutrition (Lepoint *et al,* 2000; Vizzini *et al*., 2002).

The studies on brackish water algae in and around Sundarbans are noticed in the works of Santra *et al*. (1988), Sen *et al.* (1998), Sen and Naskar (2003), Naskar *et al*. (2006, 2007), Naskar (2007), Naskar and Naskar (2007), Naskar *et al*. (2008a, 2008b, 2008c), Naskar (2011a, 2011b) and Naskar *et al*. (2009). However, there is a lacuna of publication of such database on brackish water epiphytic algae of Sundarbans in North 24 Parganas, west Bengal, India. Hence, this study focuses on the influence of environmental variables on algal epiphytism and its diversity in brackish water environment of Sundarbans in North 24 Parganas district, West Bengal, India.

Materials and methods

Study site

The study sites were situated in the District North 24 Parganas which is the Southern zone of the state West Bengal, India. Indian part of Sundarbans is only located in the Districts of North 24 Parganas and South 24 Parganas of West Bengal, India. The studied District North 24 Parganas lies between 22°11'6"N and 23°1'2"N latitude and between 88°20'E and 89°5'E longitude. Out of 22 blocks of the district North 24 Parganas, 12 blocks have brackish water fisheries (figure 1). The brackish water blocks are Hingalganj, Sandeshkhali I and II, Haroa, Hasnabad, Minakhan, Basirhat I and II, Baduria, Barasat II, Rajarhat and Deganga. The first six brackish water blocks are under Sundarbans jurisdiction and the rest are at the outskirts of Sundarbans. Every four blocks were considered as one station considering the advent of sampling algae and water followed by seasons summer (March to May), monsoon (June to August), post monsoon (September to November) and winter (December to February) during 2002-2005. Station 1 represents Hingalganj, Sandeshkhali I and II, Station 2 represents Haroa, Hasnabad and Minakhan. Basirhat I and II; Baduria belong to station 3 and station 4 with Barasat II, Rajarhat and Deganga**.** Station 1 and 2 come under Sundarbans and station 3 and 4 are at the outskirts of Sundarbans.

Analysis of water parameters

Determination of the physicochemical parameters viz. water temperature, transparency, pH, salinity, phosphate and nitrate were carried out using the techniques followed by APHA (1975).

Determination of epiphytic algae

Algal samples were preserved in 4% formalin and deposited in the laboratory of Central Inland Fisheries Institute (ICAR), Salt Lake, Kolkata. Microscopic examina -tions of algae were performed following camera lucida drawing. Identification of algae was based on the keys given by Desikachary (1959), Ramanathan (1964), Sen and Naskar (2003) and Smith (1933).

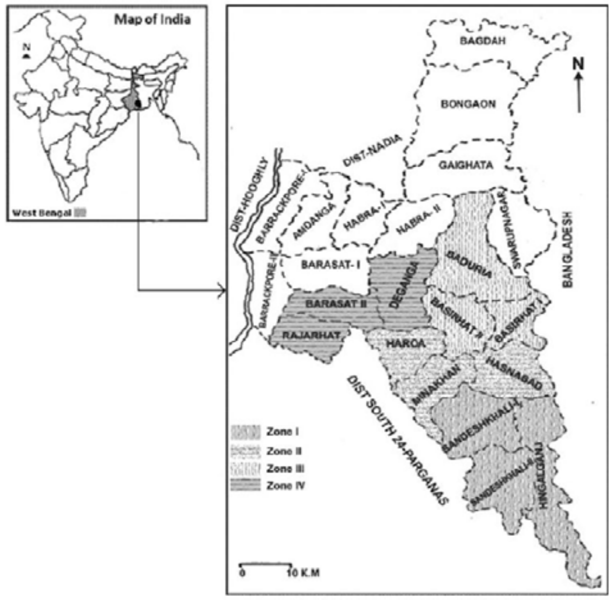


Figure 1: Map of different zones of brackish water wetlands in the District 24-Parganas (North), West Bengal, India

Numerical and Statistical methods

For environmental data, we considered average values for all stations and sampling data within each station. For algal taxa, we developed a presence-absence matrix of species based on their presence in different seasons. This matrix was used for the construction of a dendrogram based on Jaccard's similarity index (Jaccard, 1908) which was calculated by the formula $J = a/(a+b+c)$, where a represents the number of shared taxa present in any two seasons, b represents the number of taxa present in only in the first season and c represents the number of taxa present only in the second season. To analyze the relationships between algae and environmental variables, regression was performed. Relationships between the environmental variables were also analyzed.

Results and Discussion

Physicochemical parameters

Physicochemical characters of brackish water estuaries changes due to various factors that significantly influence the algal population (Choudhury and Pal, 2010). In the present investigation, the temperature and pH of the water of the study areas ranged from 18.75 - 31.95ºC and 7.75 - 8.45, respectively (figure 2, table 1). pH was highest in post monsoon months (figure 2). As evident from figure 2 and table 1, nitrate content reached its peak in summer (0.26 mgl^{-1}) and reached its minimum value in post monsoon (0.07 mgl^{-1}). Nitrate and salinity of post monsoon reached the lowest value (0.07 mgl^{-1} and 7.32 gl^{-1}, respectively). Minimum temperature was observed in winter and minimum pH was observed in monsoon. Phosphate level was the maximum in summer (0.66 mgl^{-1}) and minimum in winter (0.41 mgl^{-1}). Transparency was highest in summer followed by winter. Transparency in monsoon and post monsoon periods was lower probably because of the luxuriant growth of aquatic plants and turbidity by rainfall. Correlation among the environmental variables showed that salinity and pH had positive relationship (figure 3, R^2 = 0.26). in a natural system, pH is primarily determined by the concentration of alkali metals in the ionic forms (Na^+, K^+, Cl^-) with higher concentrations resulting in higher pH (Hinga, 2002). Thus pH is positively correlated with salinity in the present study (figure 3).

Table 1: Maximum, minimum and average values of environmental variables during the sampling period in all the four stations under this study

Parameters	Summer			Monsoon			Post-monsoon			Winter		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
Water Temp. (°C)	31.95	29.3	30.88	28.25	26.2	27.24	28.7	25.35	27.25	21.5	18.75	19.81
Transparency(cm)	47.15	17.75	35.09	24.6	11.05	18.19	27.25	13.65	21.7	33.75	16.45	28.65
pH	8.45	8.25	8.3	8.45	7.75	7.96	8.7	8.05	8.25	8.5	7.95	8.2
Salinity (gl^{-1})	16.25	7.85	12.05	11.3	4.05	7.67	9.05	4.4	7.32	9.9	5.0	7.71
Nitrate (mgl^{-1})	0.4	0.13	0.26	0.18	0.08	0.13	0.08	0.06	0.07	0.12	0.08	0.10
Phosphate (mgl^{-1})	1.2	0.11	0.66	0.88	0.21	0.56	0.72	0.03	0.49	0.68	0.02	0.41

Table 2: Floristic list of epiphytic algae recorded in brackish water with host names

Group	Name of epiphytic algae	Host
Cyanophyceae	*Chamaesiphon curvatus*	*Lola* spp., *Enteromorpha* spp.
	Dermocarpa leibleiniae	*Lyngbya* spp., *Uronema* spp.
	D. olivacea var. *gigantea*	*Phormidium* spp.
	D. sphaerica	*Lyngbya* spp.
	Stichosiphon sansibaricus	*Lola* spp., *Enteromorpha* spp.
	Xenococcus kerneri	*Lyngbya* spp.
	Phormidium corium var. *capitatum*	Bamboo sticks
	Anabaena ambigua	*Chaetomorpha* spp.
	Calothrix bharadwajae	Plant twigs
	C. scytonemicola	Many green algae
	Gloeotrichia raciborskii var. *conica*	Sticks
Chlorophyceae	*Ulothrix tenerrima*	*Dermocarpa* spp.
	U. variabilis	Plant twigs
	Uronema confervicolum	Many green algae
	U. gigas	Many green algae
	Enteromorpha intestinalis	Periphytic on Bamboo sticks
	E. compressa	Periphytic on Bamboo sticks
	E. clathrata	Periphytic on Bamboo sticks
	Rhizoclonium grande	Periphytic on twigs
Xanthophyceae	*Botrydium granulatum*	Green algae
	Peroniella curviceps	*Chaetomorpha*
	Characiopsis pyriformis	Green algae

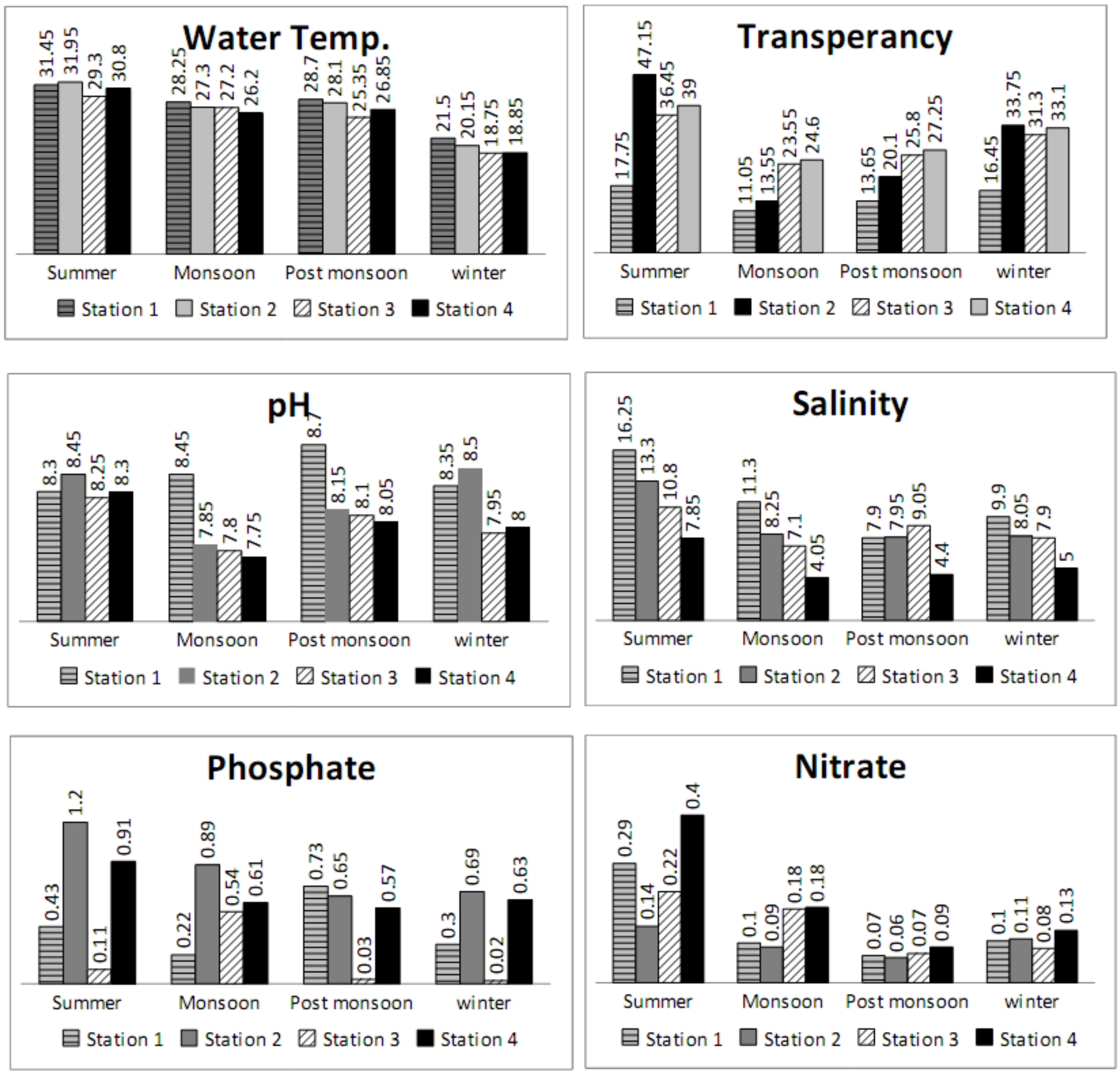


Figure 2: Different physicochemical parameters of water recorded in different stations in different seasons

Algal community structure

As the epiphytic algae are dependent (Reid *et al.*, 1995), the host name for every algal taxa is also noteworthy (table 2). The epiphytic algae contribute with a large share of total productivity and perform relevant functions in the dynamics of aquatic ecosystem of Sundarbans (Moresco and Rodrigues, 2010). In this study, the Cyanophycean alga *Chaemaesiphon curvatus* was found to grow on Chlorophycean algae (*Lola* spp., *Enteromorpha* spp.). Similarly, other members of Cyanophyceae viz. *Dermocarpa leibleiniae*, *D. olivacea* var. *gigantea*, *Stichosiphon sansibaricus* prefer to be attached with Chlorophycean and Cyanophycean algae. However, two other Cyanophycean members viz. *Dermocarpa spherica* and *Xenococcus kerneri* prefer only Cyanophycean hosts (table 2). Of these two, the epiphytic Cyanophycean alga *Dermocarpa spherica* was reported for the first time from backish water environment of West Bengal, India by Naskar (2007). The

Chlorophycean alga *Ulothrix tenerrima* was found to be attached with Cyanophycean members. So, we have noticed that some epiphytic algae have host specificity while others were attached with some twigs and non-living objects in brackish water of Sundarbans. The percentage composition of epiphytic algae showed that members of Cyanophyceae were the most abundant (50%), followed by Chlorophyceae (36%) and Xanthophyceae (14%) (table 2).

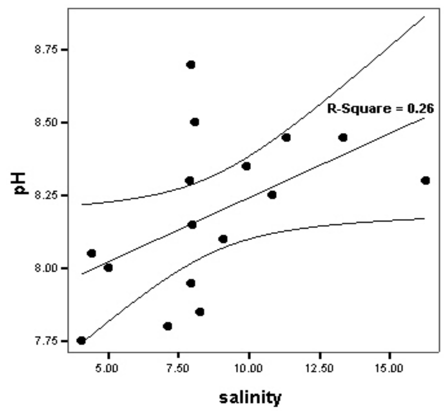


Figure 3: Correlation of pH with salinity

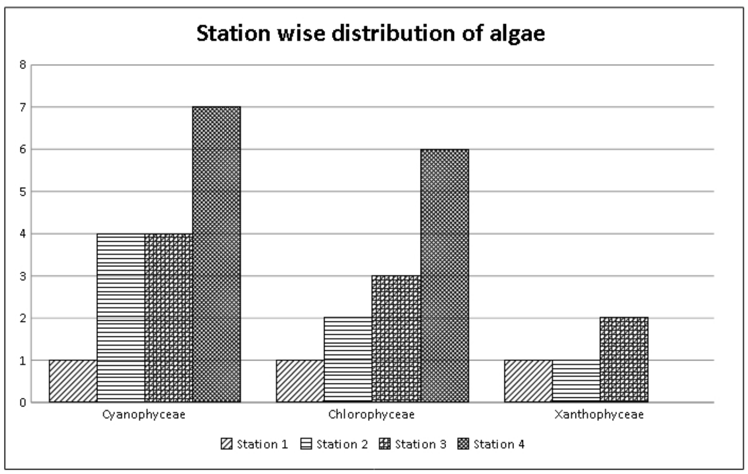


Figure 4: Station wise distribution of different group of algae.

Now, the taxonomic diversity and abundance of epiphytic algae depend on factors viz. substratum type, light intensity, temperature, nutrient availability and system hydrodynamics (Moschini-Carlos *et al*., 2000). Table 3 depicts the availability of epiphytic algal taxa which are found in different numbers in different seasons. The relative density of different algal groups was variable. In summer, the number of Cyanophycean algae was eight, while Chlorophyceae represented six members and Xanthophyceae was represented by only one species. During monsoon, Chlorophyceae and Cyanophyceae represent two taxa each while Xanthophyceae represents three members. During postmonsoon, Cyanophycean algae were almost absconding while Chlorophyceae showed two members and Xanthophyceae with single taxa. The winter season is rather favourable for the growth of brackish water epiphytic algae. Total ten taxa were found in this season which is remarkable by the absence of Xanthophycean members (table 3). So, the seasonal changes have an impact on the presence or absence of brackish water epiphytic algae.

There were considerable variations in the diversity of different epiphytic algal groups in different stations (table 4, figure 4). Cyanophyceae was found to be maximum (7) in station 4 while station 2 and 3 represent 4 taxa and single taxa in station 1. *Dermocarpa leibleiniae* appears in all stations of the study site. Other members were not found uniformly in all stations except *Dermocarpa spherica* which appears in station 3 and 4.

Table 3: Seasonal variation of the brackish water epiphytic algae studied

Group	Name of epiphytic algae	Season			
		Summer	Monsoon	Post monsoon	Winter
Cyanophyceae	*Chamaesiphon curvatus*	-	-	-	+
	Dermocarpa leibleiniae	+	-	-	+
	D. olivacea var. *gigantea*	+	-	-	-
	D. sphaerica	+	-	-	+
	Stichosiphon sansibaricus	+	+	-	+
	Xenococcus kerneri	-	+	-	
	Phormidium corium var. *capitatum*	+	-	-	+
	Anabaena ambigua	-	-	-	+
	Calothrix bharadwajae	+	-	-	-
	C. scytonemicola	+	-	-	-
	Gloeotrichia raciborskii var. *conica*	+	-	-	-
Chlorophyceae	*Ulothrix tenerrima*	+	+	-	-
	U. variabilis	-	-	-	+
	Uronema confervicolum	+	-	-	-
	U. gigas	+	-	-	-
	Enteromorpha intestinalis	+	+	+	+
	E. compressa	+	-	-	-
	E. clathrata	+	-	-	+
	Rhizoclonium grande	-	-	+	+
Xanthophyceae	*Botrydium granulatum*	+	+	-	-
	Peroniella curviceps	-	+	+	-
	Characiopsis pyreformis	-	+	-	-
Total		14	7	3	10

('+' indicates presence; '-' indicates absence)

The Chlorophycean algae were found to be the maximum (6 taxa) in station 4 while station 3 represents 3 taxa and stations 2 and 1 represent 2 and a single taxa, respectively. The members of the Xanthophyceae were rather scanty which were totally absent from station 4. Station 3 represents two taxa while station 2 and station 1 represent single taxa each. *Botrydium granulatum* appeared in station 1 and 2 only. So, the epiphytic algal taxa were most abundant in station 4 (table 4).

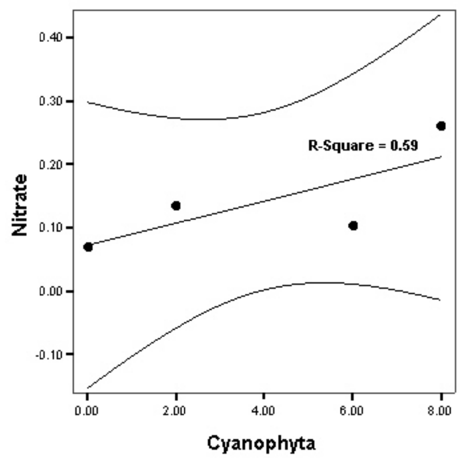
Algal diversity and correlation with physicochemical parameters

Total 22 epiphytic algae were recorded of which, six blue-green algal taxa (27%) were recorded only from winter months and two were recorded only from monsoon months. There is only one blue-green alga (*Xenococcus kerneri*) which was available only in monsoon. No Cyanophycean algae were found in post monsoon period (table 3). As no Cyanophycean epiphytic algae were found in post monsoon season, correlation with number of cyanophycean algae of all other seasons with physico-chemical parameters was investigated. The highest correlation was observed (figure 5) with nitrate and salinity (R^2 = 0.59 for both nitrate and salinity). Thus, the Cyanophycean epiphytic algae of this study could not survive in low nitrate and salinity level. The overall correlation between algae and nitrate was high (R^2 = 0.74).

Table 4: List of epiphytic algae collected from the four different regions

Group	Station 1	Station 2	Station 3	Station 4
Cyanophyceae	*Dermocarpa leibleiniae*	*Chamaesiphon curvatus*	*Dermocarpa leibleiniae*	*Chamaesiphon curvatus*
		Stichosiphon sansibaricus	*D. sphaerica*	*Dermocarpa leibleiniae*
		Phormidium corium var. *capitatum*	*Stichosiphon sansibaricus*	*D. olivacea* var. *gigantea*
		Anabaena ambigua	*Xenococcus kerneri*	*D. sphaerica*
				Calothrix bharadwajae
				C. scytonemicola
				Gloeotrichia raciborskii var. *conica*
Chlorophyceae	*Rhizoclonium grande*	*E. compressa*	*Enteromorpha intestinalis*	*Ulothrix tenerrima*
		E. clathrata	*E. clatterata*	*U. variabilis*
			Rhizoclonium grande	*Uronema confervicolum*
				U. gigas
				Enteromorpha intestinalis
				Rhizoclonium grande
Xanthophyceae	*Botrydium granulatum*	*Botrydium granulatum*	*Peroniella curviceps*	
			Characiopsis pyriformis	

There were only two algae from Chlorophyta and one from Xanthophyta which were found in post monsoon (table 3). Due to influx of freshwater from perennial rivers and seasonal rainfall causing low salinity, sudden decline in algal population especially Cyanophycean population from summer to monsoon and post monsoon was observed. Similar observations were recorded for diatoms (Figueredo and Giani, 2001; Choudhury and Pal, 2010). Algal diversity was also highly correlated with transparency (R^2 = 0.73). It was previously reported that the periphyton and benthic productivity depends on the light availability (Vadeboncoeur *et al.*, 2008). The highest correlation, however was shown with nitrate concentration (R^2 = 0.74). It is, thus, evident that nitrate is a key nutrient for these epiphytic algae. Thus in the present study, the multi-parameter regression analysis showed significant positive correlation of algal diversity with nitrate, transparency and salinity of the water. Additionally, the present study showed that summer is the most productive season for the growth of epiphytic algae.



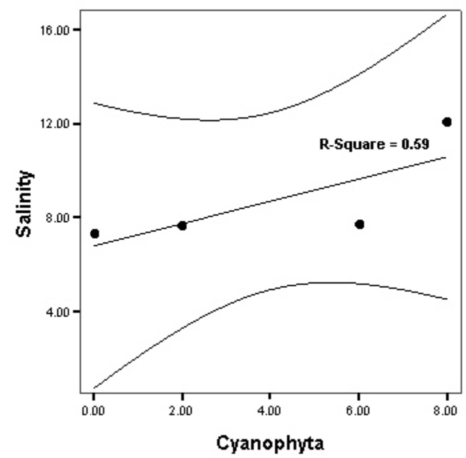


Figure 5: Correlation of salinity and nitrate concentration with Cyanophyceae

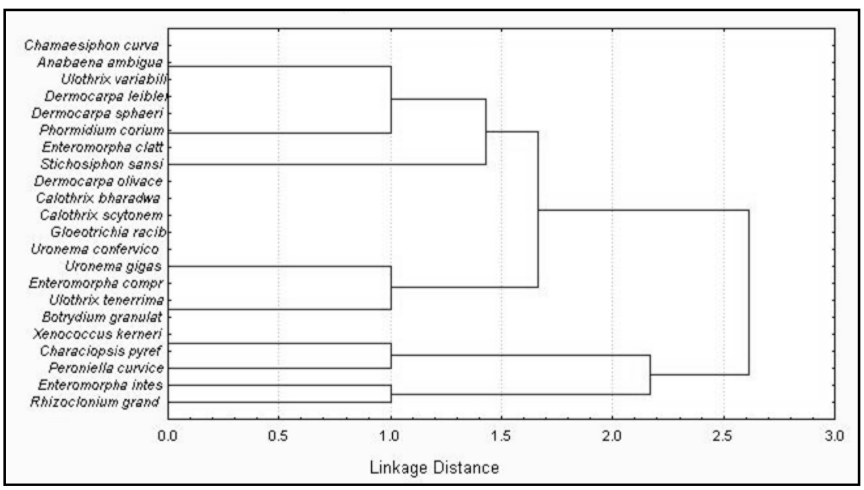


Figure 6: Dendrogram of different epiphytic algae based on their abundance in different seasons

Cluster analysis

The result of cluster analysis showed that brackish water epiphytic algae of Sundarbans are divided into two main subclusters (figure 6) based on their seasonal availability. The first group was larger and contains eighteen algae. This subcluster is further divided into two groups. The first group contains those species which are mainly available both in winter and summer. The second group contains mainly summer and monsoon algae. These are mainly comprised of Chlorophycean algae. The small subcluster contains mainly those algae which are available in post monsoon season. This subcluster contains only one member of Cyanophyceae namely *Xenococcus kerneri*.

In conclusion, it can be said that seasonality is the major factor in determining the epiphytic algal diversity in the brackish water of Sundarbans associated with nutrient especially nitrate concentration, salinity and transparency. The epiphytic algae of brackishwater wetlands may be used as database for biomonitoring studies (Naskar and Naskar, 2007). In the context of global climate change, epiphytic communities may be considered. The water bodies with floating plants and macrophytes may be affected by local warming (Meerhoff and Mazzeo, 2004) which have an impact on the ecology of algal communities associated with substrata. It is also noteworthy that the structure and functionality of epiphytic organisms may give the idea of future changes in a warming scenario.

Acknowledgment

Authors acknowledge the support and cooperation of the Director, Central Inland Fisheries Institute (ICAR), Principal, Barasat Govt. College and Teacher In-charge, Dinabandhu Mahavidyalaya.

References

APHA. 1975. *Standard methods for the examination of water and wastewater (14th ed)*, American Public Health Association, Washington, D.C.

Choudhury AK and Pal R. 2010. Phytoplankton and nutrient dynamics of shallow coastal stations at Bay of Bengal, Eastern Indian coast. Aquatic Ecol. 44: 55-71.

Chung MH and Lee K-S. 2008. Species composition of the epiphytic diatoms on the leaf tissues of three *Zostera* species distributed on the southern coast of Korea. Algae 23(1): 75-81.

Connolly RM, Hindell JS and Gorman D. 2005. Seagrass and epiphytic algae support nutrition of a fisheries species, *Sillago schomburgkii*, in adjacent intertidal habitats. Mar Ecol Prog Ser. 286: 69-79.

Desikachary, T.V. 1959. *Cyanophyta, Monograph*, I. C. A. R., New Delhi, India.

Figueredo CC and Giani A. 2001. Seasonal variation in the diversity and species richness of phytoplankton in a tropical eutrophic reservoir. Hydrobiologia 445: 165-174.

Hinga KR. 2002. Effects of pH on coastal marine phytoplankton. Mar Ecol Prog. Ser. 238: 281-300.

Jaccard P. 1908. Nouvelles rescherches sur la distribution florale. Bull. Soc. Vaud. Sci. Nat. 44: 223-270.

Lepoint G, Nyssen F, Gobert S, Dauby P and Bouquegneau JM. 2000. Relative impact of a seagrass bed and its adjacent epilithic algal community in consumer diets. Marine Biol. 136: 513-518.

Meerhoff M and Mazzeo N. 2004. Importancia de las plantas flotantes libres de gran porte en la conservación y rehabilitación de lagos someros de Sudamérica. Ecosistemas 13(2): 13-22.

Moresco C and Rodrigus L. 2010. Structure and dynamics of the periphytic algae community of Iraí reservoir Paraná State Brazil, Acta Scientiarum: Biol. Sci. 32(1): 23-30.

Moschini-Carlos V, Henry R and Pompêo MLM. 2000. Seasonal variation of biomass and productivity of the periphytic community on artificial substrata in the Jurumirim Reservoir (Sâo Paolo, Brazil). Hydrobiologia 434: 35-40.

Naskar, N. and Naskar, K.R. 2010. *Brackish Water Alage of Sundarbans, India: Sundarbans, Brackish water, Wetlands, Algal diversity, Ecosystems.* Lambert Academic Publishing (LAP), Germany.

Naskar NM. 2007. First report of *Dermocarpa* *spherica* Setchell *et* Gardner from West Bengal. Environ and Ecol. 25(3): 719-720.

Naskar NM and Naskar KR. 2007. Diversity of Ulotrichales in estuarine wetlands of North 24-Parganas district, West Bengal. Indian Hydrobiology 10(2): 249-255.

Naskar NM, Naskar KR and Sen CR. 2007. Systematic Account and Ecology of Cholorococcales from Brackishwater Bheries (Wetlands) of North 24-Parganas District of West Bengal. Geobios 34: 17-20.

Naskar NM, Naskar KR and Sen CR. 2008a. Brackishwater Oscillatoriaceae from North 24 Parganas district, West Bengal. Bangladesh J. Plant Taxon 15(1): 31-38.

Naskar NM, Naskar KR and Talai S. 2008b. Occurrence of six species of *Spirulina* Turpin Em Gardner from the coastal wetlands of North 24 Parganas district, West Bengal, India. Seshaiyana 15(1): 4-5.

Naskar NM, Naskar KR and Sen CR. 2008c. A new record of blue-green alga *Lyngbya spirulinoides* Gomont – (cyanobacterium) from West Bengal, India. Seshaiyana 16(3): 3-4.

Naskar NM, Naskar KR and Talai S. 2009. Addition to the list of brackishwater Zygnemaceae of Sundarbans and its adjoining areas, India. Genus *Spirogyra* Link. Our Nature 7: 187-192.

Naskar, N.M. 2011a. Cyanobacterial biodiversity from brackish water wetlands of Sundarbans. In: *Sundarbans: Issues and threats*, Eds. K.R. Naskar and A. Bhattacharya, Central Inland Fisheries Institute (ICAR), Kolkata, India. pp: 49-66.

Naskar, N.M. 2011b. Ecosystem functions of Coastal fisheries from Sundarbans: Do algal species matter? In: *Emerging trends in Plant Science.* Eds. P.K. Das, A.K. Das and N. Das Barasat Govt. College, India. pp: 51-59.

Naskar NM, Naskar KR and Sen CR. 2006. A systematic Account of Chroococcales (Myxophyceae) from Brackish water Wetlands of North 24-Parganas District, West Bengal. Environ. Ecol. 24S(3): 655-657.

Ramanathan, K.R. 1964. *Ulotrichales*. ICAR, New Delhi.

Reid M.A, Tibby JC, Penny D and Gell PA. 1995. The use of diatoms to assess past and present water quality. Australian J. Ecol. 20: 57-64.

Santra SC, Pal UC, Maity H and Bandyopadhya G. 1988. Blue-green algae in saline habitats of West Bengal: A systematic Account., Biol. Mem., 14(1): 81-108.

Sen, N., Sarkar, D., Sarkar, A.K. and Naskar, K.R. 1998. Phytoplankton abundance in the water bodies of Sundarbans. In: *Coastal zone problems: Proceedings of the national workshop, March 20-22, 1998,* Eds. K. Datta, A.D. Mukherjee and P. Sanyal, Jadavpur University, Kolkata, India. pp. 148-154.

Sen, N. and Naskar, K.R. 2003. *Algal Flora of Sundarbans Mangals.* Daya Publishing House, Delhi 110035.

Smith, G. M. 1933. *Fresh water algae of the United States.* 1st edition, New York and London.

Vadeboncoeur Y, Peterson G, Zanden MJV, Kalff J. 2008. Benthic algal production across lake size gradients: interactions among morphometry, nutrients, and light. Ecol. 89: 2542-2552.

Vizzini S, Sara G, Michener RH and Mazzola A. 2002. The role and contribution of the seagrass *Posidonia oceanica* (L.) Delite organic matter for secondary consumers as revealed by carbon and nitrogen stable isotope analysis., Acta Oecologica, 23(4): 277-285.