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Biodiversity of Cyanobacteria in Manakudy estuary, Southwest coast of Tamilnadu, India

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Abstract

In coastal and estuarine waters, there were algae ranges from single-celled forms to the seaweeds. Cyanobacteria are algal organisms with some characteristics of bacteria. The spatial and seasonal patterns of distribution of Cyanobacterial species and their abundance in relation to physicochemical parameters were studied during March, 2012 to February 2013 from six stations of Manakudy estuary situated on the southwest coast of India, it has a total area of about 150ha, extending over 2Km and is located between 08°04'N and 77°26'E longitude. In the present study 31 species of Cyanobacteria from 17 genera were obtained from the study sites. Among these 31 species belong to 17 genera. Maximum 26 species of 15 genera were recorded from station 3 followed by 24 species belonging 14 genera, 21 species belonging 14 genera, 16 species belonging 10 genera, 14 species belonging 9 genera and 12 species belonging 7 genera in station 2, station 4, station 1, station 5 and station 6 respectively.

Key words: Cyanobacteria, Manakudy, Estuary, Air temperature, Water temperature

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1. Introduction

Estuaries are transitional environment between fresh water and salt water, where fresh water mixes with sea water exhibiting oligohaline to mesohaline (Schuchardt *et al*., 1999). While the fluctuating physical and chemical environment limits the number of species in estuaries. Hydrographic features like temperature, pH, dissolved oxygen, salinity, and biological oxygen demand constitute the important environmental requisites which govern the distribution and abundance of flora and fauna in estuaries (Rajashree Gowda and Panigrahy, 1993).

The transitional regions of estuaries are the initial point for the distributions of marine Cyanobacteria in the epi-pelagic zone of seas and ocean. Cyanobacteria are photosynthetic prokaryotes that capture sunlight for energy using chlorophyll a and various accessory pigments. They are oxygen evolving photosynthetic prokaryotes which inhabits in lakes, ponds, springs, wetlands, streams, rivers, and saline backwaters, various types of marine and hyper saline salt pans. They play a major role in the nitrogen, carbon, and oxygen dynamics of many aquatic environments and also they occupy a key position at the base of the marine food web and contribute significantly to global primary productivity (Partensky *et al*., 1999).

Ecologically, there are three major groups in the aquatic environment mat-forming species, which form periphytic biofilms over rocks, sediments, and submerged plants; bloom-formers, which create a wide range of water quality problems and that are most common in nutrient-rich lakes; and picocyanobacteria, which are extremely small cells (<3 mm in diameter) that are often abundant in clear-water lakes. Estuarine Cyanobacteria can alter phytoplankton succession, competition and bloom formation.

Cyanobacterial blooms occur when algae that are normally present grow exuberantly. Within a few days, a bloom can cause clear water to become cloudy. The blooms usually float to the surface and can be many inches thick, especially near the shoreline. They can occur in marine, estuarine, and fresh waters, the blooms are of greatest concern while Cyanobacterial harmful algal blooms (CyanoHABs) CyanoHABs are algae blooms that threaten people, animals or the environment. They are dangerous for many reasons: dense CyanoHABs can block sunlight and use up all the oxygen in the water, killing other plants and animals. CyanoHABs can make people, their pets, and other animals sick.

The basic and fundamental requirement in the ecological study of any ecosystem in the environmental field is first to enumerate the natural biodiversity and to understand their innate properties which could be harmful or useful for a variety of purposes and baseline studies.

So far, there has been no systematic survey of the blue-green algae of Manakudy estuary except the short term study of Cyanobacterial abundance and diversity in the coastal wetlands of Kanyakumari district including Manakudy by Sivakumar *et al*., (2012).

Hence, this present work is the first of its kind, surveying a continuous stretch of the estuary. Studies on Cyanobacteria of Manakudy is expected to provide a wealth of information that is not only academically gratifying, but also very useful in planning mass cultivation strategies oriented towards the biotechnological exploitation of these organisms. The present investigation also focused on the Manakudy estuary to understand seasonal variations of various physico-chemical characteristics and their effect on the Cyanobacteria.

2. Materials and Methods

Manakudy estuary situated on the southwest coast of India, it has a total area of about 150ha, extending over 2Km and is located between 08°04'N and 77°26'E longitude. It is a tropical bar build estuary. This estuary formed by the confluence of Pazhayar River and open into Arabian Sea near Manakudy on the south west coast of India. The present study was carried out on the hydrobiological and ecological parameters of the Manakudy estuary.

Surface water samples were collected from Manakudy estuary from six stations (Fig.1) station

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1 near mouth subsequent station numbers up to six towards river Pazhayar at monthly intervals for a period of one year from March 2012 to February 2013, for the estimation various physicochemical parameters. Onsite temperature (air and surface water) was measured using a standard centigrade thermometer. Salinity was estimated with the help of a Salinometer Model-E-2 and pH was measured using and Elico pH meter (Model L – 120). Dissolved Oxygen (DO) and Biological Oxygen Demand (BOD) were estimated adopting the standard procedure described in American Public Health Association (APHA, 1992).

Fig. 1. Sampling locations in Manakudy Estuary

Planktonic Cyanobacteria were collected using the plankton net made up of bolting silk cloth no. 25 (pore size 64µM) and the net was towed for 10 minutes in the surface water. The collected plankton soup was preserved in 5% formalin subsequently the sample was analyzed under the microscope. Cyanobactera specimens were identified using the taxonomic publications (Biswas, 1949; Geitler, 1932; Prescott, 1951; Desikachary, 1959 and Starmach, 1966). The mean and standard deviation for annual variations mean for seasonal variations, Analysis of Variance (ANOVA) and correlations were calculated by using the software SPSS 7.5.

3. Results and Discussion

Seasonal and annual environmental variables are presented in the Table 1 and 2 respectively. The station-wise differences of the parameters are illustrated in figure 2, 3, 4, 5, 6 and 7. The air temperature and water temperature during the study period varied from 30.00^{o} C to 33.87^{o} C and 26.97^{o} C to 31.26^{o} C respectively, the seasonal deviations in the temperature values are statistically high significant ($F=7.925$; $p<0.000$ & $F=10.140$; $p<0.000$; df=23, 48) significant positive correlation ($r= 0.931$; $p<0.01$) was noted between air and water temperature whereas water temperature and DO exhibited significant negative correlation ($r = - 0.877$; df=70 $p<0.01$).

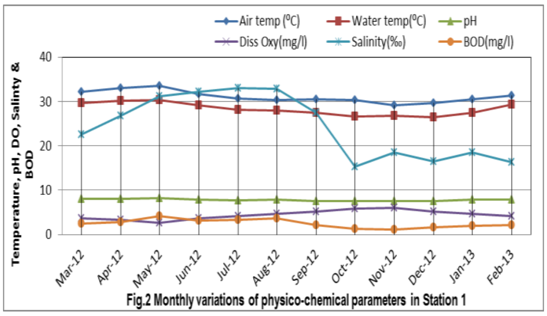

Fig.2 Monthly variations of physico-chemical parameters in Station 1

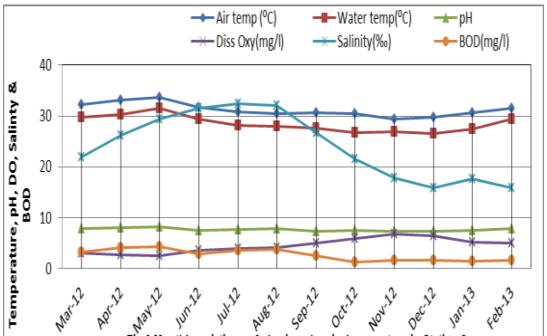

Fig.3 Monthly variations of physico-chemical parameters in Station 2

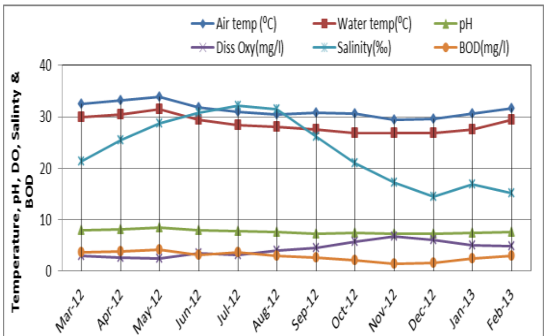

Fig.4 Monthly variations of physico-chemical parameters in Station 3

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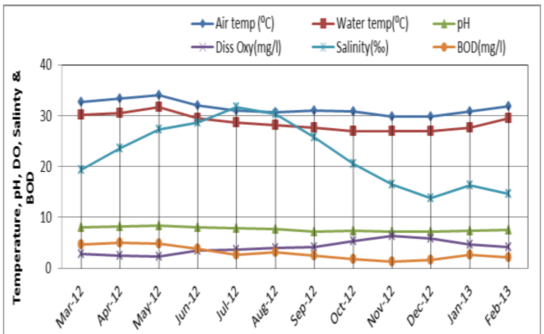

Fig.5 Monthly variations of physico-chemical parameters in Station 4

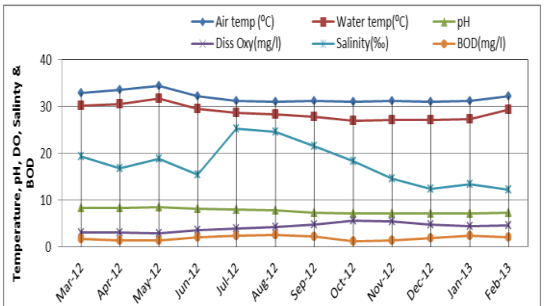

Fig.6 Monthly variations of physico-chemical parameters in Station 5

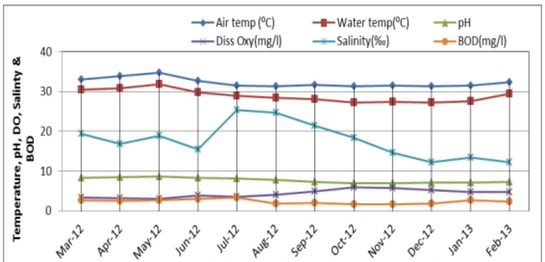

Fig.7 Monthly variations of physico-chemical parameters in Station 6

The pH values recorded during this period varied from 7.07 to 8.43 the seasonal deviations in the pH values are statistically high significant (F=11.737; p<0.000). The dissolved oxygen estimated during this period varied from 2.53 mg/l to 5.95 mg/l the seasonal deviations in the pH values are statistically high significant (F=21.205; p<0.000). A significant negative correlation was exhibited between DO and BOD (r=0.746; p<0.000).

The salinity recorded during the study varied from 18.33% to 32.70% (Table 1) the seasonal deviations in these values are statistically high significant (F=7.046; p<0.000). The biological oxygen demand (BOD) estimated during this period varied from 1.53 mg/l to 4.87 mg/l the seasonal deviations in the BOD values are high significant (F=9.625; p<0.000).

The physico-chemical characteristic features of the estuarine system which closely follow the pattern of river runoff and tidal variations were mostly controlled by the seasonal regimes (Nedumaran and Perumal, 2012). Air and water temperature variations in the estuarine environment can influence the other physico-chemical characteristics. High atmospheric temperature was recorded during summer season due to clear sky with more solar radiation whereas less solar radiation with cloudy sky and more rainfall during the monsoon season greatly reduced the atmospheric temperature. The surface water temperature largely depends on the intensity of solar radiation, evaporation and freshwater influx. The presently recorded summer peaks in temperature closely resemble the data generated earlier workers from the south west coast of India (Kavitha *et al*., 2006, Kannappan and Karthikeyan, 2013).

The hydrobilogical parameters of the environment in general are governed by factors like pH, temperature, nutrients, tidal actions, monsoonal flow etc. Such changes alter the productivity of the environment (Quasim and Gupta, 1981). In the present study notable seasonal variations were observed. The pH values remained higher during summer and low during monsoon season by the influx of fresh water and also due to the decomposition of organic matter carried into the riverine ecosystem. This is not agreement with the observations of Upadhyay (1988). The decline in pH, higher oxygen concentration, and low phytoplankton density during monsoon period of the present study is in conformity with the remarks of Murugan and Ayyakkannu (1993).

Higher salinity during summer and the low salinity during monsoon periods recorded in the present study are similar to the earlier observations of Prema, (2000) and Thara Devi, (2002). Higher BOD level in the stations 2, 3 and 4 due to decomposing nature of bottom and this finding concordant with the earlier report by Vareethiah and Haniffa, (1998) in Thengaipattanam estuary.

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Table -1: Seasonal variation of Physico-chemical parameters recorded in various stations of Manakudy Estuary during March 2012 to February 2013

Parameters	Seasons	STATIONS					
		1	2	3	4	5	6
Air Temperature(^{o}C)	SUM	32.90	33.00	33.20	33.40	33.63	33.87
	SWM	30.87	30.97	31.07	31.23	31.50	31.80
	NEM	30.00	30.10	30.30	30.53	31.20	31.50
	PM	30.53	30.63	30.67	30.87	31.50	31.73
Water Temperature (^{o}C)	SUM	30.10	30.57	30.60	30.73	30.83	31.03
	SWM	28.40	28.50	28.63	28.77	28.87	29.07
	NEM	26.97	27.07	27.10	27.20	27.33	27.57
	PM	27.73	27.83	27.97	28.00	27.97	28.13
pH	SUM	8.10	8.07	8.17	8.20	8.33	8.43
	SWM	7.77	7.70	7.77	7.87	8.00	8.07
	NEM	7.53	7.43	7.33	7.23	7.20	7.07
	PM	7.73	7.60	7.40	7.33	7.23	7.13
Dissolved Oxygen (mg/l)	SUM	3.20	2.77	2.63	2.53	2.97	3.20
	SWM	4.13	3.90	3.57	3.67	3.90	3.87
	NEM	5.67	5.93	5.67	5.30	5.30	5.53
	PM	4.60	5.57	5.30	4.90	4.60	4.90
Salinity (‰)	SUM	26.80	25.80	25.13	23.40	18.33	18.33
	SWM	32.70	32.03	31.47	30.20	21.80	21.80
	NEM	20.43	22.10	21.43	20.93	18.17	18.17
	PM	17.10	16.50	15.53	14.93	12.63	12.63
Biological Oxygen Demand (mg/l)	SUM	3.17	3.90	3.90	4.87	1.47	2.60
	SWM	3.33	3.43	3.27	3.20	2.33	2.80
	NEM	1.53	1.83	2.07	1.83	1.60	1.77
	PM	1.93	1.60	2.33	2.13	2.10	2.27

SUM – summer, SWM – South West Monsoon, NEM - North East Monsoon and PM – Post Monsoon

Table- 2: Annual mean variation of Physico-chemical parameters recorded in various stations of Manakudy Estuary during March 2012 to February 2013

Sl. No.	Parameters	STATIONS					
		1	2	3	4	5	6
1	Air Temperature(^{o}C)	31.08±1.31	31.18±1.31	31.31±1.36	31.51±1.35	31.96±1.14	32.23±1.12
2	Water Temperature (^{o}C)	28.30±1.41	28.49±1.58	28.58±1.55	28.68±1.55	28.75±1.62	28.95±1.37
3	pH	7.78±0.24	7.70±0.28	7.67±0.39	7.66±0.43	7.69±0.52	7.68±0.63
4	Dissolved Oxygen (mg/l)	4.40±1.02	4.54±1.44	4.29±1.43	4.10±1.29	4.19±0.94	4.38±0.98
5	Salinity (‰)	24.26±7.08	24.11±6.42	23.39±6.56	22.37±6.33	17.73±4.45	13.83±7.46
6	Biological Oxygen Demand (mg/l)	2.49±0.95	2.69±1.12	2.89±0.91	3.01±1.31	1.88±0.46	2.36±0.57

Table -3: Cyanobacteria recorded in Manakudy Estuary during March 2012 to February 2013

S.No	Species	STATIONS					
		1	2	3	4	5	6
1	*Anabaena ambiqua*	+	+	+	+	+	-
2	*Anabaena variabilis*	+	+	+	+	-	-
3	*Aphanocapsa sp.*	-	+	+	+	-	-
4	*Aphanothece sp.*	-	-	+	-	+	+
5	*Chroococus tenax*	+	-	-	-	-	-
6	*Cylindrospermum majus*	+	+	+	+	-	-
7	*Gloeocapsa aeruginosa*	+	+	+	+	-	-
8	*Gloeocapsa sp.*	-	-	-	+	+	-
9	*Lyngbya aesturrii*	+	+	+	-	-	-
10	*Lyngbya sp.*	-	+	+	+	+	-
11	*Microchaete sp.*	-	+	+	+	-	+
12	*Microcystis flos-aquae*	+	+	+	-	+	+
13	*Microcystis lamelliformis*	-	-	-	+	-	+
14	*Microcystis littoralis*	+	+	+	-	-	-
15	*Nostoc paludosam*	-	+	+	+	-	-
16	*Oscilaltoria agardhii*	-	-	+	+	-	+
17	*Oscillatoria amoena*	+	+	+	+	-	+
18	*Oscillatoria earlei*	-	+	+	+	+	+
19	*Oscillatoria pseudogeminata*	-	+	+	-	+	-
20	*Oscillatoria salina*	+	+	-	-	-	-
21	*Oscillatoria tenuis*	-	+	+	-	+	+
22	*Phormidium fragile*	+	+	+	+	-	-
23	*Phormidium retzii*	+	-	+	+	-	+
24	*Phormidium sp.*	+	-	+	+	+	-
25	*Phormidium tenue*	+	+	+	-	+	-
26	*Spirullina subsalisa*	-	+	+	+	+	+
27	*Spirullina subtilissima*	+	+	+	+	+	+
28	*Symploca sp.*	-	+	-	-	+	+
29	*Synechococcus elongatus*	-	+	+	+	-	-
30	*Synechocystis sp*	-	+	+	+	+	-
31	*Trichodesmium erythraeum*	+	+	+	-	-	-
	Total number of species / genera	10 /16	14 /24	15 /26	14 /21	9 /14	7 /12

+ = Present; - = Absent

Totally 31 Cyanobacteria species were recorded from the six stations during various seasons and these 31 species belongs to 17 genera (Table 3). Maximum 26 species of 15 genera were recorded from station 3 followed by 24 species belonging 14 genera, 21 species belonging 14 genera, 16 species belonging 10 genera, 14 species belonging 9 genera and 12 species belonging 7 genera in station 2, station 4, station 1, station 5 and station 6 respectively.

There have been a number of sporadic reports on the occurrence of Cyanobacteria in the marine environment of India such as planktons of Indian Ocean by Cleve, (1901), Cyanobacterial flora from the salt lakes of Calcutta by Biswas, (1926) and *Trichodesmium* from Kurusadai Island by Iyengar, (1927). But these reports are not comprehensive and are limited to certain areas and species only. There are other reports such as occurrence of ten species of Cyanobacteria from

seawater near Bombay by Ramachandran, (1982), 17 species of seven genera from Madras coast by Anand and Venkatesan, (1985), 25 taxa from Madras and South Arcot District by Anand *et al.* (1986), 67 taxa from various saline habitats of West Bengal by Santra *et al.*, (1988) and 163 species from southern east coast of India by Thajuddin and Subramanian, (1991 and 1992).
There are reports proving that Cyanobacteria could grow in salinities ranging from 0-99% (Prabaharan, 1988). The remarkable adaptability of Cyanobacteria to various habitats is, well known (Desikachary, 1959; Van Baalen, 1962; Fogg *et al.*, 1973; Carr and Whitton, 1982). Despite the fact that this group of photosynthetic prokaryotes is structurally simple, it is physiologically diverse and well adapted to environmentally extreme conditions, especially nutrient deprivation and excesses (Paerl, 1999). The Cyanobacteria have developed an array of biochemical and ecological mechanisms to access the limiting nutrients; the foremost is the ability of numerous genera to fix atmospheric nitrogen. They have also exploited anthropogenic alterations of coastal environments causing eutrophication.

4. Conclusion

The present investigation shows that Manakudy estuary is endowed with morphologically diverse group of Cyanobacterial forms. Most of the species had shown wide salinity tolerance, as they were found distributed in almost all the stations. Therefore, it was difficult to strictly segregate most of the species into exactly saline and freshwater species as can be done with other algal forms. In all, 31 species of Cyanobacteria from 17 genera were obtained from the study sites.

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