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ORIGINAL ARTICLE

Physico-Chemical Parameters and Phytoplankton Diversity of Ennore Mangrove Ecosystem

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ABSTRACT
The present studies were made on the diversity of phytoplankton in relation to Physico-chemical parameters with respect to pollution status of Ennore mangrove ecosystem, Tamil Nadu, India. Surface water samples were collected from six different locations of Ennore at monsoon, post monsoon, summer and pre-monsoon seasons. A total of 101 species of phytoplankton observed belonging to different taxonomic groups were identified, out of which 48 species belong bacillariophyceae, 34 species to cyanophyceae and 19 species to chlorophyceae.
Keywords: *Ennore mangrove, Physico-chemical parameters, phytoplankton, relation.*

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INTRODUCTION

Plankton biodiversity is a fundamental research area in the aquatic ecological studies and it is used for the variety of marine ecological problems, such as protection of biodiversity, bionetwork roles and services. Therefore, the phytoplankton is involving the various ecological processes with influence the species diversity [1, 2].

Mangroves are economically important ecosystems for fisheries in tropical regions and it acts as a buffer zone between land and sea [3, 4]. Among the various environs, mangroves are one of the most important ecosystem for distribution of plankton in tropical region because their physical and chemical variables. Biomass production of phytoplankton in different size ranges are important factors regulating the productivity of higher tropic-level organisms.

Phytoplankton production contributes about 95% of total production in the marine environment [5]. The phytoplankton distribution is not always consistent and varies spatially and temporally. Among all nutrients, availability plays a key role in determining the phytoplankton population density [6, 7]. The qualitative and quantitative studies of phytoplankton have been utilized to assess the quality of water [8, 9, 10, 11]. Several phytoplankton species are reported as a bioindicators [12, 13, 14, 15] and water pollution studies [16, 17, 18].

Phytoplankton ecology at different parts of Bay of Bengal coast was well documented over a period of time (19, 20, 21, 22, 23). The Ennore mangrove ecosystem comprises of lagoons, with salt marshes and backwaters, which are submerged under during high tide and form an area of the sea opening in to the Bay of Bengal. Increasing pressure on mangrove forests due to urbanization, industrialization and intensive aquaculture in this area poses a threat to this ecosystem. Present scenario Ennore manrove is mostly polluted by various pollutants and anthropogenic activities so with this aspect, this project focuses on the effect of pollutants in Ennore ecosystem. A regular monitoring of water bodies with required number of parameters, not only prevents outbreak of diseases and occurrence of other hazards but also checks the water from further deterioration. The management of any aquatic ecosystem is a means of conservation of fresh water habitat with an aim to maintain the water quality or to rehabilitate the Physico-chemical and biological settling of water [24]. Based on the above mentioned facts, it is suggested to make an inventory of the physicochemical parameters and phytoplankton diversity of Ennore mangrove ecosystem.

MATERIALS AND METHODS

The water samples were collected from six different locations Ennore mangrove ecosystem (Fig 1 and 2). Biological samplings and observations are carried out seasonally during the pre monsoon, monsoon, post monsoon and summer seasons except the samples of heavy metal analysis (done by post monsoon season - February 2014). The Sampling was done during morning hours, the water samples were collected in polypropylene plastic bottles, which were pre-cleaned with 1 N HCl and the samples were kept in an icebox on immediately after collection.

The water temperature and pH were noted immediately on the spot after collection, whereas the remaining parameters were analyzed in the laboratory. All the water quality parameters were collected at season wise analyzed according to APHA [25]. The salinity was estimated by argentometric method, dissolved oxygen was analyzed by modified Winkler's method, carbon dioxide was analyzed by titrimetric method, nitrate was determined by calorimetric method, silicate was determined by molybdosilicate method, sulfate was be determined by turbidimetric method, the phosphate was determined by ascorbic acid method, the BOD was determined as given in APHA, 1995 and COD was determined by dichromate reflux method . The estimation of chlorophyll was done by spectropotometric method and the primary productivity was measured by light and dark bottle method according to Strickland and Parsons [26]. All the biological parameters (flora and fauna) were collected and identified according to Kathiresan and Rajendran, [27].

Figure 1. Map showing the sampling points of study area in Ennore Creek

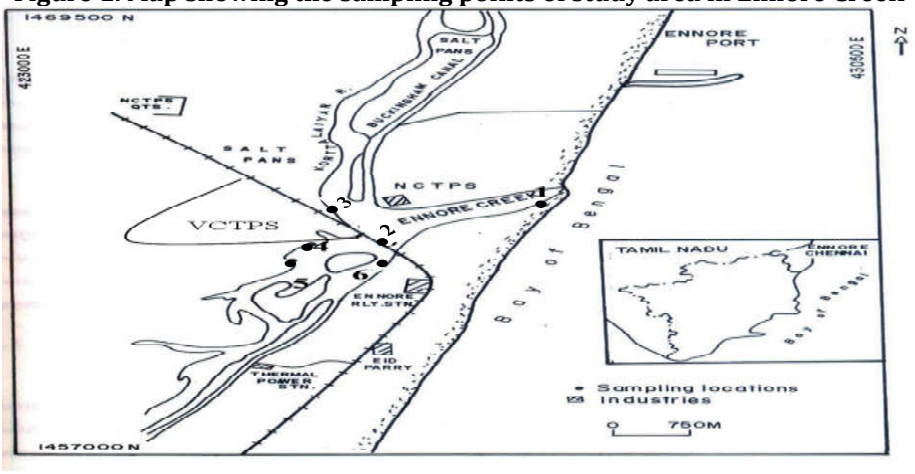

Figure 1b. Map showing the sampling points of study area in Ennore Creek (Satellite view)

The plankton samples were collected by planktons net made up of bolting silk (mesh size 64 µm) and preserved in lugol's solution. The preserved samples were brought to the laboratory for qualitative and quantitative analysis. Phytoplanktons were identified by using the standard methods suggested by Smith [28], Phillipose, [29] and Adoni [8]. Quantitative studies were made by using Sedgwick rafter cell. Sample was properly agitated to distribute the organisms evenly. By using a pipette, one ml of sample was transferred onto the cell. The Cover slip was placed properly avoiding any air bubble. The planktons were

allowed to settle for some time and counting was made under microscope. All the planktons, present in the cell were counted by moving the cell vertically and horizontally, covering the whole area.

RESULTS AND DISCUSSION

The result of physicochemical parameters observed from Ennore mangrove ecosystem were tabulated in Table 1, 2 and 3. Atmospheric and surface water temperature varied from 30°C to 32°C and 26°C to 32°C respectively during monsoon and summer seasons. The surface water temperature showed an increasing trend from December 2003 to March 2004. In general, surface water temperature is influenced by the solar radiation intensity, evaporation and insolation and the recorded low temperature during monsoon could be due to strong sea breeze and cloudy sky [30, 31]. The observed spatial variation in temperature could be due to the viable intensity of prevailing currents and the consequent mixing of water [32].

The pH of the water sample registered alkaline in nature ie. 7.4 to 8.3. This range is good for growth of aquatic organisms like phyo and zoo planktons reported by many authors [33, 34]. Low P^H values were recorded during the rainy season due to the fresh water inflow to the mangrove ecosystem. Increased P^H values noted may be due to the discharge of domestic waste water, sewage and industrial effluent etc.

Dissolved oxygen content in the water sample ranged from 1.6 to 3.6 mg/l. The partial of dissolved oxygen in water depends upon the partial pressure of gas in the air close to water, rate of photosynthesis and oxygen holding capacity of water [35]. The minimum of 3mg/l DO is required for survival of microorganisms [36]. The dissolved free carbon dioxide (CO_2) ranged from 13.2 to 30.8 mg/l during the study period. Free CO_2 is essential for photosynthesis and its high concentration affects the aquatic fauna and its productivity [37].

Salinity showed wide variations in the ranges of 31.9 to 41.9 %. The salinity is the main physical parameter and act as a limiting factor which influences the distribution of planktonic community [38, 39]. The salinity changes in the brackish water habitats such as estuaries, backwaters and mangrove are due to the influx of freshwater from land run off, caused by monsoon or by tidal variations [40]. In the present study, maximum value of grass productivity was recorded during the post monsoon and summer season (0.33 mgc/l/hr). Similarly, high gross primary productivity was observed in Arabian Gulf and Gulf of Oman, during the post monsoon and summer seasons [41]. The maximum net productivity was observed in (0.18mgc/l/hr) during the post monsoon and summer season and minimum (0.03mgc/l/hr) net productivity was recorded at all locations of pre monsoon and monsoon season. The chlorophyll 'a' was ranged from 1.87mgc/m^3 to 5.28mgc/m^3. It is supported by the work of Verlecar and Dhargalkar 1992 [42], who found that chlorophyll 'a' concentration in the surface waters varied between 0.73 and 6.30 mg m-3 in the Goa reigon.

Concentrations of nutrients viz. nitrate (0.14 to 0.30), phosphate (0.19 to 0.40), silicate (0.15 to 0.47) and sulphate (0.52 to 1.55) also varied independently. Nutrients are the most important parameters in the mangrove environment for the diversion of phytoplankton. Distribution of nutrients is due to the season, tidal conditions and freshwater flow from land sources. High concentration of nitrate, inorganic phosphate observed during monsoon season might possibly be due to intrusion of upwelling seawater into the creek and anthropogenic inputs [43, 44]. The recorded least amount during non-monsoonal period may be due to high photosynthetic activity of phytoplankton and also due to the dominance of marine water intrusion with negligible amount of nitrate [45, 20, 46]. The low values of phosphate were observed during post monsoon and summer seasons due to decreased runoff and due to the utilization by phytoplankton [47]. The high (0.47mg/l) silicate concentration was recorded at summer season and low (0.14 mg/l) silicate concentration was recorded at premonsoon season. The maximum (1.55 mg/l) sulphate concentration was recorded at summer season and minimum (0.52 mg/l) was recorded at monsoon season. High amount of silicate and sulphate was observed in post monsoon and summer may be due to heavy influx of fresh water derived from land drainage carrying silicate leached out from rocks and also from the bottom [44].

In the present study estimated that the high COD (2.85 mg/l) was recorded at summer season and low (0.50 mg/l) concentration was recorded at location 5 of monsoon season. The high (2.4mg/l) BOD concentration was recorded at post monsoon seasons and the low (0.4mg/l) BOD concentration was recorded at pre-monsoon season (2.4mg/l). The high BOD might be due to the decomposition of organic matter and decay of vegetation in river which mixed sea water during rainy season and high COD due to runoff from the surrounding areas of Ennore mangrove ecosystem. The concentration of water quality parameters depends upon the fresh water inflow, discharge of domestic sewage and industrial effluent.

Due to the seasonal environmental fluctuations, the distribution and abundance of phytoplankton in tropical waters, varied remarkably. These variations are well pronounced in the sheltered system of coastal mangrove waters. In the present investigation, diatoms formed the dominant group followed by blue greens and greens at all the 6 locations of Ennore mangrove ecosystem. Many authors emphasized

that the diatoms were found to be dominant in mangrove waters, which could be due to the fact that diatoms can tolerate the widely changing hydrographical conditions [47, 48, 49, 50].

This study recorded 101 species of phytoplankton species belonging to diverse groups such as 48 species belong bacillariophyceae, 34 species to cyanophyceae and 19 species to chlorophyceae (Table 4 and 5).

The current survey, observed high population density and species diversity during Summer and Premonsoon might be due to the predominance of diatoms viz. *Apanocapsa banarasensis, A. microscopica , Lungbya semiplena, L. putealis, Johannesbaptistia pellucid, Chlorella vulgaris, Chlorella vulgaris, Korshikoviella limnetica, Pleurotanium ehrenbergi, Stephanodiscus niograroe, Lauderia annulata, Leptocylindrus danicus, L. minimus, Gyrosigma bolticum, Pleurosigma elongatum* and *Nitzschia longissima.* The abundance of phytoplankton in summer season might be attributed to the better salinity, pH, high temperature and high intensity of light penetration during the season [51].

The maximum density was recorded during summer in Location 3 (6414 cells U/L^{-1}) and minimum during monsoon at location 4 (150 cells U/L^{-1}). Location 3 showed comparatively high population density due to high nutrient concentrations and optimal salinity than others. The ranges of phytoplankton population density in all locations were: 150 - 6414 cells U/L^{-1}. In contrast of our fingings, the ranges of phytoplankton in pitchavaram mangrove ecosystem were 750 -3, 21,000 cells/L (40). The low level of species observed in all locations of Ennore compared to other mangrove ecosystem like pitchavaram mangrove and vellar estuary [40, 49].

The present findings show that there are certain members of species in the Chlorophyceae and Cyanophyceae which are tolerant to organic pollution and resist the stress caused by pollutants. Abundance of such taxa in the polluted habitats suggests their possible use a “indicator organism”.

Therefore, the results of this investigation suggest that the Ennore mangrove ecosystem is heavily contaminated by rapid urbanization and industrialization to release untreated industrial effluents and domestic sewages to this ecosystem. However urgently need the regular biological monitoring of water and fish for safety in seafood consumption from Ennore area. So avoid such kind of problem in the Ennore ecosystem to practicing safe disposal mechanism of industrial effluents and domestic sewages.

Table 1, 2 & 3: Physicochemical parameters of Ennore Mangrove Ecosystem.

Locations	Monsoon					Post Monsoon					Summer					Pre Monsoon				
	AT	WT	pH	DO	Co_2	AT	WT	pH	DO	Co_2	AT	WT	pH	DO	Co_2	AT	WT	pH	DO	Co_2
1	31°C	27°C	8.3	3.2	22.0	32°C	30°C	8.3	2.8	17.6	32 °C	29°C	8.2	3.2	30.8	31°C	28°C	8.3	2.4	26.4
2	31°C	28°C	7.9	2.8	17.6	32°C	30°C	8.1	2.4	22.0	32 °C	29°C	8.1	2.0	26.4	31°C	27°C	8.1	2.0	17.6
3	32°C	28°C	7.8	2.8	22.0	32°C	31°C	8.0	2.4	22.0	32 °C	30°C	8.0	2.4	26.4	31°C	28°C	8.0	2.8	22.0
4	32°C	30°C	7.8	2.0	13.2	32°C	32°C	8.2	2.0	13.2	32 °C	31°C	8.1	2.0	22.0	31°C	29°C	8.1	1.6	13.2
5	31°C	28°C	7.6	3.6	30.8	32°C	30°C	8.1	3.2	26.4	32 °C	30°C	8.0	3.2	30.8	30°C	26°C	8.0	2.8	26.4
6	31°C	28°C	7.6	2.8	17.6	32°C	30°C	8.1	2.8	22.0	32 °C	30°C	8.0	2.8	26.4	30°C	26°C	8.0	2.4	22.0

Table 2

Locations	Monsoon					Post Monsoon					Summer					Pre Monsoon				
	Sal	Gro	Net	Ch ‘a’	NO_2	Sal	Gro	Net	Ch ‘a’	NO_2	Sal	Gro	Net	Ch ‘a’	NO_2	Sal	Gro	Net	Ch ‘a’	NO_2
1	39.9	0.15	0.03	3.20	0.20	39.9	0.26	0.18	2.06	0.20	40.9	0.22	0.11	2.91	0.19	40.4	0.22	0.11	3.76	0.20
2	40.4	0.15	0.03	2.81	0.23	35.9	0.22	0.15	2.19	0.21	39.9	0.18	0.15	3.20	0.24	40.9	0.11	0.03	3.65	0.23
3	32.9	0.15	0.03	4.70	0.23	31.9	0.30	0.18	2.48	0.22	32.9	0.22	0.18	4.54	0.25	32.4	0.11	0.03	4.33	0.24
4	41.4	0.11	0.03	1.87	0.14	40.9	0.18	0.15	1.93	0.18	41.9	0.03	0.03	2.32	0.14	40.9	0.04	0.03	2.39	0.14
5	32.9	0.30	0.03	4.83	0.30	32.4	0.33	0.11	3.14	0.25	31.9	0.33	0.15	4.76	0.26	32.4	0.30	0.11	4.09	0.27
6	33.9	0.22	0.03	3.28	0.23	33.4	0.26	0.15	1.99	0.26	32.9	0.22	0.11	3.24	0.25	33.4	0.22	0.11	3.69	0.27

Table 3:

Locations	Monsoon					Post Monsoon					Summer					Pre Monsoon				
	Po_4	Sio_2	So_4	BOD	COD	Po_4	Sio_2	So_4	BOD	COD	Po_4	Sio_2	So_4	BOD	COD	Po_4	Sio_2	So_4	BOD	COD
1	0.32	0.15	0.52	1.6	1.71	0.26	0.24	0.78	1.2	1.71	0.30	0.25	0.84	1.6	2.85	0.31	0.24	0.68	1.2	1.71
2	0.33	0.25	1.36	1.2	1.71	0.32	0.29	1.28	1.2	1.14	0.34	0.31	1.21	0.8	2.28	0.33	0.15	0.73	1.2	1.14
3	0.37	0.19	0.78	1.6	1.14	0.36	0.38	1.10	1.2	1.71	0.37	0.35	1.15	1.6	1.71	0.35	0.14	1.13	1.6	1.14
4	0.24	0.42	1.21	0.8	1.14	0.19	0.39	1.52	0.8	0.57	0.31	0.47	1.55	0.8	1.14	0.24	0.31	1.47	0.4	0.57
5	0.40	0.23	0.81	2.0	0.50	0.40	0.41	1.0	1.6	1.14	0.38	0.36	1.05	2.0	1.14	0.39	0.21	1.0	2.0	1.14
6	0.39	0.43	1.13	1.6	1.14	0.37	0.36	1.05	1.6	0.57	0.38	0.34	0.97	1.2	0.57	0.37	0.43	1.42	1.6	0.57

Table 4: Phytoplankton Biomass recorded from Ennore Mangrove Ecosystem (Location 1, 2 and 3).

S. No	Name of the Species	Season (Units – Cells/Lit.)											
		Location 1				Locatio2				Location 3			
		Mon	POM	SUM	PRM	Mon	POM	SUM	PRM	Mon	POM	SUM	PRM
I	***Cyanophyceae*** **(Blue green Algae)**												
1.	*Apanocapsa banarasensis* Bharswaja	50	40	400	300	190	200	180	-	190	220	270	260
2.	*A. grevillei* Hans	-	-	-	-	60	-	-	-	-	-	60	20
3.	*A. microscopica* Naeg.	-	-	150	40	-	-	80	20	-	40	60	50
4.	*A. pallida* Kutz.	-	20	-	-	-	20	-	-	-	30	-	10
5.	*A. pulchra* Kutz.	-	-	950	-	-	-	-	30	-	-	10	40
6.	*A. stagnina* Spreng	-	-	200	100	-	-	120	90	-	60	140	80
7.	*Chrooccoccus indicus* Zeller	-	-	170	-	-	30	140	-	-	40	100	10
8.	*C. Minor (Kutz.)* Naeg.		120	-	90	-	-	-	150	-	10	-	160
9.	*C. minimus(Keister)* Lemm	-	-	-	-	40	10	-	10	30	20	-	10
10.	*C. turgidus (Kuetz)* Naeg.	-	-	-	-	-	30	-	-	-	20	20	-
11.	*C. tenax*	-	-	-	-	-	-	60	-	-	-	50	40
12.	*Merismopedia minima* Beck	-	-	-	-	80	-	-	-	-	40	-	10
13.	*M.pulverea*	-	-	-	-	-	-	50	-	-	-	60	-
14.	*Synechocystis crassa* Woronich	-	-	-	30	-	-	10	-	-	-	20	-
15.	*Arthrospira platensis* Nordst	30	20	-	60	10	40	-	50	10	30	-	40
16.	*Lungbya semiplena*	-	70	160	80	-	20	180	70	-	10	240	60
17.	*L. putealis*	40	100	270	50	20	110	280	60	40	130	250	50
18.	*L. pulvera*	-	-	80	-	-	-	100	10	-	-	130	20
19.	*L. celonica*	-	-	-	60	-	-	10	60	-	-	20	70
20.	*Oscillatioria earli* Gardner	-	-	-	90	-	10	-	100	-	-	10	110
21.	*O. nigroviridis Thwaites* ex Gomont	-	-	70	-	-	-	90	10	-	-	60	40
22.	*O. pseudogeminata* Schmid G	-	-	20	10	-	-	10	30	-	-	40	20
23.	*O. simplssima* Gomont	-	-	40	70	-	10	30	80	-	20	20	70
24.	*O. subbrevis*	30	20	-	10	40	-	-	30	-	-	-	50
25.	*O.tanganyikae* West.Gs.	-	-	-	-	-	-	-	10	-	-	10	10
26.	*O.terebriformis* Ag.ex.Gomont	-	-	-	50	-	-	-	80	-	-	-	60
27.	*Nostoc muscorum* Ag.ex. Born. Et flah	30	30	20	40	40	50	30	80	60	40	70	100
28.	*Spirulina laxissima*	-	-	20	20	-	-	10	40	-	-	20	20
29.	*S.labrinthiformis*	-	-	-	60	-	-	-	10	-	-	-	20
30.	*S.meneghiniana*	-	-	-	-	-	-	-	10	-	-	-	20
31.	*S.princeps*	-	-	-	50	-	-	-	60	10	-	-	80
32.	*Phormidium retzei*	-	-	-	10	10	-	-	20	10	-	-	60
33.	*Rivularia aquatic* De Wild.	-	-	-	20	-	10	-	10	-	-	-	80
34.	*Johannesbaptistia pellucid*	-	-	-	700	-		10	580	-	-	60	660

	(Dickie) Taylor et Drouet												
II	***Chlorophyceae* (Green Algae)**												
35.	*Ankistrodesmus falcatus* (Corda)	-	-	-	20	-	-	-	20	-	-	-	30
36.	*Chlorella vulgaris* Beji	10	10	170	60	-	10	190	100	-	30	170	120
37.	*Closteriopsis longissima* (Lemm) Lemm.	10	10	20	20	20	20	-	60	30	10	-	90
38.	*Korshikoviella limnetica* (Lemm) Silvap	-	230	20	20	-	190	30	30	-	240	40	80
39.	*Senedesmus armatus* (Chod) G.M.Smith	-	-	20	10	-	-	30	30	-	-	60	130
40	*S.quaricauda (Turp.)*Breb	-	-	-	10	-	-	-	-	-	20	-	-
41	*S.arquatus*	-	-	-	10	-	-	10	-	-	-	20	-
42	*S.obilius*	-	-	-	-	-	-	10	-	-	-	20	10
43	*Schroedevia indica* Phil	-	10	-	-	-	20	-	-	-	30	10	-
44	*Hormidium flaccidum* (A.Br) Born et Flah.	-	-	-	20	-	-	-	30	-	-	-	20
45	*Docidium baculum* Breb.	-	-	-	10	-	-	-	10	-	-	-	40
46	*Gonatozygon aculeatum*	-	-	-	10	-	-	-	-	-	-	-	-
47	*G.brebissonni*	-	10	10	-	-	-	10	10	-	-	20	40
48	*G. Kinahanii*	-	-	-	-	-	-	10	10	-	-	30	20
49	*G.Mnotaenium* De Bary	-	-	-	10	10	-	-	10	-	10	-	20
50	*Penium cylindrus*	-	10	-	10	10	-	-	-	-	-	10	10
51	*P.margratacium*(Ehn)Breb	-	-	-	-	-	-	-	10	-	-	10	20
52	*Pleurotanium ehrenbergi* (Breb.) De Bary	-	10	10	30	10	10	20	10	20	40	10	20
53	*Euastrum spinlosum* Delp	-	10	-	-	10	10	-	10	30	20	10	20
III	***Bacillariophyceae* (Diatoms)**												
54.	*Stephanodiscus niograroe* Ehr.	-	-	-	790	-	-	100	990	-	60	160	890
55.	*Stephanopsis palmeriana* (Greville Grunow)	-	-	-	-	-	-	10	-	-	-	10	10
56.	*Seletonema costatum* (Greville) Cleve	-	-	20	10	10	-	10	20	20	-	40	60
57.	*Cyclotella meneghiniana* Kutzing	-	-	-	10	-	-	10	10	-	-	20	20
58.	*C.striata*(Kutzing)	-	-	-	-	-	-	10	10	-	-	20	20
59.	*Coscinodiscus concinnus* W.Smith	-	10	-	10	-	20	-	20	-	30	-	10
60.	*C. centralis* Ehrenberg	10	-	-	-	30	-	-	-	30	-	10	10
61.	*Planktoniella sol* (Vallich) Schiitt	-	-	-	-	-	-	-	20	-	-	-	40
62.	*Lauderia annulata* Cleve	20	-	70	920	10	20	90	870	30	40	100	950
63.	*Leptocylindrus danicus* Cleve	40	10	20	90	30	40	-	80	60	20	-	100
64.	*L. minimus*	30	-	70	40	20	-	100	50	60	-	110	90
65.	*Guinardia flaccida* (Casttracaqne)	-	10	-	-	10	10	-	10	20	30	-	20
66.	*Rhizosolenia styliformis* Bright Well	-	-	10	10	-	10	30	20	-	20	50	80
67.	*R. settigera* Bright Well	-	-	-	10	-	-	10	30	-	-	20	50
68.	*R. allata* Bright Well	-	-	-	-	-	-	-	-	-	-	-	10
69.	*Chaetoceros indicus sp.*Nov.	-	-	-	10	-	-	-	20	-	-	10	90
70.	*C.densum*	-	-	-	20	-	-	10	40	-	-	20	60
71.	*C.affinis Lauder var.*	20	-	-	-	40	-	-	20	40	-	-	70
72.	*Rhabdonema mirifiform* W.Smith	-	-	10	-	-	-	-	10	-	-	-	20
73.	*Climacosphenia elongate* Bailey	-	-	-	10	-	-	10	20	-	-	50	60
74.	*Fragilaria oceanica*	-	-	20	30	-	-	20	40	-	-	10	20
75.	*Thallasionema mitzschioides* Grunao	-	10	-	-	-	30	-	10	-	20	10	10
76.	*Thallasiothrix longissima* Cleve & Grunao	-	-	10	10	-	-	30	20	-	-	20	10
77.	*T.frauenfeldi* Grunow	-	-	-	-	-	-	-	-	-	-	-	10
78.	*Asterionella glacialis Castracane*	-	-	10	-	-	-	10	-	-	-	-	-

79.	*Cocconeis sigmoides sp.* Nov	-	-	-	10	-	-	10	10	-	-	180	-
80.	*Gyrosigma bolticum* (Ehrenberg)	40	10	300	240	60	-	290	220	160	-	260	230
81.	*Pleurosigma elongatum* W.Smith	-	150	220	260	-	150	220	260	-	-	-	280
82.	*P.normanni* Ralfs	-	-	120	-	-	-	130	60	-	210	120	40
83.	*P.angulatum (Quekett)*W.Smith	-	-	80	-	-	-	80	-	-	120	-	10
84.	*P.aestuarii Brebisson*					-	-	-	10	-	-	-	20
85.	*P.directum Grunow var.*	-	10	-	-	-	-	-	-	-	-	-	10
86.	*Anomoeoneis sphaerophora* (Kuetz) Pfitzer	-	-	-	-	-	-	-	-	-	-	-	-
87.	*Neidium iridis (Her.)* Pfitzer	-	10	-	10	-	10	-	10	-	-	10	20
88.	*Navicula longa (Gregory)*Ralfs	-	10	20	-	-	10	20	-	-	10	10	-
89.	*N.rhyncocephala* kuetz	-	-	-	-	-	-	10	-	-	50	-	10
90.	*Cymbella marina* Castracane	-	30	-	-	-	-	-	-	10	-	-	
91.	*C.tumida (Breb)* Vantleurck	-	-	-	-	-	-	-	-	-	-	20	-
92.	*Bacillaria paradoxa Gmelin*	20	30	10	60	-	40	10	80	-	-	20	60
93.	*Bidulpia mobilensis*	-	-	-	-	-	-	10	-	-	20	60	-
94.	*Nitzschia closterium* (Ehr)W.Smith	10	20	30	40	30	30	40	50	20	-	120	10
95.	*N.longissima (Brebisson)* Ralf	100	980	40	60	-	880	70	80	-	40	-	60
96.	*Hemidiscus hardmannianus*	-	-	-	-	-	-	-	-	-	790	10	-
97.	*Guinardia flaccid*	10	-	-	-	-	-	10	10	-	-	10	10
98.	*Hemiaulus sinensis*	-	10	-	10	10	10	10	-	-	-	-	10
99.	*Odentella mobiliensis*	10	-	10	-	-	-	-	10	-	10	10	10
100.	*Asterionellopsis glacialis*	-	20	10	10	10	10	10	10	-	10	10	10
101.	*Ceratium tripos*	10	-	-	10	-	-	10	10	10	20	10	-
Total													

- denotes absence

Table 4: Phytoplankton Biomass recorded from Ennore Mangrove Ecosystem (Location 4,5,6).

S. No	Name of the Species	Season (Units – Cells/Lit.)											
		Location 4				Locatio5				Location6			
		Mon	POM	SUM	PRM	Mon	POM	SUM	PRM	Mon	POM	SUM	PRM
I	***Cyanophyceae* (Blue green Algae)**												
1.	*Apanocapsa banarasensis* Bharswaja	30	20	10	60	40	-	10	80	160	220	190	40
2.	*A. grevillei* Hans	10	-	30	10	10	-	50	60	30	20	10	-
3.	*A. microscopica* Naeg.	-	20	40	30	-	30	30	40	-	100	110	60
4.	*A. pallida* Kutz.	-	20	-	-	-	30	-	10	-	40	10	-
5.	*A. pulchra* Kutz.	-	-	-	20	-	10	-	10	-	-	10	50
6.	*A. stagnina* Spreng	-	30	80	30	-	40	70	60	-	-	120	100
7.	*Chrooccoccus indicus* Zeller	-	30	70	20	-	20	80	30	-	40	100	-
8.	*C. Minor (Kutz.)* Naeg.	-	20	-	70	-	10	-	60	-	-	-	140
9.	*C. minimus(Keister)* Lemm	10	10	-	10	-	20	-	50	50	20	-	10
10.	*C. turgidus (Kuetz)* Naeg.	-	-	-	-	-	-	-	10	-	10	-	-
11.	*C. tenax*	-	-	-	-	-	-	-	-	10	-	130	-
12.	*Merismopedia minima* Beck	-	-	-	10	-	-	-	20	70	10	-	10
13.	*M.pulverea*	-	-	20	-	-	10	50	-	-	-	80	-
14.	*Synechocystis crassa* Woronich	-	-	-	-	-	10	-	-	-	-	110	10
15.	*Arthrospira platensis* Nordst	-	-	-	-	-	-	-	-	20	30	20	40
16.	*Lungbya semiplena*	-	10	60	40	-	-	80	30	10	30	160	80
17.	*L. putealis*	10	10	50	20	20	20	60	50	30	140	200	90
18.	*L. pulvera*	-	-	-	-	-	-	-	10	-	-	110	10
19.	*L. celonica*	-	-	10	-	-	-	10	-	10	-	20	50
20.	*Oscillatioria earli* Gardner	-	-	20	10	-	-	10	10	-	20	-	120

21.	*O. nigroviridis Thwaites* ex Gomont	-	-	-	-	-	-	-	-	-	-	80	20
22.	*O. pseudogeminata* Schmid G	-	-	-	-	-	-	-	-	-	-	30	20
23.	*O. simplssima* Gomont	-	20	10	30	-	10	10	20	-	20	20	100
24.	*O. subbrevis*	-	-	-	20	-	-	-	40	50	-	-	20
25.	*O.tanganyikae* West.Gs.	-	-	-	-	-	-	10	-	-	-	-	10
26.	*O.terebriformis* Ag.ex.Gomont	-	20	-	10	-	-		20	-	-	-	90
27.	*Nostoc muscorum* Ag.ex. Born. Et flah	10	-	10	30	-	210	-	160	50	60	20	100
28.	*Spirulina laxissima*	-	20	10	-	-	-	50	-	10	-	20	60
29.	*S.labrinthiformis*	-	-	-	-	10	-	-	-	-	-	-	40
30.	*S.meneghiniana*	-	-	-	-	-	-	-	-	-	-	-	10
31.	*S.princeps*	-	-	-	10	-	-	310	-	10	-	-	50
32.	*Phormidium retzei*	-	10	-	-	-	-	-	-	20	-	-	30
33.	*Rivularia aquatic* De Wild.	-	-	-	20	20	-	-	10	-	10	-	10
34.	*Johannesbaptistia pellucid* (Dickie) Taylor et Drouet	-	-	-	-	10	80	650	540	50	-	40	500
II	***Chlorophyceae* (Green Algae)**												
35.	*Ankistrodesmus falcatus* (Corda)	-	-	-	-	-	40	60	20	-	-	-	30
36.	*Chlorella vulgaris* Beji	10	-	-	10	-	60	110	140	-	20	220	120
37.	*Closteriopsis longissima* (Lemm) Lemm.	-	-	-	-	50	60	70	40	60	30	-	90
38.	*Korshikoviella limnetica* (Lemm) Silvap	-	-	-	-	10	60	60	30	-	170	20	70
39.	*Senedesmus armatus* (Chod) G.M.Smith	10	-	-	-	10	40	30	10	-	-	40	40
40	*S.quaricauda (Turp.)*Breb	-	-	-	-	-	-	-	-	-	-	-	-
41	*S.arquatus*	-	-	-	-	-	-	-	-	-	-	20	-
42	*S.obilius*	-	-	-	-	-	20	60	-	-	-	-	-
43	*Schroedevia indica* Phil	-	-	-	10	-	10	-	-	10	30	-	10
44	*Hormidium flaccidum* (A.Br) Born et Flah.	-	-	-	-	-	-	-	-	-	-	-	20
45	*Docidium baculum* Breb.	-	-	-	-	-	-	-	40	-	-	-	20
46	*Gonatozygon aculeatum*	-	-	-	-	-	-	30	20	-	-	-	-
47	*G.brebissonni*	-	-	-	-	-	-	-	20	-	-	20	20
48	*G. Kinahanii*	-	-	-	-	10	-	-	-	-	-	20	-
49	*G.Mnotaenium* De Bary	-	-	-	-	-	-	10	-	-	10	-	-
50	*Penium cylindrus*	-	-	-	10	10	10	20	10	10	-	10	-
51	*P.margratacium*(Ehn)Breb	-	-	-	-	-	-	10	10	-	-	-	-
52	*Pleurotanium ehrenbergi* (Breb.) De Bary	10	-	-	-	10	10	30	60	20	20	30	-
53	*Euastrum spinlosum* Delp	-	-	-	-	-	-	10	-	-	-	-	20
III	***Bacillariophyceae* (Diatoms)**												
54.	*Stephanodiscus niograroe* Ehr.	-	-	-	-	20	30	650	670	20	-	70	950
55.	*Stephanopsis palmeriana* (Greville Grunow)	-	-	-	-	-	-	10	30	-	-	-	-
56.	*Seletonema costatum* (Greville) Cleve	10	-	-	10	10	-	40	10	20	-	20	10
57.	*Cyclotella meneghiniana* Kutzing	-	-	-	-	-	10	-	-	10	-	20	-
58.	*C.striata*(Kutzing)	-	-	-	-	-	-	-	-	-	-	-	20
59.	*Coscinodiscus concinnus* W.Smith	-	10	-	-	-	20	10	20	-	10	-	40
60.	*C. centralis* Ehrenberg	-	-	-	-	20	-	20	20	40	-	-	-
61.	*Planktoniella sol* (Vallich) Schiitt	-	-	-	40	10	-	-	40	-	-	10	10
62.	*Lauderia annulata* Cleve	-	-	-	-	20	30	80	870	20	10	80	890
63.	*Leptocylindrus danicus* Cleve	-	-	-	-	40	30	-	130	20	60	10	100
64.	*L. minimus*	-	-	-	-	60	-	130	80	40	-	80	60
65.	*Guinardia flaccida* (Casttracaqne)	-	-	-	-	20	20	-	20	20	10	-	-

66.	*Rhizosolenia styliformis* Bright Well	-	-	-	10	-	10	60	60	-	20	20	10
67.	*R. settigera* Bright Well	-	-	-	-	10	10	20	80	-	-	10	60
68.	*R. allata* Bright Well	-	-	-	-	-	-	-	-	10	-	-	-
69.	*Chaetoceros indicus sp.*Nov.	10	-	-	-	10	-	20	50	-	-	-	30
70.	*C.densum*	-	-	-	-	-	-	30	80	-	-	20	70
71.	*C.affinis Lauder var.*	-	-	-	-	-	-	-	10	50	-	-	30
72.	*Rhabdonema mirifiform* W.Smith	-	-	-	-	10	-	-	40	-	-	-	10
73.	*Climacosphenia elongate* Bailey	-	-	-	-	10	10	-	-	-	-	20	100
74.	*Fragilaria oceanica*	-	-	10	-	10	-	10	40	-	-	10	80
75.	*Thallasionema mitzschioides* Grunao	-	-	-	10	-	10	20	10	-	50	-	10
76.	*Thallasiothrix longissima* Cleve & Grunao	-	-	-	-	10	-	20	10	-	-	20	10
77.	*T.frauenfeldi* Grunow	-	-	-	-	-	-	-	-	-	-	10	-
78.	*Asterionella glacialis Castracane*	-	-	-	-	-	-	-	-	-	-	-	-
79.	*Cocconeis sigmoides sp.* Nov	-	-	-	-	-	-	-	-	10	-	10	10
80.	*Gyrosigma bolticum* (Ehrenberg)	-	-	10	10	260	-	260	270	160	-	280	240
81.	*Pleurosigma elongatum* W.Smith	-	-	-	-	20	140	280	310	20	180	200	250
82.	*P.normanni* Ralfs	-	-	-	-	-	220	-	90	-	-	80	50
83.	*P.angulatum (Quekett)*W.Smith	-	-	-	10	-	-	100	150	-	-	70	10
84.	*P.aestuarii Brebisson*	-	-	-	-	-	-	-	-	-	-	-	-
85.	*P.directum Grunow var.*	-	-	-	10	-	-	-	160	-	-	-	20
86.	*Anomoeoneis sphaerophora* (Kuetz) Pfitzer	-	-	-	-	-	-	-	10	-	-	10	-
87.	*Neidium iridis (Her.)* Pfitzer	-	-	-	-	-	50	-	70	-	20	-	20
88.	*Navicula longa (Gregory)*Ralfs	-	10	-	-	-	60	20	50	-	20	10	-
89.	*N.rhyncocephala* kuetz	-	-	-	-	10	-	40	30	-	-	20	-
90.	*Cymbella marina* Castracane	-	-	-		10	-	-	30	-	-	-	-
91.	*C.tumida (Breb)* Vantleurck	10	-	-	-	-	-	-	-	-	-	-	-
92.	*Bacillaria paradoxa Gmelin*	-	-	-	-	-	30	40	-	-	30	60	70
93.	*Bidulpia mobilensis*	-	-	20	-	-	-	10	10	-	-	20	-
94.	*Nitzschia closterium* (Ehr)W.Smith	-	10	10	10	10	60	70	50	40	20	30	80
95.	*N.longissima (Brebisson)* Ralf	-	-	-	-	-	690	130	80	-	760	80	100
96.	*Hemidiscus hardmannianus*	-	-	-	-	-	-	-	-	-	-	-	-
97.	*Guinardia flaccid*	-	10	-	10	10	20	-	20	10	-	10	10
98.	*Hemiaulus sinensis*	-	-	-	10	10	10	10	10	10	10	10	-
99.	*Odentella mobiliensis*	10	-	-	10	-	-	10	10	-	-	10	10
100.	*Asterionellopsis glacialis*	-	-	10	10	10	-	10	10	-	-	10	10
101.	*Ceratium tripos*	10	-	-	10	-	-	10	10	-	-	10	-
Total			-										

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