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Seasonal Variations and Diversity of Planktonic Diatoms of Kodikkarai and Velanganni, Southeast Coast of India

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Abstract: The present study "Seasonal variations and diversity of planktonic diatoms of Kodikkarai and Velanganni, Southeast Coast of India" was carried out for a period of one year (from June 2010 to May 2011). For this study, two stations were chosen from the districts Nagapattinam. The study focuses attention on the survey, systematic of marine diatom diversity and the influence of meteorological and physico-chemical factors on their seasonal distribution. During the study period a total of 37 species belonging to 24 genera of marine diatoms were recorded from the both stations. The most common genera were *Amphora, Amphiprora, Asterionellopsis, Bacteriastrum, Biddulphia, Chaetoceros, Coscinodiscus, Cyclotella, Diploneis, Diplomenora, Pinnulariosigma, Pinnularia, Pleurosigma, Rhabdonema, Rhopalodia, Rhizosolenia, Skeletonema, Surirella, Synedra, Trachyneis* and *Tropidoneis*. Higher values of diatom population density were found during summer at both stations. The seasonal distribution and abundance are discussed in relation to hydrographical parameters.

Key words: Physico-Chemical factors · Marine Water · Diatoms · India

INTRODUCTION

Diatoms (Division: Bacillariophyta) one of the largest groups of microorganism is among the most successful groups of photosynthetic eukaryotes. They occur in almost all wet/damp places with a diverse range of habitats across the continents. Diatoms are found in both fresh water and marine environments as well as in moist soil, on wet surfaces, in unusual places like whale skins, in hot springs or highly basic or acidic environments; ice brine canals etc. Diatoms an important group of eukaryotic microorganisms on earth and are probably well in excess of 100,000 species [1], are either free-floating, planktonic forms or attached to a substrate, benthic forms 2µm to 1mm in size, [2, 3] and are probably well in excess of 100,000 species [1]. Diatoms grow as single cells, or form simple filaments/colonies. They form the base of aquatic food webs in marine and fresh water habitats. Diatom species are sensitive to the physical and chemical parameters of water such as pH, nutrients, salinity, temperature and water current in which they live [4-6] assemblage patterns of diatoms. Diatoms are unicellular photo autotrophic eukaryotes that play an important role in ecology by fixing large amounts of carbon dioxide (CO_2) and generate most of the organic matter that serves as food for life in the sea. They greatly influence global climate, atmospheric carbon dioxide concentration and marine ecosystem function [7]. Diatoms are valuable indicators of environmental conditions, since they respond directly and sensitively to many physical-chemical and biological changes that occur, in aquatic environment. Among unicellular micro algae, diatoms probably represent one of the most diverse groups, with the number of species estimated to be between 10000 and 100000 [8]. Hence they constitute an ideal group to study its biodiversity. Perusal of literature reveals that extensive works carried out on the qualitative and quantitative aspects of planktonic diatom in the coastal waters of the south east coast of India are mostly limited. Hence the present work was undertaken to study the seasonal variation and biodiversity of planktonic diatoms and hydrographical parameters in Kodikkarai and Velanganni coastal areas, Southeast Coast of India.

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MATERIALS AND METHODS

The planktonic diatoms were collected from the surface water of the study areas by towing plankton net (mouth diameter 0.35 m) made of bolting silk cloth (No.35 mesh size 48µm) for 20 minutes. Water samples were collected from the surface during the monthly intervals for a period of six months (from June 2010 to May 2011) at two stations in Kodikkarai and Velanganni of Nagappattinam coast. Water samples were preserved in 4 % neutralized formalin and used for qualitative analysis. For quantitative analysis of diatoms, the settling method described by [9]. Cleaning of diatom sample by Nitric acid Method [10]. Identification of diatoms by Standard Manuals [10-17].

RESULTS AND DISCUSSION

Environmental Parameters and Their Influence: Monthly variations in meteorological and physico-chemical parameters, rainfall, air and surface water temperature, salinity, reactive silicate, pH, dissolved oxygen, inorganic phosphate, organic phosphate, nitrate and nitrite are recorded for period of one year from June 2010 to May 2011. The total annual rainfall recorded from the study area (S I and S II) varied from (0.0 mm) to (596.9 mm). Minimum (0.0 mm) rainfall was recorded during March and May 2010 (Fig. 1) at Station 1. Maximum (596.9mm) rainfall was recorded during November 2010 (Fig. 2) at station II. Rainfall was totally absent during the month of March and May 2011 at stations I (Fig. 1). The Physico-chemical parameters of the present study area are subjected to wide spatial temporal variations. Rainfall is the most important cyclic phenomenon in tropical countries as it brings about important changes in the physical and chemical characteristics of the coastal and estuarine systems.

In the present study, the study areas (Stations I and II) located on the southeast coast of India received bulk of the rainfall during Monsoon (November, 2010). No rainfall was recorded in the month of March 2011 at stations I. From Fig. 2, it is clear that the major portion of rainfall (596.9mm in November 2010) was received on this coast during monsoon season effected by the northeast monsoon. These monsoonal rains brought in to the study areas lot of terrigenous matter and abundant nutrients as land run off. This evident in the present study because high values of nutrients (11.16, Po_4-P in July 2010, 11.61, No_3 N^1 in May 2011) in water have been registered during monsoon (October, November and December) as compared to other months. During the period of highest rainfall (November 2010) there were low diversity of diatom populations and only a restricted number of species belonging to the genera *Amphiprora, Caloneis, Rhabdonema, Rhopalodia, Rhizosolenia, Skeletonema, Surirella, Thalassiothrix* and *Trachyneis* were present. During monsoon season especially in pre and mid monsoon periods the diatom populations were low at all the stations as compared to moderate populations recorded during late monsoon (December 2010) [18-22]. Air temperature varied from 24 to 36°C during the study period, minimum temperature values were recorded during the May 2011 (Fig. 3) 25°C at station II whereas maximum temperature were recorded 36°C at Station 1 in the month of April 2011.

Water temperature showed a fluctuation from 24 to 34°C at both stations (Fig. 4). Minimum temperature values were recorded 24°C during the season at both Station 1 and II. Maximum temperature values were observed during summer season at both stations, 34°C at Station 1 in the month of September 2010 and 34°C at station II in the month of June 2010. Temperature variation is another important factor in the coastal and estuarine environments, which influences the physico-chemical characters. In general, air and water temperatures were recorded during the summer months. The minimum temperature recorded during the monsoon and post monsoon month could be attributed to the rainfall caused by the northeast monsoon. During the present study period, surface water temperature was always lower than that of air temperature. This indicates that water temperature was mainly influenced by air temperature, besides water currents. Similar observations were reported by [23] from Tranquebar- Nagapattinam region, [24] from Vellar estuary [21] from Parangipettai and Cuddalore Coast.

Salinity values ranged from 28-37 ppt. The minimum salinity values were recorded (28 ppt) at Station II in December 2010 (Fig. 5). At stations I and II maximum salinities were recorded (37 ppt) during August and September 2010. Salinity is one of the key factors that determines the distributions of diatoms. In the present study, salinity was higher during summer and post monsoon months. This could be due to the continuous evaporation of water from the all study area especially during these seasons as observed by [23, 25] from Gulf of Kachchh and [26] from Vellar estuary, Southeast Coast of India. In all the above studies the salinity was found fluctuating widely which was mainly due to the influence of rainfall and influx of the fresh water into the system.

Fig. 1: Rainfall at different months in Station I

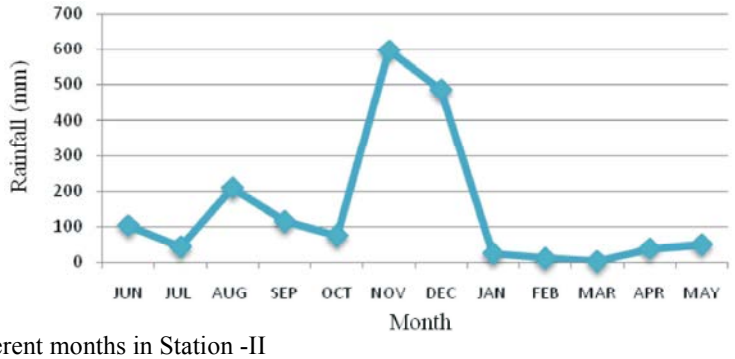

Fig. 2: Rainfall at different months in Station -II

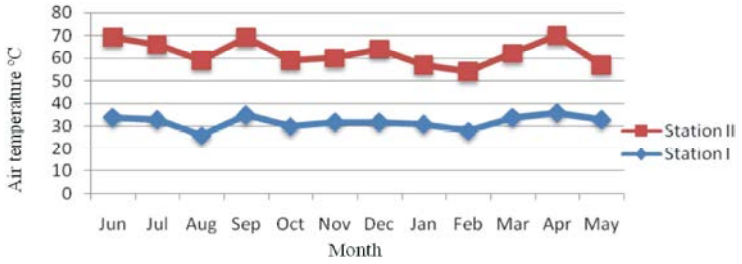

Fig. 3: Air temperature at different months in Station I and II

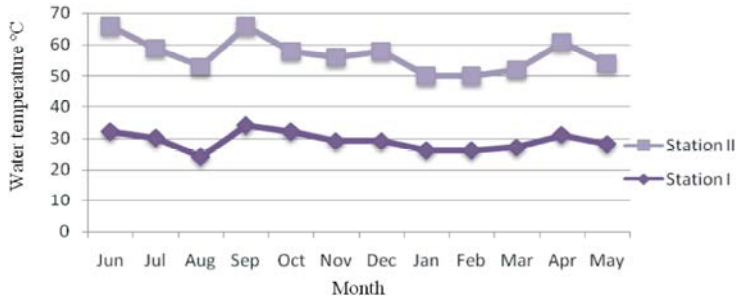

Fig. 4: Water temperature at different months in Station I and II

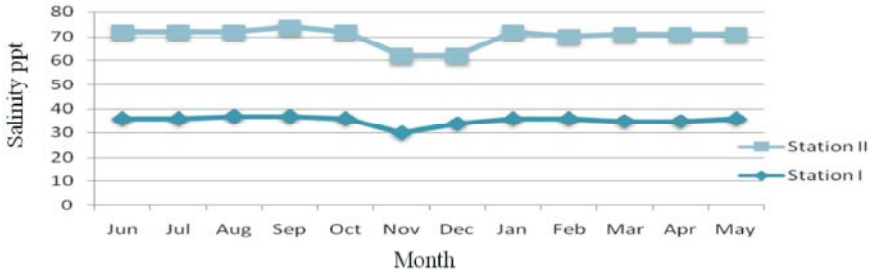

Fig. 5: Salinity at different months in Station I and II

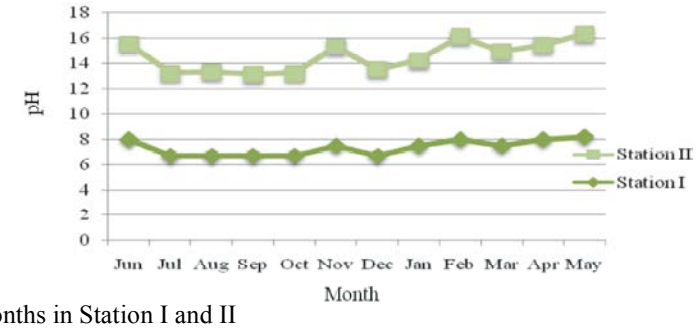

Fig. 6: pH at different months in Station I and II

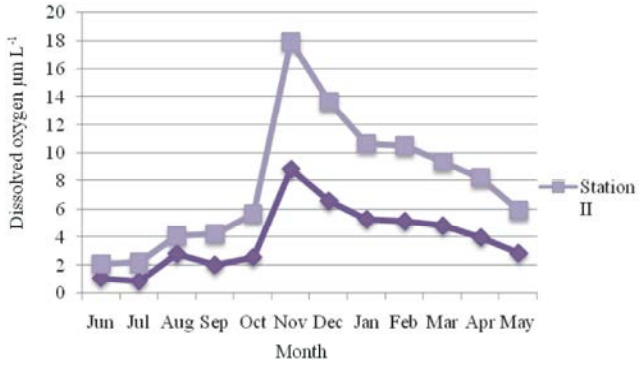

Fig. 7: Dissolved oxygen at different months in Station I and II

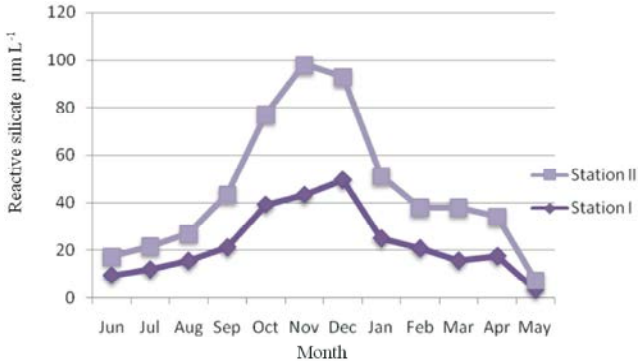

Fig. 8: Reactive silicate at different months in Station I and II

The pH of water samples ranged from 6.4 to 8.2 (Fig. 6). At Station II, minimum recorded (6.4) during the month of September 2010 and the maximum recorded (8.2) during the summer season (May 2011). At station I, the hydrogen ion concentration (pH) of water may influence many biological and chemical characteristics of marine waters [27]. But the pH values observed in the present study did not show any definite seasonal pattern with the range of variations which were very narrow. The pH remained alkaline throughout the study period at all stations registering a maximum (8.2) during summer month of May 2011. pH was low during monsoon (6.4 at station II) due to the influence of fresh water influx, dilution of saline water, reduction of salinity and temperature as suggested by several authors [20, 21, 28, 29].

Dissolved oxygen concentration was varied from 0.85 m L^{-1} to 9.11 µmL^{-1}. Minimum (0.85 µm L^{-1}) recorded in the month of July 2010 at station I and maximum recoded in the month (9.11µm L^{-1}) of November 2010 at station II. In general, the maximum values recorded during the monsoon month and minimum during the summer month (Fig. 7) Dissolved oxygen showed a wide range of variations throughout the study period at both stations. Dissolved oxygen contents were low during pre monsoons and summer months and high during monsoon (Fig. 8) were due to the large influx of freshwater into the study areas. This is attributed to the variations in freshwater inflow and tidal ingress [30-33]. This was accomplished by lowering of salinity and air and surface water temperature values. This is in conformity with the

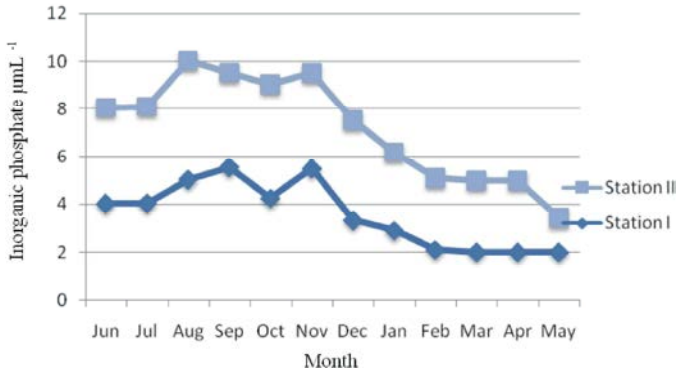

Fig. 9: Inorganic phosphate at different months in Station I and II

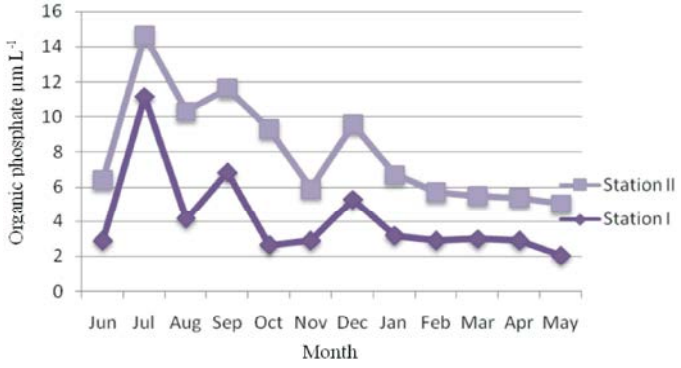

Fig. 10: Organic phosphate at different months in Station I and II

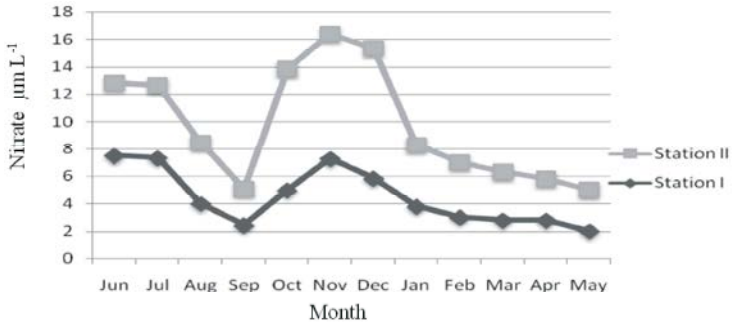

Fig. 11: Nitrate at different months in Station I and II

earlier works of Redfield [24, 33-36] who reported that high concentrations of dissolved oxygen in low saline water coupled with low temperature during monsoon. It was noted that in both the stations, the standing crop of diatoms were more during summer months (when dissolved oxygen concentrations was low due to cessation of freshwater flow) as reported [36] in Pitchavaram mangroves and [33] in Karaikal Coast.

Reactive silicate ranged from 3.2 to 54.9 μml^{-1}. The lowest value recorded during summer (May 2011) at station I and maximum during November 2010 at station II (Fig. 9). Nutrients concentrations showed distinct seasonal variations. In the present investigation, the reactive silicate concentration was found to be much higher than inorganic phosphate, organic phosphate, nitrate and nitrite. Station I recorded more silicate than stations II. High silicate concentration recorded during the monsoon (November 2010). Furthermore silicate present at the bottom sediments might go into upper surface layers when the bottom region is agitated by wind action during the monsoonal floods. Low values of silicate recorded during the summer may be due to the abundant planktonic diatoms for their biological activity [37]. In addition to planktonic diatom uptake, some related processes like absorption and co-precipitation of soluble silicon might also govern the distribution of dissolved silicate in the marine environment [20, 33, 38, 39].

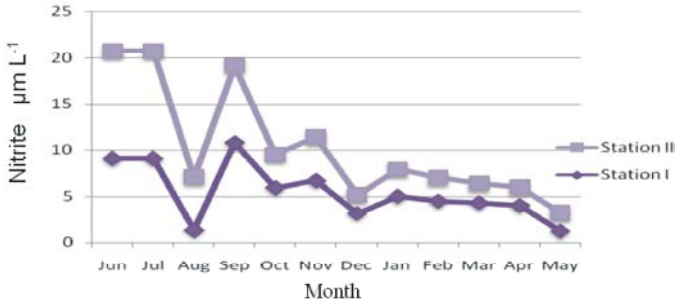

Fig. 12: Nitrite at different months in Station I and II

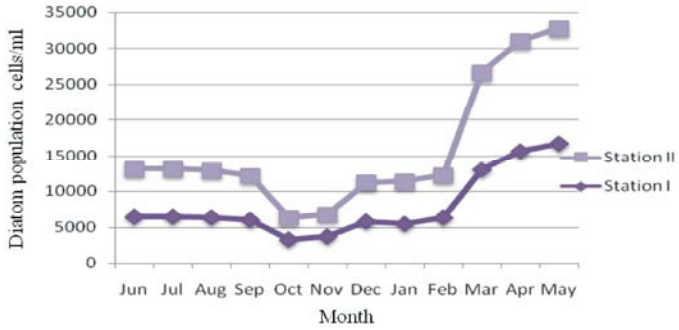

Fig. 13: Diatom population density at different months in Station I and II

Inorganic phosphate concentration ranged from 1.44 to 5.5µmL^{-1} Minimum concentration was observed during the month of May 2011 at station II and maximum (5.5µmL $^{-1}$) during the month of November 2010 at station I (Fig. 10) Inorganic phosphate (Fig. 10) recorded peak values during the monsoon months and the low values during summer months. This could be due to the land runoff from the irrigation channels and release of the phosphate from the sediments due to high wind action during this season. The lower phosphate concentrations during the summer season could be attributed to the utilization of the nutrients by the planktonic diatoms, which present in higher densities during summer season. Similar observations have been made [20].

Organic phosphate concentration value varied between 2.05 and 11.16µmL $^{-1}$. The lowest value was recorded during the month of May 2011 at station I and maximum value was recorded in the month of July 2010 at station I (Fig. 11) Nitrate concentration ranged from 2.0 to 9.49 µmL^{-1}.The minimum value recorded was 2.0 µmL^{-1} during the month of May 2011 at stations I. The maximum value recorded was 9.49µmL^{-1} during the month of December 2010 at station II. (Fig. 12) In the present study nitrate values (Fig. 12) showed monthly variations. Higher values of nitrates were recorded during early monsoon (December 2010) at station II. This was mainly due to the freshwater inflow. The reports made earlier [35, 36, 40, 41] also confirm this. The lower concentrations of nitrate observed during summer season at all station were due to the utilization of this nutrient by diatoms that occurred abundantly, as also observed [42].

Nitrate concentration varied from 1.2 to 11.61 µmL^{-1}. The minimum (1.2µm L^{-1}) concentration was recorded during May 2011at station I and maximum 11.61 µmL^{-1} concentration was recorded during the month of May 2011 at station II (Fig. 13). Nitrite contents (Fig. 13) were also found to be higher during pre monsoon and monsoon months and seasonal variations could be attributed due to the influence of seasonal floods. The low nitrite contents during the summer months of April and May 2011 might be due to less freshwater input higher salinity, higher pH and also uptake by planktonic diatoms. The same was recorded [19] from Cuddalore Uppanar estuary [43] from Palk Bay and Satpathy (1996) from coastal waters of Kalpakkam.

Diatom Population Density: The diatom population density varied from Station I, minimum population density was recorded (3216 cells/ml) during the October 2010 and maximum number of cells population were recorded (16696 cells/m1)during the May 2011 at station I. In Station II the population density minimum population density was recorded from (3056 cells/m1) and maximum number of (16128 cells/m1) recorded. The minimum was recorded the month of November 2010 and maximum was recorded during the month of May 2011 at Station II.

Table 1: Check List of Diatoms

S. No	Name of the Diatoms
1.	Amphora ovalis (Kutz) (Kutz)
2.	Amphiprora alata (Ehrenberg) Kützing
3.	Asterionellopsis glacialis Castracanne,
4.	Bacteriastrum furcatum Shadbolt
5.	Bacteriastrum hyalinum Lauder
6.	Biddulphia mobiliensis Bailey
7.	Biddulphia aurita (Lyngbye) Brebisson
8.	Biddulphia retiformis Mann
9.	Caloneis permagna (Bailey) Cleve
10.	Chaetoceros coarctatus Lauder
11.	Coscinodiscus rothii Ehr Grun
12.	Coscinodiscus gigas Ehr
13.	Coscinodiscus radiatus Ehr.
14.	Coscinodiscus kutzingii A.Schmidt
15.	Cyclotella meneghiniana Kutz
16.	Cyclotella stylorum Btoo
17.	Diplomenora cocconeiforma A and S Plaze
18.	Diploneis suborbcularis (Gregory) Cleve
19.	Diploneis subovalis Cleve
20.	Diploneis ovalis (Halse) Cleve
21.	Diploneis crabro Ehr
22.	Diploneis weisflogii (A.Schmidt) Cleve
23.	Navicula cincta (Ehrenberg) Ralfs
24.	Pinnulariosigma reana Desikachary, Rajarao and Sridharan (= *Navicula reana* (Castr) De Toni)
25.	Pinnularia viridis (Nitzsch) Ehrenberg
26.	Pleurosigma aestuarii (De breb.)W.Smith
27.	Pleurosigma normanii Ralfs in Pritchard
28.	Rhabdonema mirificoom w.smith
29.	Rhizosolenia alata Brightwell
30.	Rhopalodia gibberula Kutz
31.	Skeletonema costatum (Greville) Cleve
32.	Surirella minuta Brébisson in Kützing
33.	Synedra fulgens (Greville) W.Smith
34.	Synedra formosa Hantzsch
35.	Thalassiothrix longissima Cleve
36.	Trachyneis aspera (Ehr) Cleve
37.	Tropidoneis vitrea (W.Smith) Cleve

Table 2: List of planktonic diatom genera occurring at Station I and II

	Number of species	
Genus	Station I	Station II
Amphora	1	1
Amphiprora	-	1
Asterionellopsis	1	1
Bacteriastrum	1	2
Biddulphia	3	2
Caloneis	1	-
Chaetoceros	1	1
Coscinodiscus	4	3
Cyclotella	2	1
Diplomenora	1	1
Diploneis	4	5
Navicula	1	-
Pinnulariosigma	1	1
Pinnularia	1	1
Pleurosigma	2	2
Rhabdonema	1	1
Rhopalodia	1	1
Rhizosolenia	1	1
Skeletonema	1	1
Surirella	1	1
Synedra	2	2
Thalassiothrix	1	-
Trachyneis	1	1
Tropidoneis	1	1
Total	34	31

The present observations on nutrients, agree well with the statement of [38] as the distribution and behaviour of nutrients in the coastal environments particularly near the shore water and estuaries may exhibit considerable seasonal variations depending upon the local conditions like rain fall, diatom uptake and regeneration. The maximum population density was recorded at station I due to increase in nutrients from the domestic and sewage waters discharged into adjacent river causing the large influx of nutrients in the study area.

Totally 37 species belonging to 24 genera were identified from the study area (Table 1 and 2). The study area showed greater number of species belonging to the genera Coscinodiscus (4 species), *Diploneis* (5 species) *Biddulphia* and *Cyclotella* (2 species), *Synedra* (2 species) from two stations. Among the stations, station I showed maximum population in the summer months (June 2010, April and May 2011) and minimum (station II) recorded in the monsoon months. Similar observations were made by many workers [20, 33, 36].

Monthly variations of 37 diatom species were recorded in both stations. In the present study, 11 species of Pennate diatoms and 8 species of centric diatoms were reported. Pennate diatoms were recorded in both stations *Amphora, Amphiprora, Asterionellopsis, Diploneis, Navicula, Pinnulariosigma, Pinnularia, Pleurosigma, Synedra, Thalassiothrix, Tropidoneis* and the Centric diatoms *Bacteriastrum, Biddulphia, Caloneis, Chaetoceros, Coscinodiscus, Cyclotella, Rhizosolenia, Skeletonema* were also recorded. At Station I (Kodikkarai) the diatoms which occurred almost throughout the year, were species of *Amphora, Amphiprora, Bacteriastrum, Biddulphia, Caloneis, Chaetoceros, Coscinodiscus, Cyclotella, Diploneis, Diplomenora, Navicula, Pinnulariosigma, Pinnularia, Pleurosigma, Rhabdonema, Rhopalodia, Rhizosolenia, Skeletonema, Surirella, Synedra, Thalassiothrix, Trachyneis Tropidoneis.* In Station II (Velanganni) the following

diatom species were occurred *Amphora, Amphiprora, Asterionellopsis, Bacteriastrum, Biddulphia, Chaetoceros, Coscinodiscus, Cyclotella, Diploneis, Diplomenora, Pinnulariosigma, Pinnularia, Pleurosigma, Rhabdonema, Rhopalodia, Rhizosolenia, Skeletonema, Surirella, Synedra, Trachyneis Tropidoneis* The diatom species composition was highest at Kodikkarai (station I) than at Velanganni (station II).Similar type of observation of diatom domination were also made from Coleroon estuary, [44] and Pitchavaram mangrove water [45, 46].

Most of the species composition of diatoms recorded at summer season and post-monsoon both station I (Kodikkarai) and station II (Velanganni). Similar observations were reported [47] in Vellar estuary [39] in Gopalpur coastal waters. In compare to post-monsoon period, the dominance of diatoms common in the estuary of India [48-50] in Zuari estuary, Goa (West Coast of India) [51-56] in Gurupur estuary [32] were identified. A total number of 59 genera of phytoplankton were recorded during the study period.

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