Diversity of Phytoplankton in South Andaman

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Introduction

Andaman and Nicobar Islands are located in the west basin in the Andaman Sea occupying an area of about 6 × 105 km^2 and an average depth of about 1,100 m (Dutta et al., 2007). Physio-chemical processes of the Andaman Sea were recorded earlier (Sewell, 1928 and 1929). Later, data were collected on the hydrology of Andaman and Nicobar Islands by research cruises such as *Challenger, Valdivia, Siboga, Galathea,* INS *Kistna* and RV *Vityaz* and expeditions such as Dana Expedition and International Indian Ocean Expedition have been carried out in this region. The present study provides the scenario of density and diversity of phytoplankton of the two study areas of Port Blair region of South Andaman Islands. Phytoplanktons are microscopic, autotrophic, unicellular plants which are responsible for the 95% primary productivity of the sea (Steeman Nielsen, 1975). They are the primary producers in the sea which form the base of food chain. Ocean ecosystem is entirely dependent on phytoplankton. Phytoplankton is a prime component of the marine ecosystem as they bring about approximately half of the global (terrestrial and marine) net primary production (Field *et al.*, 1998). Total of 4000 marine phytoplankton species have been described (Simon *et al.,* 2009). High diversity increases the community stability and productivity which makes the system less susceptible to invasion (Tilaman, 1999).

Phytoplanktons are the indicators of water quality (Chellappa *et al.*, 2009) and pollution in the aquatic environment. Their population and composition can be very well accounted for the prediction of the health of the water they are present. They are the direct indicators of human intervention in the marine environment. Any extreme changes in their population or composition can be taken as an alarm signal to check the source of pollution in the system.

Incidents of harmful bloom all over the world have necessitated marine biologists from time to time to

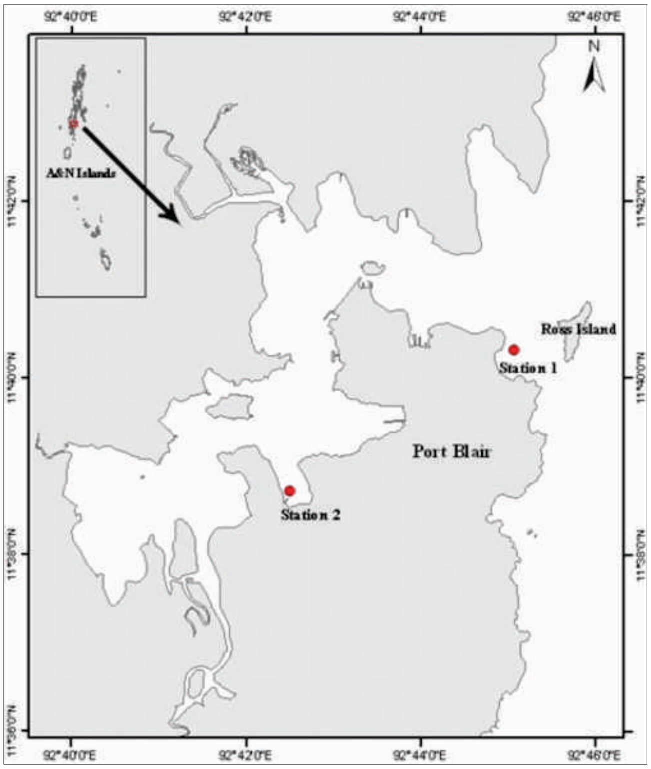

Fig.1. Map of Port Blair Bay (South Andaman) showing the two sampling stations.

undertake investigations on the community structure, growth pattern and succession in phytoplankton. Several works have been done world wild on occurrence of such algal blooms (Sournia, 1991; Hallegraeff, 1993; Burkholder *et al.*, 1995; Anderson *et al.*, 1998) Graneli and turner, 2006) in Indian waters (Banse, 1959; Devassy *et al.*, 1979; Devassy and Bhat, 1991; Godhe *et al*, 1996; Bhat and Matondkar, 2004; Bhat *et al.*, 2006) as well as in Port Blair Bay (Dharani *et al.*, 2004; Eashwar *et al.*, 2001). Phytoplankton composition studies in Andaman waters have been carried out previously by others (Devassy and Bhattathiri, 1981; Sarojini and Sarma, 2001; Boonyapiwat, 2006). This paper illustrate the findings of weekly sampling that have been carried out for the period of December 2009 to February 2010 at the two locations in Port Blair Bay to study the phytoplankton abundance and diversity prevailing in the two areas.

Study Area

The present study areas are located at the two end of Port Blair Bay in South Andaman Islands. The Station-1 is an open seawater area in front of Port Blair Bay called "Aberdeen Bay" and Station-2 is the enclosed end of Bay called "Minnie Bay" (Fig. 1). The distance between the two sampling stations is about 5.2 km (Fig.1). The Aberdeen Bay is very broad and its average depth is 20 m. Aberdeen jetty is the major jetty for recreational activities and it receives large amount of anthropogenic wastes and sewage discharges. Minnie Bay is situated at the head end of Port Blair Bay and it is approximately about 0.538 km^2 in area with an average depth of 3 m. Mangrove vegetation comprising of *Rhizophora* sp., and *Avicennia* sp., grows on its embankments.

Material and Methods

The co-ordinates for the sampling station 1 and sampling station 2 were 11° 41' 01.050"N and 92° 43' 06.680"E and 11° 39' 24.317"N and 92° 43' 29.333"E respectively, it was recorded by using a hand held GPS (Garmin eTrex). Analysis of phytoplankton was done by collecting 5L volumes of water samples using Niskin water sampler and fixed with Lugol's iodine (Sournia, 1978) and formaldehyde (4%). Samples were reduced from 5L to 10 mL following the sedimentation techniques (Utermohl, 1931). Phytoplankton density and diversity were analyzed using final samples volume of 5 mL using Nikon Eclipse E600 Optiphot microscope with phytoplankton identification standard keys of Venkataraman (1939), Cupp, (1943), Subrahmanyan (1946), Desikachary and Ranjithadevi (1986) and Santhanam (1987).

Species diversity of phytoplankton were calculated using the Shannon-Wiener diversity index "H" (Shannon, 1948) along with species evenness index "J" (Pielou, 1966) and Margalef Species richness "d" (Margalef, 1958).

Shannon-Weiner Diversity Index

$$Hs = -\sum_{i=1}^{S} (Pi)(\ln Pi)$$, where

Hs - Symbol for the diversity in a sample of S species or kinds

S - The number of species in the sample

Pi - Relative abundance of i^{th} species or kinds measures, = ni/N

N - Total number of individuals of all kinds

ni - Number of individuals of i^{th} species

In - Natural log

Pielou's evenness index

$$J' = \frac{H'}{H'_{max}}$$

$$J' = \frac{H'}{H'_{Log2}}$$

Margalef's richness index

$$d = (S-1)/ln(n),$$

Where, S is the number of taxa, and n is the number of individuals.

Results

The density (Nos./L) of phytoplankton in station 1 ranged from 3280 to 32300 with an average of 8969 ± 7671. The density in station 2 ranged between 4040 to 140000 with an average of 35052 ± 40855. A total of 108 phytoplankton species identified from the study. (Table. 1). Total number of species in the station 1 recorded from 28 to 48 with an average of 38 ± 8 species. In station 2 total species ranged from 25 to 48 with an average of 34 ± 5 species. *Chaetoceros curvisetus* was dominating species with composition of 93.19 % in station 1 during 5th February 2010 and *Nitzschia closterium* in station 2 with composition of 23.43 % during 26th February 2010.

The species recorded in station 1 belong to families with average density and percentage composition [Nos./L(% composition)] such as Chaetocereae 2806 (31.29), Naviculoideae 2408 (26.84), Nitzschiaceae 2343 (26.12), Fragilaroideae 372 (4.15), Peridiniaceae 331 (3.69), Soleniae 298 (3.36), Coscinodisceae 240 (2.68), Cyanophyceae 68 (0.75), Hemiaulineae 29 (0.33), Noctilucaceae 20 (0.22), Biddulphieae 14 (0.15) and Ceratiaceae 6 (0.07). The station 2 families include Nitzschiaceae 14655 (41.81), Naviculoideae 9954 (28.40), Perdiniaceae 4520 (12.90), Soleniae 3400 (9.70),

Table. 1. **List of Phytoplankton species recorded from two stations at Port Blair, South Andaman.**

S. No.	Family/ Species	Station 1	Station 2
	Nitzschiaceae		
1	*Nitzschia closterium*	+	+
2	*Nitzschia longissima*	+	+
3	*Nitzschia migrans*	-	+
4	*Nitzschia seriata*	+	+
5	*Nitzschia sigma*	+	+
6	*Nitzschia delicatissima*	+	+
7	*Bacillaria paradoxa*	+	+
	Biddulphieae		
8	*Biddulphia* sp.	+	-
9	*Eucampia groenlandica*	+	-
10	*Eucampia zoodiacus*	+	+
11	*Streptotheca indica*	+	-
	Ceratiaceae		
12	*Ceratium bucephalum*	+	-
13	*Ceratium extensum*	+	+
14	*Ceratium furca*	+	+
15	*Ceratium fusus*	+	-
16	*Ceratium macroceros*	-	+
17	*Ceratium lineatum*	-	+
	Chaetocereae		
18	*Chaetoceros borealis*	+	+
19	*Chaetoceros breve*	+	-
20	*Chaetoceros compressus*	+	+
21	*Chaetoceros constrictus*	+	-
22	*Chaetoceros croactatus*	+	-
23	*Chaetoceros curvisetus*	+	+
24	*Chaetoceros didymus*	+	-
25	*Chaetoceros diversus*	+	-
26	*Chaetoceros indicus*	+	-
27	*Chaetoceros lorenzianus*	+	+
28	*Chaetoceros peruvianus*	+	+
29	*Chaetoceros simplex*	+	+
30	*Chaetoceros* sp.	+	+
31	*Chaetoceros wighamii*	+	+
32	*Bacteriastrum furcatum*	+	+
33	*Bacteriastrum hyalinum*	-	+
	Coscinodisceae		
34	*Skeletonema costatum*	+	+
35	*Melosira mummuloides*	+	+

S. No.	Family/ Species	Station 1	Station 2
36	*Coscinodiscus concinnus*	+	-
37	*Coscinodiscus gigas*	+	+
38	*Coscinodiscus jonesiannus*	+	-
39	*Coscinodiscus marginatus*	+	+
40	*Coscinodiscus* sp.	+	-
	Cyanophyceae		
41	*Trichodesmium erythraeum*	+	+
	Dinophyceae		
42	*Alexandrium catenella*	-	+
43	*Goniaulax* sp.	-	+
	Fragilaroideae		
44	*Asterionella glacialis*	+	-
45	*Asterionella japonica*	+	+
46	*Climacosphenia elongata*	+	-
47	*Climacosphenia moniligera*	+	-
48	*Fragilaria brevistriata*	+	+
49	*Fragilaria crotonensis*	+	-
50	*Fragilaria cylindrus*	-	+
51	*Fragilaria oceanica*	+	-
52	*Fragilaria* sp.	+	-
53	*Lycmophora abbreviata*	+	+
54	*Lycmophora lyngbei*	+	+
55	*Thalassionema nitzschioides*	-	+
56	*Thalassiothrix frauenfeldii*	+	+
57	*Thalassiothrix longissima*	-	+
	Hemiaulineae		
58	*Hemiaulus hauckii*	+	
59	*Cerataulina dentata*	+	+
60	*Cerataulina* sp.	+	+
	Naviculoideae		
61	*Navicula clavata*	+	+
62	*Navicula directa*	+	+
63	*Navicula granii*	+	+
64	*Navicula hennedyii*	+	+
65	*Navicula longa*	+	+
66	*Navicula membranaceae*	+	+
67	*Navicula* sp.	+	+
68	*Caloneis madraspatensis*	+	+
69	*Pleurosigma angulatum*	+	+
70	*Pleurosigma elongatum*	+	+
71	*Pleurosigma normanii*	+	+

S. No.	Family/ Species	Station 1	Station 2
72	*Gyrosigma balticum*	+	+
73	*Amphiprora gigantea*	+	+
74	*Amphopra lineolata*	+	+
75	*Amphora abbreviata*	+	-
76	*Amphora coffeoeformis*	+	+
77	*Amphora ostrearia*	+	+
78	*Amphora* sp.	+	+
79	*Amphiprora gigantea*	-	-
80	*Tropidineis semistrata*	+	-
81	Diploneis smithii	+	+
82	*Diploneis robustus*	-	+
83	*Diploneis* sp.	+	+
84	*Diploneis weissflogii*	+	+
85	*Grammatophora undulata*	+	
86	*Cymbella marina*	-	+
	Noctilucaceae		
87	*Noctiluca scintillans*	+	+
	Peridiniaceae		
88	*Peridinium achromaticum*	+	+
89	*Peridinium diversus*	+	+
90	*Peridinium globulum*	+	+
91	*Peridinium ovatum*	+	+
92	*Peridinium pallidum*	+	+
93	*Peridinium pallucidum*	+	-
	Prorocentriaceae		
94	*Prorocentrum gracile*	+	-
95	*Prorocentrum maximum*	+	+
96	*Prorocentrum micans*	+	+
	Soleniae		
97	*Corethron hystrix*	+	-
98	*Corethron inerme*	+	-
99	*Dactyliosolen fragilissmis*	+	+
100	*Rhizosolenia alata*	+	-
101	*Rhizosolenia hebetata*	+	+
102	*Rhizosolenia imbricata*	+	+
103	*Rhizosolenia setigera*	+	+
104	*Guinardia cylindrus*	+	+
105	*Guinardia delicatula*	+	+
106	*Guinardia flaccida*	+	+
107	*Leptocylindrus danicus*	+	+
108	*Leptocylindrus minimus*	+	-
	Total=108		

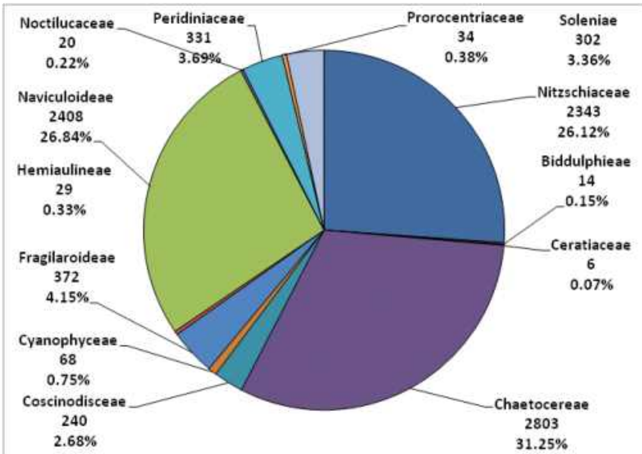

Fig. 2. Chart showing the Phytoplankton family density and percentage composition in station1.

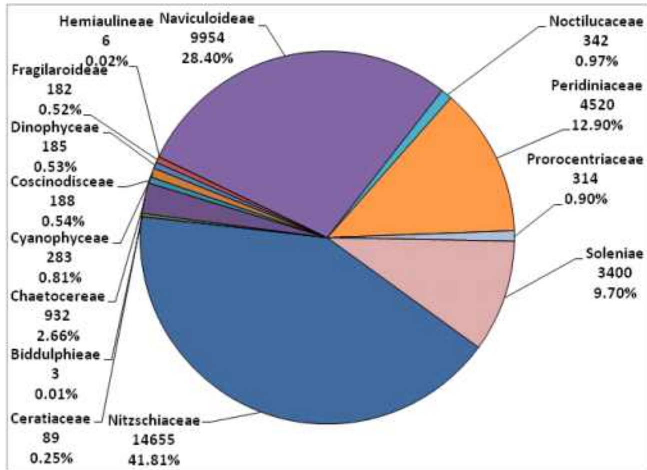

Fig. 3. Chart showing the Phytoplankton family density and percentage composition in station2.

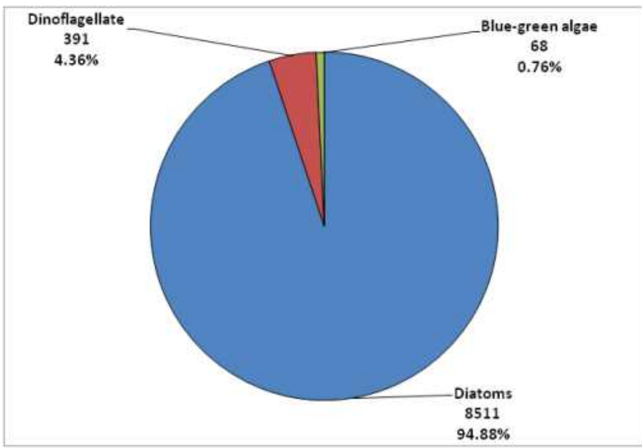

Fig. 4. Chart showing the domination of diatoms and its percentage composition in station1.

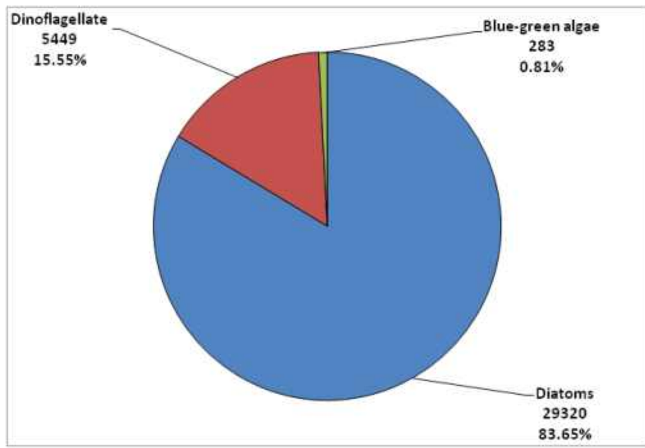

Fig. 5. Chart showing the domination of diatoms and its percentage composition in station 2.

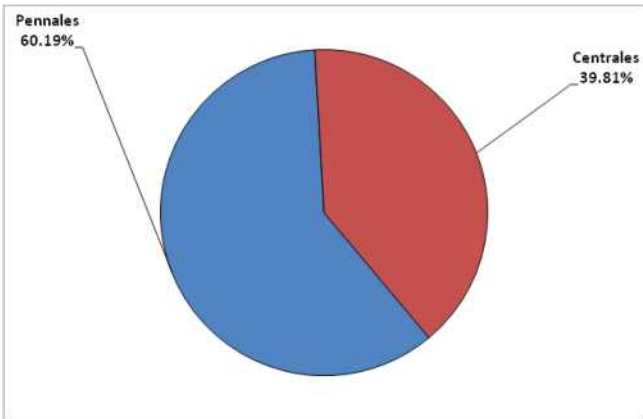

Fig. 6. Chart showing diatoms composition in station1.

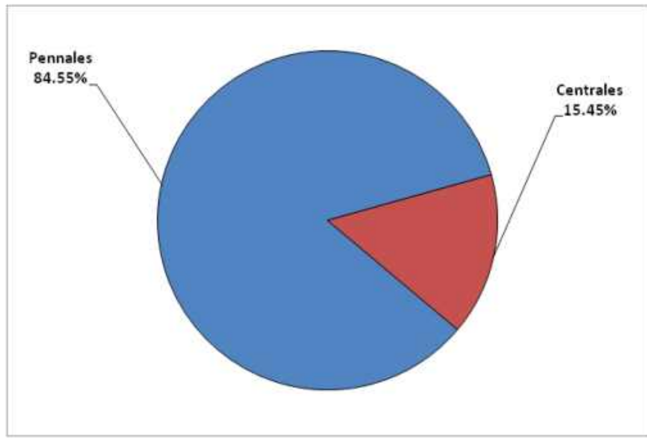

Fig. 7. showing diatoms composition in station 2.

Chaetocereae 932 (2.66), Noctilucaceae 342 (0.97), Prorocentiaceae 314 (0.90), Cyanophyceae 283 (0.81), Coscinodisceae 188 (0.54), Dinophyceae 185 (0.53), Fragilaroideae 182 (0.52), Ceratiaceae 89 (0.25), Hemiaulineae 6 (0.02) and Biddulphieae 3 (0.01). (Fig. 2 and 3)

Shannon-Wiener Diversity index "H" of phytoplankton at station 1 and station 2 ranged from 0.44 to 3.47 and 0.65 to 3.07 respectively. Species richness "d" (Margalef) ranged from 2.60 to 6.80 and 2.45 to 4.93 in station1 and 2 respectively. Species evenness "J" (Pielou) ranged from 0.13 to 0.86 and 0.18 to 0.85 in station1 and station 2 respectively. Station 1 exhibited higher phytoplankton diversity compared to station 2 in spite of high density. Species richness is also recorded higher in station 1 than in station 2. Species evenness which refers to closeness of numbers of each species in an environment is more or less similar in both the stations.

Study accounts that the diatoms are by far the dominating group in station 1 and station 2. The density of diatoms in station 1 was enumerated as 8510 Nos./L with 94.88% composition out of total population. Dinoflagellate were 391 Nos./L with 4.36% and blue-green algae or cyanobacteria 68 Nos./L with 0.76% composition. Diatoms 29329 Nos./L with 83.65%, dinoflagellates 5449 Nos./L with 15.55% and blue-green algae 283 with 0.81% composition in station 2. An interesting point to state here is the higher number of dinoflagellate in station 2 in comparison to station 1. (Fig. 4 and 5)

Out of the diatom population in station 1, 60.19% belong to the order Pennales and 39.81% of the population comprised of Centrales. Whereas, in station 2, 84.55% come under order Pennales and 15.45% belongs to Centrales. (Fig. 6 and 7)

Discussion

Phytoplanktons supply the base of the marine food web and drive the biogeochemical cycles of carbon and nutrients (Smith *et al.,* 2009). Phytoplankton belong to range of sizes acquire importance due to their unique role in the ecosystem. Picoplanktons (< 2 μm) and nanoplankton (2 μm to 20μm) can contribute to the downward carbon flux. (Gorsky *et al.*, 1999). The diatoms and the dinoflagellates are the two chief component of phytoplankton (Severdrup *et al.*, 1942). Amongst the two, the diatoms are major component of phytoplankton fixing approximately 40% of the marine carbon, acting as a defense mechanism against Global warming (Maheswari and Bowler, 2006).

Diatoms (Bacillariophyta) are classified into 2 orders, the Centrales and the Pennales. The Centrales or centric diatoms have a radial symmetry and are common in marine waters. They are planktonic and non motile (Tappan, 1980). The Pennales or pinnate diatoms occupy varied habitat from soil, fresh water to marine. They have radial symmetry (Armstong and Brasier, 2005). The diversity of the phytoplankton increases due to manifestations of centrales and pennales. The station 1 was found more diverse than station 2, this can be related to the fact that oligotrophic waters are more diverse compared to eutrophic waters (Raymont, 1980), station 2 being located at the opening end of the bay receives the low nutrient water from the open sea.

The species recorded during the study have been reported earlier from the Indian mainland (Menon, 1945; Subramanyan, 1946; Subramanyan, 1968; Desikachary and Ranjithadevi, 1986; Desikachary and Prema, 1987; Ilangovan, 1987; Paul *et al.*, 2007) and Andaman waters (Dharani *et al.,* 2004; Eashwar *et al.*, 2001; Boonyapiwat, 2006; Mehmuna Begum, *et al.*, 2009; Vinithkumar *et al.*, 2009). Station 2 may be called more productive containing the higher phytoplankton density. Station 2 located in Minnie Bay is bordered by mangrove forest and its average depth is 3 m. The organic matter is very high in the area due to mangrove vegetation. The productivity is probably due to the untreated sewage from the residential colony which finds its way directly into in the Minnie Bay water environment. Elevated levels of nutrients especially nitrate and phosphate boosts up the growth of phytoplankton and thereby increasing the productivity of the system until it reaches the stage of eutrophication or bloom as recorded previously by Dharani *et al.,* 2004. Tides play a crucial role in this area as twice a day it washes out the bay by bringing the water from outer open sea. The activity of tides brings about turbidity and siltation in this area. During the period of study no algal bloom was recorded from two stations. However, the station 1 was holding more diverse form of phytoplankton. Both the stations were containing small celled diatoms, bitter diatoms and dinoflagellates, the three distinguished groups created by Marglef, 1955, 1958 and 1967, after surveys of Spanish Mediterranean, North West Spain and Caribbean waters. In this study, cyanobacteria were also encountered from both the stations. *Trichodesmiun erythraeum* (Red tide species) recorded from both the stations, its occurrence in Indian waters is considered as regular feature (Devassy and Bhat, 1991).

An important point to make is the dominance of diatoms in both the stations, indicating the sufficient amount of silicate in the bay waters (Madhupratap *et al.,* 2003). Diatoms account for approximately 40% of oceanic primary productivity (Falkowski *et al.,* 2004). Abundance of pinnate diatoms were high in both the stations, however, centric diatoms are higher (39.81%) in station 1 in comparison to station 2 (15.45%). Dinoflagellates were low (4.36%) in station 1 as compared to station 2 (15.55%). This could be due to the strong mixing and turbulence in waters of station1 (Aberdeen Bay) which reduces the chance for dinoflagellate (Hartwell, 1975). Although, dinoflagellates were encountered from both the station but their number was not exceeding to any alarming level of bloom. The two study stations presented a very well diverse picture of phytoplankton in the region. The present study depicts the status of productivity and stability of the two differently located areas in Port Blair Bay. The abundance and composition analysis of phytoplankton in two study areas indicated that the areas are productive with high degree of diversity especially in the outer area of the bay. However, dinoflagellates were recorded in the waters of both the areas their number is not at all alarming during the period of study. Nevertheless, the continuous phytoplankton monitoring of the bay would help coastal area management and planning in general and during the incidents of bloom due to eutrophication.

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