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Diatom Diversity in Hypersaline Environment

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Abstract: The present study is the first detailed investigation of the diversity and distribution of diatoms in relation to the hydrography in the Saltpans of Southern coasts of India starting from Vedharanyam to Mandapam. Totally 52 taxa, both centric and pinnate diatoms were identified in the present investigation. When compared to Palk Strait and Palk Bay regions less diversity of diatoms was observed in the Bay of Bengal region. Highest diversity of diatoms was observed in the 50 ppt. But only 4 taxa namely *Achnanthes hauckiana*, *Cyclotella striata*, *Pseudonitzschia seriata* and *Thallassionema eccentrica* were observed at higher salinity (150 ppt).

Key words: Biodiversity, saltpans, survey, salinity, parameters

INTRODUCTION

Hypersaline environments are one of the extreme environments. Though the oceans are, by far, the largest saline body of water, hypersaline environments are generally defined as those containing salt concentrations in excess of seawater (3.5% total dissolved salts) (Das Sarma and Arora, 2002). Saltpans are one of the hypersaline extreme environments. They are characteristically exposed to a wide range of environmental stress and perturbations manifest mainly through salinity changes. Among halophilic microorganisms, bacteria, cyanobacteria, diatoms, green algae and fungi are abundant in saltpans. The biodiversity of photosynthetic diatoms found in both fresh and salt water, are so important to marine food webs that, they have been called the Pastures of the Sea (Chapman and Chapman, 1973; Bold and Wynne, 1978). Plant body is unicellular or colonial cells generally possess discoid, two plate or stellate chromatophores. They produce glassy protective coverings, some of exceptional beauty. These consist of top and bottom valves that fit together like a pillbox. Accumulations of the glassy walls of diatoms over thousands of years have produced fossil deposits of diatomaceous earth that may be hundreds of meters thick. This slightly abrasive substance is widely used in products such as toothpaste and metal polish. Diatoms reserve food as on their buoyancy in water helps their bodies to float near the surface, where light is abundant for photosynthesis. Pre historia accumulations of diatoms and their stored oil may contribute to today's petroleum reserves. (Wojtal *et al*., 1999). Some researchers have given detailed report on marine Planktonic flora (Misra, 1956; Subrahmanyan, 1946, 1958; Guillard and Ryther, 1962; Wojtal *et al*., 1999; Nübel *et al*., 2000) but the study on hypersaline diatoms has been very meager and rudimentary. The basic and fundamental requirement for initiating marine microbial biotechnology is to first enumerate the available natural microbial wealth. With this in view, an attempt has been made to survey diatom flora of saltpans of Southern coast of India.

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MATERIALS AND METHODS

The survey of diatoms of saltpans was carried out extending from Vedharanyam (Lat. 10°22'N and Long. 79°51'E) to Mandapam (Lat. 9°23'N and Long. 79°12'E) including Palk Strait, Palk Bay and Bay of Bengal regions during the year 2005. Physicochemical parameters of the water samples collected from different saltpans of southern coasts of India starting from Vedharanyam to Mandapam were estimated as per the methods recommended in Stickland and Parsons (1972), Wetzel and Likens (1979, 2000) and Eaton *et al*. (1995). Plankton samples were collected by filtering 10 L of salt pan water using plankton net (mesh size 10 μm) and transferred to wide mouthed polytene bottles containing 5% formaldehyde, then analyzed under light microscope at the Department of Microbiology, J.J. College of Arts and Science, Pudukkottai, Tamil Nadu, India. Planktonic diatoms were identified using the publications of Desikachary (1959). The diversity index like Simpson's index, Shannon index, Shannon evenness, Species richness and Dominant index were calculated using the procedures of Beena *et al*. (2000) for the diversity of diatoms in different regions of different salinities by using the number of organisms recorded in each sample.

RESULTS

The analysis of water samples from different saltpans revealed physicochemical variations. These variations greatly influence the biodiversity and distribution of diatoms (Table 1). Diatoms are eukaryotic algae surrounded by silica walls and are commonly found but rarely abundant in hypersaline environment. The biodiversity of diatoms in saltpans of different areas namely, Bay of Bengal region, Palk Strait and Palk Bay region were studied in detail. When compared to Palk Strait and Palk Bay regions less biodiversity of diatom was observed in Bay of Bengal region (Table 2). Of the 92 species recorded in the area of survey, only 19 species namely, *Achnanthes hauckiana*, *Amphora turgida*, *Asteromphalus hookeri*, *Bacteriastrum comosum*, *Diplonies smithii*, *Diplonies subovalis*, *Navicula lyra*, *Navicula lyra*. var. *hennedyi*, *Navicula ramossima*, *Nitzschia lorenziana*, *Pleurosigma elongatum*, *Surirella fastuosa*, *Synedra tabulata*, *Synedra ulna*, *Thalassiotrix logissima*, *Thallassionema eccentrica*, *Thallassionema nitzschioides*, *Triceratium favus* var. *pentagona* and *Triceratium favus* var. *tetragona* were considered as a versatile species since they occurred in all the surveyed saltpans. It was observed that pinnate type of diatoms was dominated over the centric diatoms. Highest diversity of diatoms was observed in 50 ppt of the salinity i.e., 92 species of 46 genera. Sixty species of diatoms belonging to 35 genera recorded in 98 ppt of salinity. Only 4 diatom species namely, *Achnanthes hauckiana*, *Cyclotella striata*, *Pseudonitzschia seriata* and *Thallassionema eccentrica* were observed at 150 ppt of salinity (Table 3).

Table 1: Physicochemical parameters in different salinities of saltpans

Physicochemical parameters	48 ppt	50 ppt	62 ppt	91 ppt	98 ppt	150 ppt	185 ppt
pH	9.400	7.26	9.70	8.00	7.59	7.71	7.73
Chloride (g L^{-1})	26.490	27.999	33.999	49.998	53.998	81.997	101.49
Carbonate (mg L^{-1})	136.00	80.00	152.00	186.00	100.00	120.00	250.00
Bicarbonate (mg L^{-1})	96.00	126.00	213.00	296.00	316.00	520.00	600.00
Dissolved oxygen (mg L^{-1})	5.801	4.321	4.163	3.43	3.85	2.76	2.85
Calcium (mg L^{-1})	5860.00	6600.00	7200.00	6600.00	6800.00	7600.00	8860.00
Magnesium (mg L^{-1})	1520.00	2520.00	8020.00	6520.00	7400.00	8020.00	8520.00
Nitrate (mg L^{-1})	0.08	0.15	0.18	0.15	0.15	0.22	0.12
Nitrite (mg L^{-1})	0.56	0.46	0.036	0.046	0.036	0.036	0.036
Ammonia (mg L^{-1})	0.018	0.090	0.011	0.010	0.012	0.013	0.080
Inorganic phosphate (mg L^{-1})	20.00	25.00	27.00	30.00	39.00	21.00	30.00
Sulphate (mg L^{-1})	2.20	2.06	2.045	1.12	1.22	1.45	1.20
Sulphide (mg L^{-1})	0.012	0.036	0.086	0.036	0.042	0.091	0.130

Table 2: Diversity indices of flora of diatoms in saltpans of different regions

Region	Name of the organism	Species richness	Simpson's index	Shannon index	Shannon evenness	Dominance index
Bay of Bengal region	Diatoms	6.8	8.2	0.366	0.037	33.6
Palkstrait region	Diatoms	11.0	3.2	0.326	0.020	55.4
Palk bay region	Diatoms	15.9	1.6	0.191	0.008	78.2

Table 3: Flora of diatoms in different salinities of saltpans

	Salinity (ppt)		
Name of the organism	50	98	150
Achnanthes brevipes Ag.	+	+	-
Achnanthes hauckiana Ag.	+	+	+
Actinocyclus readiatus Raff.	+	+	-
Actinoptychus splendens Shadf.	+	+	-
Amphipleura rutilens (Trentepohl.) Cl.	+	+	-
Amphiprore paludosa Greg.	+	+	-
Amphora crassa Greg.	+	-	-
Amphora ovalisvar. Liybica (Ehrenb)	+	+	-
Amphora spectabilis Greg.	+	+	-
Amphora turgida Greg.	+	+	-
Asteromphalus hookeri Ehrenb.	+	+	-
Auliscus caeliatus (Schimidt . A) Hustedt.	+	-	-
Bacillaria paradoxa Tmelin.	+	+	-
Bacteriastrum comosum Pavill	+	+	-
Biddulphia arurita V. obtuse (Odontele obtuse)	+	-	-
Biddulphia arurtia (Lyngbye) Breb and Godey	+	-	-
Biddulphia obtuse (Kutz.) Ralfs.	+	+	-
Biddulphia pulchella Gray, S.F.	+	+	-
Biddulphia rhombus (Ehrenb.) Smith.	+	+	-
Calonies amphisbaena (Boxy) Cleve.	+	-	-
Camphylodiscus incertus A. S.,	+	-	-
Camphylodiscus schmidtii Grun.	+	+	-
Cascinodiscus radiatus Ehrenb.	+	+	-
Cascinodiscus asteromphalus Ehrenb.	+	+	-
Cascinodiscus marginatus Ehrenb.	+	-	-
Climacosphenia moniligera Ehrenb.	+	+	-
Cocconeus lyra Schmidt, A.	+	+	-
Cocconeus heteroidea Hantz.	+	-	-
Cocconeus scutellum Ehrenb.	+	+	-
Cyclotella brightwelleii (Kuetz.) Grun.	+	+	-
Cyclotella striata (Kuetz.) Grun.	+	-	+
Cyclotella stylorum Btw.	+	+	-
Cymbella affinis Kuetz.	+	-	-
Cymbella aspera Her.	+	-	-
Denticula ketzingii Grun.	+	+	-
Diatoma hiemale (Lyngb.) Heiberg.	+	+	-
Diploneis bomboides (Schmidt. A)	+	+	-
Diploneis crabro Ehrenb.	+	-	-
Diploneis interupta (Kuetz) Cl.	+	+	-
Diploneis smithii (Breb. ExWm. Sm.) Cl.	+	+	-
Diploneis splendida (Greg.) Cleve.	+	-	-
Diploneis suborbicularis (Greg).	+	+	-
Diploneis subovalis Ceve.	+	+	-
Entophlta coconeiformis Meresch Kowsky.	+	+	-
Fragilaria consticta Ehr.	+	+	-
Fragilaria intermedia (Graun.) Grun.	+	+	-
Gomphonema angustatum Kutzing.	+	-	-
Gomphonema gracil Ehr.	+	-	-
Gomphonema olivaceum Var. salinum Grun.	+	+	-
Gomphonema purvalam (Kuetz) Grun.	+	-	-
Grammatophora undulata Ehrenb.	+	+	-
Grammatophora marina (Lyngbye) Kuetz.	+	+	-

Table 3: Continued

	Salinity (ppt)		
Name of the organism	50	98	150
Mastogloia euxina Cleve.	+	-	-
Mastogloia lineata Cl. and Grove.	+	+	-
Navicula directa (Smith. W)	+	+	-
Navicula disjuncta Hustedt.	+	-	-
Navicula impercepta Host.	+	-	-
Navicula lyra Ehrenb.	+	+	-
Navicula lyra Var. dilatata. A. Schmidt	+	-	-
Navicula lyra. Var. hennedyi W. Smith	+	+	-
Navicula muticoides Hustedt.	+	+	-
Navicula palea (Kutzing) W. Smith.	+	-	-
Navicula ramossima. Ag. Cl.	+	+	-
Navicula rhynchocephala Kuetz.	+	-	-
Navicula semiapproximata Hust.	+	-	-
Nitzschia granulate Grun.	+	-	-
Nitzschia gracilis Hantzsch.	+	-	-
Nitzschia lorenziana Grun.	+	+	-
Nitzschia plana V. *coarctata* Grun. In Cl. and Grun.	+	-	-
Pseudonitzschia seriata (Cl.) Perag.	+	+	+
Odonetella aurita Lyngby. Breb.	+	+	-
Opephora schwartzii (Grun.) Petit.	+	-	-
Paralia sulcata Ehrenb.	+	-	-
Perissonoe crucifera (Kilton.) Desik. *et al*.,	+	-	-
Plagiogramma pulchellum Grev.	+	+	-
Plagiotropis lepidoptera (Greg.) Kuetze.	+	+	-
Pleurosigma angulotum (Quek.) Wm. Sm.	+	+	-
Pleurosigma elongatum Wm. Sm.	+	+	-
Pleurosigma normanii (Grun).	+	+	-
Prichynesis aspera (Ehrn.) Cl.	+	+	-
Rhopaldia gibba (Ehrenb.) Mueller.	+	+	-
Surirella fastuosa Ehrenb.	+	+	-
Synedra tabulata (Ag.) Kutz.	+	+	-
Synedra ulna (Nitz) Ehrenb.	+	+	-
Thalassiotrix logissima Cl. and Grun.	+	+	-
Thallassionema eccentrica (Ehrenb)	+	+	+
Thallassionema nitzschioides (Grun) Van Heurck	+	+	-
Trachyneis aspera Ehr.	+	-	-
Triceratium favus Var. *pentagona* Truan.	+	+	-
Triceratium favus Var. *tetragona* Ehrenb	+	+	-
Triceratium rivale A.S.	+	-	-
Trigonium arcticum (Btw.) Cleve.	+	-	-
Total No. of species	92	60	4

+: Present, -: Not detected

DISCUSSION

pH, salinity and chloride contents depend on nature and stage of saltpans while producing the salts (Table 1). As far as the microbial population was concerned salinity, bicarbonate, magnesium, ammonia, dissolved oxygen and inorganic phosphate increase the microbial load and sulphide levels reduces the microbial population of that region (Rosenberg, 1985; Howarth, 1988). Many of the earlier workers have concentrated their attention only on a limited number of factors in a particular season or area and have indicated the importance of those factors on phytoplankton levels in marine environments. For example, Jayaraman and Shesappa (1957) positively correlated phosphate level with phytoplankton content. Confield *et al*. (1985) and Sakamoto *et al*. (1989) found both nitrogen and phosphorous influencing phytoplankton abundance. Pearse and Gunter (1957), Provasoli *et al*. (1957) and Munda (1978) have all emphasized the role of salinity in phytoplankton maintenance.

Only 4 diatom species namely, *Achnanthes hauckiana*, *Cyclotella striata*, *Pseudonitzschia seriata* and *Thallassionema eccentrica* were observed at 150 ppt of salinity (Table 3). As stated by DasSarma and Arora (2002), a variety of diatoms have been found at about 2 mol L^{-1} NaCl, although the upper limit for diatom growth is about 3 mol L^{-1} NaCl. Examples of common diatoms in hypersaline environments are *Amphora coffeaeformis* and *Nitzschia* and *Navicula* species. The present study of surveying the saltpans of Tamil Nadu, India not only gives an idea about the enormous diversity and wealth of diatom population but also provides an opportunity to understand their distribution and versatility in order to exploit these hyper saline forms.

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