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BIODIVERSITY, ULTRASTRUCTURE AND SCANNING ELECTRON MICROSCOPY WITH ENERGY DISPERSIVE SPECTROSCOPIC STUDIES OF FRESHWATER MICROALGAE

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ABSTRACT Studies were made on the seasonal variation of phytoplankton in the Perumal lake for a period of one year from 2017-2018. The physico-chemical parameters such as atmospheric temperature, water temperature, pH, salinity, dissolved oxygen, electrical conductivity and total dissolved solids were at the ranges of 28.1-36.5°C, 27.0-34.4°C, 7.9- 8.7, 1.2-2.5 mg/l, 2.62.4.34 mg/l and 2.5-5.2 mg/l, respectively. Totally 213 species of phytoplankton belonging to Bacillariophyceae (76 species), Chlorophyceae (63 species), Cyanophyceae (60 species) and Euglenophyceae (14 species) were recorded. Transmission electron microscopic studies on Euglena, The outer cell wall layer is more electron dense than the inner layer, the inner layer is translucent. The outer component of the cell comprises the euglenoid pellicular complex, composed of a plasmamembrane and a proteinaceous pellicle. The chloroplasts are numerous and scattered randomly or arranged radially, and they lack pyrenoids mitochondria, golgibodies were frequently observed and vacuole is absent. Species of Fragillaria, Mastogloia, Navicula, Cymbella and Nitzschia (Bacillariophyceae); Chiorella, Scenedesmus, Pediastrum, Closterium and Spirogyra (Chlorophyceae) and Chrococcus, Aphancapsa, Spirulina, Oscillatoria, Anabaena and Nostoc (Cyanophyceae) were found in all the seasons. The phytoplankton density was high (1672 cells/I) during the summer season and low (1200 cells/l) during the monsoon season. Bacillariophyceae formed the dominant group. Commonly occurred genera, Oscillatoria (Cyanophyceae), Navicula (Bacillariophyceae) and Scenedesmus (Chlorophyceae), were subjected to energy dispersive spectroscopic analysis (EDS). They were found to accumulate different elements such as Zn, P, S, Ca, Mg, Fe, N, Si, Cl and Mn. Among these the member cyanophyceae contained Zn, P, Mg, Ca, Mn, S and N. Bacillariophyceae Si, Zn, Mg, Cl, N, Fe and Ca. Chlorophyceae Ca, Mg, N, Fe, Cl, Zn, Si and Mn. Thus these observations would determine the chemical dialogue between the cell structures and role of the elements. Further, it gives the clue about the phytoplankton growth requirements.

KEYWORDS : Biodiversity, Phytoplankton, Ultrastructure, SEM-EDS.

INTRODUCTION

Biodiversity of algal flora in the water bodies is governed by the ambient physico-chemical factors. Algae are the primary producers in the food-chain of the aquatic ecosystem and their productivity depends upon the quality of water. Among the aquatic algae, phytoplankton occupy an important position in the food-web of the freshwater ecosystems, as primary producers. Any change in the phytoplankton community will reflect on the entire aquatic system. So, knowledge on their abundance, composition and seasonal variation is an essential pre-requisite for any successful aqua-management programme. Further, the phytoplankton are good indicators of changes in water quality because they are strongly affected by environmental conditions and they respond quickly to the changes in environmental quality. Hence, qualitative and quantitative studies of phytoplankton are of great importance.

In India, numerous lakes and reservoirs have been studied for their water quality in relation to algal taxonomy by Trivedi and Goel (1984), Desikachary (1986), Anand (1988), David et al. (2003), Veereshakumar and Hosamani (2006), Tiwari and Shukla (2007), Sivakumar and Senthilkumar (2008), Poonguzhali and Mayakannan (2009) and Khelchandra Singh et al. (2010). But still there are many aquatic ecosystems that remain unexplored, particularly in the state of Tamil Nadu. Lake water sparkling in afternoon sunlight hides a minuscule waterscape in closer to a slum than a paradise. It contain millions of organism in every cubic centimeter, some of which are photosynthetic, others of which feed on live and dead, dissolved and particulate organic materials present in the water which contains their excretions and secretions, faces and corpses, intermixed with debris washed into suspension from the surrounding land.

In limnological studies, to determine the water quality in lake, stream, river and to identify of algae that composed to primary productivity and to obtain this continuity are very important. Studies showed that most of the algae were a great deal sensitive to the varying environment condition. That is to say negative changes in algae which are primary producers affects all living creatures Therefore algae that formed the first rung of food chain should be examined taxonomically and ecologically. Also composition, quality seasonal variation of the algae and the factors that affected the seasonal variation should be examined. The Perumal Lake is the oldest and largest lake of Tamilnadu. Its water is used to irrigate about 3457 acres of agricultural land.

Phytoplankton forms the vital source of energy as primary producers and serves as a direct source of food to the other aquatic plants and animals. It accounts substantially for the organic production of waters ways. They provide information on the productivity of the environment. In India some lakes and reservoirs have been studied for the water quality and fisheries (Nautiyal et al., 1988; Kartha and Rao, 1992; Pandey, 1993; Ravikumar et al., 2006; Tas and Gonulal, 2007). The varying nature of micro and macro habitats of indigenous freshwater system makes them the hot spot of diverse and rare algal communities. Algae, the primary producers are the large and morphologically diverse phototrophic group which occur in almost every habitat on earth. Tropical climatic conditions such as those prevailing in India provide favourable environment for the luxuriant growth of these organisms in the natural different ecosystems viz., freshwater bodies, oceans, saline backwaters, estuaries, effluents, polar regions and also hyper saline saltpans (Jeyachitra et al., 2004; Shyamkumar et al., 2013; Lewis-Oscar et al., 2015). Biodiversity of freshwater algae from Tamil Nadu was made Sivakumar (2016). Fresh water diatom flora of penukonda region Ananthapuram District, Andhra Pradesh was made Meeravali et al. (2017). Taxa of Desmidaceae from Tamil Nadu was made Maheswari and Baluswami (2017). There are many such aquatic ecosystems that remain unexplored. The Perumal lake has also not received due attention. Hence, the present study was made to know the influence of physico-chemical parameters of water on phytoplankton diversity and their seasonal variation, ultrastructure and scanning electron microscopy with energy dispersive spectroscopic studies of freshwater microalgae have been made in Perumal lake.

MATERIALS AND METHODS

Perumal lake is situated at Lat. 11°35'N; Long. 79°40'E in the Cuddalore District of Tamilnadu (Fig. 1). The lake is being used for various purposes such as irrigation, fish catching and peoples' washing and bathing. The lake measures 17 km North-South and 3 km East-West. The minimum depth is 5.44 m and water holding capacity is 574 M. cft.

Water samples were collected from selected stations of Perumal lake namely Kundiyanallur (Southern Side), Palliodai (Northern side), Sripalaiyur (Eastern side) at monthly intervals for a period of one year from March 2017 to February 2018 for the analysis of pH, salinity, dissolved oxygen, electrical conductivity and total dissolved solids. The physico-chemical parameters were analysed by water and soil analysis kit model 1160-E. Phytoplankton samples were collected by towing a plankton net (mouth diameter 0.35 mm) made up of bolting silk (no. 30; mesh size 48 mm) for half an hour. The samples were collected in black polythene bags and immediately preserved with 4% formalin for quantitative and qualitative analysis.

Phytoplankton was identified by referring to the standard keys of Desikachary (1959), Prescott (1964), Cox (1996), Anand (1998), and David et al., (2003). Species diversity index (H') was calculated using the formula of Shannon and Wiener (1949).

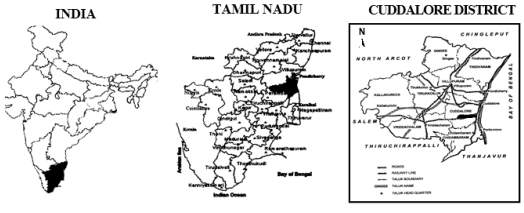
TRANSMISSION ELECTRON MICROSCOPE

Phytoplankton samples were collected using a plankton net (mesh size 20 µm) in the selected study areas and phytoplankton cells were isolated by using pastern capillary pipette. Unialgal cultures were grown in AF-6 medium (Watanabe and Hiroki, 1997) and maintained in test tubes at 20°C with conditions of 14:10 light: dark period and 30 µ mol photons m-2 s-1 supplied by white fluorescent tubes.

Euglena cells were fixed in 2.5% glutaraldehyde in the culture medium (pH 6.8) at 4°C for 2 hr. They were rinsed with medium and post fixed in 1% of Osmium tetroxide (OsO4) in distilled water at 4°C for 2 hr. The fixed cells was embedded in 1% (w/v) agar and dehydrated in a graded ethanol series. They was dehydrated by three changes of absolute ethanol at room temperature, by a mixture of absolute ethanol and propylene oxide for 15 min and finally by two changes of propylene oxide for 15 min. The dehydrated cells were embedded in Spurr's epoxy resin (Spurr, 1969) and polymerized at 70°C for 48 h. Ultrathin serial sections (60-80 nm) which were cut using a glass knife on an ultra microtome. Silver and gold coloured sections thus obtained were mounted on grids. Ultrathin sections were sequentially stained with uranyl acetate and lead citrate (Reynolds, 1963) and examined with JEOL, Transmission electron microscope (JAPAN).

SCANNING ELECTRON MICROSCOPE WITH EDS STUDIES

Phytoplankton samples were fixed in 3% glutaraldehyde in 0.1 M phosphate buffer at pH 6.8. Specimens were dehydrated through a graded series of alcohol at 12-15 minutes interval at 4°C up to 70% of alcohol. Then dehydrated phytoplankton sample was treated with critical point drier (CPD) and fixed on a stub and the specimens were coated to examine in Joel JSM-56010 LV (INSA-EDS). Electron micrographs was taken selectively from the computer screen. Simultaneously selected portions of micrograph was subjected to Energy Dispersive Spectroscopic analysis (EDS). This was conducted with an EDS 700 series interfaced with a data general NOVA2 computer and a Texas instrument silent 700 ASR. The EDS X-ray spectrometer was interfaced with a scanning electron microscope (20 kV) stage. The area of different components such as cell wall and cellular inclusion was analysed. To find out the fluxes of particular mineral, both the counts per second (S-1 or CPS) value and the apparent relative atomic percentage of weight in different components of the cell wall and cellular inclusion details were documented.



SAMPLING STATIONS OF PERUMAL LAKE

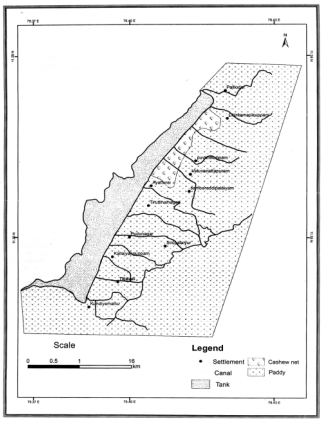


Fig. 1. Location map of Perumal Lake

FIGURE 2 PERUMAL LAKE

A view of Perumal lake from Eastern side, it shows lot of vegetation of aquatic weeds and hydrophytic plants

This is neighbour area of east to west direction where the rearing of animals for water bathing and the area occupies water Hyacinth, Azolla, Salvinia and some hedge plants etc.

RESULTS

Atmospheric temperature

Atmospheric temperature varied from 28.1 to 36.5°C (Fig. 3) during the study period at Perumal lake. Minimum temperature was recorded during the month of October (monsoon season). The maximum temperature was recorded during the summer season in the month of June.

Surface water temperature

The surface water temperature varied from 27.0 to 34.40°C (Fig. 3). Minimum temperature was recorded during the monsoon season in the month of November and December in Perumal lake. Maximum temperature was observed during the summer, in the month of May.

pH There was a narrow range of fluctuation in water pH during the study period. It was between 7.9 to 8.7. Minimum pH value (7.9) was recorded in pre-monsoon, August and a maximum of 8.7 was observed in post-monsoon (February) (Fig. 3).

Salinity

The water salinity at Perumal lake varied from 1.2 to 2.5 mg/L (Fig. 3). Minimum value was recorded during the pre monsoon season, mid-monsoon. The maximum value was recorded during the summer.

Dissolved oxygen

The value of dissolved oxygen content of water at Perumal lake was varied from 2.62 to 4.34 mg/L (Fig. 3). Minimum value was observed during the summer and maximum was observed during the monsoon season.

Total dissolved solids (TDS)

Total dissolved solid content varied from 2.5 to 5.2 mg/L (Fig. 3). The minimum value 2.5 mg/L was observed during the post-monsoon season in Perumal lake. But there is no proportional seasonal difference with respect to dissolved solids, which showed that TDS is not dependent on seasons.

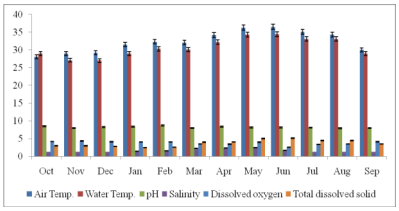


Fig. 3 Physico-chemical parameters of Perumal Lake

Table 1. Seasonal variation of distribution of phytoplankton species at Perumal lake (2017-2018)

Micro-algae S. No.		Name of the Species	Monsoon (Oct.-Dec.)	Post-monsoon (Jan-Mar)	Summer (April-June)	Pre-monsoon (July-Sep)
			Perumal Lake			
Class: Bacillariophyceae Order: Centrales						
1	1.	Chaetoceros orientalis Schiller	-	+	+	-
2	2.	Cyclotella meneghiniana Kutz.	+	+	+	+
3	3.	Skeletonema costatum (Grev.) Cleve.	-	+	+	-
4	4.	Thalassiosira marginata Sp. Nov.	+	+	+	-
Order: Pennales						
5	5.	Achnanthes inflata Kutz.	-	+	+	+
6	6.	Achnanthes hauckiana Grun.	-	+	+	+
7	7.	Actinella punctanta (Lewis)	+	+	+	-
8	8.	Amphora coffoeformis Ag.	-	+	+	+
9	9.	Amphora ovalis Kutz.	+	+	+	+
10	10.	Anomoeneis serians (Breb.) Celve	-	+	+	-
11	11.	Anomoeneis sphoerophora (Kutz.)	+	+	+	-
12	12.	Calonies silicula (Ehr.) Cleve	-	+	+	-
13	13.	Cosinodiscus sps	+	-	+	-
14	14.	Cymbella alpina Grun	+	+	+	+
15	15.	Cymbella cymbiformis Kutz.	+	+	+	+
16	16.	Cymbella naviculiformis Auersward	-	+	+	+
17	17.	Cymbella tumida (Breb.)	-	+	+	-
18	18.	Cymbella turgida (Greg) Cleve	-	+	+	-
19	19.	Diatoma sps.	+	+	+	+
20	20.	Diploneis ovalis (Hilse)	-	+	+	-
21	21.	Diploneis interrupta (Kutz.)	-	+	+	+
22	22.	Diploneis subovalis Cleve	+	+	+	+
23	23.	Eunotia monodon Her.	+	+	+	-
24	24.	Eunotia pectinalis (Kutz.) Rabenh.	+	+	+	+
25	25.	Fragillaria brevistriata Grun	+	+	+	+
26	26.	Fragillaria capucina	-	+	-	+
27	27.	Fragillaria intermedia Grun	-	+	+	+
28	28.	Frustulia rhomboids (Ehr.) De Toni	-	+	+	-
29	29.	Gomphonema herculeana (Ehr.) Cleve	-	+	+	+
30	30.	Gomphonema intricatum (Kutz.)	+	+	+	-
31	31.	Gomphonema lanceolatum Ehr.	-	+	+	+
32	32.	Gomphonema parvulum (Kutz.)	-	+	+	-
33	33.	Gomphonema targestinum	-	-	-	-
34	34.	Gomphonema vibrio Ehr. C.G. Augur Ehr.	-	+	+	-
35	35.	Gyrosigma acuminatum (Kutz.) Rabh.	-	-	+	-
36	36.	Mastogloia oxigua Lewis	-	+	+	+
37	37.	Melosira granulata (Ehr.) Ralfs	+	+	+	-
38	38.	Navicula acicularis Kutz.	+	+	+	+
39	39.	Navicula cincta Kutz.	-	+	+	+
40	40.	Navicula lacustris Greg.	+	-	+	-
41	41.	Navicula laterostrata Hust.	-	+	+	-
42	42.	Navicula peregrina Kutz.	+	+	+	+
43	43.	Navicula capitatoradiata Kutz.	-	+	+	+
44	44.	Navicula cuspidate Kutz.	+	+	+	+
45	45.	Navicula mutica Kutz.	-	+	+	-
46	46.	Navicula palaceae	-	+	-	+
47	47.	Navicula pupulla	-	-	-	-
48	48.	Navicula pycmae Kutz.	-	+	+	-
49	49.	Navicula radiosa Kutz.	+	+	+	+
50	50.	Navicula rectangularis Kutz.	-	+	+	+
51	51.	Navicula sps.	+	-	+	-
52	52.	Navicula virididula	+	-	+	+
53	53.	Neidium iridis (Ehr.) Pfitzer	-	-	+	+

54	54.	Nitzschia amphibia Grun.	+	+	+	-
55	55.	Nitzschia brebissonii W. Smith	-	+	+	-
56	56.	Nitzschia palaceae (Kutz.)	+	+	+	+
57	57.	Nitzschia palea (Kutz.)	+	+	+	+
58	58.	Nitzschia plana Wm. Sm.	+	+	+	-
59	59.	Nitzschia sps.	+	+	+	-
60	60.	Nitzschia sps.	-	+	+	-
61	61.	Nitzschia vitrea Norman	+	+	+	+
62	62.	Pinnularia acrosphoeria Breb.	+	+	+	+
63	63.	Pinnularia borealis Her.	+	-	+	-
64	64.	Pinnularia braunii Grun.	-	+	+	-
65	65.	Pinnularia gibba Ehr.	+	+	+	+
66	66.	Pinnularia interrupta W. Smith	-	-	+	+
67	67.	Pinnularia viridis (Nitzsch) Ehr.	+	+	+	+
68	68.	Pleurosigma delicatulum W. Smith	-	-	+	-
69	69.	Pleurosigma salinarum Grun.	+	+	+	-
70	70.	Rossithidium linearis	-	+	+	-
71	71.	Stauroforma exiguiformis	-	+	+	+
72	72.	Stauroneis anceps Ehr.	+	+	+	+
73	73.	Surirella elegans Ehr.	+	+	+	+
74	74.	Synedra ulna (Nitz.)	+	+	+	+
75	75.	Tabellaria fenestrata	+	+	+	-
76	76.	Tabellaria quadrisepta	-	-	-	-
		Class: Chlorophyceae Order: Volvocales				
77	1.	Chlamydomonas globosa Snow.	+	+	+	+
78	2.	Chlamydomonas polypyrenoideum Presc	+	+	+	+
79	3.	Chlorosarcina consociate (Klebs) G.M. Smith	+	+	+	+
80	4.	Eudorina elegans Ehr.	-	+	+	-
81	5.	Palmella miniata Lieb.	-	+	+	-
82	6.	Pandorina morum Bory.	+	-	+	+
83	7.	Tetraspora lubrica (Roth) Ag.	-	-	+	-
		Order: Chlorococcales				
84	8.	Ankistrodesmus falcatus (Corda) Ralfs.	+	+	+	-
85	9.	Chlorella protothecoids	-	-	+	+
86	10.	Chlorella pyrenoidosa Chick	+	+	+	+
87	11.	Chlorella vulgaris Beyernick	-	+	-	+
88	12.	Chlorococcum humicola (Nag.) Rabenh	+	+	+	-
89	13.	Coelastrum microporum Nag.	-	-	+	+
90	14.	Ellipsoidea Gerneck.	+	+	-	+
91	15.	Pediastrum biradiatum Presc.	-	+	+	-
92	16.	Pediastrum boryanum (Turp.) Menegh.	+	+	+	+
93	17.	Pediastrum duplex Meyen	+	+	+	+
94	18.	Pediastrum simplex Hey. var. Biwanse Fukush	+	+	+	+
95	19.	Pediastrum tetras (Ehr.) Ralfs.	+	+	+	+
96	20.	Scenedesmus accuminatus (Kutz.)	-	-	-	-
97	21.	Scenedesmus armatus (Chodat) Smith	+	-	+	+
98	22.	Scenedesmus bijiuga (Reinsch)	-	+	+	+
99	23.	Scenedesmus dimorphus (Turp.) Kutz.	+	+	+	+
100	24.	Scenedesmus quadricauda (Turp.) Breb.	+	+	+	+
101	25.	Selenastrum biraianum Reinsch	-	+	+	-
102	26.	Selenastrum gracile Reinsch	+	+	+	-
103	27.	Tetraedron trigonum (Nag.) Hansg.	-	+	-	+
104	28.	Westella botryoides (W. West)	-	-	+	+
		Order : Ulotrichales				
105	29.	Ulothrix variables	-	+	+	+
		Order: Cladophorales				
106	30.	Cladophora glomerata (L.) Kutz.	-	-	+	+
107	31.	Cladophora crispate (Roth) Kutz.	-	+	+	-
108	32.	Pithophora polymorpha	-	+	-	+

		Order: Chaetophorales				
109	33.	Actinotaeminum cucurbita (Breb.) Teil.	-	+	-	+
110	34.	Actinotaeminum diplosporum (Lemd) Teil.	-	-	-	-
111	35.	Staurastrum indertatum	+	-	+	+
112	36.	Stigeoclonium tenue (Ag) Kutz.	+	-	-	+
		Order: Conjugales				
113	37.	Euastrum ansatum Her. var. dideliforme Ducell	-	-	-	-
114	38.	Euastrum bidentatum Nag.	+	-	-	+
115	39.	Euastrum gessneri Krieger and Bourrelly	-	+	+	+
116	40.	Euastrum insulare (Wittr.) Roy	+	+	+	+
117	41.	Euastrum spinlosum	-	-	+	+
118	42.	Netrium digitus (Ehr.) Itz & Rothe	+	+	+	+
119	43.	Spirogyra rhizobrachialis	-	+	-	+
120	44.	Spirogyra subsalsa	+	+	+	+
121	45.	Spirogyra varians	+	+	+	-
122	46.	Staurastrum hexaserum (Ehr.) Wittr.	+	+	-	+
		Order: Zygonematales				
123	47.	Closterium acerosum (Schrank) Ehr.	+	+	+	+
124	48.	Closterium archerianum cleveform	+	-	+	+
125	49.	Closterium crenulatum	-	-	-	-
126	50.	Closterium fontigenum	+	-	+	-
127	51.	Closterium mecilentcem (Breb.) var. Japonicum	+	+	+	+
128	52.	Closterium meneghinii	-	-	-	-
129	53.	Closterium portianum	-	-	-	-
130	54.	Closterium purvulum Nageli	+	+	+	+
131	55.	Closterium sps.	+	+	+	+
132	56.	Closterium tumidum Gay	-	+	+	+
133	57.	Cosmarium botrytis Menegh	+	+	+	+
134	58.	Cosmarium depressum (Naeg.) Lund	+	+	-	+
135	59.	Cosmarium subcostatum Nordst	-	+	-	+
		Order-unknown				
136	60.	Netrium digitus Ehrbg. Itzigsohn & Rothe	-	-	-	+
137	61.	Pleurotaenium ehrenbergii (Breb.) de Bary	-	+	+	+
138	62.	Stictospermum	+	+	+	+
139	63.	Uronema conservicolum	-	-	-	-
		Class: Cyanophyceae Order: Synechococcales				
140	1.	Aphanocapsa banaresensis Bharadwaja	-	-	+	-
141	2.	Aphanocapsa grevillei (Hass.) Rabenh	+	+	+	-
142	3.	Aphanocapsa pulchra (Kutz.) Rabenh	-	+	+	+
143	4.	Aphanocapsa littroralis Hansgirg	+	+	+	+
144	5.	Aphanotheceae bullosa (Menegh) Rabenh	+	+	+	+
145	6.	Aphanotheceae microscopica Nag.	-	+	+	+
146	7.	Chroococcus turgidus (Kutz.) Naeg.	+	+	+	-
147	8.	Chroococcus disperses (V. Keissler) Lemm.	-	+	+	-
148	9.	Chroococcus macrococcus (Kutz.) Rabenh	+	-	+	+
149	10.	Chroococcus minor (Kutz.) Nageli	-	+	+	+
150	11.	Chroococcus prescottii Drouet & Daily	-	+	-	+
151	12.	Chroococcus tenax (Kirchn) Hieron	-	-	+	+
152	13.	Gloeocapsa magma (Breb.) Kutz.	+	-	-	+
153	14.	Gloeocapsa nigrescens Nag.	-	-	-	+
154	15.	Gloeocapsa punctata Nag.	-	-	-	-
155	16.	Gomphosohaeria aponina (Kutz.)	+	+	-	-
156	17.	Marssoniella elegans Lemm.	+	+	+	-
157	18.	Merismopedia elegans G.M. Smith	-	+	+	-
158	19.	Merismopedia glauca (Ehr.) Nag.	+	+	-	-
159	20.	Merismopedia minima Beck	+	+	-	+
160	21.	Merismopedia punctata (Meyen)	-	-	+	+
161	22.	Microcystis flos-aquae (Wittr.) Kirchner	+	+	+	-
162	23.	Synechococcus aeruginosa Nag.	+	+	+	-

		Order: Chamaesiphonales				
163	24.	Mixosarcina amethystine J.J. Copeland	-	+	+	+
164	25.	Stichosiphon regularis Geitler.	-	+	+	+
		Order: Oscillatoriales				
165	26.	Arthrospira jenneri Stizenb. et Gomont	-	-	-	-
166	27.	Arthrospira platensis (Nordst)	+	-	+	-
167	28.	Lyngbya aestuari Liebm Ex Gomont	+	-	+	+
168	29.	Lyngbya martensiana Mengh. Ex. Gomont.	-	+	+	+
169	30.	Lyngbya shackletoli West	-	-	-	-
170	31.	Lyngbya versicolor (Vartm) Gom.	+	-	-	+
171	32.	Oscillatoria chlorina Kutz. ex Gomont	+	+	+	+
172	33.	Oscillatoria curviceps Ag. ex Gomont	+	+	+	+
173	34.	Oscillatoria laeteviresis (Grouan) Gomont.	-	+	+	+
174	35.	Oscillatoria magartifera Kutz Ex Gomont.	-	-	-	-
175	36.	Oscillatoria obtuse	+	+	+	-
176	37.	Oscillatoria pseudogeminata G. Schmidle	-	-	-	-
177	38.	Oscillatoria sancta	-	-	-	-
178	39.	Oscillatoria subbrevis Schmidle F. Crassa	-	-	-	-
179	40.	Oscillatoria terebriformnis	-	+	+	+
180	41.	Oscillatoria vizagapatens Rao. C.B.	+	+	-	+
181	42.	Oscilltoria tenuis Ag. Ex Gomont	-	+	+	+
182	43.	Phormidium pachydermaticum Fremy	-	-	-	-
183	44	Phormidium papyraceum Ag. Gomont.	-	-	-	-
184	45.	Spirulina gigantea (Schmidle)	-	-	-	-
185	46.	Spirulina major (Kütz.) Gomont	+	+	+	+
186	47.	Spirulina meneghiniana Zanard ex. Gomont	+	-	+	-
187	48.	Spirulina princeps Voucher ex. Gomont	-	-	-	-
188	49.	Spirulina subsalsa Oerst. ex. Gom.	+	-	+	+
189	50.	Anabaena circinalis Robenhorst ex. Born et Flah.	-	+	-	-
190	51.	Anabaena spiroides Klebahn	+	+	+	+
		Order: Nostacales				
191	52.	Nostoc calcicola Breb ex. Born et Flah.	-	-	+	+
192	53.	Nostoc carneum Ag. ex. Born et. Flah.	+	+	+	+
193	54.	Nostoc muscorum	-	+	+	+
194	55.	Nostoc pruniforme Ag.	+	+	+	+
		Order: Rivulariales				
195	56.	Calothrix fusca (Kutz.) Born et. Flah.	+	+	+	-
196	57.	Calothrix simplex	-	-	-	-
197	58.	Calothrix tenella	-	-	+	+
198	59.	Homeothrix hansgirgi	-	-	-	-
199	60.	Homeothrix varians	-	-	-	-
		Class: Euglenophyceae				
200	1.	Euglena viridis Ehr.	+	+	-	+
201	2.	Euglena chlamydophora	+	+	+	+
202	3.	Euglena convolute Korsch	-	-	-	-
203	4.	Euglena deses fo intermedia	-	-	-	-
204	5.	Euglena deses fo Klebsi	-	-	-	-
205	6.	Euglena elastica Presc	-	-	-	-
206	7.	Euglena oxyuris fo. Maior	-	-	-	-
207	8.	Euglena polymorpha	-	+	+	-
208	9.	Euglena spirosura var. fusca	-	-	-	-
209	10.	Euglena viridis	+	+	+	+
210	11.	Euglena spirogyra Ehr.	+	+	+	+
211	12.	Phacus acuminatus Stokes	+	-	+	+
212	13.	Phacus longicauda Ehr.	-	-	-	+
213	14.	Phacus pleuronectes dujardin	-	+	-	-

+ Present; – Absent

Table 4 and Fig. 4. Seasonal variation of phytoplankton population (cells/litre) in Perumal lake from July 2017 to June 2018

Season	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Euglenophyceae
Monsoon (Oct.-Dec.)	523	402	201	74
Post monsoon (Jan.-Mar.)	670	474	175	120
Premonsoon	000	000	000	000

Summer (April-June)	724	523	255	170
Total	000	000	000	000

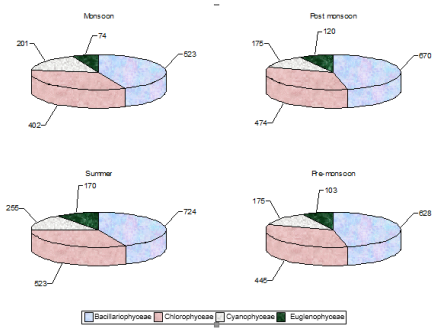
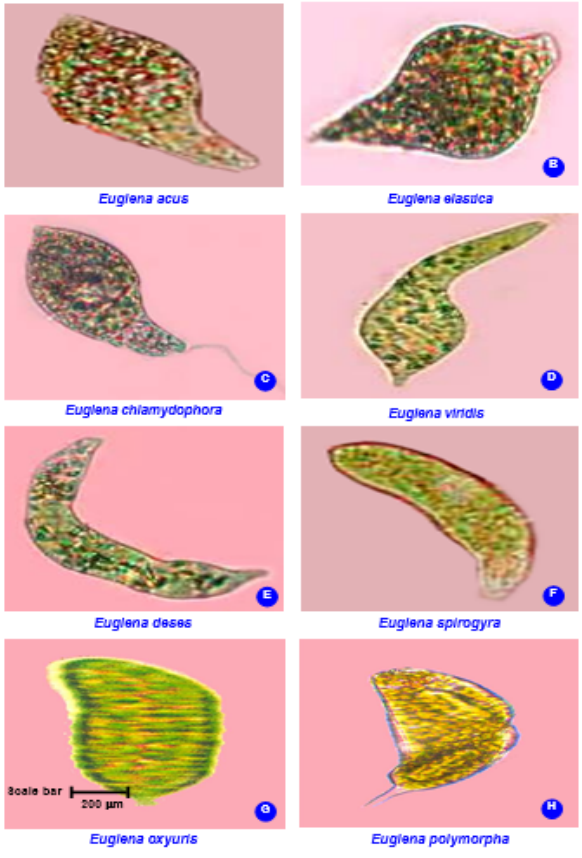


Fig. 5 (Euglenophyceae)



SPECIES DESCRIPTION EUGLENOPHYCEAE

Euglena acus (Fig. 5a)

Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : acus

Cells 7-28.3 µm wide, 60-180 µm long, needle shaped, elongate spindle shaped, sometimes bent and sometimes assuming an s-shaped, anterior end narrowed and apically truncate; posterior end tapered to a long fine point pellicle delicately striated; chloroplast small, numerous, peripheral, disc-like without pyrenoids; paramylon bodies numerous, long, rod-shaped; flagellum short about one sixth to one-third cell length; eyespot small, located towards end of canal; euglenoid movement absent; swims straight forwards rather rapidly rotating slowly cyst not observed.

Euglena elastica (Fig. 5b)

Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : elastica

Cells 9.5-11 µm wide, 76-100 µm long, usually spindle-shaped; anterior end narrowing abruptly, posterior end occasionally with a narrow, rounded apex; pellicles smooth; chloroplasts numerous, irregular, plate-shaped, with no pyrenoids; paramylon bodies short and rod-like, numerous, scattered throughout cell; flagellum about two-thirds cell length; eye spot at anterior end; euglenoid movement violent and some times greatly bulging.

Euglena chlamydophora (Fig. 5c)

Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : chlamydophora

Cells 9-20 µm wide, 32.2- 45 µm long, spindle shaped, anterior end rounded and posterior end narrowing to a tail piece when swimming freely; euglenoid movement violent, shape sometimes changes to broadly cylindrical; pellicle distinctly striated; chloroplasts disc-shaped, numerous, small, ellipsoidal or oblong; flagellum as long as cell; cysts unknown.

Euglena viridis (Fig. 5d)

Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : viridis

Cells 14-18 µm wide, 38-62 µm long, spindle-shaped to broadly spindle-shaped; anterior end rounded; posterior end usually tapering to a point of variable length; pellicle faintly spirally striated; chloroplast single, irregular and star-like, with pyrenoids; paramylon bodies ovoid, ring-like to brick shaped, a mass of paramylon surrounds the central area of chloroplast, generally distributed throughout the cell; flagellum slightly shorter or longer than cell, easily discarded; eye spot bright crimson, posterior to central mass of paramylon and surrounded by ribbons of chloroplasts; euglenoid movement fairly frequent and also swims very rapidly; longitudinal division in a thick or thin walled cyst.

Euglena deses (Fig. 5e)

Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : deses

Cells 1-17 µm wide, 83- 133 µm long, elongate cylindrical to ellipsoidal, occasionally reported as slightly flattened; anterior end rounded or slightly truncate and posterior end narrowed to a blunt point; pellicle delicately striated; chloroplasts parietal and numerous, lens- shaped, each with a pyrenoid, paramylon bodies rod shaped, generally scattered; flagellum relatively short, about one sixth cell length, usually retracted, eyespot large; euglenoid movement violent, twisting and turning continuously, swimming rapid but sometimes weak, often creeping; division common when in the extended condition, with or without cysts.

Euglena spirogyra (Fig. 5f)

Division : Euglenophyta
Class : Euglenophyceae

Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : spirygoyra

Cells 12-27 µm broad, 80-125 µm long, longitudinally spindle shaped and sometimes flattened, with sides nearly parallel; anterior end bluntly rounded, posterior end extended into a distinctly bent tail piece; pellicle yellowish in colour and sometimes bearing rows of shining granules or beads; chloroplasts numerous, small, disc-shaper, lying close together, without pyrenoids; variable numbers of small, rectangular paramylon granules present, granules usually in two (three) clusters, one lying anterior to nucleus another posterior to nucleus; flagellum about one-tenth to one–quarter cell length; eye spot bright, relatively large and prominent; euglenoid movement in form of squirming and markedly bending, or twist a little but does not shorten; cysts unknown.

Euglena oxyuris (Fig. 5g)
Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : oxyuris

Cells 16-46 µm wide, 95-250 µm long, longitudinally cylindrical and slightly twisted, sometimes slightly flattened; anterior end rounded; posterior end tapering gently to a tail piece; pellicle clearly spirally striated; chloroplast numerous, ovoid or disc-shaped, without pyrenoids; paramylon bodies large, rectangular or ring shaped, usually 2 with one anterior and other posterior to the nucleus; flagellum short, up to one-third cell length; eye spot blood red, lateral to cell reservoir; euglenoid movement slight, bends and rotates in a spiral fashion.

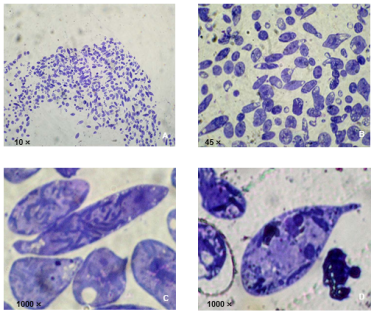
Euglena polymorpha (Fig. 5h)
Division : Euglenophyta
Class : Euglenophyceae
Order : Euglenales
Family : Euglenaceae
Genus : Euglena
Species : polymorpha

Cells 20-26 µm wide, 80-90 µm long, almost spherical, ovoid to pear shaped and narrowing gradually to a short, blunt, conical tail piece; pellicle markedly spirally striated; chloroplast 12-15, plate or disc like with laciniate margins, each with a double sheathed pyrenoids; paramylon bodies small; flagellum twice cell length; euglenoid movement violent; division during palmelloid stage.

TRANSMISSION ELECTRON MICROSCOPIC STUDIES OF *Euglena*

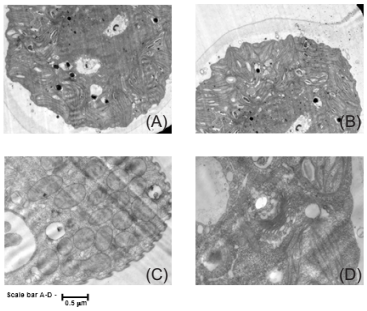
Transmission electron microscopic studies on Euglena were shown in (Fig. 7). The outer cell wall layer is more electron dense than the inner layer, the inner layer is translucent. The outer component of the cell comprises the euglenoid pellicular complex, composed of a plasma membrane and a proteinaceous pellicle. The chloroplasts are numerous and scattered randomly or arranged radially, and they lack pyrenoids, mitochondria, golgibodies were frequently observed and vacuole is absent.

Fig. 6



A - D – Light microscopic pictures of resin embedded semi thin sections of Euglena

Fig. 7



A&B – Transmission electron micrograph of outer most component of the cell comprises the euglenoids pellicular complex, composed of a plasma membrane. The chloroplasts are numerous and scattered randomly or radially arranged.

C. The epiplasmic layer was slightly electron opaque and semi continuous under the Plasma lemma. Mitochondria are numerous and they are freely distributed in the cytoplasma/groundplasm.

D. – Ultrastructure of Golgi complex, paramylon starch and endoplasmic reticulam

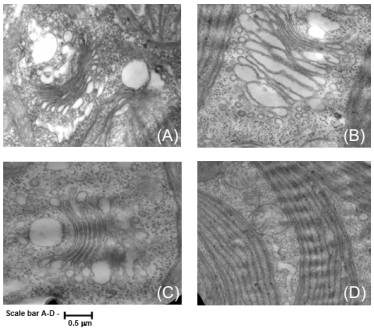
Most of the ultrastructural features observed in that the pellicular strips were discoid in shape. The cell body was striated with helically oriented ridges, which were alternately high and low. The pellicle consisted of the plasmalemma, epiplasmic layer. The plasmalemma overlay the ridge-groove articulation of the overlapping pellicular strips. The epiplasmic layer was slightly electron opaque and semi continuous under the plasmalemma (Fig. 7c).

The mitochondria was located under the pellicular region as well as centre part of the groundplasm. The mitochondria are spherical in shape and scattered throughout the cytoplasm. The contents of the mitochondria are generally homogenous (Fig. 7c).

Golgi complex is often concave and convex in shape, each Golgi complex is composed of 5-8 stacked cisternae. Golgi body is closely associated with the reserve food material of paramylon starch (Fig. 7d).
Electronmicrograph observations of thin sections reveal the presence of three membranous components flattened sacs or cisternae (Fig. 8a) small tubules and vesicles (Fig. 8b). Large vacuoles filled with an amorphous or granular substance (Fig. 8c). These membranous structures are characterized by the absence of ribosomes i.e. they are smooth membranes.

The cisternae or lamellae are the most constant elements of the Golgi complex. They consist of flattened, parallel sacs piled one upon the other to form stacks. The number of cisternae in a stack varies from 5-8 (Plate 8a,b,c). Golgi complex is polarized and has a "forming face" and a "maturing face". The forming or proximal face is on the outer side while the maturing or distal face is on the opposite side (Fig. 8c). New lamellae are formed on the forming face and mature lamellae are lost on the maturing face. The membrane of the Golgi complex is in dynamic equilibrium. They are continually receiving lamellae through budding of vesicles from the smooth endoplasmic reticulum, and losing membranes through formation of secretary vesicles (Fig. 8b).

Fig. 8



A – The ultrastructure of the cisternae or lamellae consist of Golgi complex they are flattened, parallel sacs piled upon the other to form stacks.

B – The membranes of the Golgi complex are continually receiving lamellae through budding of vesicles from the smooth ER, and losing membranes through formation of secretary vesicles.

C – The cis forming or proximal face is on the outside while the maturing or distal face is on the opposite side, new lamella are formed on the forming face and mature lamellae are lost on the maturing face Golgi complex was surrounded by numerous number of ribosomes.

D – The chloroplasts are randomly or radially arranged and they lack pyrenoids. The photosynthetic lamellae are composed of triple stranded thylakoids.

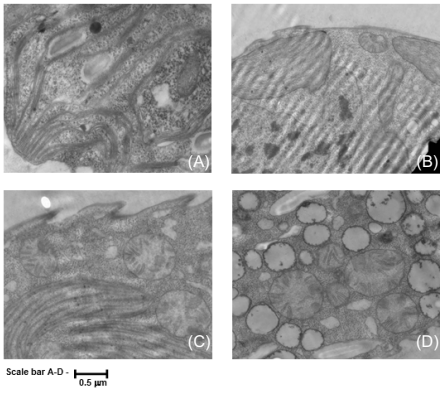
The chloroplasts are numerous and scattered randomly or arranged radially, and they lack pyrenoids. In an individual section, the plastids often show two or three osmiophilic lipid droplets. The photosynthetic lamellae are composed of stacks of three thylakoids (Fig. 8d). The paramylon bodies were small rod or discoid in shape. They are densely clustered in the aggregation of centre of each chloroplast group and some were freely scattered in the cytoplasm (Fig. 7a,b).

Most of the ultra structural features observed in the typical Euglenoid, in the nucleus, including the condensed chromosomes was sub centrally located in the cell (Fig. 9b). The shape of the nucleus varies in different cells. The nucleus is bounded by a nuclear envelope or karyotheca, within the nucleus, is a clear or slightly acidophilic mass called the nuclear sap (Fig. 9b).

Electron micrograph (Fig. 9c) at high magnification showed that the Euglena cell body was striated with helically oriented ridges, which were alternatively high and low (Fig. 9c). The pellicle consisted of the plasmalemma, epiplasmic layer. The epiplasmic layer was slightly electron opaque and semi continuous under the plasmalemma.

Mitochondria are spherical in shape and scattered throughout the cytoplasm. Most of the mitochondria are situated near the plastids (Fig. 9c). The mitochondrial inner wall is projected into the central matrix and forms cristae. The contents of the mitochondria are generally homogenous. Each mitochondrion shows 10-15 cristae (Fig. 9c,d). In the present observation filamentous mitochondrion swells at one end it gives a club shaped appearance. If the swollen end hollows out then the appearance is that of a tennis racket. Pleomorphic forms may contain swelling at both ends, if there is a central clear zone the mitochondrion becomes vesicular (Fig. 9d).

Fig. 9



A – The photosynthetic reserve food substance in Euglenophyceae member is paramylon starch, they are small rod or ovoid in shape. They are freely scattered in the cytoplasm.

B – Nucleus is situated at the periphery of the cytoplasm due to vacuolation. Nucleus is spherical or ovoid in shape, it has a typical morphology with a distinct nucleolus at the centre, chromatin granules were disbursed in the nucleoplasm.

C – Higher magnification of pellicle showed helically oriented ridges which were alternatively high and low individual section, the plastids often showed two-three osmiophilic lipid droplets.

D – Mitochondria are spherical in shape and scattered throughout the cytoplasm. The inner wall of the mitochondria is projected in to the central matrix and form cristae. Each mitochondria showed 10-15 cristae.

Scanning Electron Microcopy with energy dispersive spectroscopic analysis

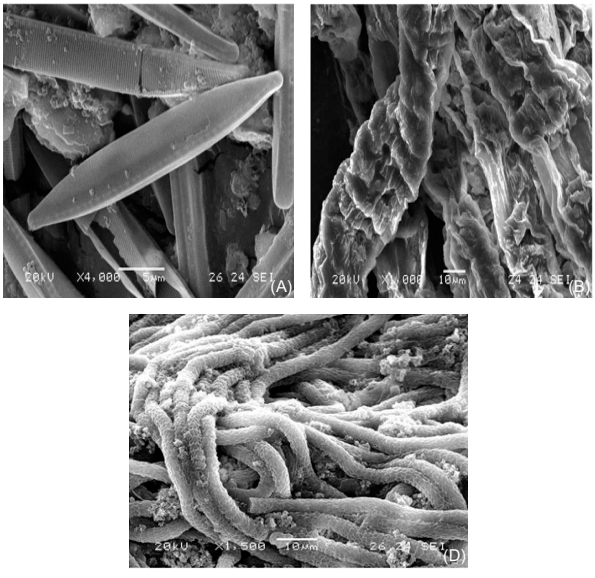
Table 3 and Fig. 10 shows the presence of different chemical elements in the Bacillariophyceae, Chlorophyceae, Cyanophyceae of freshwater microalgae. Nitzschia (Bacillariophyceae) contained eight elements in the following order: Si > Mg > Zn > Cl > Mn > Ca > N > Fe. The contribution of Si in the Bacillariophycean cell wall was 26% wt. compared to 16% wt. of Mg. Spirogyra (Chlorophyceae) contained seven chemical elements in the following order: Ca > Mg > Fe > N > Cl > Zn > Mn. Contribution of Ca being maximum 25% wt. Oscillatoria (Cyanophyceae) contained eight chemical elements in the following order: Zn > P > Mg > Ca > S > Mn > N > Si. Thus the constituents of different chemical elements in Nitzschia, Spirogyra and Oscillatoria varied not only by quality but also in quantity.

Table 3 and Fig. 10. SEM-INSA-EDS (Energy dispersive spectroscopy) analysis of Bacillariophyceae, Chlorophyceae and Cyanophyceae

Sl. No.	Name of the chemical elements	Bacillariophyceae	Chlorophyceae	Cyanophyceae
		(Nitzschia sp.) (wt. %)	(Spirogyra sp.) (wt.%)	(Oscillatoria sp.) (wt. %)
1.	Zn	13 0.28	9 0.42	24 0.38
2.	P			15 0.35
3.	S			11 0.23
4.	Ca	8 0.48	26 0.36	14 0.42
5.	Mg	16 0.31	21 0.46	14 0.38
6.	Fe	6 0.43	14 0.47	–
7.	N	8 0.36	12 0.35	6 0.43
8.	Si	26 0.23	–	3+0.41
9.	Cl	11 0.42	10 0.46	–
10.	Mn	9 0.49	4 0.48	10 0.4

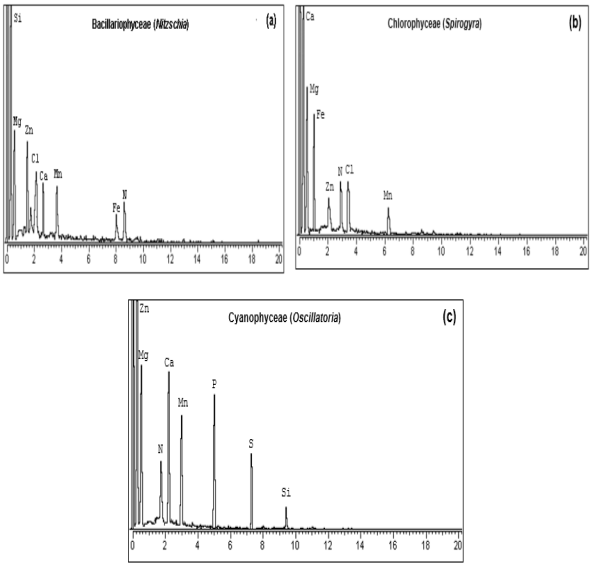
All the parameters are in triplicate values.

Fig. 10



SEM-EDS analysis of Bacillariophyceae (Nitzschia), Chlorophyceae (Spirogyra), and Cyanophyceae (Oscillatoria)

Fig. 11. SEM-INSA-EDS (Energy dispersive spectroscopy) analysis of Bacillariophyceae, Chlorophyceae and Cyanophyceae



DISCUSSION

Physico-chemical parameters

Monthly variations in physico-chemical parameters of Perumal lake and the seasonal change of productivity is related to variation in temperature and photic conditions. Similar findings were reported by Sondergaard and Sand Jensen (1979) and Spencer and King (1989). Temperature is an important factor which regulates the biogeochemical activities in the aquatic environment. Maximum temperature was recorded during May and June and minimum in September and October. Water temperature influences aquatic weeds and algal blooms (Zafer, 1968) and surrounding air temperature (Gupta and Shárma, 1993). All metabolic and physiological activity and life process such as feeding, reproduction, movements and distribution of aquatic organisms are greatly influenced by water temperature. The pH concentration was in the ailcaline range and it varied from 7.9 to 8.4 with minimum value in. August and maximum value in April. Wani and Subla (1990) reported that the pH values above 8 in natural waters were produced by photosytithetic rate that demands more CO2- than quantities furnished by respiration and decomposition.

Salinity acts as major ecological factor controlling the phytoplankton population of freshwater as well as brackish water and appearance or disappearance of species depend upon the salinity condition. During the present study maximum value for salinity was recorded in summer season and minimum in pre-monsoon and monsoon period. High salinity concentration was associated with high density of phytoplankton population as observed by Shibu (1991).

The maximum electrical conductivity was observed in January 2018 and minimum in May 2018. A sudden rise in conductivity in water during monsoon and post monsoon season indicates addition of some pollutants (Trivedy and Goel, 1984). High values of electrical conductivity designate pollution status of the lake (Kadam, 1990). The maximum dissolved oxygen was recorded during monsoon period in November and minimum during summer period in June. Dissolved oxygen is affected by the photosynthetic activity and aeration rate (Gautam et al., 1993). The distribution of dissolved oxygen in the reservoir water is governed by a balance between input from the atmosphere, rainfall and photosynthesis and losses by the chemical and biotic oxidations. The values of total dissolved solids in water varied from minimum of 2.5 mg/l (January 2018) to maximum of 5.2 mg/I (June 2018). The highest average value might be due to accumulation of the anthropogenic activity of cloths washing with hampered the quality of water.

Totally 213 species of phytoplankton belongint to Bacillariophyceae (76 species), Chlorophyceae (63 species) and Cyanophyceae (60 species) and Euglenophyceae (14 species) were recorded. The percentage composition showed marked variation with Bacillariophyceae occupying dominant position (Table 1). The population density ranged between 467 and 2545 cels/l with maximum production in summer season causing the lake ater column dark green due to the abundance of Chlorophyceae and minimum in winter season (Table 2 and Fig. 4).

South, East and West waters part of Perumal lake waters exhibited a good relation with environmental variable and phytoplankton assemblage. Tropical lake environments are unique spatial and temporal changes in physical, chemical and biological environments are extreme and therefore the environmental parameters which influence the phytoplankton production forms an important aspects of the study.

The phytoplankton population was stable during the months of April and May the density slowly declined during pre-monsoon period and the lowest values was recorded during monsoon season of 2018. In the present study, the maximum phytoplankton production coincide with the optimum water depth of 1 m. This is an agreement with the earlier findings of Sukumaran and Das (2001) in some freshwater reservoirs of Karnataka. In the present investigation it may be noted that the phytoplankton population of the lake appears closely related with the seasonal variationin hydrography. Though the Perumallake is small, it's phytoplankton composition, distribution, richness and diversity are almost similar to that of other major Indian reservoirs.

Transmission electron microscopic studies of Euglena

Many ultrastructural features of euglenoids indicate that a significantly greater diversity exhibits within this group than previously recognized light microscopic studies (Triemer and Farmer, 1991a,b). The pellicular complex and its associated microtubules have been used to infer phylogenetic relationships of euglenoids (Leedale and Hibbered, 1974, Kivic and Walne, 1984). The pellicular microtubules are continuous with microtubules of the reservoir base and considered to give the body its shape, elasticity and/or rigidity (Willey et al., 1988). In the present study, articulation of the overlapping pellicular strips were observed. This findings supports that ultrastructure of Phacus trypanon (Euglenophyceae) presents an emphasis on striated fibre and microtubule arrangement (Shin and Boo, 2001).

All euglenoids posses pellicles that are plastic semirigid or rigid and have either a helical pellicle or a longitudinally arranged pellicle strips. In the present study, the genus Euglena was defined, slightly to highly flattened and completely rigid having helically or longitudinally arranged ridges. Recently, Leander and Farmer (2001b) described four basic types of pellicular strips: S shape, plateau shape, M shape and A shape. They also suggested that the ancestral state included strips that are few in number, flat and fused. In the present study 'M' shape pellicular strips was observed. As in the case of phagotrophic euglenoids, with few longitudinally arranged strips, it was believed to represent an ancestral state (Montegut-Felkner and Triemer 1997).

Mollenhauer and Whaley (1963) suggested that in certain plant cells the Golgi complex is polarized and has a “forming face” and a “maturing face”. The forming or proximal face is on the outer side while the maturing or distal face is on the opposite side. It is believed that the smooth membrane of endoplasmic reticulum buds off vesicles, which then gets arranged on the forming face of the stack. It is also possible that a lamella is formed on the forming face and mature lamella is lost on the maturing face, the membrane of the Golgi complex is in dynamic equilibrium. They are continuously receiving lamellae through budding of vesicles from the smooth endoplasmic reticulum, and losing membranes through formation of secretary vesicles.

The Golgi complex is constantly being formed, changed, broken down and reformed. Beams and Kessel (1968) have suggested that the Golgi lamellae may be derived from the endoplasmic reticulum by loss of ribosomes. It is believed that the Golgi complex arises from the granular endoplasmic reticulum, which changes to smooth endoplasmic reticulum and then becomes the Golgi cisternae. The cisternae on the forming face are constantly being formed by fission of vesicles derived from the endoplasmic reticulum. The cisternae on the maturing face are believed to form secretary vesicles.

The secretary product completely fills the cisternae. The secretary products within the Golgi lamellae are very similar to the contents of the secretary granules near the Golgi complex. In the present study the ends of the Golgi cisternae may be pinched off to form small secretary granules. These may then fuse to form larger granules. In the present

investigation, the individual cisternae on the "maturing face" may be completely filled with secretary products, and then become rounded to form secretary granules. New cisternae would then apparently be formed on the "forming face". It is possible that the lamellae of the endoplasmic reticulum may become Golgi lamellae by loss of ribosomes.

Plastids are small bodies found free in the cytoplasm of most plant cells. The most common of the plastids are the chloroplast. They are very important for the plant, because photosynthesis takes place in them. Chloroplast may be spherical, ovoid or disc shaped. The chloroplasts of some algae are in the form of stellate plates or spiral bands.

Chloroplasts thus have three different membrane types, the outer membrane, the inner membrane and the thylakoid membrane. The morphology of mitochondria and chloroplast is remarkably similar. The outer membranes of both organelles are analogous. The inner membrane of chloroplast corresponds to the inner membrane of the mitochondria without the cristae. Thylakoids can be considered to be analogous to mitochondrial cristae pinched off from the inner membrane. Indeed, thylakoids are formed by invagination of the inner chloroplast membrane.

The outer membrane of chloroplast, as with the outer mitochondrial membrane is freely permeable to small molecules. The inner chloroplast membrane is impermeable to small molecules, even to H+. It however, has translocators for a number of compounds for passage of substances across the membrane, both in the inward and outward directions. These substances include dicarboxylic acid, ATP and other organic phosphates.

The thylakoid membrane contains all the enzymatic compounds required for the photosynthesis. Interaction between chlorophyll, electron carriers, coupling factors and other compounds take place within the thylakoid membrane. Light energy is used for splitting water to oxygen. Reduction of NADP+ and phosphorylation of ADP takes place simultaneously. The resulting products NADPH and ATP, respectively are utilized by the stroma enzymes which fix carbondioxide, synthesize and breakdown starch and catalyse the oxidative pentose pathway.

Finally this study shows the ultrastructure of cistenae of Golgi complex and its formation, the chloroplast which are randomly or radially arranged without pyrenoids. Further, the electron micrographs also show reserve food material of euglenophyceae (Paramylon starch) and nucleus and pellicle with ridges. Mitochondria is also focused with cristae. These reports add a novel way to modern research on the taxonomy of algae.

Scanning electron microscopy with energy dispersive spectroscopic analysis (SEM-EDS)

The major elements detected in phytoplankton cells correspond to those seen in other freshwater algae, including the presence of Si. This element is generally regarded as being cell wall associated and has been detected by X-ray Micro Analysis (XRMA) in a range of algal cells including blue green algae (Clay et al., 1991; El-Bestway et al., 1996; Sivakumar and Rengasamy, 1999; Krivtso et al., 2000). In the present study, the element Ca, Zn, Mg and N is commonly present in Nitschia, Spirogyra and Oscillatoria among which the Nitschia has eight chemical elements in the following order Si > Mg > Zn > Cl > Mn > N > Ca > Fe; Spirogyra: Ca > Mg > Fe > N > Cl > Zn > Mn and Oscillatoria: Zn > P > S > Ca > Mg > Mn > N > Si.

Nitschia and Oscillatoria contain silica but it is absent in Spirogyra. Silica provides rigidity and strengthening of cell wall. It enhances the physiological availability of zinc in plants and counteracts zinc deficiency induced phosphorus toxicity. Diatoms require silica for formation of their skeletal structure and constitute an important group of the plankton. In Chlorophyceae, calcium is linked with the carbon dioxide and is an important constituent of the skeletal structure of organisms. Calcium forms the most abundant ion in freshwater. So it reaches Spirogyra and calcium makes up to an average of about 48% of total cations. Calcium is also commonly found in Bacillariophyceae, Chlorophyceae and Cyanophyceae.

Magnesium is essential for chlorophyll containing organisms, as it is the central element of the porphyrin ring of chlorophyll. The presence of calcium and magnesium along with their carbonates, sulphates and chlorides make the water hard. Like other elements, magnesium is also found dissolved in water and influence the flora and fauna. Nitrogen is of special importance because soil nitrogen is entirely the result of biological action (nitrogen fixation by certain bacteria and blue green algae). Nitrogen is constituent of proteins, nucleic acids, vitamins, hormones, co-enzymes, ATPs, chlorophylls, thus, plays an important role in almost all the metabolic reactions, as have the growth and reproduction. Many species of the genus Nitzschia are recognized as indicators of organic enrichment or pollution of the water in which they are found Lowe (1974). Cholonoky (1968) has attributed this pollution-tolerant behaviour to the fact that many Nitzschia species are nitrogen heterotrophs and capitalize on organic nitrogen molecules in the water. Thus, they are found in largest numbers where organic nitrogen is abundant, areas of organically polluted water, and in this sense might be thought of as "pollution dependent" rather than "pollution tolerant". Nitzschia palea is one of the most common and pollution-dependent species in this genus (Palmer, 1969 and Tuchman, 1996) reported that N. palea was able to utilize 21 different organic substances.

Phosphorus was another element released by microbes from decomposition of plant materials. The high level of phosphorus was obtained in the present study only in Cyanophyceae member may be due to concentrated nature of the water body resulted from the evaporation. Sulphur is one of the chemical which may enter into the water through the agricultural wastes and aquatic animal wastes. The high amount of sulphur was observed in Cyanophyceae members. From this result it can be concluded that there is no greater deviation in the amount of sulphur. Manganese is found in Bacillariophyceae, Cyanophyceae and Chlorophyceae and is the characteristic photosynthetic reserve food substance.

It plays a key role in nourishment of nutritive material. Presence of manganese is needed for catalysing the photolysis of water and oxygen evolution associated with photosystem-II. Magnesium is present in all the members of algae. It forms the nucleus for the porphyrin ring and hence its presence in the chromatophores is understandable. The chemical elements Si > Ca > Mg > N are specific to Nitzschia sp., Spirogyra sp. and Oscillatoria sp. respectively. The specific chemical requirements of the freshwater algae which was found in Perumal lake may be perhaps the first report in India.

SUMMARY AND CONCLUSION

The present study revealed that the abundance of Bacillariophyceae which formed the major component of the phytoplankton at Perumal lake may be attributed to higher salinity. Chlorophyceae was the dominant group of phytoplankton during the wet season.

Thus the results indicate that different ecological factors have influenced the plankton abundance. The present study ensures that variation in the abundance of phytoplankton can be best explained when environmental factors jointly influence. Thus it may be concluded that the density of phytoplankton is dependent on different abiotic factors either directly or indirectly.

As far as the habit is concerned, the phytoplankton as a whole, is very simple, some of its members may be complicated in structurally but even they do not exhibit so much complexity. They are widely distributed and occur perhaps every where. An almost endless variety of structural and morphological peculiarities and adaptation of different living conditions is prevalent among algae which may be beneficial to human welfare Thus, a complete survey has been made on all seasons over a period of one year in Perumal lake in Cuddalore district area for future prospectus.

From the highly sophisticated instruments like scanning electron microscopy with energy dispersive spectroscopic analysis, the study was focused on the incorporation of the intracellular elemental pattern into models of chemical element uptake. Microalgal population dynamics allow simultaneous consideration of a wide range of chemicals. The approach presented here could be easily used as an applied model of aquatic ecosystem, bioreactors, chemostate and enclosure experiments. It may therefore be potentially beneficial for various commercial applications.

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