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Biodiversity of Microalgae and Their Elemental Components from Veeranam Lake, Tamilnadu, India

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An attempt was made in the Veeranam freshwater lake with the objectives to collect, identify, describe and document the algae occurring from March 2007 to August 2007. Qualitative and quantitative characterization of phytoplankton and analysis of physico-chemical parameters of water samples were carried out at monthly intervals during the study period in the western and eastern sides of the lake. It was found that the phytoplankton community embraced 68 genera belonging to four classes *viz.*, Bacillariophyceae (40), Chlorophyceae (22), Cynophyceae (4) and Euglenophyceae (2). There were significant influences of various physico-chemical parameters on the phytoplankton population density. 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.

Key words : freshwater microalgae, elemental composition, Veeranam lake

INTRODUCTION

Temporal variability in the structure and function of a microalgal community is of fundamental importance to aquatic system. Aquatic environments are subjected to high temporal variability, with frequent reorganization of relative abundance and species composition of phytoplankton, as a result of interaction between physical, chemical and biological variables. Water temperature is an important factor controlling the algal growth in natural environments and growth response to water temperature may be essential in regulating the predominance of phytoplankton species (Harris, 1986). There is growing evidence that human activities are changing the distribution and movement of nutrient elements resulting in increased nutrients loading to aquatic environments, and the changes of nutrients can alter the species composition of primary producers.

The Veeranam lake (Lat. 11° 17′N; Long. 79° 32′E) is being used to a wide range of land areas for multipurpose utility. The catchment areas of the lake comprise agricultural lands, horticultural areas, commercial crop lands, etc. The Veeranam lake is situated in the Cuddalore district of Tamilnadu state. It was constructed during the 9^{th} century and as on date its age is 1039 years. The lake is located in the western half of Chidambaram and southern half of Kattuman-

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narkoil in the Cuddalore district. It was constructed by the Prince Rajathithar, son of Parandaga Cholan. In India, many such lakes and reservoirs have been studied for the water quality and fisheries (Nautiyal *et al.*, 1988; Srivastava *et al.*, 1991; Kartha and Rao, 1992; Pandey, 1993; Ravikumar *et al.*, 2006; Tiwari and Shukla, 2007).

The chemical composition of phytoplankton samples used for their calibration has been conventionally determined by bulk analysis techniques (Behrendt, 1990). This leads to estimation of elemental concentrations for the whole sample without separation into separate constituents, *e.g.*, algae, detritus, small animals, etc. Inevitably, such data on natural blooms of various phytoplankton species could, therefore, contain errors due to the presence of other species and/or detritus particles in the analyzed samples. In this study, the elemental composition of phytoplankton is determined for individual species by X-ray microanalysis (XRMA), thus avoiding the above problems. XRMA has sufficient resolution to analyze single phytoplankton cells within a mixed population (Chandler, 1977), and involves the simultaneous determination of a range of elemental concentrations for each cell-thus providing a comprehensive assessment of nutrient status (Sigee *et al.*, 1998). This research represents the first attempt to examine on microalgae with SEM-EDS. But still there are many such aquatic ecosystems that remain unexplored. The Veeranam lake, has also received due attention it deserves. Hence, the present attempt has been made to study the influence of physico-chemical parameters of water on phytoplankton populations and their elemental components.

MATERIALS AND METHODS

1. General information about the lake and sites

The Veeranam lake is a major reservoir in Cuddalore district of Tamilnadu, which has historical importance of South India and largest lake in Tamilnadu (Fig. 1). This lake is an open type with 16 km long from north-south and 5 km width from east-west. In the present investigation, 3 stations were selected: Ss-I (Vadavar) and Ws-II (Pazhanjanallur) are the major water receiving sites and Es-III (Lalpet) is major water outlet. People using water for bathing and washing site.

2. Environmental variables

The hydrobiological studies of the water were analysed from March 2007 to August 2007 at monthly intervals during forenoon hours (8.00 AM to 12.00 Noon). The water samples were analysed immediately on the spot for temperature, pH, salinity, electrical conductivity (EC), dissolved oxygen (DO) and total dissolved solids (TDS) by using water and the soil analysis Kit model 1160-E and monthly water storing capacity were also recorded.

3. Collection of microalgae and enumeration

Phytoplankton samples were collected at monthly intervals during March 2007 to August 2007 from the surface water the selected stations by towing plankton net (mouth diameter 0.35 m) made up of bolting silk (no. 30; mesh size 48 μm) for half an hour. The samples were collected in black polyethylene cover and immediately preserved in 4% formalin for numerical estimation for the quantitative analysis of phytoplankton; the settling method described by Sukhanova (1978) was adopted. Numerical plankton analysis was carried out using a compound microscope and elemental composition was analysed using a scanning electron microscopy with energy dispersive spectroscopy analysis (SEM-INSA-EDS).

Identification of phytoplankton was made by using standard keys of Prescott (1962), Desikachary (1959), Anand *et al.* (1986), John *et al.* (2003) for the sake of convenience, the phytoplankton was assigned to 4 major groups *viz.*, Bacillariophyceae (diatoms), Chlorophyceae (green algae), Cyanophyceae (blue green algae) and Euglenophyceae (euglenoid flagellates).

RESULTS

The water capacity level from March 2007 to August 2007 was full tank level (FTL). Data obtained on the water quality were given in Table 1. The following physico-chemical parameters were measured during the study period; air temperature, water temperature, pH and salinity, EC, DO and TDS. Studies on phytoplankton revealed the community included 68 genera belonging to Bacillariophyceae 40, Chlorophyceae 22, Cyanophyceae 4 and Euglenophyceae 2 (Table 2).

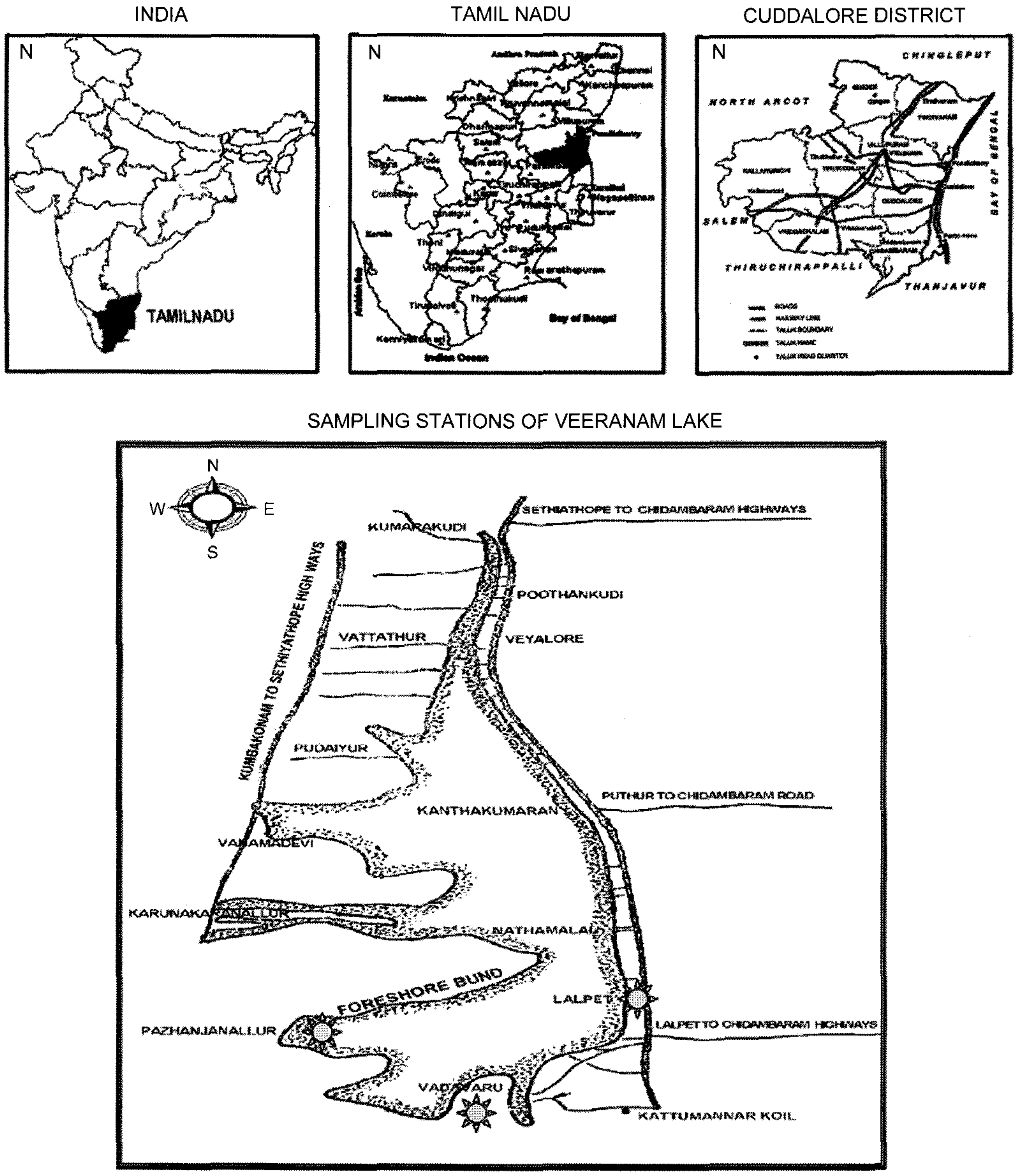

Fig. 1. Location map of Veeranam lake.

Phytoplankton of the Veeranam lake composed 5% of Cyanophyceae, 22% of Chlorophyceae, 71% of Bacillariophyceae and 2% of Euglenophyceae. Phytoplankton was abundant in March (50%), April (60%) and May (70%). Seasonal variation of major groups of phytoplankton showed that Bacillariophyceae and Cyanophyceae were abundant during dry season but Chlorophyceae was high in wet season. Monthly variation of phytoplankton group (percentage) of Veeranam lake is presented in Table 3.

1. Population density (cells litre^{-1})

Phytoplankton population density varied from 174 to 6,128 cells L^{-1} at station I, 75 to 200 cells L^{-1} at station II and 64 to 580 cells L^{-1} at station III. The peak of Cyanophyceae was observed in March that of Bacillariophyceae was in May and that of Chlorophyceae in August. Euglenophyceae was present only in May and June. Cyanophyceae and Bacillariophyceae were found throughout the study period (Table 3).

Table 1. Physico-chemical parameters of Veeranam lake during March 2007 to August 2007.

Parameters	March 2007			April 2007			May 2007			June 2007			July 2007			August 2007		
	Ss-I	Ws-II	Es-III	Ss-I	Ws-II	Es-III	Ss-I	Ws-II	Es-III	Ss-I	Ws-II	Es-III	Ss-I	Ws-II	Es-III	Ss-I	Ws-II	Es-III
Water capacity in feet		44.00			47.50			45.30			43.10			46.40			45.10	
Air temperature (°C)	36	36	36	34	34	34	36	36	36	38	38	38	36	36	36	34	34	34
Water temperature (°C)	34	34	34	33	33	33	34	34	34	36	36	36	34	34	34	32	32	32
pH	8.0	8.0	8.0	7.5	7.5	7.5	7.7	7.7	7.7	8.0	8.0	8.0	7.5	7.5	7.5	8.2	8.2	8.2
Salinity (g L^{-1})	1.4	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.2	1.2	1.2	1.1	1.1	1.1
Electrical conductivity (Micro simens, μs)	10.3	9.8	10.1	10.2	9.9	10.4	9.2	9.1	9.6	9.1	9.2	9.7	8.7	8.5	8.6	7.8	8.1	7.9
Dissolved oxygen (mg L^{-1})	6.5	6.5	6.5	6.0	6.0	6.0	6.5	6.5	6.5	6.5	6.5	6.5	7.5	7.5	7.5	8.2	8.2	8.2
Total dissolved solids (mg L^{-1})	3.5	3.6	4.0	4.1	4.3	4.6	4.8	4.9	5.0	4.7	4.6	4.5	3.9	3.8	4.0	2.0	2.1	2.2

All the parameters are in triplicate values.

Table 2. List of microalgae collected from Veeranam lake during March 2007 to August 2007.

Name of phytoplankton	Stations			Name of phytoplankton	Stations		
	Ss-I	Ws-II	Es-III		Ss-I	Ws-II	Es-III
Bacillariophyceae				**Chlorophyceae**			
Order: Centrales				Order: Volvocales			
1. *Cyclotella meneghiniana*	+	+	−	1. *Chlamydomonas globosa*	+	+	+
2. *C. stelligera*	+	+	−	2. *Chlorella vulgaris*	+	+	+
Order: Pennales				3. *Eudorina elegans*	−	−	+
3. *Fragillaria brevistriata*	+	+	+	Order: Chlorococcales			
4. *F. ratonensis*	+	+	+	4. *Selenastrum gracile*	+	+	+
5. *F. intermedia*	+	+	+	5. *Scenedesmus dimorphus*	+	+	+
6. *Synedra ulna*	+	−	−	6. *S. bijuga*	+	+	+
7. *Mastigloia exigua*	+	+	+	7. *S. quadricauda*	+	+	+
8. *M. dolosa*	+	+	+	8. *S. abundans*	+	+	−
9. *Achnanthes hauckiana*	+	+	−	9. *S. opoliensis*	+	+	+
10. *A. inflata*	+	+	−	10. *Pediastrum simplex*	+	+	−
11. *Mastogloia brauni*	+	+	+	11. *P. boryanum*	+	+	−
12. *M. smithii*	+	+	+	12. *P. duplex*	+	+	+
13. *Coconeis placentula*	+	+	+	13. *P. tetras*	+	+	−
14. *Diploneis subovalis*	+	+	−	14. *P. biradiatum*	+	+	−
15. *D. interrupta*	+	+	−	Order: Cladoporales			
16. *Anomoeneis sphoaerophora*	+	+	−	15. *Cladophora fracta*	−	+	+
17. *Stauroneis anceps*	+	+	−	16. *C. crispata*	−	+	+
18. *Navicula cuspidata*	+	+	+	Order: Conjucales			
19. *N. peregrina*	+	+	+	17. *Closterium acerosum*	−	−	+
20. *N. lacustris*	+	+	−	18. *C. purvulum*	−	−	+
21. *N. cincta*	+	+	+	19. *Cosmarium botrytis*	+	+	+
22. *N. rostellata*	+	+	+	20. *C. portianum*	+	+	+
23. *N. laterostrata*	+	+	+	Order: Zygnematales			
24. *N. salinarum*	+	+	+	21. *Spirogyra varians*	+	+	+
25. *N. lyra*	+	+	−	22. *S. communis*	+	+	+
26. *N. hasta*	+	+	−	**Cyanophyceae**			
27. *Nitzschia. acicularis*	+	+	+	Tribe-A: Cocoogoneae			
28. *Pinnularia gibba*	+	+	−	Order: Chroococcales			
29. *P. acrospheria*	+	+	+	1. *Chroococcus dispera*	+	+	+
30. *P. interrupta*	+	+	−	2. *Aphanocapsa Sp*	+	+	+
31. *P. braunii*	+	+	+	Tribe-B: Hormogoneae			
32. *P. viridis*	+	+	+	Order: Oscillatoriales			
33. *Amphora coffoeformis*	+	+	+	3. *Oscillatoria curviceps*	+	+	+
34. *A. ovalis*	+	+	+	Order: Nostocales			
35. *Gomphonema intricatum*	+	+	+	4. *Anabaena spiroides*	+	−	+
36. *G. lanceolatum*	+	+	+	**Euglenophyceae**			
37. *Cymbella naviculiformis*	+	+	+	Order: Euglenales			
38. *C. cistula*	+	+	+	1. *Euglena spirogyra*	−	−	+
39. *Nitzschia vitrea*	+	+	+	2. *Phacus pleuronectus*	−	−	+
40. *Bacillaria paradoxa*	+	+	+				

2. Elemental composition

Table 4 shows the presence of different chemical elements in the Bacillariophyceae, Chlorophyceae, Cyanophyceae of freshwater microalgae. The *Navicula* (Bacillariophyceae) contained six elements in the following order: Si > Zn > Mg > Cl > N > Fe > Ca. The contribution of Si in the Bacillariophyceae cell wall was 30% wt. compared to 16% wt. of Zn. The *Scenedesmus* (Chlorophyceae) contained 8 chemical elements in the following order: Ca > Mg > N > Fe > Cl > Zn > Mn > Si. Contribution of Ca being maximum 20% wt. The *Oscillatoria* (Cyanophyceae) contained

Table 3. Monthly variation of phytoplankton (cells litre^{-1}) in the Veeranam lake during March 2007 to August 2007.

Month	Bacillariophyceae	Chlorophyceae	Cyanophyceae	Euglenophyceae
March 2007	174	170	580	–
April 2007	5200	155	458	–
May 2007	6128	100	310	108
June 2007	863	80	180	80
July 2007	606	75	75	–
August 2007	604	225	64	–

Table 4. SEM-INSA-EDS (Energy dispersive spectroscopy) analysis of Bacillariophyceae, Chlorophyceae and Cyanophyceae.

Sl. No.	Name of the chemical elements	Bacillariophyceae	Chlorophyceae	Cyanophyceae
		(*Navicula* sps) (wt. %)	(*Scenedesmus* sps) (wt. %)	(*Oscillatoria* sps) (wt. %)
1.	Zn	16	8	26
2.	P	–	–	15
3.	S	–	–	11
4.	Ca	7	28	13
5.	Mg	14	17	15
6.	Fe	9	10	0
7.	N	10	13	7
8.	Si	32	7	0
9.	Cl	12	10	0
10.	Mn	–	7	13

All the parameters are in triplicate values.

six chemical elements in the following order: Zn > P > Mg > Ca > Mn > S > N. Thus the constituents of chemical elements in *Navicula, Scenedesmus* and *Oscillatoria* varied not only by quality but also in quantity.

DISCUSSION

The physical and chemical parameters of the reservoir were listed in the Table 1. In our present investigation there was no greater deviation in the atmospheric and water temperature. Atmospheric temperature was ranged from 34°C to 36°C and the water temperature was ranged from 32°C to 36°C. The pH of the water samples ranges from 7.5 to 8.2. Throughout the study period the pH of the water was alkaline in nature. Jagatheesan (1999) obtained the same results. The changes in pH are due to the changes in the concentration of the chemicals present in the water.

The temperature seems to have no direct influence on phytoplankton production. Similar observations were made by Gopinathan (1972), Mathew and Nair (1981) and Thangaraj (1984). However, in the present observation lower densities of phytoplankton were recorded generally during wet season while many fold increase in phytoplankton population was noticed during the dry season. The seasonal dynamics of the phytoplankton population is influenced by the climatic conditions as well as the physico-chemical characteristics. The lower transparency and the heavy water currents will prevent the growth of phytoplankton during the wet season and in dry season the water turns to be more lacustrine and the addition of nutrients will favor the growth of phytoplankton. Turbidity and light penetration along with other ecological factors were found to be influencing the phytoplankton density in aquatic systems (Tucker, 1957; Davis, 1962; Shibu, 1991). The atmosphere becomes cloudy in rainy season and prevented light penetration, which in turn might have had some effect on the phytoplankton. The higher water level during the rainy season might have resulted the reduction of phytoplankton population. Besides, greater rainfall disturbing the normal oxygen level, carbon dioxide exchange, which might inhibit the growth of phytoplankton as recorded by Bhatt *et al.* (1985).

Salinity acts as major ecological factor controlling the phytoplankton population. The range of salinity during the present study was 1.1 to 1.7 g L^{-1} and seasonal average showed that salinity was high (1.7 g L^{-1}) during dry season and low during wet season (1.1 g L^{-1}). High saline concentration associated with high density of phytoplankton population as observed by Shibu (1991).

The salts already present in the water mainly determine electrical conductivity of the water (Trivedy *et al.*, 1985). In our present work values ranged from 7.9 to 10.3 µs. The maximum value was obtained in April 2007 and minimum value in August 2007 and this was due to the more amounts of salts present in the water. The total solids ranged from 2.2 to 5.0 mg L^{-1}. This described the high amount of soluble and insoluble solid materials present in the water.

The amount of dissolved oxygen reflects the physical and biological processes prevailing in the water. Its presence in the water is essential to maintain the aquatic life in the water. When the dissolved oxygen content goes below the minimum tolerant level, the life forms are severally affected (Tsai, 1975). In our present work the dissolved oxygen values ranged from 6.00 to 8.02 mg L^{-1}. The maximum value was obtained in August 2007 and low amount in March 2007. Abdul-Hussein and Mason (1988) obtained the same results. It had been widely accepted that any water containing below the level of 7 mg L^{-1} of dissolved oxygen was considered as polluted (Mortimer, 1971). Solubility increased with decrease of water temperature and decreased due to utilization by the aerobic bacteria (Nabi and Reginaa, 2003). Similar observations were also made in the present study. This was in accordance to the findings of Brezonic and Fox (1974).

South, East and West station part of Veeranam lake waters exhibited a good relation with environmental variables 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 aspect of study.

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 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 *Navicula, Scenedesmus* and *Oscillatoria* among which the *Navicula* is following order of the chemical element Si > Zn > Mg > Cl > N > Fe > Ca; *Scenedesmus*: Ca > Mg > N > Fe = Cl > Zn > Mn = Si and *Oscillatoria*: Zn > P > Mg > Ca = Mn > S > N.

Navicula and *Scenedesmus* contained silicon but it is absent in *Oscillatoria*. The silicon provides rigidity and strengthening of the 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 ions in freshwater. It reaches to *Scenedesmus* is understandable Calcium makes up an average of about 48% of total cations. Calcium is commonly found in Bacillariophyceae, Chlorophyceae and Cyanophyceae.

Magnesium is essential for chlorophyll bearing organisms, since it goes into the composition of the pigments. 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, it 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, its thus, plays an important role in almost all the metabolic reactions, as have the growth and reproduction. In the present study nitrogen was commonly found in all the phytoplanktons.

Phosphorus was another parameter which could be increased due to the release of phosphorus 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. This was accordance by Jagatheesan (1999). Sulphur is the chemicals which can be entered 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 Cyanophyceae and Chlorophyceae and is the characteristics photosynthetic reserve food substance. It is 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 its forms the nucleus for the porphyrin ring and hence it is present in the chromatophores is understandable. The chemical elements Si > Ca > Mg > N are specific to *Navicula, Scenedesmus* and *Oscillatoria* respectively the specific chemical requirements of the freshwater algae of the Veeranam lake perhaps the first report in India.

CONCLUSIONS

Incorporation of the intracellular elemental pattern in to models of chemical element uptake and microalgal population dynamic allows simultaneous consideration of a wide range of chemicals the approach presented here could be easily (within the specified constraints) applied models of aquatic ecosystem, bioreactors chemostate and enclosure experiments. It may therefore, be potentially beneficial for various commercial applications.

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