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PHYTOPLANKTON OF THE VELI LAKE, A LAGOON ON THE SOUTH-WEST COAST OF INDIA

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ABSTRACT

Qualitative and quantitative studies were undertaken on the phytoplankton of Veli lake, a brackish water lake, on the south-west coast of India, for a period of 12 months during 1977. The seasonal fluctuations of the main constituent groups of phytoplankton in relation to some of the environmental variables have been discussed. 53 genera of algae were recorded from the lake. The major families of phytoplankters were Cyanophyceae, Chlorophyceae and Bacillariophyceae, of which Chlorophyceae dominated over others. Three peaks of phytoplankton were discernible in January, April and July.

INTRODUCTION

Great stress is being laid on developmental measures requiring proper assessment of the environmental factors and ecological parameters regulating the inland waters in relation to fish production. Limnological observations with the main objective of fish culture, have been few in our country and this is especially true of Kerala. Although there are a few lakes in and around Trivandrum, a systematic study of the plankton in relation to the different environmental variables have never been attempted on any of the lakes or other fresh water environments of this region. Moreover, Veli lake is unique in its ecological features and hence constitute a dynamic ecosystem inhabited by a distinct flora and fauna. Considering the above, the present investigation was undertaken to study the phytoplankton population in two stations of Veli lake in relation to some of the hydrological features of the lake water during the year 1977.

Topography of the lake

Veli lake is the smallest of the slightly brackish water lakes confined to the southern part of the State and is situated 5 km north-west of Trivandrum city at 08°28′N latitude and 76°57′E longitude. The lake proper is about 1 km long and 0.3 km broad and progressively widens from the barmouth to the eastern part. It is connected to the slightly bigger Kadinamkulam lake lying north, through a canal, the Parvathiputhanar. On the southern part it is connected to the Chackai canal, a small freshwater body of the Aukkulam lake and one or two small streams are also connected with the lake. Unlike large backwaters such as the Vembanad and the Ashtamudi lakes, it has no permanent connection with the sea; being separated

from the sea by a narrow strip of sandy beach. During the monsoon months the barmouth to the sea breaks open for a brief period (2–5 days), thus establishing connection with the sea. In the vicinity there are two factories. The effluents from the Travancore Titanium Products are discharged into the sea and can enter the lake when the bar is open. The lake is shallow. The average depth being 2–3 m which increases by about a metre during the time of monsoon floods. The bottom of the lake is composed of silt washed down during the rainy season. Two sites were selected in the lake for the present study.

MATERIALS AND METHODS

The data for the present study were based on observations during January to December 1977. Weekly collections were made using standard procedures (Patnaik, 1973; Patnaik and Sarkar, 1976) and the phytoplankters were counted in a Sedwick-Rafter counting cell. Water samples from the surface were also taken along with the phytoplankton collections. Hydrographic data, viz., salinity, dissolved oxygen and nutrients such as phosphate, silicate, nitrite (Strickland and Parsons, 1965) and nitrate (Mullin and Riley, 1955) were estimated from surface samples during the period. Temperature and pH of the water samples were also noted. Transparency was measured with a Secchi disc.

Station 1 was near the barmouth and station 2 at the place where Chackai canal and Aukkulam lake join the Veli lake. Station 2 was more of a fresh water type than station 1.

RESULTS

The hydrographic data collected at the two stations are presented in Figs. 1 to 4.

Temperature

The temperature of the surface water at station 1 varied between 27.1°C and 31.9°C and at station 2 between 27°C and 32.3°C. The temperature reached maximum in the month of April and minimum in November at both stations.

Transparency

Transparency values ranged between 0.1 m to 2.07 m and 0.36 m to 0.89 m at station 1 and 2 repectively. The maximum value at station 1 was in April while at station 2 it was in December. The values were low during the monsoon months.

Dissolved oxygen

The oxygen concentration of the surface water varied between 3.3 ml/l to 4.9 ml/l in station 1 and 3.8 ml/l to 4.8 ml/l at station 2. The oxygen values showed the peak in May at both stations and the lowest in February and June at stations 1 and 2 respectively.

pH

pH values of station 1 and 2 showed fluctuations below 7.6 (August) and 8.15 (February) and 7.5 (August) and 8.1 (February) respectively. Fluctuations were

remarkably smaller and similar at both stations. pH values were comparatively low during the monsoon months.

Salinity

Salinity values ranged between 0.4–4.5‰ and from 0.2‰ to 2.8‰ at stations 1 and 2 respectively. With the onset of the monsoon the surface water begins to get diluted owing to inflow of fresh water and in July–August nearly freshwater occupies the lake. Consequently, a drastic decrease in salinity values were observed during the monsoon months. The maximum salinity value was noticed in the month of April. Of the two stations studied, station 1 (near the barmouth) was found to show higher salinity.

NUTRIENTS

Nitrites and nitrates

Nitrate and nitrite concentrations at station 1 varied from 6.31 µg-at/l (January) to 12.3 µg-at/l (September) and from 0.13 µg-at/l (March) to 0.98 µg-at/l (October) respectively. The same ranged between 6.0 µg-at/l (January) and 11.9 µg-at/l (September) and 0.17 µg-at/l (June) and 1.2 µg-at/l (October) at station 2 respectively. Nitrate and nitrite fluctuations were remarkably similar at both stations. A sharp increase in nitrate content was apparent in the month of September at both the sampling points, due presumably to the effect of the monsoon.

Phosphate

In Veli lake, the phosphate concentration at stations 1 and 2 fluctuated from 0.66 to 2.41 µg-at/l and from 0.66 to 2.41 µg-at/l respectively. At both the stations the values reached highest in September and lowest in June. The obsereved peak in September may be attributed to the decomposition of organic matter and resulting regeneration of phosphates and this organic matter was brought into the lake by monsoon floods.

Silicate

Water samples from both stations indicated remarkable similarity in the fluctuation of silicate. During the monsoon months the silicate content was relatively high and reached its maximum (97.2 µg-at/l) in August at station 1 and at station 2 in September (121.5 µg-at/l). The values were observed to be minimum in April (46.3 and 54.1 µg-at/l) at both stations. Increase in the amount of silicate matter by content observed during the monsoon months may be due to the leaching of sillicious freshwater flow during rains.

Distribution ana fluctuations of phytoplankton population

The phytoplankton community of the Veli lake was composed of 53 genera of algae, of which 41 genera (7 of Cyanophyceae, 10 of Chlorophyceae, 22 of Bacillariophyceae and 2 of Dinophyceae) were recorded from station 1 and 47 genera (9 of Cyanophyceae, 17 of Chlorophyceae, 19 of Bacillariophyceae, 1 of Dinophyceae and 1 of Euglenineae) were collected from station 2. Station 2 was found to be richer

in phytoplankton as compared to station 1. Both fresh and brackishwater forms were noted during the present study.

Seasonal fluctuations in phytoplankton abundance

Monthly variations in the cell counts of phytoplankters (excluding nanoplankton) at the two stations are presented in Fig. 5. The phytoplankton crop showed, in general, three peaks. First peak occurred in January, second in April and the third one in July of which the highest was in January. At station 2, a peak was observed in December which was slightly higher than that in January and this was due to the thick bloom of *Merismopedia*. The lush growth of a blue green alga, *Oscillatoria* formed the peak in July. The dominant species

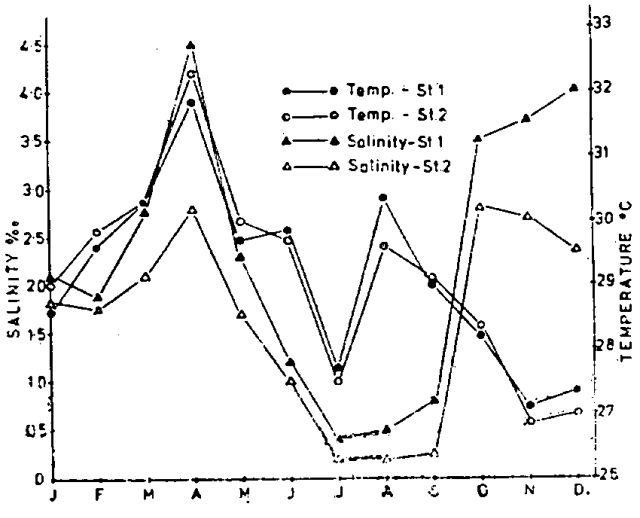

Fig. 1. The average monthly variations in temperature and salinity at two stations of the Veli lake.

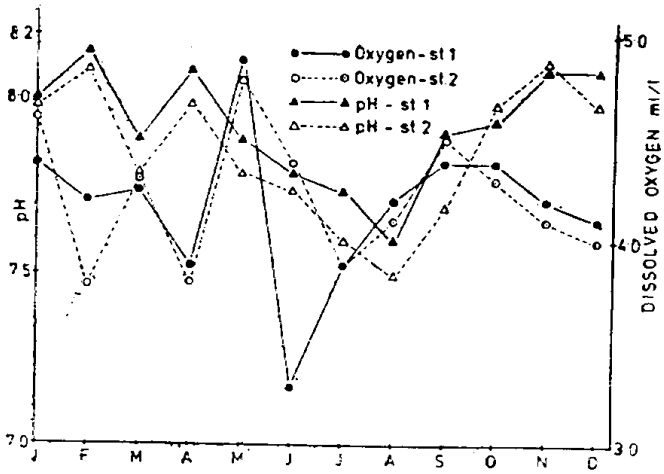

Fig. 2. The average monthly variations in pH and dissolved oxygen at two stations of the Veli lake.

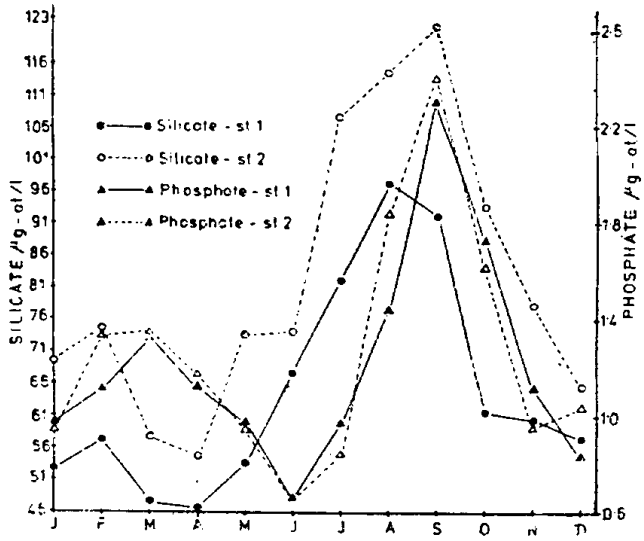

Fig. 3. The average monthly variations in silicate and phosphate at two stations of the Veli lake.

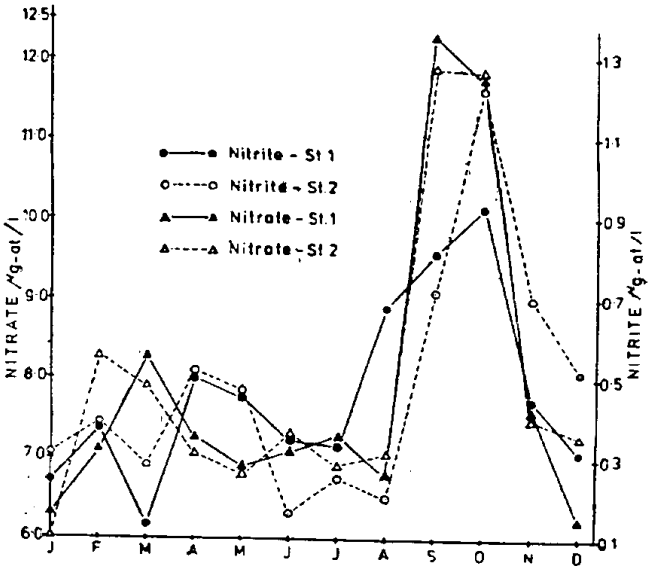

Fig. 4. The average monthly variations in nitrite and nitrate at two stations of the Veli lake.

forming the peak in January was *Spirogyra* spp. at station 2. In station 1 diatoms mainly *Bacillaria paradoxa* and *Cerataulina bergonii* were responsible for the January peak. Species of diatoms such as *Navicula gracilis, Coconeis placentula* and *Fragilaria* sp., green algae such as *Spirogyra* sp. and *Oedogonium* sp. and blue green algae like *Oscillatoria* sp. and *Scytonema* sp. determined the peak in April at both stations. The phytoplankton increase in April was followed by a decrease in May. Thereafter the number increased almost to July peak level in June. The onset of the monsoon had enhanced the growth of conjugales, filamentous desmids and filamentous diatoms which in turn resulted in the increased level of phytoplankters in June. The period of minima was observed in the months of March, May, September, November and December at station 1 and in August, September, October and November at station 2.

Diatoms (Bacillariophyceae)

Diatoms constituted about 28.98 and 15.82% of the total phytoplankters at stations 1 and 2 respectively. Diatom crop showed two peak periods (Table I), first peak in January and a second peak in April at both stations. At station 1 the January peak was at a higher magnitude than that in April. During the peak monsoon months they were barely present. Diatoms showed a preference to premonsoon months and 26 species were recorded from station 1, namely, *Cyclotella meneghiniana* Kutz., *Lauderia annulata* Cleve, *Rhizosolenia* sp., *Chaetoceros orientalis* Schiller, *Ditylum brightwellii* (West) Grunow, *Bellarochea malleus* (Brightwell) Van-Heurek, *Biddulphia sinensis* Greville, *Cerataulina bergonii* Peragallo, *Plagiogramma vanheurckii* Grunow, *Fragilaria oceanica* Cleve, *Fragilaria capucina, Asterionella* sp., *Achnanthes inflata* Grun., *Synedra ulna* Ehrenberg, *Cocconeis placentula* Ehrenberg, *Amphora normani, A. ovalis* Kutz., *Amphiprora* sp., *Pinnularia viridis* (Nitzsch) Ehr., *Navicula gracilis, N. longicephala* Hust, *Pleurosigma stagosum* W. Smith, *Bacillaria paradora* Gmelin, *Nitzschi sigmoidea Nitzsch, N. palea, Surirella robusta* Ehrenberg.

From station 2, 23 species of diatoms were recorded and almost all of them were of the same as at station 1 excepting a few fresh water diatoms like *Tabellaria flocculosa* (Roth) Kutzing, *Cymbella* sp. and *Diploneis* sp. Some of the brackish water and marine forms though appeared at station 1 did not appear at station 2. The diatom abundance in January was due to *Cerataulina bergonii* and *Bacillaria paradoxa* constituting about 50% of the total phytoplankters whereas species of *Coconeis, Fragilaria* and *Navicula* formed the peak in April at both the stations, and composed 22.5% and 25.9% of the total phytoplankers at stations 1 and 2 respectively. Marine forms such as *Bellarochea* sp. and *Lauderia* sp. were observed in June, at both stations forming 99% of the diatom population of that month. The occurrence of such filamentous marine diatoms in Veli lake was due presumably to the mixing up of sea water with the lake water when the barmouth was opened by the end of May. With the exception of a few marine forms such as *Bellarochea malleus* (Brightwell) Van Heurck, *Lauderia annulata* Cleve, *Plagiogramma vanheurckii, Cerataulina bergonii* Peragallo, *Rhizosolenia* sp., *Fragilaria oceanica* Cleve, *Biddulphia sinensis* Greville and *Ditylum brightwellii* (West) Grunow and marine and brackish water

Table 1. Monthly fluctuations in the chief groups of phytoplankton at the two stations of Veli lake during 1977.

Groups	Stations	J	F	M	A	M	J	J	A	S	O	N	D
Bacillario-	I	97650	8213	1460	77080	8783	44000	—	—	400	13500	1580	1000
phyceae	II	63180	23648	46150	76250	16508	28050	70	2222	nil	3250	11590	8828
Chlorophyceae	I	76564	21000	600	42000	1400	110575	11091	34804	12000	24352	31580	3500
	II	253736	48000	33300	95750	7996	144060	9268	19395	16600	—	24090	8500
Cyanophyceae	I	25532	1250	—	46280	3000	303	160000	840	722	7737	1771	6804
	II	6040	10331	24900	75140	18750	600	260000	1120	1200	—	610	306920

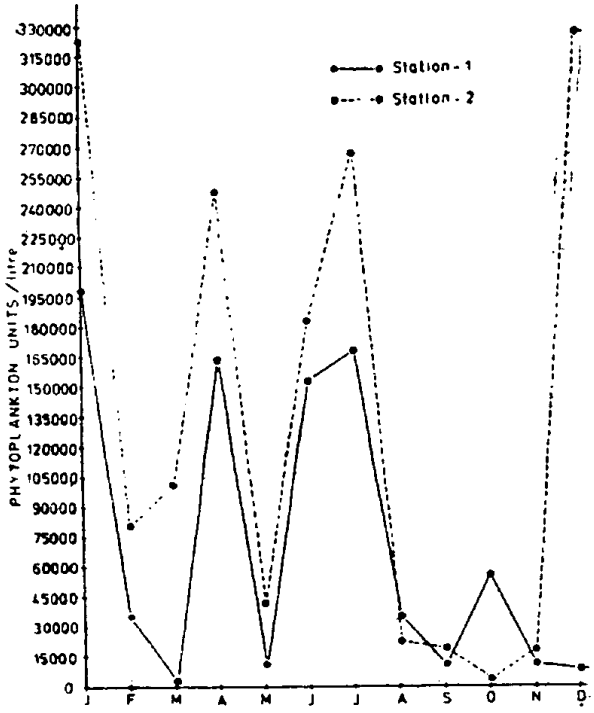

Fig. 5. Monthly fluctuations in phytoplankton abundance at two stations of the Veli lake.

diatoms such as *Cyclotella meneghiniana* Kutz., *Bacillaria paradoxa* Gmelin others were freshwater forms.

Green algae (*Chlorophyceae*)

Green algae comprised of about 38·18% at station 1 and 42·66% at station 2. Table I presents the average monthly abundance of green algae during the year 1977 at stations 1 and 2. The pattern of monthly fluctuation was the same at both stations, but their abundance varied. Station 2 was richer in green algae than station 1. Green algal crop in Veli lake exhibited 2 peaks, one in January and other in June. At station 1, June peak was bigger than that in Junuary whereas at station 2 the January peak was of a higher magnitude. Among green algae, *Spirogyra* spp. were the most abundant and frequently occurring ones that determined the green algal peak in January. The peak in June was due to conjugales mainly of filamentous desmids, such as *Desmidium* sp., *Gymnozyga* sp., *Pleurotaenium* sp., *Microsterias* sp., *Hyalotheca* sp., *Baileyi, Zygnema* and *Mougeotia* and they formed 71% and 78% of the total phytoplankters in the same month at stations 1 and 2 respectively. Species of *Oedogonium* and *Spirogyra* were found to play the important part in determining the seasonal variation of green algae. They were almost absent in March at station 1 and in October at station 2. Stray records of *Enteromorpha* were seen at station 1. Genera represented at station 2 were *Tetraedron, Oocystis, Coelastrum, Dictyosphaerium, Scenedesmus, Volvox, Ulothrix, Oedogonium, Spirogyra, Zygnema, Mougeotia, Desmidium, Gymnozyga, Pleurotaenium, Hyalotheca, Microsterias* and *Closterium*. The forms reported from station 1 were *Dictyosphaerium, Volvox, Ulothrix, Enteromorpha, Oedogonium, Spirogyra, Mougeotia, Desmidium, Gymnozyga* and *Baileyi*.

Blue green algae (*Cyanophyceae*)

In the present study, 7 genera of blue green algae, viz., *Microcystis, Merismopedia, Oscillatoria, Sprirulina, Scytonema, Microchaete* and *Aphanizomenon* were observed in station 1 and they comprised of about 29·36% of the total phytoplankters. At station 2, they formed about 39·27% of the total phytoplankters. 9 genera such as *Gloeocapsa, Merismopedia, Oscillatoria, Spirulina, Lyngbya, Syctonema, Microchaete, Aphanizomenon* and *Anabaena* were encountered at station 2. Cyanophyceae showed only one peak in July at station 1 and two at station 2 in the months of July and December (Table I). The peak in July was due to an *Oscillatoria* bloom and that in December was determined by *Merismopedia* bloom. Blue green algal production was scanty during monsoon and early post-monsoon months with exception of certain bloom occuring months. At station 1 these algae did not appear at all in some of the pre-monsoon months. Hence a seasonwise assessment of blue green algal production in Veli lake was difficult. Among the blue greens *Oscillataria* spp. occurred almost throughout the year. Of the blue green algae represented 75% of them were seen in the month of April when the maximum salinity was recorded for the Veli lake.

Miscellaneous

This group included *Peridinium* sp. and *Ceratium* sp. of Dinophyceae and

Euglena sp. of Euglenineae. They were of very rare occurrence and were observed only in very small numbers during post-monsoon months.

DISCUSSION

As stated by Reid (1961) "the successful development and maintenance of a population depend upon the harmonious ecological balance between environmental conditions and tolerance of organisms to variations in one or more of these conditions". Considering the above, the present study has covered the various hydrological features and phytoplankton population of Veli lake, a tropical brackish water lake of the south-west coast of India.

The temperature as such seems to have no direct influence in phytoplankton production in Veli lake. A similar observation was made by Gopinathan (1972) in Cochin backwater. During monsoon months the lake water was highly turbid and the phytoplankton counts were scanty except for a bloom in July. Thus an inverse relationship between phytoplankton production and turbidity of the water has been observed. This observation confirms the findings of Legare (1951), Welch (1952), Dutta, Malhotra and Bose (1954) and Jhingran (1963) who reported that the high turbidity was accompanied with low production of plankton. Patnaik (1973) found that both high turbidity and sudden dilution due to the influx of freshwater could be responsible for low production of plankton in Chilka lake. However, an inverse relationship between transparency values and plankton counts has been established by Kaliamurthy (1973) and Raman, Ramakrishna, Radhakrishnan and Rao (1975) in the Pulicat lake. On the other hand in Veli lake, the highest transparency values in April and December at stations 1 and 2 coincided with phytoplankton peaks thereby indicating a direct correlation. The low transparency values observed during monsoon may be due to combined effect of turbidity, rainfall, runoff and wind action etc.

Results of the present investigation on the abundance of plankton in the Veli lake indicate that, in general, phytoplankton consisted of freshwater, brackish-water and marine species which appeared and disappeared depending upon the salinity conditions. For example, when the salinity was very low freshwater species dominated in the lake. The variation in salinity operate mainly as a selective agency in determining the composition or types of species that make up the population than on the fertility of the region (Sverdrup, Johnson and Fleming, 1942). The sudden appearance of 6 species of filamentous desmids in June, *Oscillatoria* bloom in July and diatom peak in April when the salinity of the lake water was 1·2‰, 0·2–0·4‰ and 4·5‰ respectively, can be accounted for on the basis of the statement given above. pH variation in Veli lake was not so pronounced and the water remained alkaline throughout. Reynolds and Allen (1968) emphasized the role of pH as a factor in determining the composition of freshwater phytoplankton communities. A good number of Chlorococcalean algae observed in the present study when the pH of the water was 8 or above, supports the finding of Philipose (1967) that alkaline waters were generally rich in Chlorococcales. In the present study no direct bearing of phytoplankton population on the dissolved oxygen content was observed

which is probably because of considerable mixing of alien waters as well as diffusion from and to the atmosphere.

Nutrients such as phosphates, nitrates, nitrites and silicates showed no distinct relationship with phytoplankton abundance. But an increase in nutrient concentrations was observed during late monsoon months. The phytoplankton peak in December and January was possibly due to the rapid vegetative multiplication consequent on the rise of salinity and the enrichment of water after monsoon. Among phytoplankters, green algae (Chlorophyceae) showed its dependence on phosphate and diatoms (Bacillariophyceae) on silicates. The phosphate content of the water decreases with green algae especially in the months of January and June and conversely with the decrease in abundance of green algae there was an increase in phosphate content during September and October. Similarly the silicate values increased during the monsoon period. It was also observed that the silicate content of the water decreased with the increase of diatom population. This confirms the findings of Gopinathan (1975) in Cochin backwater. A detailed account of the definite correlation of the silicate content and diatom population of the Cooum estuary has been given by Iyengar and Venkataraman (1951).

In the present study the phytoplankton peak in July coincided with low salinity and low temperature. As observed by Qasim, Bhattathiri and Devassy (1972), direct relation of phytoplankton production with low salinity and temperature seems an adaptation by phytoplankton to utilise the nutrients to the maximum degree.

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