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SEASONAL PERIODICITY OF PHYTOPLANKTON AND CHLOROPHYLL CONTENT IN LAKE MANCHAR

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Abstract

Seasonal fluctuations of 16 dominant genera of phytoplankton, belonging to 4 groups, (Cyanophyta, Chlorophyta, Euglenophyta and Bacillariophyta) found in Manchar lake were studied. Genus *Anabaena, Chroococcus*, *Merismopedia, Microcystis* and *Pediastrum* were found dominant during spring and summer months. *Oocystis* and *Scenedesmus* were dominant during autumn. In winter, *Chloroococcus, Cyclotella,* and *Oscillatoria* were found dominant. *Gomphosphaeria* was recorded in high density during summer months, while during winter, very small numbers of colonies were observed. Genus *Cymbella* gradually increased during warmer months, with a peak in July, and then it gradually decreased. During cold months; the population was very low. The peak of *Cyclotella* was observed in the month of January. Frequency of Cyanophycean species ranged between 60-70%.

Chlorophyll content of water varied within 19-40 µg/l, during the year. These fluctuations are mostly dependant upon environmental factors such as temperature, salinity, nitrates and phosphate in Manchar lake water.

Introduction

It is a well established fact that more than 75% of freshwater fishes feed on plankton at one or the other stage of their life cycle (Jafri *et al*., 1999). Phytoplankton are the primary producers of water bodies, these are the main source of food directly or indirectly for various animal groups (Rao, 1957). The measurement of primary and secondary productivity gives indication regarding fish production (Panday, 1981).

Physico-chemical parameters and quantity of nutrients in water play significant role in the distributional patterns and species composition of plankton, in aquatic habitat, the penetration of light, temperature, salinity, pH, hardness, phosphates and nitrates are the important factors for growth and density of phytoplankton, on which zooplankton and higher consumer depend for their existence (Mahar *et al*., 2000).

Very little information is available regarding the phytoplankton succession and chlorophyll content of water bodies in Pakistan. Nazneen (1980) described the seasonal abundance and density of phytoplankton in Keenjhar lake. Seasonal variation of phytoplankton in Bakar Lake (Leghari *et al*., 1999), limnological study of Tatta Pani and river Punch (Leghari *et al*., 2000), comparative ecological study of phytoplankton of Bakar and Phoosna lakes (Leghari & Leghari 2001) are mentioned in this connection. The primary production can also be calculated from biomass and chlorophyll content. Only phytoplankton biomass is often estimated by measurement of chlorophyll (Cloern *et al*., 1995).

Present studies report on the seasonal variation of phytoplankton and planktonic chlorophyll of Manchar lake with a view to contribute some knowledge about the biological status of this shallow lake of Sindh.

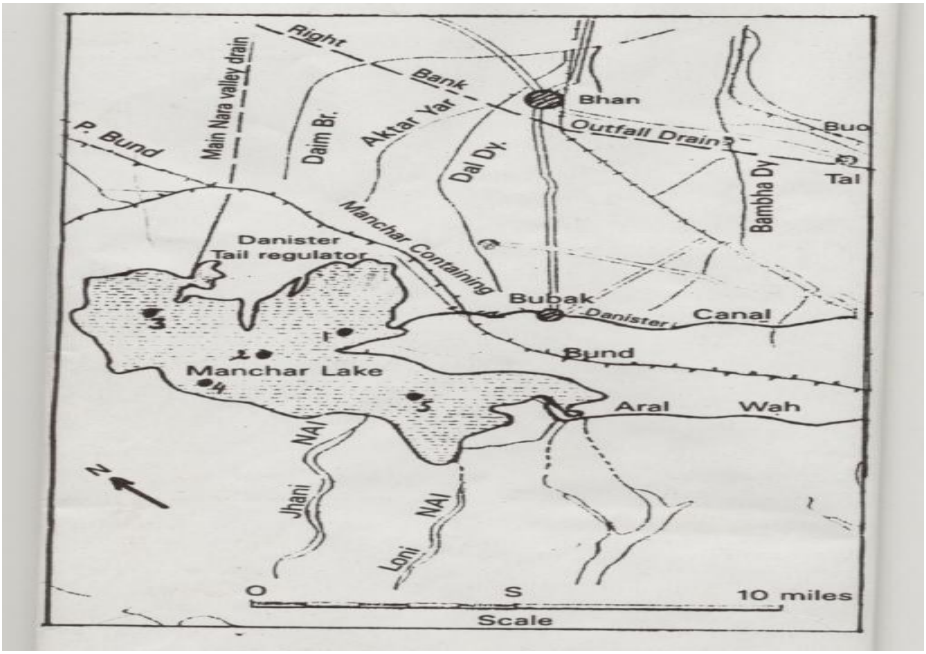

Fig. 1. Sampling stations in the map of Manchar lake.

Materials and Methods

Five sampling stations were selected in Manchhar lake (Fig. 1). Surface water sampling of algae was carried out on monthly basis for the study of species composition, seasonal variation of phytoplankton and estimation of chlorophyll contents. Sampling was carried out between 8.00 am to 4.00 p.m. during January to December 2004.

Phytoplankton samples were collected by plankton net (mesh size 55µm) and preserved in 4% formalin and brought to the laboratory. For quantitative study of phytoplankton genera, one liter of lake water was taken in sterilized glass bottles from sampling site, next day the samples were centrifuged in laboratory at 500 rpm for 5 minutes. Residues were placed in Sedgwick Rafter counting chamber, enumeration was done by drop method. The taxonomic identification and systematic arrangement of the species were done according to the classification of new millennium given by Shameel (2001).

For analysis of chlorophyll content in water of Manchar lake, 500 ml of water sample was taken, 3-5 drops of aqueous solution of Magnesium carbonate (50%) was added to avoid the degradation of chlorophyll. Sample was brought into laboratory and centrifuged at 2000 rpm for 15 minutes. The supernatant layer (water) was discarded and then residue was added in 10ml of acetone (90%). The filtrate was transferred into dark bottle and capped tightly; it was placed in refrigerator for 14 hours to allow complete extraction of chlorophyll. Again the content of brown bottle was centrifuged at 3000 rpm for about 15 minutes. The supernatant was transferred to a volumetric flask of 10 ml and the volume of contents was raised to 10ml by further adding 90% acetone. The optical density (OD) of the extract was recorded on Hitachi 220 Spectrophotometer at 630nm, 645nm, 663nm and 750 nm according to the recommended method of APHA (Anon., 1992).

Results

The total algal flora consisting of 28 genera and 74 species (36 species of Cyanophyta, 23 species of Chlorophyta, 8 species of Euglenophyta and 7 species of Bacillariophyta) were recorded from Manchar lake (Table 1).

The seasonal variations of 16 dominant genera have been studied (Figs. 2-5). Higher population of *Chroococcus* was recorded in February (Fig. 2). Population was much reduced in May and June. Lower population was recorded in July and November. Three peaks of *Coelosphaerium* occurred during February, May and November. The population occurred with slight variations during rest of the year, except January when the population was lowest. Occurrence of *Microcystis* showed a gradual increase from winter to summer months, with a peak in July to August. The population slowly declined till December. The seasonal fluctuations of *Merismopedia* showed two peaks, one observed in March and the other in August. The population was fairly consistent during rest of the year. Higher population of *Gomphosphaeria* was observed in summer months (May to August). Population of this genus was lower in October and February. No population of this genus was recorded during September, December January, March and April. Higher population of A*nabaena* species was observed during the period of February to May. During this period, the water level declined gradually. Due to the entry of freshwater and rainwater into the lake after summer months, the population of *Anabaena* was comparatively reduced from July to November (Fig. 3). The seasonal fluctuation in *Cylindrospermum* showed distinct change. Low population was observed in winter months while higher number was recorded in summer. Peak of this genus occurred during August. Three peaks were observed in the population of *Oscillatoria* in February, June and September. *Scenedesmus* contributed to the community throughout the year. Low population was observed from January with a small peak in March, while high population was recorded from August to November. The presence of *Oocystis* was low during April-September peak was found in October. Genus *Pediasterium* was recorded throughout the year except November. Two maxima (April and October) and two minima (June and November) were conspicuous. The occurrence of genus *Cosmarium* was irregular. The population was recorded from all stations of the lake, throughout the year except July. One maxima (April) and two minima (July and October) were apparent (Fig. 4). The population of genus *Euglena* was very low throughout the year. A single peak however occurred during February. The population of genus *Phacus* showed two peaks, one was observed during January and other in October. The population of this genus was low during summer months and was not recorded at any station during the month of May (Fig. 5). There was a prominent peak of *Cyclotella* in January and was low during rest of the year. Genus *Cymbella* was present throughout the year at almost all stations. Population was low during cold season while from April onward, their number gradually increased upto July (a prominent peak) and decreased gradually up to October (Fig. 6).

The seasonal variation of phytoplankton show the rate of primary production throughout the year the population of total phytoplankton gradually increased as temperature rose from April with highest density in August. The populations gradually decreased up to December (Fig. 7).

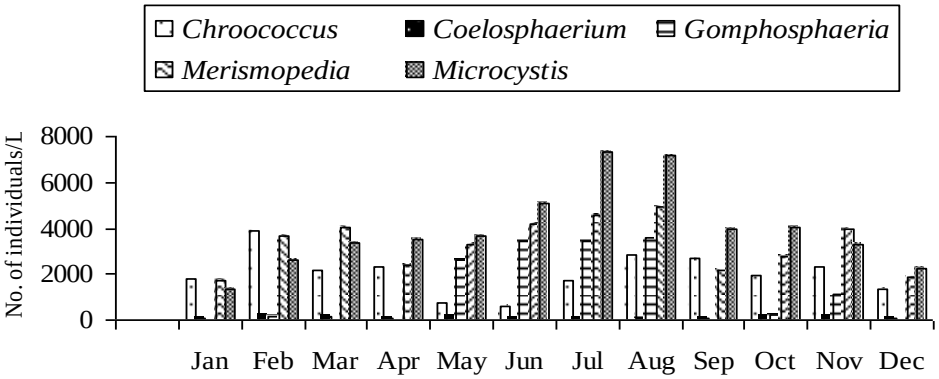

Fig. 2. Seasonal abundance of phytoplankton (members of Cyanophyta) in Manchar lake.

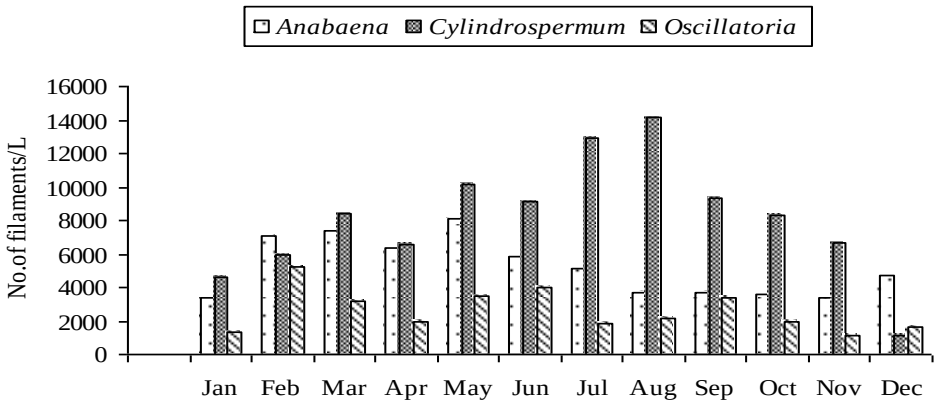

Fig. 3. Seasonal abundance of phytoplankton (members of Cyanophyta) in Manchar lake.

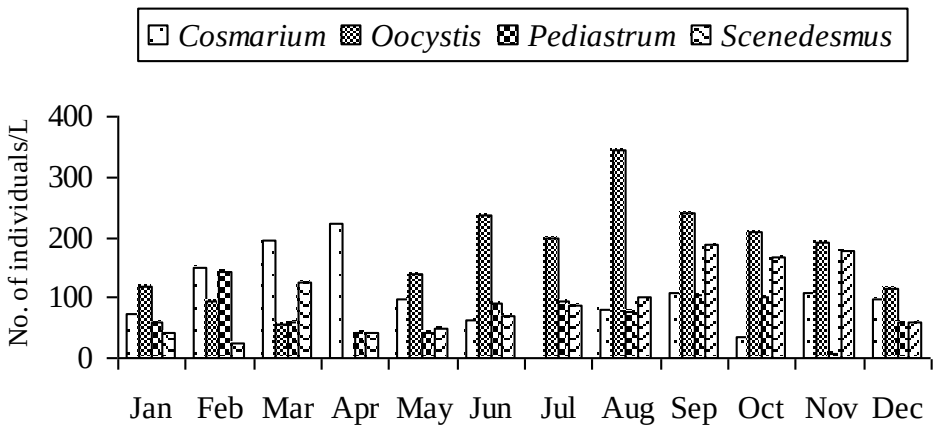

Fig. 4. Seasonal abundance of phytoplankton (members of Chlorophyta) in Manchar lake.

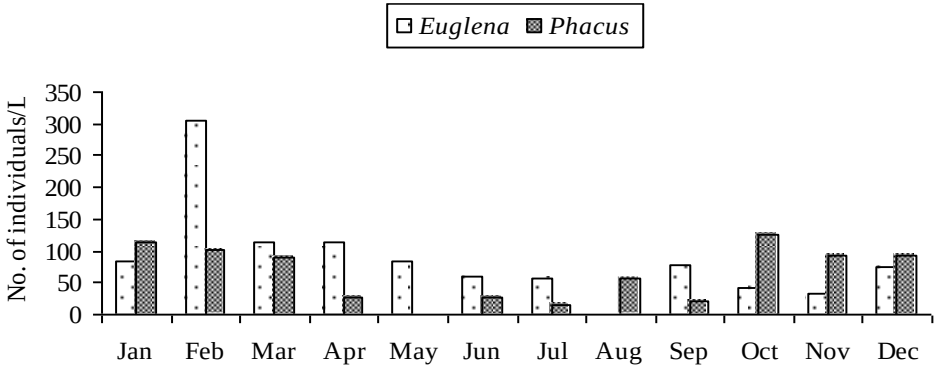

Fig. 5. Seasonal abundance of phytoplankton (members of Euglenophyta) in Manchar lake.

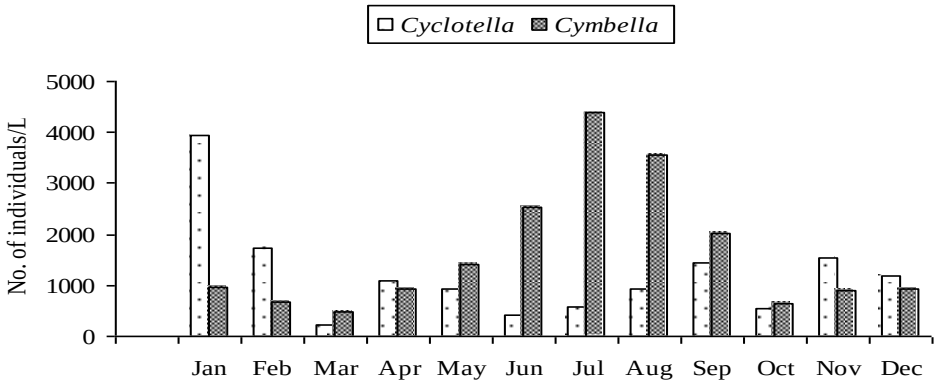

Fig. 6. Seasonal abundance of phytoplankton (members of Bacillariophyta) in Manchar lake.

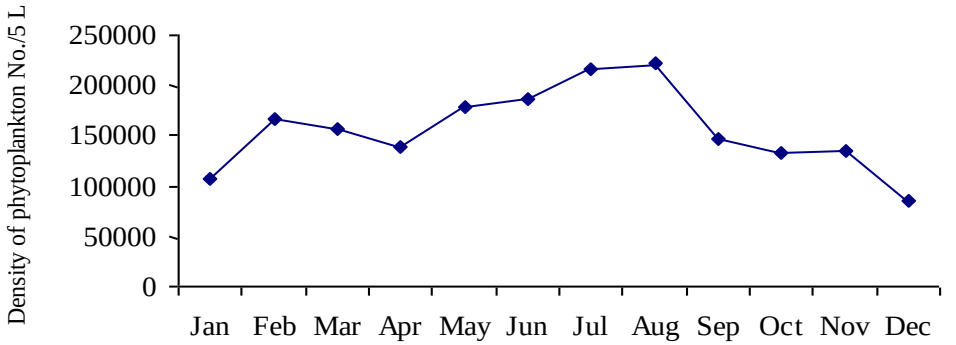

Fig. 7. Seasonal fluctuation of phytoplankton in Manchar lake.

Table 2. Seasonal succession of various phytoplankton genera in Manchar lake.

Winter (Nov.-Feb.)	Spring (Mar.-Apr.)	Summer (May-Aug.)	Autumn (Sep.-Oct.)
Euglena	*Cosmarium*	*Anabaena**	*Oocystis**
Pediastrium	*Aphanocapsa*	*Cylindrrspermum**	*Phacus*
*Chroococcus**		*Gomphosphaeria**	*Scendesmus*
Coelosphaerium		*Merismopedia**	
*Oscillatoria**		*Microcystis**	
*Cyclotella**		*Cymbella**	

*Dominant genera

Fig. 8 shows the frequency of occurrence of four major groups of phytoplankton in Manchhar lake. The most dominant group was that of Cyanophyta. Highest percentage was recorded in February. The population of this group remained high throughout the year, with a little variation (68 to 81.3%). The second dominant community was that of Chlorophyta. The over all percentage ranged from 9.24 to 15.25. The population was not much different throughout the year. In Bacillariophyta, the percentage ranged from 5.31% to 19.43%. The group Euglenophyta occupied a very small portion in the phytoplankton community (0.34 to 1.11%). During winter months the occurrence of this group was higher.

Seasonal succession: Table 2 shows the seasonal succession of various genera of phytoplankton. The four seasons (a) Winter (b) Spring (c) Summer and (d) Autumn are arbitrarily recognized in the subtropical climate of Manchhar lake and are based on the atmospheric temperature which is by the temperature of water. *Cyclotella*, *Euglena* and 5 genera of Cyanophyta appear to require low light and low temperature of winter. As the light and temperature starts increasing during spring, *Cosmarium* and *Aphanocapsa* exhibit their peaks. Period of intense light and warm water during summer is dominated by a Diatom genus, *Cymbella* and 5 species of Cyanophyta. As the temperature of water and light gradually decreases in autumn, *Oocystis*, *Phacus* and *Scenedesmus* develop their blooms. All these genera are also present in other months of the year in small numbers; some of these totally disappear for a short period and then reappear again. These changes are probably due to seasonal variation in available nutrients and water temperature (Table 2).

Chlorophyll: The picture of chlorophyll a, b, and c of lake water are shown in Fig. 9. It was slightly higher during the period of May-July. The highest value (34.12 µg/l) of chlorophyll-*a* was found in May. Low value (2.796 µg/l) was found in July due to entry of river water. During winter months the high concentration was noted at all the sampling stations and low quantity was recorded in July August and September. Two peaks of chlorophyll-*b* were observed in December, January and August. In March the low values were found at all stations (2.586-6.372 µg/l). The high ratio of chlorophyll-*b* was noted in winter months in the lake. The mean values exhibit two maxima in January and December. The picture of chlorophyll-*c* is also given in Fig. 8, from January to March low values of chlorophyll-*c* were recorded. After August there was a gradual increase up to December. The monthly fluctuation in total chlorophyll is shown in Fig. 10. High values were recorded during the period of October to December. A gradual increase from July to December, but values during summer and winter months were not much different.

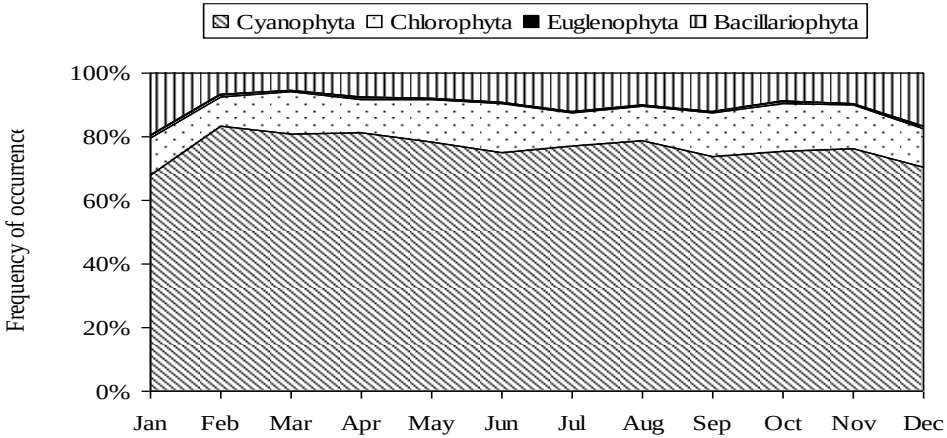

Fig. 8. Seasonal variation (in percentage) of 4 major groups of phytoplankton in Manchar lake.

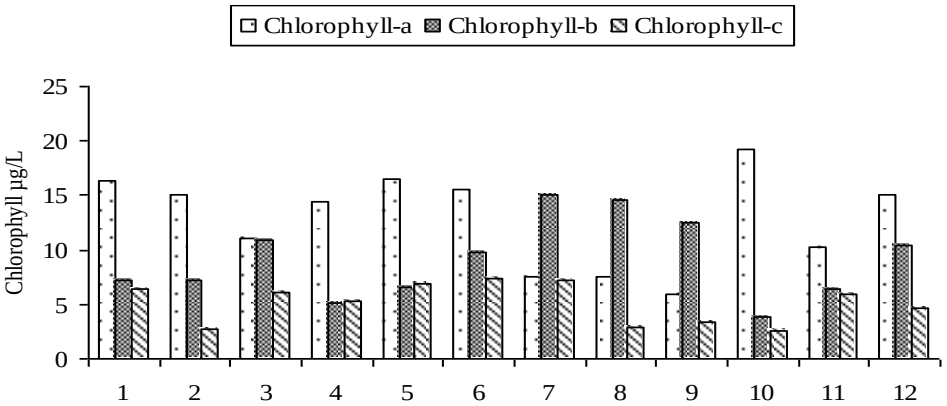

Fig. 9. Seasonal fluctuation of chlorophyll *a*, *b*, and *c* content in Manchar lake.

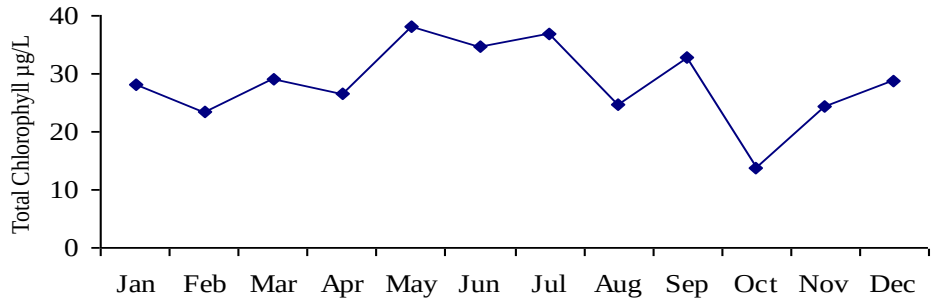

Fig. 10. Seasonal variation of total chlorophyll content in Manchar lake.

Discussion

Subtropical lake Manchar is located at longitude 67º, 34' to 67º, 43' E while its latitude extends as from 26º, 23' to 26º, 28' North on the globe. Various limnological factors indicate that it is a shallow, highly eutrophic lake (Mahar *et al*., 2004). The water temperature ranges between 16-30ºC, pH varied 7.4-8.7, Hardness 614-1000 mg/L, dissolved oxygen, salinity, orthophosphate, total nitrogen and total dissolved solids (TDS) ranged 5.2-9.1mg/L, 1.89-3.9g/L, 0.11-0.38mg/L, 1.68-3.5 µg/L and 1965-4532mg/L respectively (Mahar *et al*., 2000) Seasonal successions of phytoplankton are affected by strong seasonal and ecological influences. The members of blue green algae gradually start to increase in early summer, as temperature starts to increase and attain their maxima in mid summer. *Microcystis, Merismopedea, Aphanocapsa* and *Gomphospharium* were found to exhibit luxuriant growth in summer. Temperature plays an important role in the periodicity of blue green algae as emphasized by Mahar *et al*., (2004). Occurrence of *Microcystis* shows a gradual increase from winter to summer months, with a peak in July-August. The population slowly declines till December at all stations. This may be due to the temperature and salinity changes. Some species are observed irregularly during various seasons with maxima generally in summer. Under normal conditions in enclosed water bodies of tropical impoundments, a continuous high population of phytoplankton, especially *Microcystis aeruginosa*, occurs throughout the year, with a bloom in summer (Ganapati, 1969). Two peaks of *Merismopedea* were observed in March and August. The population was fairly consistent at almost all stations during rest of the year. The development of *Merismopedea* is related to favorable temperature. The populations of *Aphanocapsa*, *Gomphospharium, Cylindrospermum* was highest during April. The high concentration of phosphates results into blooming of *Microcystis* (Nandan & Patel, 1992). Bloom of cyanophycean algae in lake is an obvious signe of cultural eutrophication which is basically caused by addition of sewage effluents (Horn and Goldman, 1994). This is also true for Manchhar lake. Higher population of *Anabaena, Chroococcus* and *Coelosphaerium* were recorded in February. Leghari *et al*., (2000) observed that phosphates were high just prior to the development of blooming of *Anabaena raciborskii*. Nazneen (1980) also reported the occurrence *Anabaena* only during spring and early summer in Keenjhar lake. Three peaks were observed in the population of *Oscillatoria* in February, June and September. The *Oscillatoria* increases considerably in number towards the rainy season (Nandan & Patel, 1992). Genus *Oscillatoria* has been found to be very tolerant to pollution and frequently grows in polluted waters (Rai & Kumar, 1976). Present findings show that genus *Oscillatoria* dominated in lake during summer. Palmer (1969) concluded that *Oscillatoria limosa* and *O. tenuis* are more likely to be present than other species when organic pollution exists. The genus *Cosmarium* was recorded from all stations of the lake, throughout the year except July. One maxima (April) and two minima (July and October) were evident. Over all population of *Euglena* was low throughout the year. A single peak however occurred during February mainly due to higher population. Two peaks of *Phacus* were observed during January and October. The population of this genus was low during warmer months and was not recorded at any station during the month of May. Genus *Cymbella* was present throughout the year at almost all stations. Population was low during cold months while from May onward, their number gradually increased up to July (a single peak) and again decreased gradually up to October. The species of this genus have been recorded throughout the year in Keenjhar lake with maximum populations in autumn and winter

(Nazneen, 1980). Appearance of algal blooms and their end is due to chemical (nutrients) and biological (grazing) factors (Mahar *et al*., 2004). The changes in community structure of phytoplankton indicate their ability to tolerate the temperature and grazing pressure of various zooplankton and fish.

Seasonal changes in density of phytoplankton and total chlorophyll grossly reflect each other, showing a diarchic pattern having one peak in spring and the other in summer. As Manchar is a shallow eutrophic lake, the availability of nutrients is not limiting. The pattern of seasonal cycle corresponds to category 'd' mentioned by Mahar *et al*., (2004) where there are two peaks of phytoplankton growth. In Manchar lake, Cyanophyta forms more then 70% of phytoplankton. Similar situation has been reported in an African tropical lake Georg, Uganda (Horn & Goldman, 1994).

The seasonal succession of phytoplankton in the lake exhibits the typical pattern found in tropical waters when temperature is higher but various seasons are not as distinct as found in temperate climate. Summer group is dominated by *Cymbella*, *Anabaena*, *Microcystis*, *Merismopedia*, *Gomphospheria* and *Cylindrospermum*, while winter group is dominated by *Cyclotella*, *Chroococcus*, *Oscillatoria*.

The mechanism of seasonal changes in phytoplankton can be based upon physical, chemical and biological environmental factors of any water body. The distribution of phytoplankton in the lake is regulated mainly by temperature, light, nutrients, toxicants, parasitism, grazing and inter-specific competition.

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