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THE PHYTOPLANKTON OF LAKE BUYUKCEKMECE, ISTANBUL, TURKEY

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Abstract

Phytoplankton samples were taken fortnightly from alkaline and oligotrophic Lake Büyükcekmece,Marmara region, Turkey during 1996-1998. A total of 65 phytoplankton taxa belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Cryptophyceae were encountered. Bacillariophyceae was dominant among the phytoplankton groups. *Cyclotella ocellata* Pantocsek, *Navicula gracilis* Ehrenberg, *Cocconeis placentula* Ehrenberg and *Nitzschia palea* (Kutz.) W. Smith were found to be widespread. Seasonal development of phytoplankton is characterized by a definite spring peak followed by a moderate summer peak. The relationship between abiotic factors and the dynamics of phytoplankton is discussed.

Introduction

As one of the inner water reserves of Marmara region in Turkey, Lake Büyükçekmece is increasingly becoming important in terms of fishing water source and tourism. At present no scientific literature is available about the phytoplankton of this lake. All of the previous limnological investigations of the Lake Büyükçekmece were primarily concerned with physical and chemical studies, the biota with the exception of the fish, was largely ignored (Uyguner & Gözenalp, 1959; Çimen, 1988). In this paper, an effort was made to associate physical and chemical data with phytoplankton composition in Lake Büyükçekmece. Phytoplankton populations respond quickly to eutrophication. A series of quantitative and qualitative analyses defining the trophic status of Lake Büyükçekmece can be used to establish the conditions of the lake in the past.

Description of study site

Lake Büyükçekmece (41° 02' N - 28° 32' E) with an area of 1,100 ha of area and a depth of 9.4 m is a temperate, oligotrophic lagoon situated at an elevation of 0.5 m etc. (Temel, 1997). The lake water also provides a major irrigation source for the neighbouring cultivated areas. The run off from these areas is the additional source of antropogenic nutrient load of the Büyükçekmece Lake.

Sampling and methods

Four representative stations were selected in the lake (Fig. 1). Maximum depth of station 1, 2, 3 and 4 was 36, 45, 215 and 761 cm respectively. Samples were taken to determine the concentrations of chemical constituents in water and to quantify biomass and structure of algal assemblages. Water was collected using a 2 l Nansen sampling

device just below the surface. Water temperature and dissolved oxygen concentrations were measured in the field. Nutrients were determined using methods APHA (Anon., 1987).

Samples were preserved with modified Lugol's solution (Nauwerck, 1963; Vollenweider, 1969) and phytoplankton were enumerated using the methods of Lund *et al.*, (1958) which are based upon Utermöhl's (1931) techniques. The cell volume of each species was computed from the average dimensions and the geometrical shape that most closely resembled the species form (Vollenweider, 1969). The total biovolume was recorded as total volume Per millilitre.Biovolume was converted to wet weight assuming a specific gravity of 1.0.

For chlorophyll estimations a water sample was taken from the surface of the lake at stations 1,2 and 4. These samples were filtered through GF/C Whatman glass fibre papers and pigments were extracted in 10 mL of 90% acetone over a period of 24 hrs in dark at 4°C. The pigment contents of extracts were determined using the formula of Parson & Strickland (1963). The various important reviews on the subject were utilized for identification of the species after reference to literature (Cleve-Euler, 1951; Huber–Pestalozzi, 1942; Husted, 1930; Lind & Brook, 1980; Patrick & Reimer, 1975; Prescott, 1961; Krammer & Lange-Bertalot, 1986-1991; Tiffany, 1971).

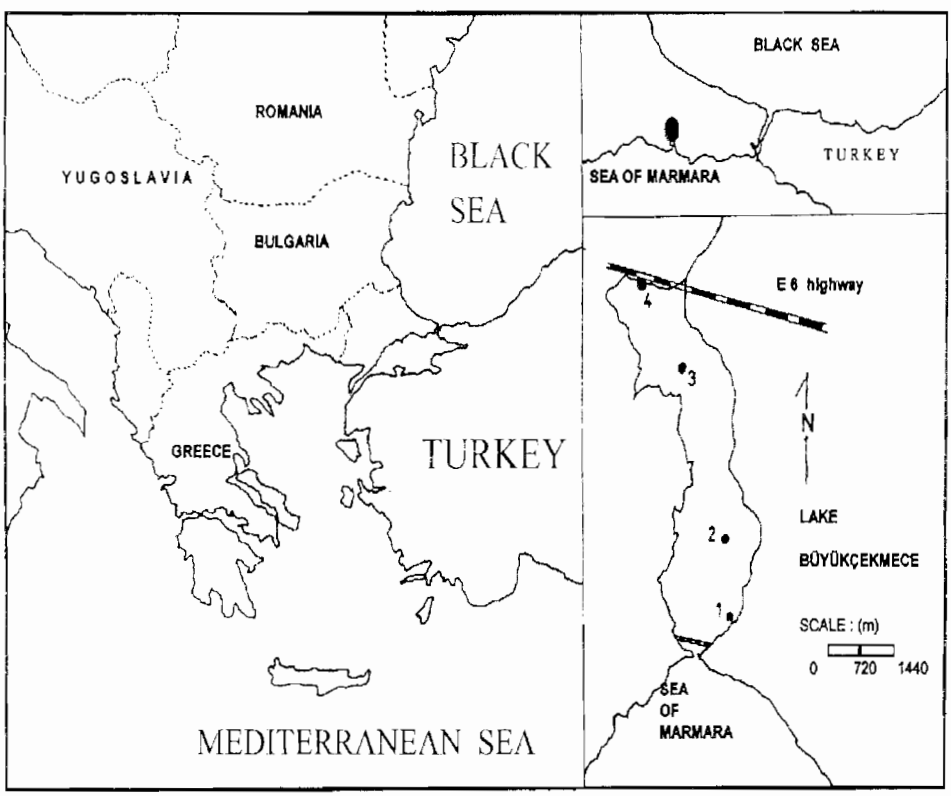

Fig. 1. Location of Lake Büyükçekmece and sampling stations.

Results

Physical and chemical factors: Seasonal mean temperature of water varied from 2-27 °C, with maximum values in summer. Dissolved oxygen varied from 7.00 to 11.09 mg.L^{-1} pH varied from 7.75 to 9.52, total hardness of water 5.5 - 18 ° F, chlorides 0.71 to 1.77 mg.L^{-1}, nitrate values between 0.01–1.83 mg.L^{-1}, with higher values at station 2 and 4 and lower values at station 1.

In Lake Büyükçekmece, 0.02-1.83 mg.L^{-1} and 0.03–1.79 mg.L^{-1} nitrate were measured at 2 and 4 stations, on March 23,1997 and on January 12,1997 respectively, whereas 0–0.007 mg.L^{-1} and 0–0.009 mg.L^{-1} phosphate were measured at 2 and 4 stations on February 23,1997 and January 22, 1997, respectively.

Numerical values per cm^3 of phytoplankton biomass are generally correlated with the amount of pigment. Predominant growth of *Spirogyra* sp., in November 1996, the amount of chlorophyll a in superficial waters was 4.52–66.87 mg.m^{-3}. In the following months it declined to 0.05 – 4.55 mg.m^{-3} with decreasing numbers of microflora (Fig. 2).

Species composition and abundance: Out of a total of 65 taxa identified (Table 1) 3 main classes in phytoplankton were distinguished: Bacillariophyceae (46 species), Chlorophyceae (8 species) and Cyanophyceae (5 species). Bacillariophyceae were dominant at all the stations in terms of the numbers of species (Fig.3). When recurrence rates were scanned according to the stations, *Cyclotella ocellata* and *Navicula gracilis* were found to be abundant at all stations . *Nitzschia palea* were abundant in 2 and 3 stations and *Cocconeis placentula* in 4 station. *Cocconeis placentula var. euglypta*, *Navicula gracilis* and *Synedra acus* were found abundant at 1 , 2 , 3 and 4 stations, whereas *Gyrosigma acuminatum* in 1 and 4 and *Meridion circulare* in the 1 station. *Cyclotella ocellata* , *Navicula gracilis* and *Nitzschia palea* were very abundant diatoms followed by *Cocconeis placentula*, *Cymbella ventricosa*, *Gyrosigma acuminatum*, *Meridion circulare* , *Synedra acus* and *Synedra ulna*. Other species were usually rare and or encountered in low concentrations.

The abundance of diatoms was high in spring 1997 at station 1 and 2. In autumn 1996 at station 2., in spring 1997 at station 3 and in winter 1998 at station 4 . It amounted to 98.43 % in May 1997 at station 1., 94.85 % in October 1996 at station 2, 99.38 % in May 1997 at station 3 and 98.36 % in January 1998 at station 4.

Green algae had a high relative abundance in summer at all the stations. The abundant green alga was *Scenedesmus quadricauda*. Cyanophyceae reached the relative abundance of 21.92 % in October 1996 at station 1, 19.63 % in August 1997 at station 1, 3.5 % in October 1996, 22.75 % in August 1997 at station 2., 11.65 % in december 1997, 31.06 % in August station 3 and 14.89 in August 1997 at station 4. Euglenophyceae were found in low numbers (3 species). The relative abundance of Euglenophyceae ranged from the minimal values of 0.0 % to the highest of 11.33 % during the sampling periods. Cryptophyceae had a maximum relative abundance in February 1998 at station 1 with 76.65 %, in January 1998 at station 2 with 30.97 %, in February 1998 at station 3 with 61.23 % and in September 1997 at station 4 with 39.76 %. *Cryptomonas erosa* of Cryptophyceae were abundant (Fig. 3).

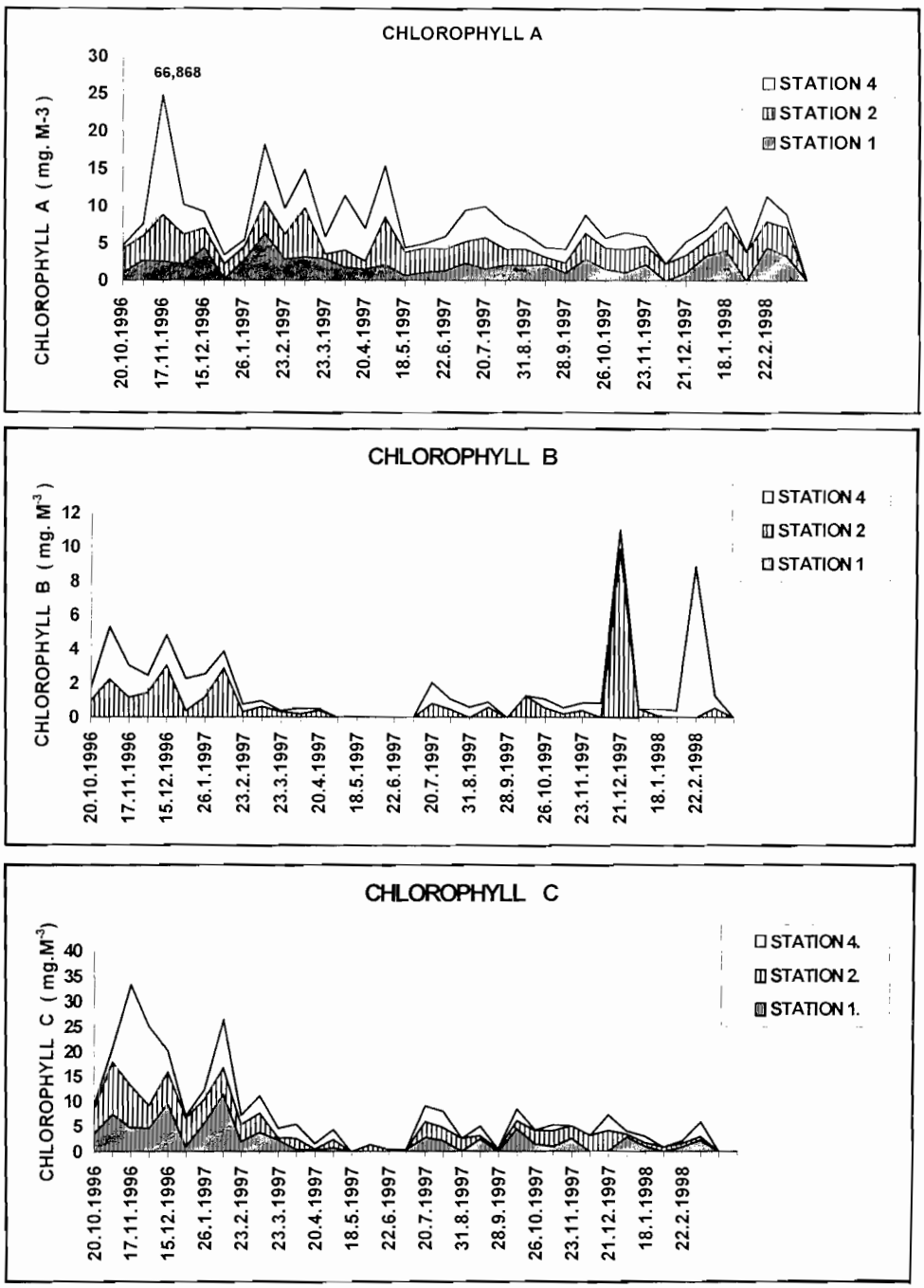

Fig. 2 . Seasonal variation in Chlorophyll a, b and c at stations 1, 2 and 4 in Lake Büyükçekmece (for October 1996 to February 1998).

Table 1. The frequency ratios of taxa at sampling stations (percentage of the number of samples in which organisms were found in relationship to the total number of samples); Very abundant, 61-100 % frequency; Abundant, 41-60 %; Common, 16-40 %; rare, 1-15 %; * = (present occasionally, single specimen); - = (absent); (data for October 1996 to March 1998).

Taxa	Stations			
	1	2	3	4
	Number of samples			
	29	24	31	31
	%	%	%	%
BACILLARIOPHYCEAE				
Centrales				
Cyclotella meneghiniana Kütz.	13.8	20.8	25.8	22.6
C. ocellata Pantocsek	65.5	75.0	67.7	61.3
Aulacoseira italica (Ehr.) Simonsen	6.9	8.3	6.5	6.5
Melosira varians C.A. Agardh	-	12.5	3.2	3.2
Pennales				
Achnanthes lanceolata (Breb.) Grun.	-	-	-	10.7
Amphora ovalis Kütz.	6.9	12.5	12.9	22.6
Asterionella formosa Hassal	10.3	-	-	3.2
Bacillaria paradoxa Gmelin	3.4	8.3	-	3.2
Caloneis amphisbaena (Bory)Cleve	-	-	-	3.2
Cocconeis placentula Ehr.	48.3	58.3	54.8	71.0
C. placentula var. euglypta (Naegeli) Hust.	17.2	4.2	-	-
Cymatopleura elliptica (Breb.) W. Smith	-	4.2	3.2	-
C. solea (Breb.) W. Smith	10.3	12.5	32.3	25.8
Cymbella affinis Kütz.	-	8.3	6.5	6.5
C. helvetica Kütz.	17.2	12.5	*	-
C. lanceolata (Ehr.) V. Heurck	20.7	12.5	9.7	12.9
C. tumida Grun.	6.9	8.3	9.7	19.4
C. ventricosa Kütz.	34.5	45.8	54.8	51.6
Diatoma vulgare Bory.	17.2	4.2	12.9	6.5
Diploneis ovalis (Hilse) Cleve	-	-	3.2	6.5
Fragilaria crotonensis Kitton	6.9	-	6.5	12.9
Gomphonema acuminatum Ehr.	4.2	-	3.4	-
G. augur Ehr.	10.3	-	*	-
G. intricatum Kütz.	20.7	-	12.9	9.7
G. olivaceum (Lyn.) Kütz.	20.7	8.3	22.6	19.4
Gyrosigma acuminatum (Kütz.) Rabh.	27.6	41.7	29.0	41.9
Hantzschia amphioxys (Ehr.) Grun.	10.3	4.2	16.1	25.8
Meridion circulare Agardh	41.4	33.3	29.0	35.5

Table 1. (Cont'd.)

Navicula cryptocephala Kütz	3.4	4.2	6.5	6.5
N. cuspidata Kütz.		4.2	6.5	6.5
N.gracilis Ehr.	86.2	87.5	90.3	93.5
Navicula sp.	6.9	16.7	35.5	3.2
Nitzschia acicularis W. Smith	44.8	41.7	41.9	38.7
N.closterium (Ehr.) W. Smith	6.9	12.5	22.6	16.1
N.hungarica Grun.	13.8	16.7	12.9	22.6
N. linearis W. Smith	20.7	25.0	38.7	19.4
N. palea (Kütz.) W. Smith	51.7	62.5	61.3	51.6
N. sigma (Kütz.) W. Smith	13.8	25.0	29.0	25.8
N. sigmoidea (Ehr.) W. Smith	13.8	8.3	6.5	6.5
Pinnularia brebissonii (Kütz.) Rabenhorst	3.4	8.3	12.9	6.5
Stauroneis anceps Ehr.	13.8	8.3	19.4	6.5
Surirella angusta Kütz.	27.6	25.0	19.4	-
S. ovalis Brebisson	10.3	8.3	22.6	16.1
Synedra acus Kütz.	41.4	45.8	48.4	38.7
s. ulna (Nitzsch.)Ehr.	37.9	45.8	48.4	41.9
S. ulna var. biceps. (Kütz.) Schonfeldt	24.1	12.5	12.9	16.1
CYANOPHYCEAE (CYANOBACTERIA)				
Anabaena affinis Lemmermann	17.2	12.5	16.1	3.2
A.spiroides Klebahn	-	-	6.5	-
Anabaenopsis sp.	20.7	8.3	9.7	12.9
Merismopedia glauca (Ehr.) Naegeli	3.4	-	-	-
Oscillatoria princeps Vaucher	13.8	12.5	6.5	3.2
Spirulina major Kütz.	3.4	-	-	3.2
CHLOROPHYCEAE				
Closterium sp.	6.9	4.2	6.5	3.2
Cosmarium formulosum Hoffman	17.2	12.5	16.1	6.5
Gonium sp.	6.9	-	-	-
Pandorina morum Bory	17.2	4.2	9.7	9.7
Pediastrum duplex Meyen	20.7	8.3	-	-
Scenedesmus-quadricauda (Turb.) Breb.)	3.4	-	*	-
S. bijuga var. Alternans (Reinsch) Borge	27.6	20.8	45.2	3.2
Spirogyra sp.	6.9	-	3.2	-
EUGLENOPHYCEAE				
Euglena acus Ehr.	17.2	16.7	35.5	12.9
E. ehrenbergii Klebs.	3.4	-	-	3.2
Phacus orbicularis Huebner	6.9	-	9.7	-
CRYPTOPHYCEAE				
Cryptomonas ovata Ehr.	34.5	29.2	25.8	35.5
C. erosa Ehr.	55.2	41.7	54.8	41.9

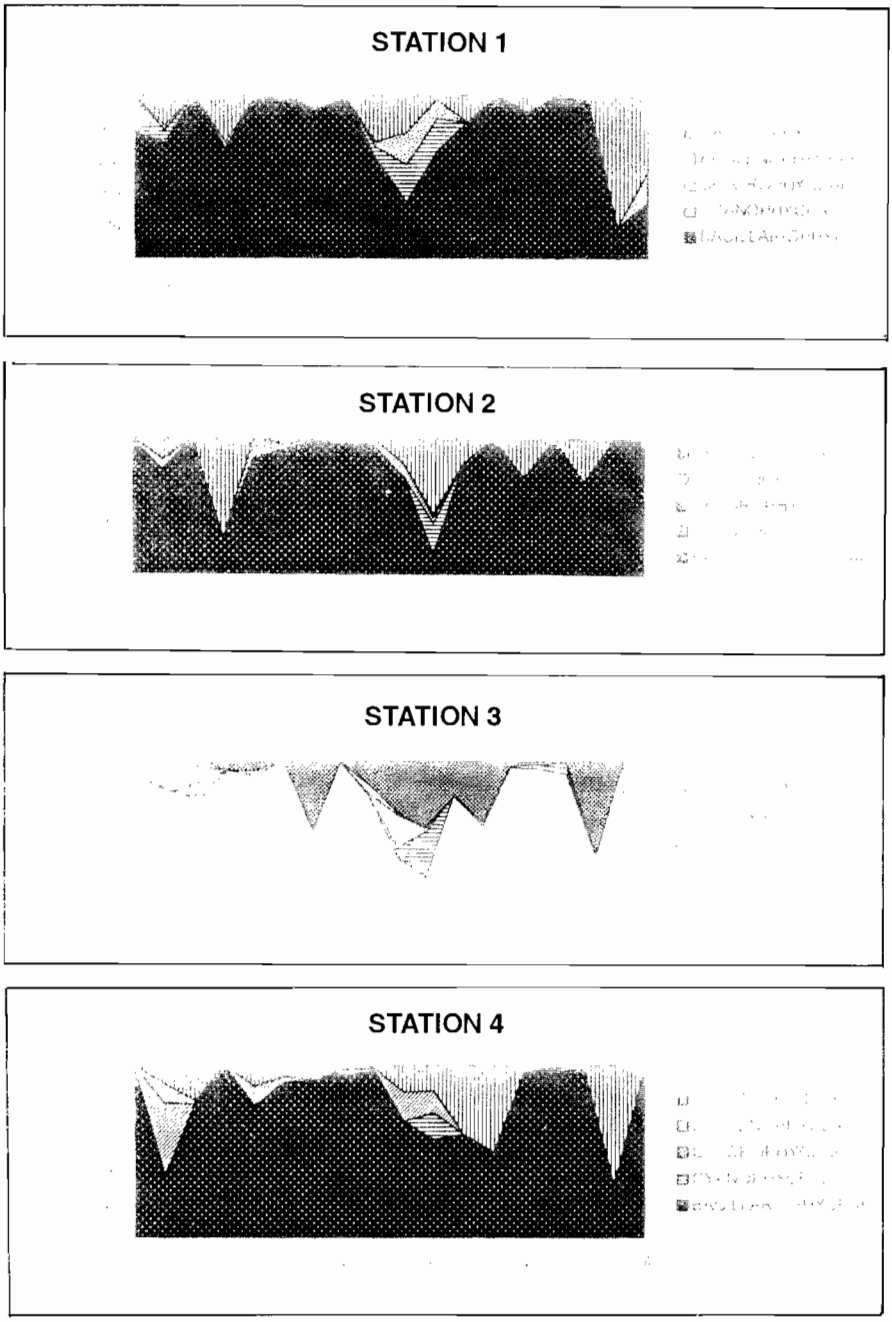

Fig. 3. Relative monthly abundance of the distinguished algal classes in Büyükçekmece Lake (for October 1996 to March 1998).

Annual cycle and seasonal variations

Cell numbers often are not representative of true biomass because of considerable variation in the size of cells among algal species (Vollenweider,1974). It was therefore considered appropriate to calculate the cell volume of the most abundant species as a means of estimating the biomass of each one (Table 2). The relative biomass of the main groups of the phytoplankton showed an annual pattern generally similar to the pattern of the relative cell abundances. But this pattern showed marked fluctuations in the less abundant groups. The Bacillariophyceae, for example, had a relatively high biomass compared with the number of cells due to the large volume of *Cocconeis placentula*.

During the autumn, Bacillariophyceae was the dominant group with a biomass of 79.61 µg /l in 1996 at the station I and 282.7 µg / l at the station II. These values corresponds to a relative biomass of 99%, respectively. The biomass of Chlorophyceae was 69.53 µg /l. During the fall the biovolume considerably increased. The dominant species in this bloom were *Spirogyra sp.*, and *Scenedesmus quadricauda*. The biovolume of Cryptophyceae increased in fall and winter. In 1997 diatoms dominated during the whole winter and autumn. Considering the biovolume of the most abundant species, *Cyclotella ocellata*, *Cocconeis placentula*, *Navicula gracilis*, *Synedra acus* and *Synedra ulna*, a winter time bloom occured with a maximum biomass of 381.25 µg / l in March 1998 at the station IV.This bloom was primarily composed of *Navicula gracilis*. Maximum values for the other 2 species were below 50 $\mu m^3/l$. In 1998 the Chlorophyceae showed low levels of relative biomass between 0.0 and 4.67%. Considering the 2 main species of this class: *Scenedesmus quadricauda* and *Spirogyra sp.*, the biovolume ranged from 0.01 to 2.12 mm^3/l. At the same time the biomass of Chlorophyceae was very low and was composed of *Spirogyra sp.*

Table 2. Calculated mean volumes of the most abundant species of Lake Buyukcekmece.

Species	Volume (μm^3)
Cyclotella ocellata	44
Cocconeis placentula	902
Navicula gracilis	423
Nitzschia palea	292
Synedra acus	337
Synedra ulna	494
Scenedesmus quadricauda	708
Spirogyra sp.	431
Oscillatoria sp.	9
Cryptomonas erosa	885
Cryptomonas ovata	2204

During the winter of 1998 the relative biomass of Cryptophyceae varied from 95% to 14%. The other algal classes were present occasionally.

The spring bloom of Bacillariophyceae produced a biomass of 79.52 µg/l in 1997 at the station III reaching 100% of total biomass. The diatom *Navicula gracilis* was the dominant species. Cyanophyceae also were represented rarely, but *Merismopedia glauca* was the species with highest volume, reaching a biomass between 0 to 0.17% of the total.

Chlorophyceae were present with a low biomass ranging between 0 and 28.32 µg/l (0 to 41.38 %). Biovolume of Bacillariophyceae reached a maximum of 381.250 µg/l in March at the station IV. The biovolume of Chlorophyceae showed a smooth curve during the summer, with very low concentrations in all stations (Fig.4).The species present was *Scenedesmus quadricauda* .The biovolume of Chrysophyceae, represented by the species *Cryptomonas erosa* showed its maximum biomass during the summer. The presence of *Scenedesmus quadricauda* indicated that Chlorophyceae had an important biomass during the summer.

During autumn, Bacillariophyceae maintained a relative high biomass with a decline in June when the green algae reached their maximum concentration. The biovolume of the diatoms increased in summer and autumn at the station III. The main species involved was *Navicula gracilis*. In 1996, the Chlorophyceae showed high levels of relative biomass at the station IV. The biomass of the Cryptophyceae reached maximum value at the station IV

Discussion

The phytoplankton of Lake Buyukcekmece was represented by members of the Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Cryptophyceae. Of the 65 taxa identified, 4 species were important for the density that they reached (>61%): *Cyclotella ocellata* Pant., *Navicula gracilis* Ehr. *Nitzschia palea* (Kiitz.) W. Smith and *Cocconeis placentula* Ehr.

The phytoplankton groups are generally considered as markers of lake types in various parts of the world. Hutchinson (1967) scanned the results of various investigators and mentioned oligotrophic and eutrophic phytoplankton groups and their subgroups. *Cyclotella* species were accepted as an oligotrophic organism especially in the lakes of Middle Europe. *C. ocellata* are most frequently found in some waters other than Lake Mogan and they can sometimes reach very high numbers (Unal, 1984). *C. ocellata* is also the most abundant species during the summer in the plankton of Lake Sapanca (Temel, 1992). *C. ocellata* was found widespread in large numbers in Lake Buyukcekmece. *Navicula gracilis* from Bacillariophyceae class reached maximal numbers during autumn and winter . *Nitzschia palea* and *Synedra acus* from pennat diatoms were constantly present in the lake and constituted the dominant species.In the phytoplankton, *Cyclotella ocellata, Navicula gracilis* and *Cocconeis placentula* were found in relatively large numbers whereas other species were quantitatively unimportant. Round (1959) described some *Fragilaria, Amphora, Pediastrum, Nitzschia sigmoidea, Cymatopleura elliptica. C. solea* and some *Navicula* species as growing prominently in neutral and mildly alkaline waters whereas *Caloneis bacillum. Gyrosigma acuminatum,Navicula pupula, N. cryptocephala* and *Amphora ovalis* species in large numbers in alkaline waters.Most of the species previously mentioned were also detected in Lake Buyukcekmece in small amounts. The pH values of the lake water was between 8 and 9.7 which constituted the optimum pH for those algae .

In Lake Buyukcekmece, 0-0,099 mg.m-^{3} and 0-0,183 mg.m-^{3} nitrate were measured in the 1st and 2nd stations, on 12 January 1997 and on 23 March 1997 respectively, whereas 0-0,0007 mg.m-^{3} and 0-0,009 mg.m-^{3} phosphate were measured in the 1st and 2nd stations on 23 February 1997 and 9 November 1997 respectively.

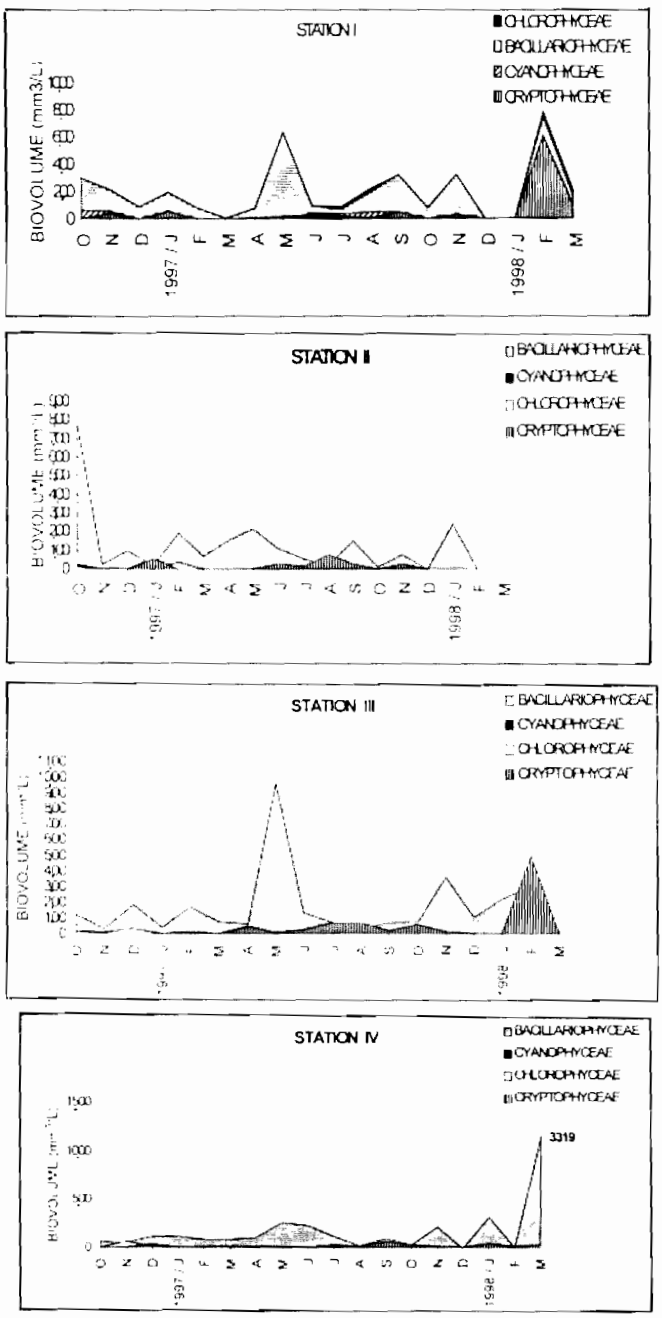

Fig. 4. Annual distribution of biovolume in main algal classes.

With an increase in total amount of phytoplankton in the 1st station in June-July 1997, Chlorophyll a values were also found to be high (4.0-4.3 mg.m^{-3}). Total count of phytoplankton started to decrease in autumn and continued to decrease in winter.

In this study, the occurrence of Bacillariophyceae as the dominant group gives an idea about the cause of high amounts of chlorophyll a and chlorophyll c. *Spirogyra sp.*, from Chlorophyceae class showed an abundance on 17 November 1996 at the 3 rd station. Therefore values of chlorophyll a and b reached maximum. Agriculture and stock-breeding took place around this station.

In oligotrophic lakes the availability of orthophosphate and nitrate limits the productivity of many phytoplankton species (Golterman,1975). In this Lake, the controlling nutrient for algal growth appears to have been phosphate.

Generally the amount of total phytoplankton considerably increased in summer in all sampling stations. Whitford & Schumacher (1963) stated that diatoms in general had low heat requirement and medium to high light requirement. All of these properties are present during Spring and Autumn. This may be the explanation for the predominance of diatoms during these seasons.

The Cyanophyceae is another group related to eutrophy, but in Buyukcekmece Lake even when they were represented by 5 species, the abundance was always low, 1 to 21, 9% of the total algae present. Prescott (1961) stated that the abiotic conditions that are related to the presence of blue-green algae are high concentrations of nitrate, a relatively large amount of orthophosphate and high temperatures. In Buyukcekmece Lake nitrates were high in comparison to phospate, but water temperatures were lower than in many situations were blue-green algae are abundant. The Cyanophyceae were found mainly in summer but also were present in winter. Smith (1983), suggests that the relative proportion of blue green algae in the epilimnetic phytoplankton is primarily dependet on the epilimnetic ratio of the total nitrogen to total phosphorous and that the occurrence of blue-green alga is independent of temperature.

Although *Merismopedia glauca* and *Oscillatoria princeps* were rarely present, other members of this group had low values in terms of both density and recurring rates. *Scenedesmus quadricauda* from Chlorophyceae class was numerous in the 3 rd stations whereas *Cryptomonas erosa* was commonly found in all stations and other organisms were rarely encountered.

Cryptomonas species were always or usually seen in phytoplankton but their quantity was relatively low. However their number increased on certain days (13 January 1997 and 7 Februaray 1997). It had been reported that *Cryptomonas ovata* reached high numbers in some periods in Kurtbogazi Dam Lake (Aykulu & Obali, 1981).

Euglena acus and *Phacus orbicularis* from Euglenophyceae class were sometimes present and they were recorded in low numbers in phytoplankton. It has been reported that members of Euglenophyceae were generally found in waters rich in organic matter (Round, 1957). *Euglena acus* and *Phacus orbicularis* from Euglenophyceae class were sometimes present and they were recorded as low numbers in phytoplankton.

Buyukcekmece Lake is a temperate, oligotrophic lagoon lake. Of the 65 taxa in the floristic list over 71 % occur in the one class where Bacillariophyceae exhibited high relative cell counts throughout the year, Chlorophyceae have their maximum cell numbers in late summer and the Cryptophyceae were at their maximum in winter while the Cyanophyceae had their maximum numbers in summer and were completely absent in the spring and winter.

The physico-chemical and biological characteristics of Lake Buyukcekmece , with a shallow basin, oxygen distribution, low concentration of nutrients and a low standing crop of phytoplankton, makes it similar to other oligotrophic lakes .

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