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AN INVESTIGATION ON THE SEASONAL VARIATION OF THE PHYTOPLANKTON DENSITY ON THE SURFACE WATER OF SAPANCA LAKE, TURKEY

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Abstract

Seasonal variations of phytoplankton composition and density of Lake Sapanca, were investigated on the littoral and pelagic sample station points between December 1999 and February 2001. Samples were collected monthly from 4 stations which were chosen in the west part of the lake. At each station, water samples were obtained at three site. The first sites were at the closest point to the shore. In addition, there is 100 m distance between each sites. In total 54 phytoplankton species were recorded: Bacillariophyta 30, Chlorophyta 12, Cyanophyta 5, Euglenophyta 3, Dinophyta 2, Chrysophya 1 and Cryptophyta 1. Bacillariophyta, Chlorophyta and Cyanophyta constituted majority of the phytoplankton both in terms of species numbers and density. No apparent differences were found in phytoplankton compositon at three sampling sites of each station. In general, surface phytoplankton were found to be rather poor as it was in the previous quantative phytoplankton studies carried-out in the lake. Chlorophyll-*a* concentrations were measured higher (8.39- 21.79 mg/m^3) than the previous studies.

Introduction

Standing at the bottom level of the food chain, phytoplankton bear a significant importance in respect of their role in aquatic ecosystems and their relations with other living organisms at upper levels. Phytoplankton is one of the top living groups, which react fast to pollution in aquatic environment. The composition of phytoplankton is utilized to identify the trophic state, productivity rate, nutrient level, water quality and pollution of lakes (Reynolds, 1998).

Lake Sapanca which is located in the Marmara Region, is a prominently significant lake, in respect of economic-sportive fishing, recreation-tourism and drinking water. The lake provides drinking water for the city of Adapazarı and the lake water is also used for cooling purposes in the industries in Izmit area (DSİ, 1989).

Several studies have been carried out in Lake Sapanca (Yücetaş, 1975; Artüz, 1983; DSİ, 1984; Worthmann *et. al*., 1985; Tuğrul *et. al*.,1989; Tüfekçi, 1999). Earlier works have dealt with some limnological characteristics and pollution level of lake, while knowledge on the phytoplankton was rather scarce. The first quantative study of phytoplankton was done by Temel (1991). Subsequently, the phytoplankton and zooplankton compositions and their relations with water quality of the lake water was investigated by Aykulu *et. al*., (1999, 2006). Studies have been studied mainly in pelagic region and at the deepest points of the lake. The first sampling sites were at the closest point to the shore and there is 100 m distance between each sites. The aim of the present study was to determine the coastal impact on the phytoplankton, and whether there are any disparities comparing to open water regarding the aspects of composition and density.

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Materials and Methods

Study site: Lake Sapanca is located (40^o 41′ N – 40^o 44′ N and 30^o 09′ E – 30^o 20′ E) in a tectonic depression and separated from Izmit Bay in the Sea of Marmara by accumulation of alluvial deposits (Temel, 1991). The lake has a 46.8 km^2 surface area with maximum depth 52 meters and an elevation of 30 m sea level (DSI., 1989). There is only one outflow, Çark Stream, which is at the eastern part of the lake. The lake is fed by several streams with seasonally changing flow rates. The retention time of the lake is 7 years (DSI., 1984).

Sampling: Four sampling stations were chosen in the west part of the lake. In total 12 sampling points were designated belonging to 4 stations. In each station closest point of the shore showed with A, 100 m forward with B and 200 m forward with C (Fig. 1). Samples were taken monthly from surface with a water sampler.

Physicochemical variables: Temperature and dissolved oxygen were measured using an oxi 330 /set model Oxygen meter, transparency was measured with a Secchi disc at sampling time. Nitrate azote (NO_3-N) and orthophosphate (PO_4–P) content in the water samples were measured with the help of Dr. Lange make kits; the pH was measured in the laboratory by using a Knick model pH meter.

Phytoplankton: Water samples for phytoplankton identification and counting were fixed with Lugol's iodine. Phytoplankters were counted with an inverted microscope according to Lund *et al*., (1958). Identification followed Patrick-Reimer (1966, 1975), Huber-Pestalozzi (1975), Krammer & Lange-Bertalot (1986), Hustedt (1930, 1985) and Prescott (1961, 1964). Chlorophyll-*a* content was measured according to Parsons & Strickland (1963).

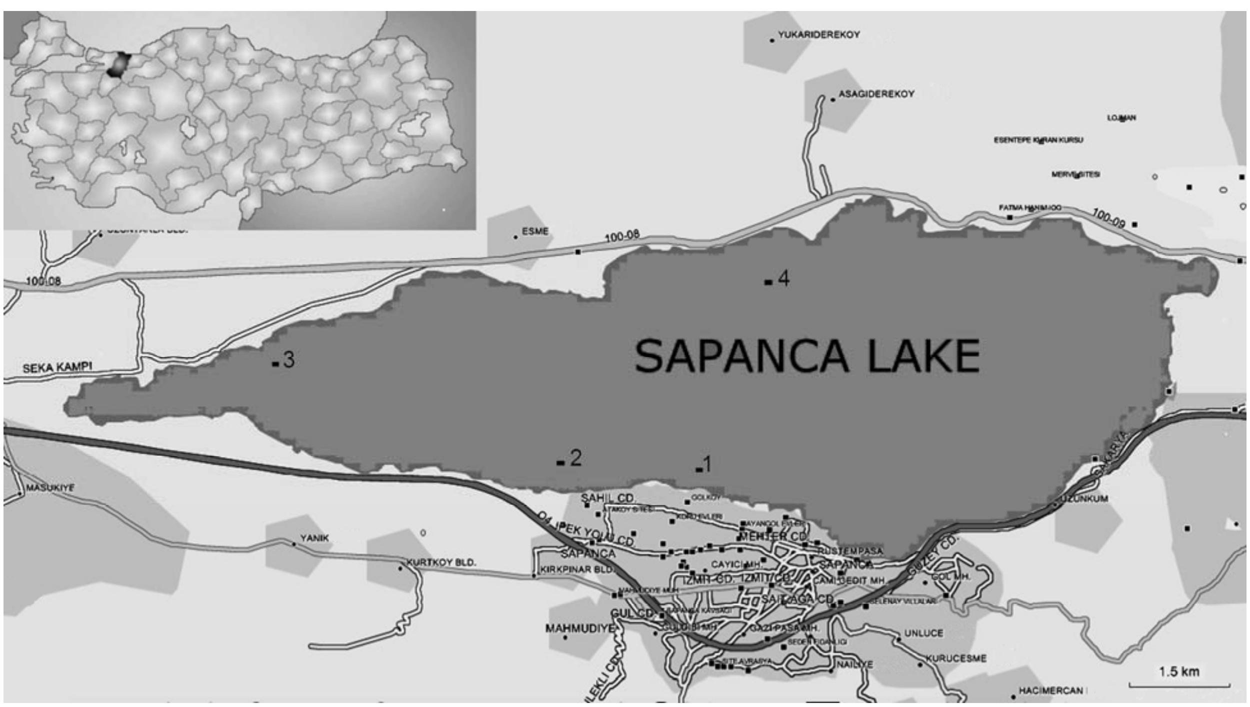

Fig. 1. Map and location of Lake Sapanca and sampling sites.

Results

Physicochemical variables: During the study the surface water temperature varied between 27.4 and 6.5°C, Secchi-depth varied between 0.9 and 7.0 m. The dissolved oxygen concentrations ranged between 14.59 and 3.84 mg l^{-1} and pH values ranged between 7.70-8.55 in the surface water. The measured nitrate values changed between 0.043-0.344 mg l^{-1} and orthophosphate values changed between 0.006-0.063 mg l^{-1} in the surface water in March, April, June and October 2000. Some measured physicochemical variables and chlorophyll- *a* content of Lake Sapanca were given in Table 1.

Phytoplankton composition and seasonal changes of phytoplankton density: In total, 54 taxa from the following groups were recorded in the surface water of Lake Sapanca: Bacillariophyta 30 (55.5%), Chlorophyta 12 (22.2%), Cyanophyta 5 (9.2%), Euglenophyta 3 (5.5%) Chrysophyta 1 (1.85%), Cryptophyta 1 (1.85%) and Dinophyta 2 (3.7%). The presence of the taxa of the phytoplankton at the sampling stations was given in Table 2. General phytoplankton numbers increased in April 2000 and December 2000. The lowest density was recorded in February 2000, November 2000 and July 2000. No apparent differences were found in phytoplankton growth at each station and their sampling sites. The seasonal changes of density of phytoplankton groups of Lake Sapanca were shown in Fig. 2a-d.

During the study 5 centric and 25 pennate diatoms belonging to the Bacillariophyta division were recorded. The centric diatom *Cyclotella ocellata* Pantocsek was recorded more frequently than other species. Pennate diatoms in terms of species variation were rich and represented by 25 taxa. The pennate diatoms *Synedra acus* Kuetzing and *Synedra ulna* (Nitzsch) Ehrenberg were found commonly in all sampling stations. *Nitzschia* species were recorded in each sampling time but did not develop in high numbers. The dominant species was *Asterionella formosa* Hassall of Bacillariophyta. Other pennate diatoms ocurred sporadically on the phytoplankton.

Members of the Chlorophyta were the second dominant group in terms of species numbers and density following the Bacillariophyta division. Chlorophyta was represented by 12 taxa belonging to 3 order. It was identificated 9 species belonging to Chlorococcales where identified of Lake Sapanca. *Monorapidium falcatus* was recorded frequently and abundantly at each stations. *Scenedesmus dimorphus* (Turpin) Kuetzing and *Scenedesmus quadricauda* (Turpin) Brebisson were found more abundant at the shore sampling sites. *Kirchineriella* sp. was found in small numbers and found usually on the phytoplankton during the study. Desmidiales order was represented by *Cosmarium formosulum* Hofmann which was recorded rarely and in low numbers in Lake Sapanca. The order Zygnematales was represented by *Mougeotia* sp. which was found more abundant at the shore sampling points. Volvocales order in terms of individual number and frequency was recorded in unimpotant numbers than Chlorococcales and Zygnematales orders.

Members of Cyanophyta generally were found in lower numbers than members of Chlorophyta. It was represented by 5 taxa. Belonging to Cyanophyta division the *Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis& Komárek was the most abundant and most frequent species. Generally *P. rubescens* was found more abundant at the shore sampling points. Other species were recorded rare and in low numbers.

Table 1. Minimum, maximum, average and standard error values of some physicochemical parameters and chlorophyll- *a* of Sapanca Lake.

Physicochemical parameters	St.	Minimum			Maximum			Average and standard error		
		A	B	C	A	B	C	A	B	C
Temperature (ºC)	St.1	9	6.5	6.6	27.1	26.7	27.3	15.84 ± 1.8	15.4 ± 1.9	15.52 ± 1.95
	St.2	7.8	7.8	7.8	26.8	27.1	27.4	15.84 ± 1.87	15.85 ± 1.89	15.85 ± 1.90
	St.3	7.9	8.1	7.9	27.3	27.2	27.2	15.83 ± 1.95	15.88 ± 1.94	15.80 ± 1.92
	St.4	7.8	7.8	7.8	27.0	26.8	26.8	15.58 ± 1.93	15.5 ± 1.93	15.50 ± 1.94
pH	St.1	7.40	7.30	7.20	8.82	8.80	8.78	8.18 ± 0.1	8.23 ± 0.1	8.25 ± 0.1
	St.2	7.10	7.20	7.30	8.73	8.77	8.78	8.21 ± 0.1	8.26 ± 0.1	8.28 ± 0.1
	St.3	7.25	7.23	7.22	8.61	8.73	8.74	8.21 ± 0.1	8.24 ± 0.1	8.25 ± 0.1
	St.4	7.28	7.28	7.2	8.79	8.82	8.80	8.27 ± 0.1	8.27 ± 0.12	8.28 ± 0.12
Secchi Disc (m)	St.1	1.0	1.5	2.0	3.3	6.5	5.6	1.98 ± 0.18	3.95 ± 0.44	3.98 ± 0.37
	St.2	0.9	1.9	2.15	4.2	6.0	6.0	2.49 ± 0.32	3.59 ± 0.39	3.61 ± 0.37
	St.3	1.2	2.0	1.75	6.0	6.0	6.0	2.59 ± 0.36	3.71 ± 0.40	3.58 ± 0.39
	St.4	1.4	1.9	2.05	3.9	6.0	7.0	2.08 ± 0.19	3.93 ± 0.39	4.12 ± 0.47
Dissolved oxygen (mg l^{-1})	St.1	5.02	4.92	4.47	13.24	12.5	12.5	8.36 ± 0.68	8.68 ± 0.69	8.63 ± 0.73
	St.2	4.59	4.64	4.61	12.23	12.42	12.35	9.19 ± 0.57	9.19 ± 0.61	9.15 ± 0.62
	St.3	3.98	3.84	3.89	11.27	12.05	12.11	8.52 ± 0.67	8.59 ± 0.73	8.71 ± 0.74
	St.4	3.96	3.88	3.87	12.85	12.96	12.9	8.83 ± 0.78	8.59 ± 0.8	8.53 ± 0.79
Nitrate (µg l^{-1})	St.1	-	0.086	-	-	0.258	-	-	0.172 ± 0.03	-
	St.2	-	0.086	-	-	0.344	-	-	0.204 ± 0.05	-
	St.3	-	0.043	-	-	0.258	-	-	0.150 ± 0.04	-
	St.4	-	0.129	-	-	0.258	-	-	0.215 ± 0.03	-
Orthophosphate (µg l^{-1})	St.1	-	0.019	-	-	0.037	-	-	0.028 ± 0.003	-
	St.2	-	0.019	-	-	0.044	-	-	0.029 ± 0.005	-
	St.3	-	0.006	-	-	0.063	-	-	0.024 ± 0.01	-
	St.4		0.019	-	-	0.061	-	-	0.034 ± 0.009	-
Chlorophyll- *a* (mg/m^3)	St.1	8.77	8.39	10.16	19.5	18.51	19.92	12.93±0.99	12.73 ± 0.94	15.20 ± 1.01
	St.2	10.29	12.18	9.61	26.16	21.59	17.62	16.08 ± 1.42	15.9 ± 0.95	13.97 ± 0.74
	St.3	8.39	7.97	10.22	20.63	21.09	21.79	13.5 ±1.10	14.07 ± 0.99	14.54 ± 1.00
	St.4	10.06	10.77	10.20	18.86	18.29	18.29	14.06 ±0.90	13.58 ± 0.74	13.55 ± 0.82

Table 2. The presence of the taxa of the phytoplankton at the sampling stations.

	Station 1			Station 2			Station 3			Station 4		
	A	B	C	A	B	C	A	B	C	A	B	C
Bacillariophyta												
Cyclotella atomus Hust.	+	+	+	+	+	+	+	+	+	+	+	+
C. bodanica Eulenstein	+	+	+	+	+	+	+	+	+	+	+	+
C. ocellata Pantocsek	+	+	+	+	+	+	+	+	+	+	+	+
Aulocoseira italica var. *tenuissima* (Grun.) Simonsen	+	+	+	+	+	+	+	+	+	+	+	+
Melosira varians Agardh	+	+	+	+	+	+	+	+	+	+	+	+
Achnanthes lanceolata (Breb.)Grun.	+	–	+	+	+	–	+	–	–	+	–	–
Amphora ovalis Kutz.	+	+	+	–	+	+	–	–	–	+	+	–
Asterionella formosa Hassall	+	+	+	+	+	+	+	+	+	+	+	+
Cocconeis placentula Ehr.	+	+	–	–	–	–	+	–	–	+	+	–
Cymbella prostrata (Berkeley) Cl.	+	+	–	+	+	+	–	+	+	+	–	+
C. tumida (Brebisson) Van Heurck	+	+	–	+	+	+	–	+	+	+	–	+
Diploneis elliptica (Kutz.) Cl.	–	–	–	–	–	–	–	–	–	+	–	–
Fragilaria crotonensis Kitton	+	+	+	+	+	+	+	+	+	+	+	+
Gomphonema sp.	–	+	–	–	–	–	–	–	–	–	–	–
Meridion circulare (Greville) Agardh	–	–	–	+	–	–	–	+	+	–	+	–
Navicula anglica Ralfs	+	+	+	+	+	+	+	+	+	+	+	+
N. cuspidata Kutz.	+	+	+	+	+	+	+	+	+	+	+	+
N. cuspidata var. *ambigua* (Ehr.) Cl.	+	+	+	+	+	+	+	+	+	+	+	+
N. gracilis Ehr	+	+	+	+	+	+	+	+	+	+	+	+
N. reinhardtii (Grunow) Van Heurck	+	+	+	+	+	+	+	+	+	+	+	+
Nitzschia acicularis (Kuetzing) Wm. Smith	+	+	+	+	+	+	+	+	+	+	+	+
N. gandersheimiensie Krasske	+	+	+	+	+	+	+	+	+	+	+	+
N. linearis (Agardh) Wm. Smith	+	+	+	+	+	+	+	+	+	+	+	+
N. palea (Kuetzing) Wm. Smith	+	+	+	+	+	+	+	+	+	+	+	+
N. sigmoidea (Nitzsch) Wm. Smith	+	+	+	+	+	+	+	+	+	+	+	+
Rhaphalodia gibba (Ehr.) O. Müll.	–	–	–	–	–	–	–	–	–	+	–	–
Surirella sp.	–	–	+	–	–	–	–	–	–	–	–	–
S. linearis Wm. Smith	–	–	–	–	+	–	–	–	–	–	–	–
Synedra acus Kutz.	+	+	+	+	+	+	+	+	+	+	+	+
Synedra ulna (Nitzsch) Ehr.	+	+	+	+	+	+	+	+	+	+	+	+

Table 2. (Cont'd.).

	Station 1			Station 2			Station 3			Station 4		
	A	B	C	A	B	C	A	B	C	A	B	C
Chlorophyta												
Monaraphidium falcatus (Corda) Ralfs	+	+	+	+	+	+	+	+	+	+	+	+
Cosmarium formosulum Hofmann	–	–	–	–	–	–	–	–	+	–	–	–
Oocystis natans (Lemm.) Wille	+	+	+	+	+	+	+	+	+	+	+	+
Pediastrum dublex Meyen	–	–	–	–	–	+	–	–	–	–	–	–
Scenedesmus dimorphus (Turp.) Kutz.	+	+	+	+	+	+	+	+	+	+	+	+
Scenedesmus quadricauda (Turp.) Breb.	+	+	+	+	+	+	+	+	+	+	+	+
Tetraedron sp.	–	–	–	+	+	+	–	+	–	–	+	+
Chlorella sp.	+	–	–	–	+	–	–	–	–	–	–	–
Coelastrum sp.	+	+	+	+	+	+	+	+	+	–	+	–
Kirchneriella sp.	+	+	+	+	+	+	+	+	+	+	+	+
Mougeotia sp.	+	+	+	+	+	+	+	+	+	+	+	+
Phacotus lenticularis (E.) Stein	+	+	+	–	+	+	–	–	–	–	–	–
Chrysophyta												
Dinobryon sp.	–	+	–	+	+	+	+	+	+	+	+	–
Cryptophyta												
Cryptomonas ovata Ehr.	–	–	+	–	–	+	–	–	+	+	+	+
Cyanophyta												
Chroococcus limneticus Lemm.	+	+	+	+	+	+	+	+	+	+	+	+
Merismopedia glauca (Ehr.) Kutz.	–	–	+	+	+	+	+	+	+	+	+	+
Anabaena affinis Lemm.	–	–	–	–	+	+	–	–	–	–	+	–
Aphanizomenon ovalisporum Forti.	–	–	–	–	+	+	+	+	+	+	+	+
Planthrotrix rubescens D.C.	+	+	+	+	+	+	+	+	+	+	+	–
Euglenophyta												
Euglena gracilis Klebs	–	–	–	+	–	–	+	–	+	+	+	–
Phacus sp.	–	+	+	+	–	–	–	–	+	–	+	+
Trachelomonas hispida (Perty) Stein	+	+	+	+	+	+	+	+	+	+	+	+
Dinophyta												
Ceratium hirundinella (Mueller) Schrank	–	–	–	–	–	–	–	–	–	–	–	+
Peridinium bipes Stein	–	+	–	+	+	+	+	–	+	+	+	+

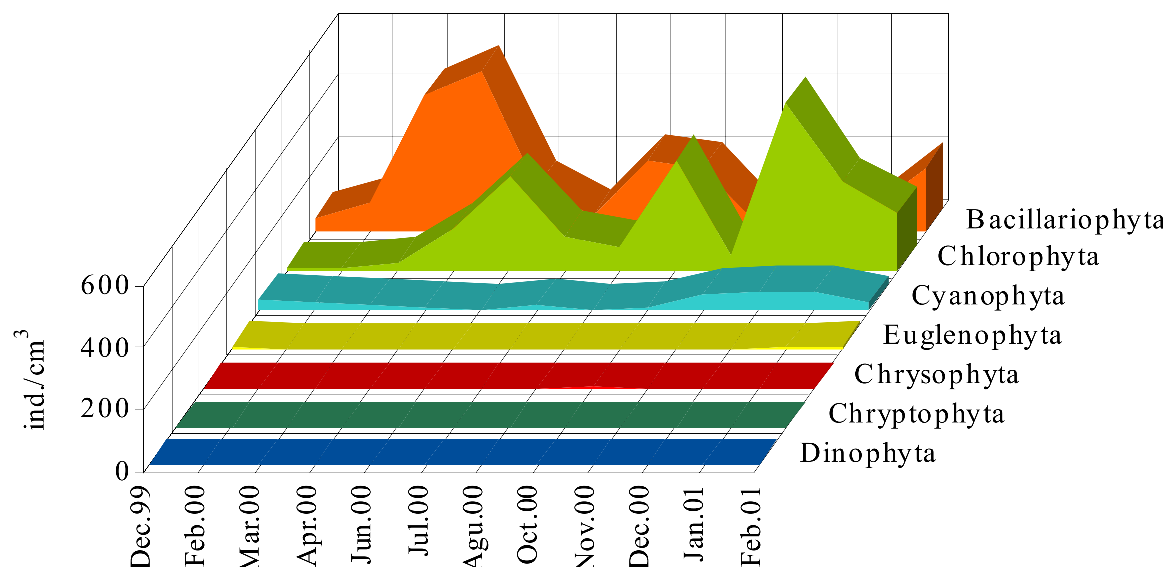

Fig. 2a. The seasonal changes of density of phytoplankton groups of Lake Sapanca at station 1.

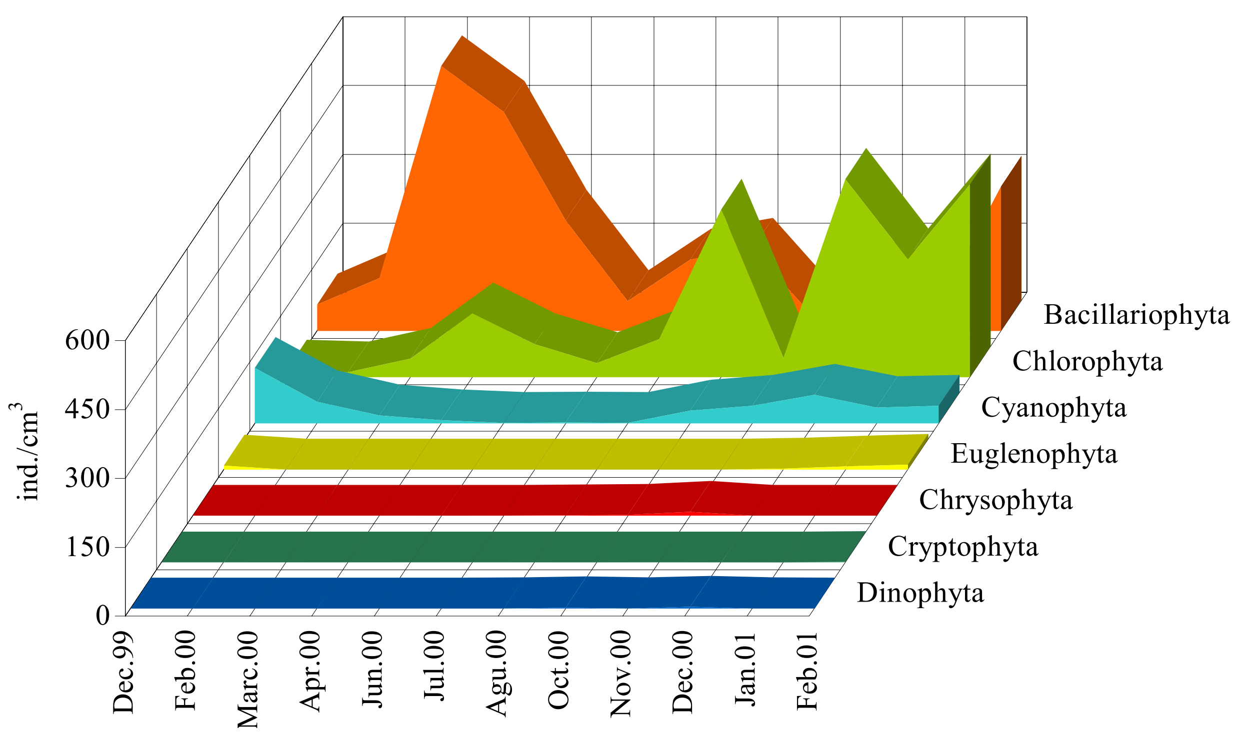

Fig. 2b. The seasonal changes of density of phytoplankton groups of Lake Sapanca at station 2.

Chrysophyta division was represented by *Dinobryon* sp. and Cryptophyta division was represented by *Cryptomonas ovata* Ehrenberg. Dinophyta division was represented by *Ceratium hirundinella* (Mueller) Schrank and *Peridinium bipes* Stein. During the present study *Dinobryon* sp., the *C. ovata*, the *C. hirundinella* and the *Peridinium bipes* Stein were recorded always in low numbers and scarcely. Euglenophyta division was represented by 3 taxa. It was determined that *Trachelomonas hispida* (Perty) Stein was found more frequently than *Euglena gracilis* Klebs and *Phacus* sp.

Station 3

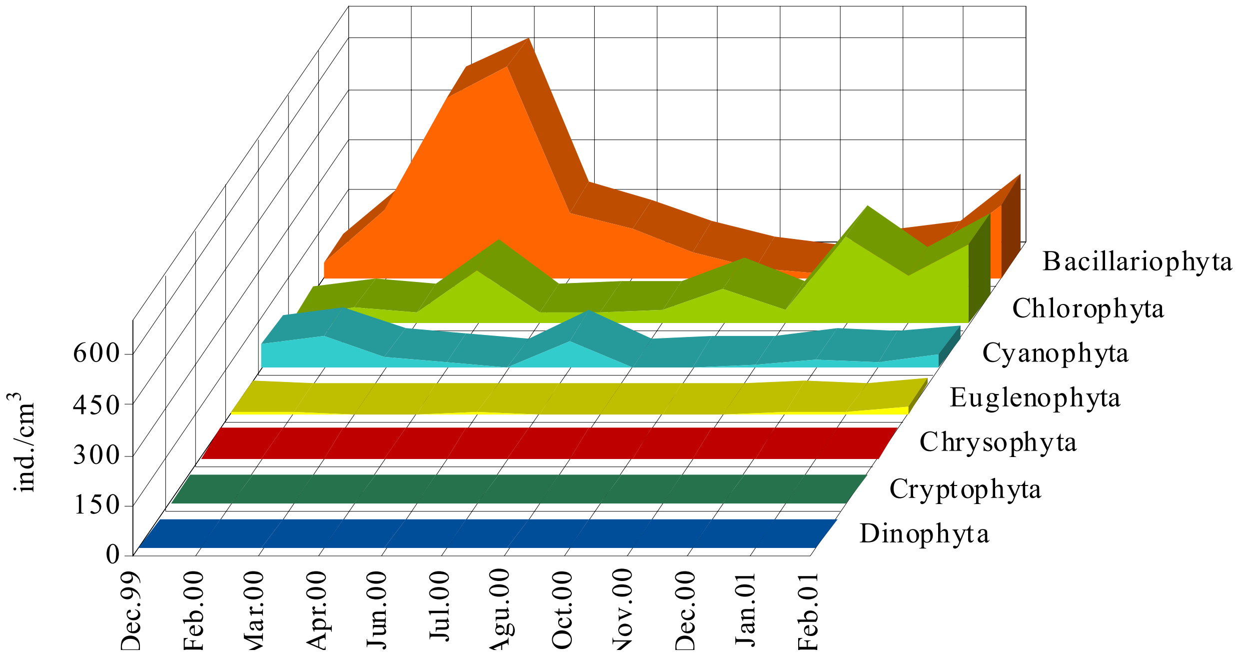

Fig. 2c. The seasonal changes of density of phytoplankton groups of Lake Sapanca at station 3.

Station 4

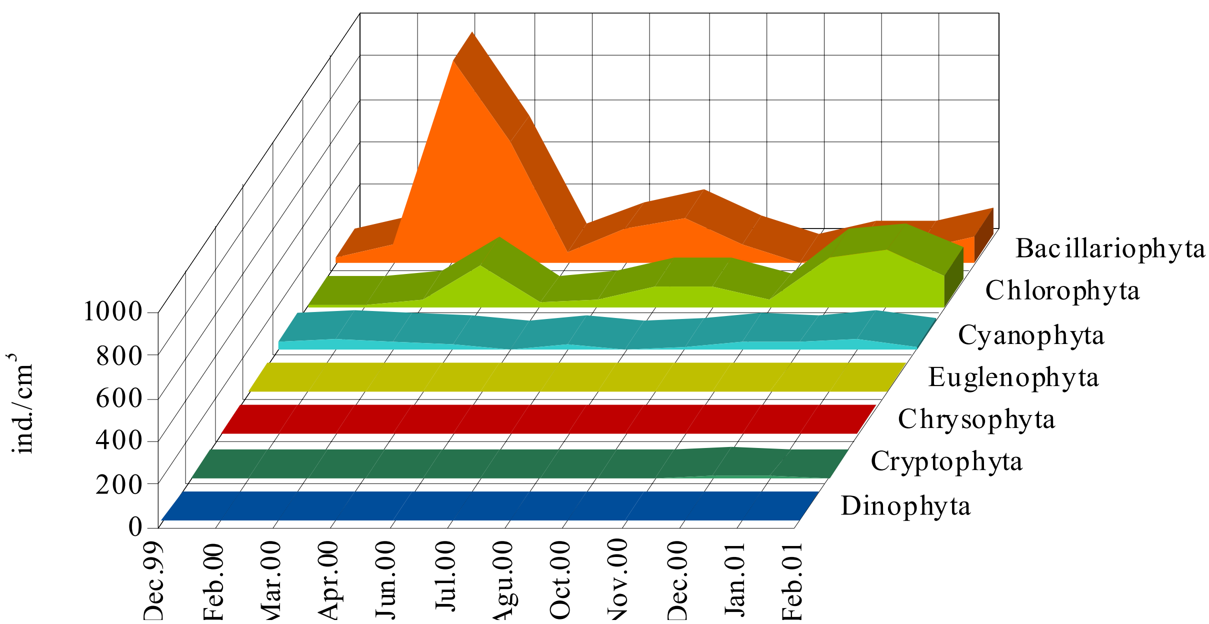

Fig. 2d. The seasonal changes of density of phytoplankton groups of Lake Sapanca at station 4.

Chlorophyll- *a* contents among the sampling stations ranged between 7.97 mg/m^3-21.59 mg/m^3 on the surface. The minimum content was measured in 3-B sampling point in March 2000 and the maximum content in 2-B sampling point in April 2000.

Discussion

Yiğit *et al.*, (1984) noted phosphate concentrations between 0.5-0.74 µg l^{-1}.Tuğrul & Morkoç (1991) noted phosphate concentrations being under 2 µg l^{-1}. Temel (1991) recorded 1-12 µg l^{-1} and Aykulu *et al.*, (2006) measured orthophosphate concentrations between 1.8- 20.9 µg l^{-1} on the surface waters of Sapanca Lake. Tuğrul & Morkoç (1991) measured nitrate concentrations 2 µg l^{-1} between the surface and 25 m. Yiğit *et al.*, (1984) couldn't record nitrate concentrations. Average of Secchi disc depth was 4.88 m in Temel (1991)'s work and 2.95 m in Aykulu *et al.*, (2006)'s study.

Productivity level of lakes coud be designated basically by chlorophyll-*a* density, Secchi disc depth and phosphate content. The average of orthophosfate was 0.028 mg l^{-1}, chlorophyll- *a* 14.1 mg/m^3 and Secchi disc depth 3.3 m . According to data obtained from the present study, in respect of orthophosfphate, chlorophyll-*a* and Secchi disc depth Sapanca Lake indicates mesotrophic character.

The composition of phytoplankton in designated water mass shows there is a trophic structure. Changes of phytoplankton compositions usually indicate there is a result of nutrient increases (Reynolds, 1998). Like earlier studies, groups which consisted the phytoplankton were same in the present study. Changes in the percentage contribution to the total phytoplankton have occured. The percentage contribution of the Bacillariophyta group was decreased. In earlier quantitative studies the taxa number was recorded 138 in Temel (1991) and 54 in Aykulu *et al.*, (1999). Additionally in earlier limnological works (Artüz, 1983; Worthmann, 1985) members of the Bacillariophyta group consisted 97% and 84% of total phytoplankton. In first quantitative works the percentage was designated 66% and 49%, in present work it was 55% of the total phytoplankton. Members of Chlorophyta were consisted 56% in Temel (1991), 22% in Aykulu *et al.*, (1999; 2006) and in these study 22.2% of the total phytoplankton. The percentage contribution to the total phytoplankton, Cyanophyta were found 9.4% in Temel (1991), 13% in Aykulu *et. al.*,(1999, 2006) and in these study 10% of total phytoplankton.

Members of the Bacillariophyta group were found to be mostly dominant on the surface when it came to number of type and number of individual. It was seen that generally in algological studies of Turkish freshwaters the Bacillariophyta divison was the dominant divison. (Altuner, 1984; Temel, 1991; Altuner & Gürbüz, 1994; Elmacı & Obalı, 1998; Gürbüz & Altuner, 2000; Gürbüz & Kıvrak, 2004). In the present study, the dominant species of the Bacillariphyta division the *Asterionella formosa* is usually an indicator species of eutrophic structure. It has been stated that the taxa can be found in high numbers in mesotrophic and eutrophic and even in oligotrophic waters (Patrick & Reimer, 1966; Rawson, 1956). *A. formosa* was stated as being phytoplankton characteristic and nutrionally rich in warm lakes in spring and when of high number has known to be the reason of the lessening in matter of dissolved nitrate and phosphate like nutrients in the water (Lund, 1950). In earlier studies (Temel, 1991; Aykulu *et al.*, 2006) very low numbers of *A. formosa* was recorded occasionally at the shore. It was an important difference between earlier studies and the present study.

The *Cyclotella atomus* Hustedt and the *C. ocellata* of Centrales order were present in every season. *Cyclotella* species were accepted as one of the typical components both of oligotrophic lakes and reservoirs by many investigators. (Hutchinson, 1967; Trifinova, 1998). The C. *ocellata* occurred as a centric diatom which was commonly dominant and frequently in both of Temel (1991)'s and Aykulu *et al.*, (1999; 2006)'s works. *Aulocoseira italica var. tenuissima* (Grunow) Simonsen was the second dominant species at certain times.

It was stated that the members of pennales order occurred significantly on the phytoplankton in small shallow lakes and ponds (Taş & Gönülol, 2007). The presence on phytoplankton of the pennales order members of bentic character was based on wave motion and exposed to wind of the lake. This situation was observed in Mogan Lake, Palandöken Lake and Çakmak Dam Lake (Obalı, 1984; Gürbüz & Altuner, 2000; Ersanlı, 2006). *S. acus* was noted occasionally dominant, *C. ocellata*, *S. acus* and *S. ulna* were specified continously presented taxa and generally *Cyclotella* and *Synedra* species were dominant in different periods by Aykulu *et al*., (1999). *S. ulna* has been stated an characteristic of eutrophic lakes (Cirik & Cirik, 1991). But these species was recorded dominant in oligotrophic Hafik Lake and Derbent Dam Lake (Kılınç & Sıvacı, 2001; Taş & Gönülol, 2007).

Chlorophyta members were usually found commonly and abundantly in mesotrophic and eutrophic lakes (Trifonova, 1998). Round (1984) explained that some of Chlorococcales members were found mostly in lakes which were heading towards from oligotrophic period to eutrophic period. *Scenedesmus*, *Oocystis* and *Pediastrum* species were found abundantly in eutrophic lakes and oligomesotrophic reservuars in Turkey (Obalı, 1984; Taş *et al.*, 2002). Chlorococcales order members were found rich in respect of species number and density in Beytepe and Alaplı lakes. Furthermore *Pediastrum* and *Scenedesmus* species were accepted eutrophic Chlorococcales in Beytepe pond (Ünal, 1984).

The *P. rubescens* was found abundantly which was the cause of discolouration of surface water in 1995-1996 and in May 1997. Both in Aykulu *et al*., (1999; 2006) and in present study it wasn't recorded in high densities of to change the colour of the surface water. In Aykulu *et al*., (1999; 2006) high individual numbers of *P. rubescens* was recorded in surface and in deep waters in June and especially in November 1997. In the present study *P. rubescens* was recorded in highest numbers in April 2000. This indicates that *P. rubescens* doesn't prefer warm waters (Dokulil *et al*., 2000). It was stated that Cyanobacteria become important in temperate climate lakes especially in shallow eutrophic lakes (Padisak & Reynolds, 1998) and form water-blooms in late summer and early autumn in mesotrophic and eutrophic lakes (Rawson, 1956; Trifonova, 1998).

Phytoplankton of Sapanca Lake is a phytoplankton type which dominates by centric and pennate diatoms, *Planktothrix rubescens* and members of Chlorococcales order. No apparent differencies of phytoplankton composition were found between littoral and pelagic sampling points. Occasionally there were differencies in phytoplankton densities in pelagic sampling points.

In earlier studies maximum chlorophyll-*a* was found 2 mg/m^3 by Temel (1991), 4 mg/m^3 by Tüfekçi (1999) and 2.31 $\mu g\ l^{-1}$ by Aykulu *et al*., (2006). In the present study chlorophyll-*a* contents were higher than the earlier studies. Generally the phytoplankton were poor and high values of chlorophyll-*a* were measured occasionally on the littoral region.

Numan (1958) and Temel (1991) described the Lake Sapanca as oligotrophic, whereas Aykulu *et al*., (1999; 2006) reported that it was changing from oligotrophic to mesotrophic. The present study also confirms the latter study that the lakes in mesotrophic character.

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