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A Study on the Phytoplankton of Hasan UĞURLU Dam Lake (Samsun-Turkey)

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Abstract: The composition and seasonal variations of phytoplankton of Hasan UĞURLU Dam Lake were studied using samples collected from two stations between July 1992 to December 1993. 57 taxa were identified belonging to the Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta and Euglenophyta divisions of phytoplankton. In the phytoplankton, *Asterionella formosa, Cyclotella planctonica, Pediastrum simplex* and *Ceratium hirundinella* caused water blooms in certain months.

The light density and temperature affected the composition and seasonal variations in phytoplankton considerably. Nutrient levels in the lake did not limit the seasonal variations in phytoplankton.

It was determined that Lake Hasan Uğurlu had mesotrophic characteristics because of the morphometric structure, physical and chemical properties of the water and a phytoplankton type which caused water blooming by various taxa during certain months

Key Words: Phytoplankton

Hasan Uğurlu Baraj Gölü (Samsun-Türkiye) Fitoplanktonu Üzerinde Bir Araştırma

Özet: Hasan Uğurlu Baraj Gölü fitoplankton topluluğu ve mevsimsel değişimi iki istasyondan alınan örneklerde, Temmuz 1992 - Aralık 1993 tarihleri arasında araştırılmıştır. Fitoplanktonda Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta ve Euglenophyta'ya ait 57 takson tesbit edilmiştir. Fitoplanktonda *Asterionella formosa, Cyclotella planctonica, Pediastrum simplex* ve *Ceratium hirundinella* belirli aylarda aşırı çoğalmalar yapmıştır.

Fitoplankton topluluğunda ve mevsimsel değişiminde ışık ve sıcaklık etkili olmuş, göldeki besin tuzları miktarı ise sınırlayıcı olmamıştır.

Hasan Uğurlu Baraj Gölü; morfometrik yapısı, suyun fiziksel ve kimyasal özellikleri ve farklı taksonların belirli aylarda aşırı çoğalmalar yaptığı bir fitoplankton tipi içermesi nedeni ile mezotrof karakter taşımaktadır.

Anahtar Sözcükler: Fitoplankton, Mevsimsel Değişim, Baraj Gölü, Türkiye.

Introduction

There have been several studies on the phytoplankton of the dam lakes of Turkey in recent years (1-5). Although the northern part of Turkey contains many lakes, dams, rivers, streams and ponds, few studies have been carried out on the algae of this region (6-10). Therefore there is inadequete information on freshwater algal flora in Turkey.

The main purpose of this study is to determine the algal flora ad the seasonal variations Lake Hasan Uğurlu and to contributed to the body of knowledge on algal flora in Turkey.

Materials and Methods

Lake Hasan Uğurlu is located in the northeastern part of Turkey on the river Yeşilırmak long: 36° 40' E, lat: 41° 10' N). The total surface area of the lake is 20 km^2. The maximum depth, 35m, is at the dam. In addition to the river Yeşilırmak, the river Kelkit and the stream Akkuş flow into this lake.

To study phytoplankton in the lake, two sampling stations, were chosen from the locations to which transport is possible. The first station was located next to the dam and the second in the southwest of the research area (Fig. 1). the samples were collected monthly from these stations with a 2-litre-capacity Hydro-bios water sampler from a depth of 2 metres between July 1992 and December 1993. For the identifications and counting chambers. The algae were identified and counted using an inverted microscope according to the method of Lund (11). In the counting process, every colony and threadlike organism was considered to be an individual unit. The remaining part of the water sample was filtered using Whatman GF/A glass fibre filter paper with a pore size of 55 μm and the residue on the filter paper was used to identify all of the algae except Bacillariophyta. Bacillariophyta members were identified on permanent slides which had been prepared according to the method of Round (12).

At the time of sampling, the water temperature was measured using a mercury thermometer. Other physical and chemical analyses were performed at the Local-Central Food Laboratory according to the standard methods (13).

The taxonomic identifications of algae were made by Husted (14), Fremy (15), Cleve-Euler (16), Huber-Pestalozzi (17-23), Prescott (24) and the algae were classified according to the system of Round (25).

Results

Environmental Conditions

Some physical and chemical properties of the surface water of the lake are presented in Table 1.

The Composition of Phytoplankton

The phytoplankton of Lake Hasan Uğurlu consisted of 57 taxa belonging to five divisions: Bacillariophyta, Chlorophyta, Cyanophyta, Dinophyta and Euglenophyta.

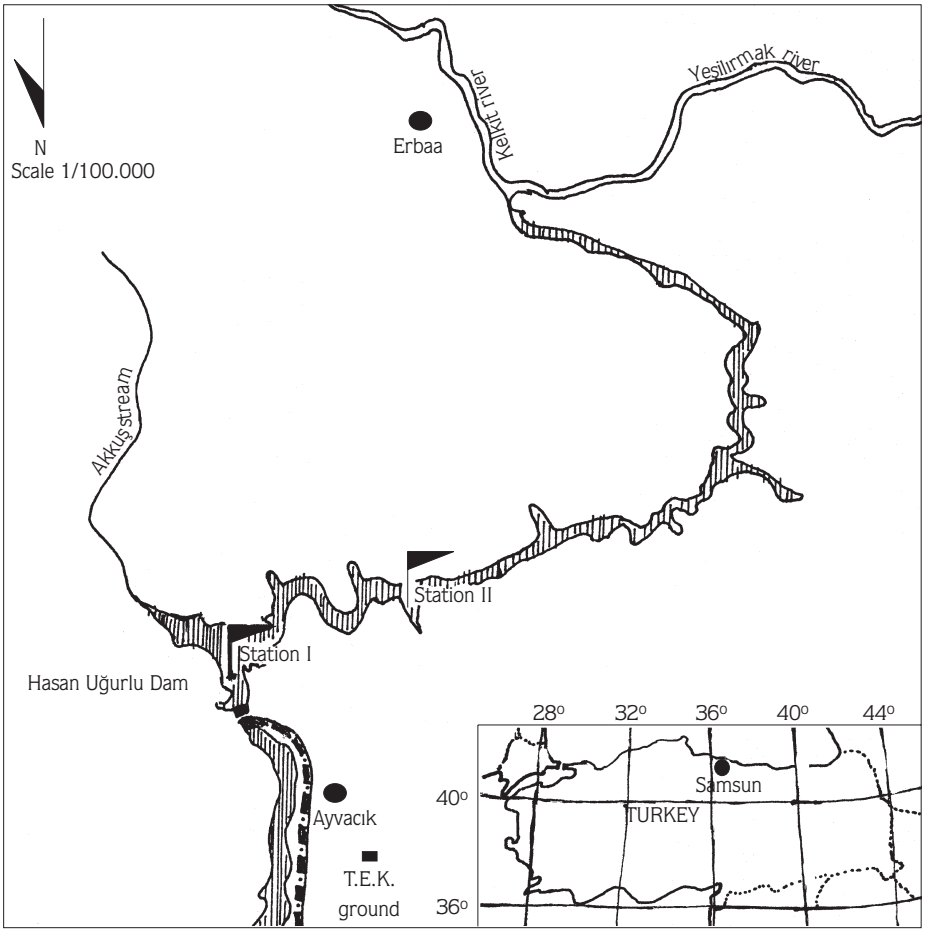

Figure 1. A Map of Lake Hasan Uğurlu.
Sampling Station

The list of recorded species is presented in Table 2.

The frequency ratios of some algae in the phytoplankton are presented in Table 3.

Seasonal Variatoins in Phytoplankton

The seasonal varitations in phytoplankton in Lake Hasan Uğurlu were investigated by dividing them into 4 seasonal groups.

Summer:

July 1992 - August 1992: *P. simplex* was found to be dominant and *C. hirundinella* was the subdominant species at the stations in these months. In July, 57% of the total 6392 cells ml^{-1}

Table 1. Some physical and chemical and chemical properties of the surface water of the lake at Station I.

Analyses	*Dates of Sampling*													
	1992						1993							
	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	July	Aug.
Temperature (^{o}C)	16	24	20	21	15	10	5	5	6	11	13	21	22	23
Turbidity (NTU)	-	-	-	-	3	3	-	-	5	10	46	10	8	5
Total Suspended Material (mgL^{-1})	200	180	180	200	240	230	210	200	200	150	140	160	180	200
Dissolved Oxygen (mgL^{-1})	8.0	7.0	7.0	6.2	6.2	7.6	10.0	9.6	8.0	9.2	9.0	7.2	8.0	6.6
pH	8.4	9.3	9.0	8.8	7.6	8.0	7.7	7.5	7.3	8.2	8.4	8.5	8.5	7.1
Conductivity (mMOH)	360	400	400	411	433	434	314	300	250	362	387	332	318	345
Phosphate (mgL^{-1})	0.10	0.05	0.20	0.24	0.17	0.30	-	-	0.33	0.23	0.12	0.21	0.21	0.20
Sulphate (mgL^{-1})	-	-	-	-	-	15.4	-	-	-	28.0	35.0	34.1	29.8	18.5
Nitrate (mgL^{-1})	6.0	7.5	7.5	7.5	3.1	17.2	-	-	5.7	2.9	3.5	13.8	5.8	7.0
Nitrite (mgL^{-1})	-	0.50	0.05	0.05	0.03	0.12	-	-	0.44	0.04	0.10	0.02	0.09	0.04
Calcium (mgL^{-1})	-	-	-	-	-	43.2	-	-	42.4	33.6	33.2	31.5	44.5	46.5
Magnesium (mgL^{-1})	-	-	-	-	-	26.5	-	-	15.8	22.1	24.2	20.7	23.6	18.0
Iron (mgL^{-1})	-	-	-	1.13	1.37	0.42	-	-	-	0.43	0.76	0.08	0.14	0.10
Copper (mgL^{-1})	-	-		0.03	0.05	0.05	-	-	-	0.05	0.03	0.01	0.02	-
Zinc (mgL^{-1})	-	-	-	0.01	0.01	0.01	-	-	-	0.01	0.01	0.01	0.01	-

Table 2. The list of taxa determined in phytoplankton of Lake Hasan Uğurlu

BACIMMARIOPHYTA
Centrales:
Cyclotella planctonica Brunnthaler
Melosira granulata (Ehr.) Ralfs
M. granulata var. *angunustissima* O.F. Müller
Pennales:
Amphora ovalis Kütz.
Asterionella formosa Hassal
A. gracillima (Hantz.) Hel.erg
Cymbella cymbiformis (Agardh) Kütz.
Hantsschia amphioxys (Ehr.) Grun.
Navicula cryptocephala Kütz.
N. radiosa Kütz.
Surirella robusta Ehr.
Synedra acus Kütz.
S. ulna (Nitzsch.) Ehr.
S. ulna var. *biceps* Kütz.
CHLOROPHYTA
Chlorococcales:
Botryococcus braunii Kütz.
Coelastrum microporum Naegeli
Crucigenia quadrata Morren
C. tetrapedia (Kirch.) W. and G.S. West

Table 2 Continue

	Crucigeniella rectangularis (Naeg.) Kom.
	Dictyospharium pulchellum Wood
	Korschikoviella michailovskoensis (Elenkin) Silva
	OOcystis gigas Archer.
	O. solitaria Wittrock
	O. solitaria var. *major* Willa
	Pediastrum boryanum (Turpin) Kütz.
	P. duplex Meyen
	P. simplex Meyen
	P. simplex var. *biwanse* Fukush
	Scenedesmus ecornis (Ralfs) Chod.
	S. dimorphus (Turpin) Kütz.
	S. disciformis (Chod.) Fott
	S. quadricauda (Turpin) Breb. and Godey
	Schroderia setigera Lemm.
	S. setigera var. *anatolica* Cirik-Altındağ
	Tetraedron minimum (A. Braun) Hansging
Desmidiales:	
	Closterium acutum Breb.
	C. acutum var. *variable* (Lemm.) W. Krieg.
	C. limneticum Lemm.
	C. lunula (O: F: Müller) Nitzsch. ex Ralfs
	Cosmarium bioculatum (Breb.) ex Ralfs
	C. formosulum Hoff.
	Staurastum gracile Ralfs
Tetrasporales:	
	Sphaerocystis schroeteri Chod.
Volvocales:	
	Chlamydomonas globasa Snow.
	Eudorina elegans (Fort.) ehr.
	E. unicocca G.M. Smith
	Pandorina morum Bory
CYANOPHYTA	
Chroococcales:	
	Aphanocapsa rivularis (Carm.) Rabh.
	Gomphosphaeria aponina Kütz.
	G. lacustris Chod.
	Microcystis aeruginosa Kütz.
Hormogonales:	
	Anabaena affinis Lemm.
	A. spiroides Klebahn
DINOPHYTA	
Peridiniales:	
	Ceratium hirundinella (O.F. Müller) Schrank
	Peridinim bipes Stein
	P. cinctum (O.F. Müller) Ehr.
EUGLENOPHYTA	
Euglenales:	
	Euglena rustica (Korsch.) Prings.

Table 3. The frequncy ratio of some algae composing phytoplankton at stations (The percentage of samples in which organisms were found to the total number of samples). 80-100% Constantly present, 60-80% Largely present, 40-60% Genarally present, 20-40% Sometimes present, 1-20% Seldom present.

	Sampling Stations / Sampling Number	Sta. I	Sta. II
	Organisms	18	18
BACILLARIO-PHYTA	Centrales:	88	80
	Cyclotella planctonica	39	40
	Melosira granulata		
	Pennales:		
	Asterionella formosa	*56*	*56*
	Hantzschia amphioxys	17	22
	Synedra acus	28	36
CHLOROPHYTA	Chlorococcales:		
	Crucigenia quadrata	17	10
	Oocystis solitaria	33	22
	Pediastrum simplex	88	80
	Scenedesmus ecornis	28	12
	Tetraedron minimum	17	10
	Desmidiales:		
	Closterium acutum	28	26
	Cosmarium bioculatum	39	28
	Staurastrum gracile	56	46
	Tetrasporales:		
	Sphaerocystis schroeteri	72	72
	Volvocales:		
	Chlamydomonas globosa	22	20
	Eudorina elegans	17	7
	Pandorina morum	44	39
CYANO-PHYTA	Chroococcales:		
	Gomphosphaeria aponina	22	10
	Microcystis aeruginosa	44	44
DINO-PHYTA	Peridiniales:		
	Ceratium hirundinella	95	90
	Peridinum bipes	61	65

were *P. samplex* and 12% *C. hirundinella* at Station I. At Station II 58% of 5874 cells m^{-1} were *P. simple* and 9% *C. hirundinella.* While the total number of organisms were decreasing, the number of Chlorophyta and Dinophyta members increased in August.

June 1993 - August 1993: *C. planctonica* was the dominant organism, making up 32% of the total organisms at the stataions in June. *P. simplex* and *C. hirundinella* were the dominant species in July and August respectively.

A. formosa, H. amphioxys, N. crytocephala and *S. acus* from Bacillariophyta; *D. pulchellum, S. schroeteri, P. morum* and *C. bioclatum* from Chlorophyta; *P. bipes* and *P. cinctum* from Dinophyta and *E. rustica* from Euglenophyta were the other organisms found in low numbers in the summer months.

Autumn:

September 1992 - November 1992: The number of total organisms increased and reached its highest value in September, and decreased in October and November. *P. simplex* remained the dominant organism, consisting of 56% - 82% of the total organisms at stations I and II in these months respectively. In September and October *C. hirundinella* was subdominant, but in November the subdominant organism was *C. planctonica.*

September 1993 - November 1993: When *P. simplex* was the dominant species, *C. hirundinalle* and *S. schroeteri* were the subdominant organisms, making up 12% and 24% of the total organisms at the stations in September. *C. hirundinella* was dominant and *P. simplex* and *S. schroeteri* were the subdominant species at the stations in October and November. In these months, *A. formosa* consisted of 7-8%, and *C. planctonica* 8-13% of the total organisms at stations I and II, respectively.

M. granulata from Bacillariophyta; *C. quadrata, D. pulchellum, P. boryanum, P. duplex* and *S. gracile* from Chlorophyta; *M. aeruginosa* from Cyanophyta; *P. bipes* and *P. cinctum* from Dinophyta were common species in the autumn months.

Winter:

December 1992 - February 1993: *P. simplex* was dominant and *C. planctonica* and *C. hirundinella* were the subdominant species in December. At Station I, 74% of the total 2897 cells ml^{-1} consisted of *P. simplex,* 8% *C. planctonica* and 8% *C. hirundinella.* At Station II, 63% of 2545 cells ml^{-1} were *P. simplex,* 12% *C. planctonica* and 11% *C. hirundinella* in this month. *P. simplex* remained the dominant organism and the total number of organisms decreased at the stations in Jaunary. *C. hirundinella* was dominant and *P. cinctum* was the subdominant species in February. In this month, 76% of the total 1000 cells ml^{-1} consisted of *C. hirundinella* and 17% *P. cinctum* at Station I. At Station II, 69% of 754 cells ml^{-1} were *C. hirundinella* and 10% *P. cinctum.*

M. granulata and *S. acus* from Bacillariophyta; *P. duplex, P. morum* and *C. bioculatum* from Chlorophyta were present in low numbers in the winter months.

Spring:

March 1993 - May 1993: The total number of organisms, which decreased in March, increased in April slightly. It reached beween 7000 - 10000 cells ml^{-1} in May. When the total number of organisms was low, *A. formosa* was dominant and *C. planctonica* was the subdominant organism in March. But *P. simplex* was the dominant species in April and May. At Station I, 71% of the total 1230 cells ml^{-1} consisted of *P. simplex,* 15% *C. planctonica* and 6% *P. morum.* At Station II 42% of the total 1046 cells ml^{-1} were *P. simplex,* 30% *C. planctonica* and 11% *P. morum* in April. *P. simplex* was dominant and *P. morum* was the subdominant species in May.

M. granulata, H. amphioxys, N. cryptocephala, S. acus and *S. ulna* from Bacillariophyta; *S. schroeteri* from Chlorophyta and *P. bipes* from Dinophyta were rarely present in the spring months.

The seasonal variations in the dominant groups are shown in Fig. 2 and the seasonal variations in some dominant species in Fig 3-5.

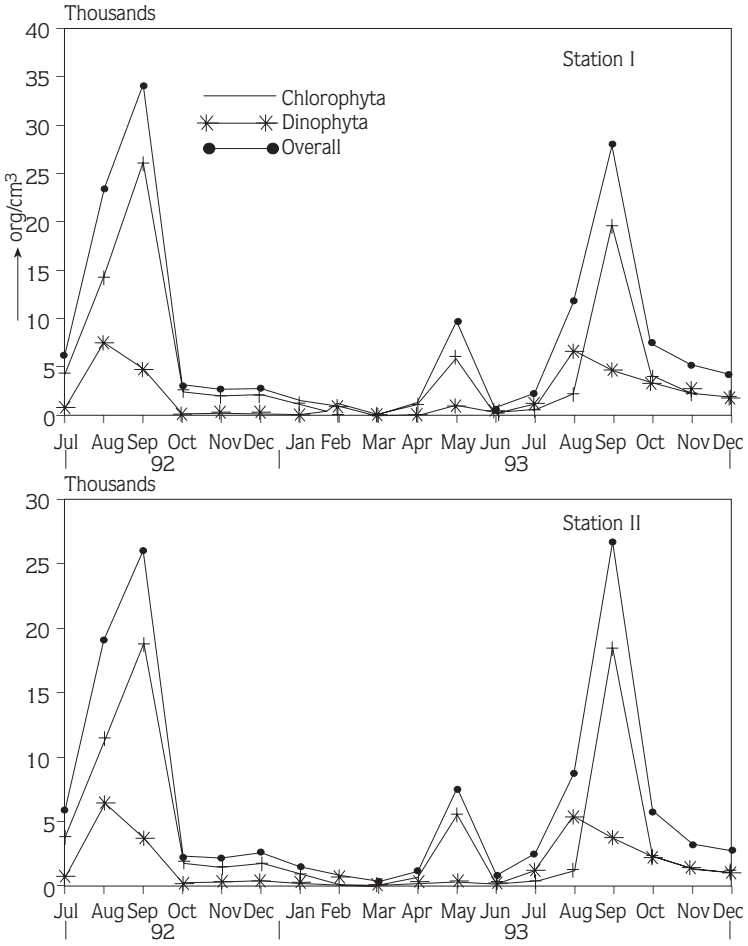

Figure 2. The seasonal variations in Chlorophyta, Dinophyta and overall phytoplankton populations at stations.

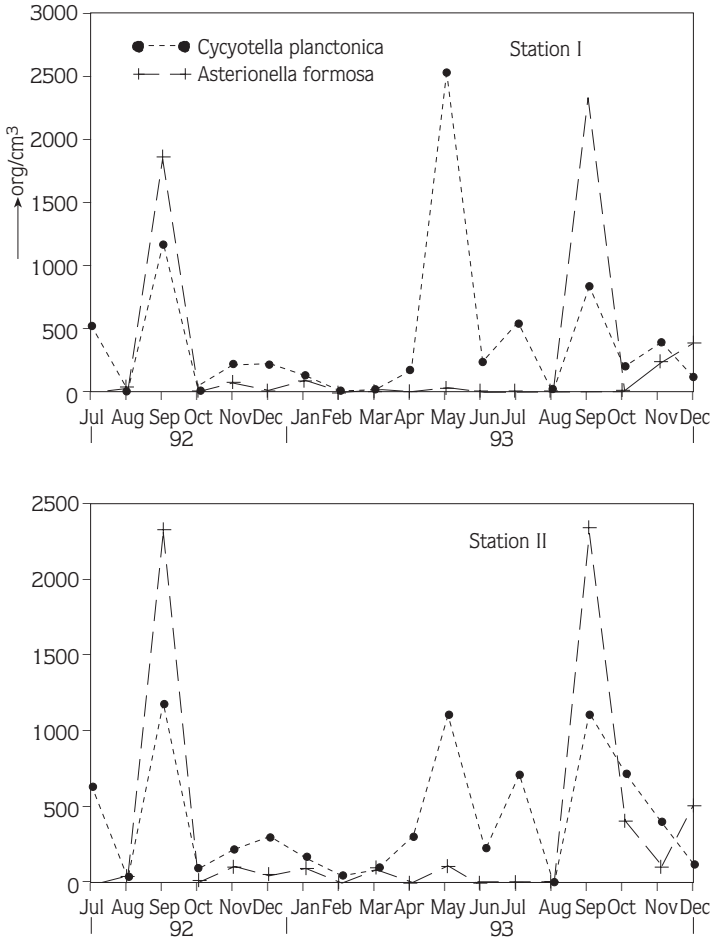

Figure 3. The seasonal variations in *Cyclotella planctonica* and *Asterionella fromosa* at stations.

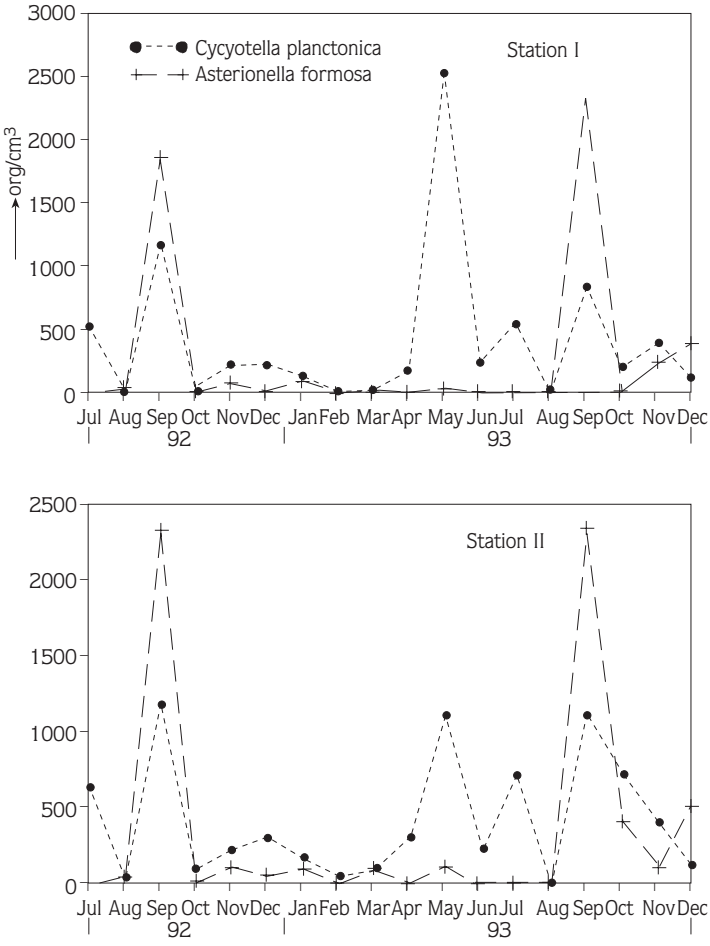

Figure 4. The seasonal variations in *Pediastrum simplex* and *Sphaerocystis schroeteri* at stations.

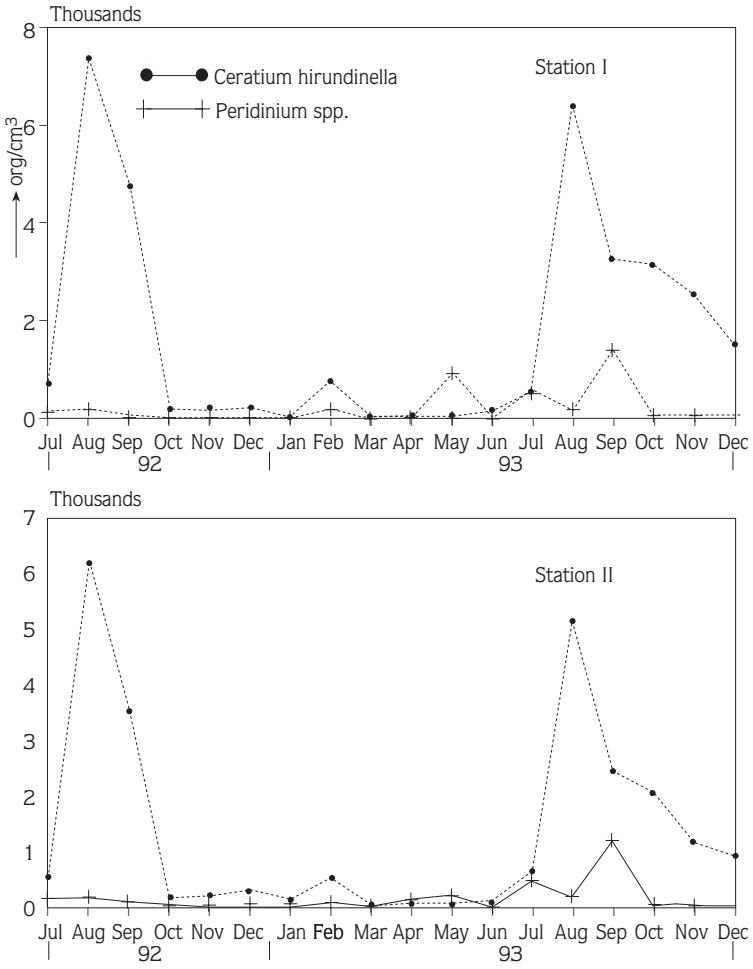

Figure 5. The seasonal variations in *Ceratium hirundinella* and *Peridinium bipes* at stations.

Discussion

The light density and temperature affected seasonal variations in phytoplankton in Lake Hasan Uğurlu considerably. In the months when the light density and the temperatures were low, the phytoplankton density was also low. The temperature varied between 5 and 24°C in Lake Hasan Uğurlu. In the periods from November to March, during which the rainfall at Lake Hasan Uğurlu is high (26), the turbidity values were low (3 to 5 NTU) while the level of total suspended materials was high (200 and 240 mgL^{-1}, respectively). In late summer and autumn, the level of total suspended materials was also high (180-200 mgL^{-1}) because of the bloom caused by *P. simplex* and *C. hirundinella.* Turbidity and separation caused by spring rainfall prevent the population of phytoplankton from reaching high densities. Lund (27) mentioned that the increase in phytoplankton density in the late summer and autumn was more significant than the increase in the spring. This periodicity model for phytoplankton was observed in Hasan Uğurlu and the other dams which have been investigated in Turkey.

In the surface water of Lake Hasan Uğurlu, nitrate values varied between 2.9 and 17.2 mgL-1 while phosphate values were between 0.05 and 0.33mgL^{-1} (Table 1). These higher values were probably because of the fact that the research area is located between urban areas and because of excessive usage of fertilizers in surrounding agricultural areas. These higher levels of nitrate and phosphate caused blooms of *P. simplex* and *C. hirundinella* in late summer and autumn. The concentrations of nutrients in Lake Hasan Uğurlu did not effectively limit algal growth. In summer, dissolved oxygen concentrations decreased due to high temperatures. Inversely, dissolved oxygen concentration increased in winter due to lower temperatures (Figure 2). According to the pH values (7.1-9.3) the Lake was alkaline (Table 1).

In Lake Hasan Uğurlu, there was a phytoplankton type characteristic of mesotrophic lakes in which the Chlorophyta, Dinophyta and Bacillariophyta members caused blooms. Phytoplankton had a low number of species but was rich in density of species. It was found that the phytoplankton communities were the same at Station I and Station II.

Of Centric Diatoms, *C. planctonica* was found constantly but *M. granulata* was sometimes present. Although these species were determined to be characteristic of oligotrophic lakes, they were also found in eutrophic lakes (28). From these species *C. planctonica* was dominant in June and subdominant in January, March, July and December. *C. ocellata* was widespread and was significantly present in Kurtboğazı (1), Çubuk-I (2), Bayındır (3), Altınapa (4) and Tercan (5). *A. formosa* belonging to Pennales was generally present during the period of the study, and it was the dominant organism in March. Round (25) indicated that *A. formosa* was a characteristic species of mesotrophic European lakes. This species was dominant in certain months in Hasan Uğurlu and Suat Uğurlu Lakes (29). From this order, *H. amphioxys* was seldom present and *S. acus* was sometimes present in Lake Hasan Uğurlu. The other members of Pennales were also found rarely in the dams which have been investigated in Turkey.

The dominant group were Chlorococcales members from Chlorophyta in Lake Hasan Uğurlu, *P. simplex* belonging to Chlorococcales was the dominant species in every month except February and March. It has been reported that *Pediastrum* species were found in plankton and

they were more common in eutrophic water than in oligotrophic water (30). According to the literature *P. boryanum, P. duplex* and *P. tetras* (Ehr.) Ralfs are cosmopolite, *P. angulosum* (Ehr.) Menegh. and *P. biraduiatum* Meyan are rare and *P. kawraiskyi* Schmidle species can be widespread in some certain areas (30). Of these species *P. boryanum* and *P. duplex* were found scarcely in every sampling, but *P. simplex* was wery common. As in Lake Hasan Uğurlu, *P. simplex* might be dominant for a long period in the lakes, in which the temperature warm and not above 30°C. *O. gigas* and *O. solitaria* were sometimes present in this lake. *Oocystis* species have been reported to be oligotrophic (28). These species were observed to be abundant in the eutrophic Karamık Lake (31), Mogan Lake (32), mesotrophic Çubuk-I Dam (2) and Kurtboğazı Dam (1). Although species of *Oocystis* have been reported to be oligotrophic in the literature, the result of this study proved that they are widespread in all types of lake. *C. quadrata, S. ecornis, S. quadricauda, S. disciformis, S. setigera* and *T. minimum* from Chlorococcales were found rarely. In addition to these, *K. michalovskoensis* that was first reported in Manisa-Marmara Lake (34) was also found in Lake Hasan Uğurlu. *S schroeteri* from Tetrasporales was a significant organism during water blooming in late summer and autumn. This species and *P. morum* from Volvocales caused water blooms. in the mesotrophic Kurtboğazı (1) and the eutrophic Bafra Fish Lakes (9). But *S. schroeteri* was subdominant and *P. morum* was the dominant organism in certain months in Lake Suat Uğurlu (28). The Desmidiales members that were widespread in oligotrophic lakes were observed rarely in Lake Hasan Uğurlu and in other dams in Turkey.

Members of Cyanophyta have sometimes been found to be present in Lake Hasan Uğurlu. *G. aponina* from this group increased slightly in August. Also *M. aeruginosa* was sometimes present. This species was found rarely in Lake Suat Uğurlu (29). It has been reported that *M. aeruginosa* caused water blooms in Kurtboğazı Dam (1), Bafra Fish Lakes (6), Mogan (32) and Karamık (31) lakes. The other members of Cyanophyta were found scarcely in Lake Hasan Uğurlu and othet lakes in Turkey.

The second dominant group in the phytoplankton was Dinophyta. *C. hirundinella* was constantly present in Lake Hasan Uğurlu and it reached its highest in the late summer and autumn months. *P. bipes* was dominant and *P. cinctum* was largely present in June 1993 in Lake Hasan Uğurlu. *P. cinctum* reached high levels occasionally in Kurtboğazı (1) but not often in Çubuk-I (2), Altınapa (4) and the other dam lakes of Turkey. These species usually prefer eutrophic lakes, but it has been reported taht these species can also occur in mesotrophic lakes (28-29, 35).

Only one species from Euglenophyta was found: *E. rustica.* This species was also present in Lake Suat Uğurlu, and was found rarely in both dam lakes. Euglenophyta members were generally present in the eutrophic Manisa-Marmara Lake (36) and Bafra Fish Lakes (8). But they were not significant in other lakes in Turkey.

It was determined that Lake Hasan Uğurlu had mesotrophic characteristics because of the morphometric structure, physical and chemical properties of the water and a phytoplankton type which caused water blooming by various taxa during certain months.

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