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Research Article

The Benthic Algal Flora of Demirdöven Dam Reservoir (Erzurum, Turkey)

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Abstract: Seasonal variations in the species composition of the benthic algae of Demirdöven Dam Reservoir were investigated in 2000 and 2001. The benthic algal flora consisted of 174 taxa belonging to the *Bacillariophyta, Chlorophyta, Cyanophyta* and *Euglenophyta*. In general, *Bacillariophyta* were dominant in terms of species number and abundance during the study period. The ranges of temporal distribution of the benthic algal composition and dominant species differed from each other at all stations.

Key Words: Algae, epipelic, epilithic, seasonal variations, reservoir, Turkey

Demirdöven Baraj Gölünün (Erzurum, Turkey) Bentik Alg Florası

Özet: Demirdöven Baraj Gölünün bentik alglerinin kompozisyonundaki mevsimsel değişimler 2000 ve 2001 yıllarında incelenmiştir. Bentik alg florası *Bacillariophyta, Chlorophyta, Cyanophyta* ve *Euglenophyta* bölümlerine ait toplam 174 taksondan oluşmuştur. *Bacillariophyta* tür sayısı ve yoğunluk bakımından dominant olmuştur. Örnekleme istasyonlarındaki bentik alglerin kompozisyonunun mevsimsel dağılım oranları ve dominant türlerin birbirinden farklı olduğu bulunmuştur.

Anahtar Sözcükler: Algler, epipelik, epilitik, mevsimsel değişim, baraj gölü, Türkiye

Introduction

Benthic algae are regarded as an important component of lakes, since they make an important contribution to the biological diversity and productivity of the lakes (Moss, 1969; Aktan & Aykulu, 2001). It has been recognised that seasonal changes, composition and production of benthic algae are affected by water chemistry and sediment structure (Round, 1984). There have been some studies on the benthic algae of the lakes, reservoirs and ponds in Turkey (Gönülol, 1985; Altuner & Aykulu, 1987; Yıldız, 1986; Gönülol, 1987; Dere, 1989; Obalı et al., 1989; Şahin, 1998; Elmacı & Obalı, 1998; Altuner & Gürbüz, 1996; Gürbüz, 2000; Çetin et al., 2002; Gürbüz & Kıvrak, 2003).

The purpose of this study was to investigate the abundance and species composition of benthic algae, and to examine the physical and chemical properties of the reservoir water.

The Study Site

Demirdöven Dam Reservoir (DDR) is located in the north-east of Turkey, 45 km from Erzurum, at latitude 41° 21′ and longitude 40° 21′ (Figure 1). It is surrounded by the Çobandede and Ağmelek mountains to the north and by the agricultural land of the Pasinler plain to the east and south. It was constructed in 1995 for the purposes of irrigation. The maximum storage capacity of the reservoir is 44.5×10^6 m^3 and the area covered by the reservoir is 1.45 km^2. The average depth is 50 m. The Tımar River carries melted snow water to the reservoir from the mountains. The weather of north-eastern Anatolia, where the DDR is located, can be characterised by a long and very cold winter with heavy snowfalls and a short summer. Therefore, the reservoir surface freezes almost every winter from December to early April.

Sampling Stations:

In order to study the benthic algae of the DDR 3 stations were chosen.

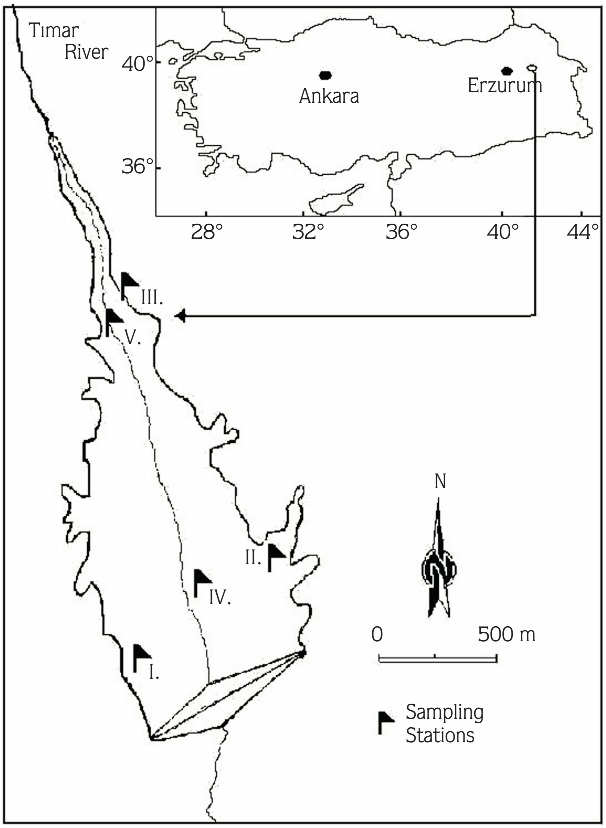

Figure 1. The Demirdöven Dam Reservoir and location of the sampling stations.

Station 1: Located in the west of the reservoir, covered with mud–sand sediment.

Station 2: Located in the east of the reservoir, covered with muddy sediment.

Station 3: Located in the north-west of the reservoir, near the Tımar River mouth, covered with muddy sediment.

The physical and chemical properties of the DDR's water were also studied at 2 stations (stations 4 and 5) in the pelagic zone (Figure 1).

Materials and Methods

Samples of the epipelic and epilithic algae were collected monthly from 3 stations in 30-50 cm water depth. Sampling was not performed between December and March, because the reservoir surface was covered with ice and snow.

Water temperature, dissolved oxygen concentrations, pH and conductivity were measured using a Multilap P4 (WTW) in the field at the sampling time. $CaCO_3$, HCO_3^-, Ca^{++}, Mg^{++}, SO_4^{2-}, Cl^-, Na^+ and K^+ concentrations were determined by titration in the laboratory (APHA, 1995).

The epipelic algal samples were collected from sediment using a PVC pipe 0.8 cm in diameter. The samples were placed in glass bottles, and immediately transported to the laboratory. The identification and enumeration of the epipelic algae in these samples were performed according to Round's methods (1953).

Stones and rocks about 10-15 cm in diameter were also collected and transferred to the laboratory for studying the epilithic algae. The epilithic algae were scraped from the surface of the stones and rocks with a brush brush and preserved in a 5% formaldehyde solution. Identification and determination of the abundance of all the epilithic algae were carried out on many temporary slides prepared from the epilithic algae samples.

Samples for diatom analysis were heated gently in a solution of 37% HCl and 6% $KMnO_4$ to remove organic matter. Clean diatom valves were washed with distilled water and mounted on a slide with Permount. Clean diatom valves were identified at 1000x magnification using an Olympus Vanox research microscope. The relative abundance (%) of each species in the epilithic diatoms was calculated by counting 100 valves per sample.

The main taxonomic references used for identification were Hustedt (1930), Cleve-Euler (1951), Patrick & Reimer (1966, 1975), Prescott (1982), Simonsen & Lange-Bertalot (1978), Findlay & Kling (1979) and Huber-Pestalozzi (1961, 1972, 1982, 1983).

Results

Physical and chemical characteristics

The surface water temperatures varied from 8.8 to 24.6 °C. Dissolved oxygen in the surface water fluctuated between 5.2 and 11.5 mg/l, and the minimum values were recorded throughout the warm period. The pH fluctuated between 7.5 and 8.3 in the surface water. Conductivity values were very low during the study and varied between 65 and 108 mS/cm. Concentrations of $CaCO_3$ had a seasonal range of 21.5-45.5 mg/l. HCO_3^-

concentrations varied between 22.6 and 46.3 mg/l. Ca^{++} concentrations were measured between 2.4 and 12 mg/l. Mg^{++} concentrations ranged between 2.1 mg/l and 5.2 mg/l. SO_4^{2-} concentrations varied between 2.6 and 10.2 mg/l. Na^+, K^+ and Cl^- concentrations were relatively low during the study period (Table 1). Many authors have reported that many lakes, dam reservoirs and ponds in Turkey have slightly alkaline and relatively soft water (Altuner & Gürbüz, 1996; Elmacı and Obalı, 1998; Gürbüz & Kıvrak, 2003).

Table 1. Some physical and chemical parameters of the Demirdöven Dam Reservoir.

Month	Stations	Temp. (ºC)	DO (mg/l)	pH	EC (mS/cm)	$CaCO_3$ (mg/l)	HCO_3^- (mg/l)	Ca^{++} (mg/l)	Mg^{++} (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)
22.4.2000	Station IV	12	11.5	8.3	88	32.5	38.3	6.8	3.4	2.7	2.5	0.18	10.2
	Station V	10.6	11.2	8.2	84	28.2	32.5	6.3	2.6	3.1	2.2	0.14	9.4
18.5.2000	Station IV	16.5	10.9	7.8	69	21.5	22.6	6.1	2.1	3.1	2.3	0.12	8.9
	Station V	15	10.8	7.9	66	23.4	25.8	7.3	2.4	2.9	2.5	0.10	9.8
16.6.2000	Station IV	22.2	10.1	8.1	86	25.3	30.5	8.0	2.4	2.5	2.7	0.09	5.5
	Station V	19.6	9.8	8.2	65	32.6	30.5	2.4	2.4	2.6	2.9	0.09	10.1
15.7.2000	Station IV	21.3	7.6	7.6	78	45.5	42.7	10.1	2.4	2.8	2.6	0.07	4.3
	Station V	21.5	7.5	7.8	67	30.1	30.5	8.0	2.4	2.9	2.4	0.06	3.9
16.8.2000	Station IV	24.6	6.3	7.9	68	23.4	25.4	11.5	2.5	3.5	3.1	0.09	7.8
	Station V	24.3	5.2	8.2	65	22.3	24.4	12.0	2.6	2.4	2.8	0.05	4.2
19.9.2000	Station IV	17.1	7.7	7.6	98	41.1	46.3	10.2	3.8	2.4	2.1	0.11	5.1
	Station V	17.5	7.6	7.8	65	26.7	30.5	10.5	3.6	2.1	2.4	0.12	6.1
17.10.2000	Station IV	14.1	7.1	7.5	89	35.6	41.2	7.5	3.4	2.6	2.2	0.11	5.2
	Station V	14.5	6.9	8.2	99	34.2	42.6	6.8	3.4	2.6	2.4	0.12	4.7
13.11.2000	Station IV	9.1	5.8	7.7	81	28.4	32.6	10.3	2.4	3.3	2.3	0.09	10.1
	Station V	9.9	5.7	7.8	84	34.2	39.2	6.8	3.6	3.5	2.2	0.06	7.7
15.4.2001	Station IV	10.2	11.2	8.2	101	32.1	38.3	4.3	2.8	4.2	3.8	0.10	3.6
	Station V	9.8	10.8	8.2	74	27.6	34.5	7.2	3.5	4.2	2.2	0.10	6.1
18.5.2001	Station IV	16	10.9	7.8	74	28.4	35.2	5.1	3.5	4.5	3.4	0.11	5.6
	Station V	15	10.8	7.6	89	25.8	30.5	4.6	2.8	4.4	3.1	0.12	5.6
16.6.2001	Station IV	17.5	9.6	8.1	96	29.9	36.6	3.8	2.4	2.4	3.2	0.19	2.6
	Station V	17.3	10.1	7.8	78	24.3	32.1	4.8	3.4	4.6	3.5	0.11	9.3
13.7.2001	Station IV	22.1	9.3	7.9	83	29.4	34.2	4.2	3.6	4.3	2.6	0.21	3.2
	Station V	21.7	9.4	7.9	108	24.1	30.5	4.1	3.6	4.3	2.7	0.16	5.3
21.8.2001	Station IV	21.8	5.6	8.2	67	28.6	32.5	6.8	2.4	4.7	3.6	0.14	8.3
	Station V	22.3	6.4	8.1	73	32.6	33.6	3.8	2.6	4.4	3.2	0.12	3.4
14.9.2001	Station IV	16.7	7.2	7.8	80	38.1	44.6	5.3	4.3	3.3	2.3	0.08	5.9
	Station V	17.3	6.5	7.8	66	26.2	41.3	3.7	5.2	3.3	2.2	0.06	8.7
12.10.2001	Station IV	14.4	7.1	8	104	25.3	33.2	6.1	4.5	3.5	2.4	0.12	5.9
	Station V	13.8	8.8	8	72	35.1	41.2	4.6	4.6	3.2	2.5	0.12	8.1
11.11.2001	Station IV	9.6	8	7.9	108	26.1	34.2	8.1	2.5	3.5	2.4	0.13	9.2
	Station V	8.8	8.6	8.2	98	34.8	43.2	4.9	3.1	2.4	2.3	0.13	8.4

DO: Dissolved oxygen; EC: Conductivity

Benthic Algal Flora

The benthic algal flora of the DDR consisted of epipelic and epilithic algal communities. A total of 174 taxa were recorded in the benthic algal communities. Most species identified in the study period belonged to the *Bacillariophyta*. A list of the identified taxa is presented in Table 2.

Epipelic algae

The epipelic algal flora consisted of 165 taxa belonging to the *Bacillariophyta*, *Chlorophyta*, *Cyanophyta* and *Euglenophyta*. The percentages of the total number of organisms belonging to the *Bacillariophyta*, *Chlorophyta*, *Cyanophyta* and *Euglenophyta* in the epipelic communities were 57%,

Table 2. List of epipelic and epilithic algae in the Demirdöven Dam Reservoir.

Taxa	E*	El*
BACILLARIOPHYTA		
Centrales		
Aulacoseira distans (Ehrenb.) Simonsen	+	+
Cyclotella kuetzingiana Thwaites	+	+
C. kützingiana var. *radiosa* Fricke	+	+
C. ocellata Pant.	+	+
M. varians C.Agardh	+	+
Stephanodiscus astrea (Ehrenb.) Grun.	+	
Pennales		
Achnanthes lanceolata (Bréb ex Kütz.) Grun.	+	+
A. lanceolata var. *dubia* Grun.	+	+
A. minutissima Kütz.	+	
Amphora ovalis (Kütz.) Kütz.	+	+
A. pediculus (Kütz.) Grun. Grun.	+	+
Asterionella formosa Hassall	+	+
Caloneis limosa (Kütz.) R.M.Patrick	+	
C. schumanniana (Grun.) Cleve	+	
C. silicula (Ehrenb.) Cleve	+	+
C. silicula var. *turuncatula* (Grun.) Cleve	+	
C. ventricosa (Ehrenb.) F.Meister	+	+
Cocconeis disculus (Schum.) Cleve	+	
C. placentula Ehrenb.	+	
C. placentula var. *euglypta* (Ehrenb.) Cleve	+	+
Cymatopleura angulata Grev.	+	
C. elliptica (Bréb.) W.Sm.	+	+
C. solea (Bréb.) W. Sm.	+	+
Cymbella affinis Kütz.	+	+
C. cistula (Ehrenb.) Kirchner	+	+
C. cistula var. *maculata* (Kütz.) Van Heurck		
C. cuspidata Kütz.	+	
C. cymbiformis C.Agardh	+	+
C. lanceolata (C.Agardh) C.Agardh	+	+
C. minuta fo. *latens* (Krasske) Reimer	+	+
C. minuta var. *silesiaca* (Bleisch ex Rabenh.) Reimer	+	+
C. muelleri fo. *ventricosa* (Temp. & Perag.) Reimer	+	
C. naviculiformis (Auersw. ex Heib.) Cleve	+	+
C. sinuata W.Greg.	+	+
C. tumida (Bréb.) Van Heurck	+	+
C. turgidula Grun.	+	+
Diatoma anceps (Ehrenb.) Kirchner	+	
D. hiemale var. mesodon (Ehrenb.) Grun.	+	+
D. vulgare var. grande (W.Sm.) Grun.	+	
Didymosphenia geminata (Lyngb.) M.Schmidt	+	+
Diploneis ovalis (Hilse) Cleve	+	+
Epithemia adnata (Kütz.) Bréb.	+	+
E. ocellata (Ehrenb.) Kütz.	+	
E. sorex Kütz.	+	+
Eunatia diodon Ehrenb.	+	+
E. exigua (Bréb.) Rabenh.	+	
Eunatia sp.		
Fragilaria vaucheriae (Kütz.) J.B.Petersen	+	+
F. ulna (Nitzsch) Lange-Bert.	+	+
Gomphonema acuminatum Ehrenb.	+	+
G. affine Kütz.	+	+
G. angustatum (Kütz.) Rabenh.	+	+
G. constrictum var. *capitata* (Ehrenb.) Van Heurck	+	+
G. gibba J.Wallace	+	+
G. olivaceoides Hust.	+	
G. olivaceum (Lyngb.) Kütz.	+	+
G. parvulum (Kütz.) Kütz.	+	+
G. truncatum Ehrenb.	+	+
Gyrosigma acuminatum (Kütz.) Rabenh.	+	+
Hannaea arcus var. *arcus* (Ehrenb.) in R.M.Patrick & Reimer	+	+
H. arcus var. *amphioxys* (Rabenh.) R.M.Patrick	+	+
H. arcus var. *linearis* Holmboe	+	+
Hannaea sp.	+	
Hantzschia amphioxys (Ehrenb.) Grun.	+	+
H. virgata (Roper) Grun.	+	
Meridion circulare (Grev.) C.Agardh	+	+
Navicula capitata Ehrenb.	+	+
N. cryptocephala var. *veneta* (Kütz.) Rabenh.	+	+
N. cuspidata (Kütz.) Kütz.	+	+
N. dicephala Ehrenb.	+	+
N. dicephala var. neglecta (Krasske) Hust.	+	
N. gracilis Ehrenb.	+	+
N. graciloides A.Mayer	+	+
N. halophila (Grun.) Cleve	+	+
N. laevissima Kütz.		+
N. mutica Kütz.	+	+
N. mutica var. *undulata* (Hilse) Grun.	+	+
N. rhynchocephala Kütz.	+	+
N. salinarum Grun.	+	+
N. viridula (Kütz.) Ehrenb.	+	+
Neidium affine (Ehrenb.) Pfitzer	+	+
N. iridis (Ehrenb.) Cleve	+	+
Nitzschia amphibia Grun.	+	+

Table 2. (Continued).

Taxa	E*	El*	Taxa	E*	El*
N. dissipata (Kütz.) Grun.	+	+	*C. lunula* (O.F.Müll.) Nitzsch ex Ralfs	+	+
N. fonticola Grun.	+		*C. parvulum* Näegeli	+	+
N. palea (Kütz.) W.Sm.	+	+	*C. ralfsii* Bréb. ex Ralfs	+	+
N. paleacea Grun.	+		*C. tumidum* Johnson	+	+
N. sinuata var. *tabellaria* (Grun.) Grun.	+	+	*Cosmarium denticulatum* (Borge) Grönblad	+	+
Pinnularia acrosphaeria (Bréb.) W.Sm.	+	+	*C. granatum* Bréb.	+	+
P. biceps W. Greg.		+	*C. margaritatum* (Lund.) Roy & Biss.	+	+
P. borealis Ehrenb.	+	+	*C. pryramidatum* Bréb.	+	+
P. brebissonii (Kütz.) Rabenh.	+	+	*C. subcostatum* Nordst.	+	+
P. isostauron (Ehrenb.) Cleve	+		*C. vexatum* W.West.	+	+
P. mesolepta (Ehrenb.) W.Sm.	+		*Cosmarium* sp.		+
P. microstauron (Ehrenb.) Cleve	+	+	*Staurastrum longiradiatum* W.& G.S.West	+	+
P. stomatophora (Grun.) Cleve	+	+	*Oedogoniales*		
P. viridis (Nitzsch) Ehrenb.	+	+	*Bulbochaeta* sp.		+
Sellaphora bacillum (Ehrenb.) D.G.Mann	+		*Oedogonium* sp.		+
S. pupula (Kütz.) Meresch.	+	+	*Ulotrichales*		
S. pupula var. *capitata* (Skv. & Meyer) comb.	+		*Ulothrix tenerrima* Kütz.	+	+
Rhoicosphenia curvata (Kütz.) Grun.	+	+	*U. zonata* (Weber & D.Mohr) Kütz.		+
Rhopalodia gibba (Ehrenb.) O. Müll.	+	+	*Ulothrix* sp.	+	+
Stauroneis anceps Ehrenb.	+	+	*Volvocales*		
S. anceps fo. *gracilis* Rabenh.	+		*Pandorina morum* (O.F. Müll.) Bory	+	+
S. phoenicenteron (Nitzsch) Ehrenb.	+		*Zygnemales*		
S. smithii Grun.	+	+	*Spirogyra fuellebornei* Schimidle	+	+
Surirella angusta Kütz.	+	+	*S. weberi* Kütz.	+	+
S. ovata Kütz.	+		*Spirogyra* sp.	+	
S. robusta Ehrenb.	+	+	*CYANOPHYTA*		
Synedra demerarae Grun.	+		*Chroococcales*		
S. parasitica var. *subconstricta* (Grun.) Hust.	+		*Merismopedia elagans* A.Braun ex Kütz.	+	+
S. radians Kütz.	+	+	*Hormogonales*		
S. rumpens Kütz.	+	+	*Anabaena aequalis* Borge	+	+
S. ulna var. *contracta* Østrup	+	+	*A. affinis* Lemmerm.	+	+
CHLOROPHYTA			*A. solitaria* Brunth.	+	+
Chlorococcales			*Oscillatoria limosa* (Roth) C.Agardh ex Gomont	+	+
Dictyosphaerium pulchellum H.C.Wood	+	+	*O. limnetica* Lemmerm.	+	+
Oocystis borgei J.Snow	+	+	*O. splendida* (Grev.) Gomont	+	+
O. tainoensis Komárek		+	*O. tenuis* C.Agardh ex Gomont	+	+
Oocystis sp.	+	+	*O. tenuis* var. natans Gomont	+	+
Pediastrum boryanum (Turpin) Menegh.	+	+	*Phormidium formosum* (Gomont) Anagn. & Komárek	+	+
P. tetras (Ehrenb.) Ralfs	+	+	*Pseudoanabaena* sp.	+	+
Scenedesmus acutiformis Schröd.	+	+	*Spirulina nordstedtii* Gomont	+	+
S. arcuatus (Lemmerm.) Lemmerm.	+	+	*EUGLENOPHYTA*		
S. disciformis (Chodat) Fott & Komárek	+	+	*Euglenales*		
S. ecornis (Chodat) Fott & Komárek	+	+	*Euglena acus* Ehrenb.	+	+
S. linearis Komárek	+	+	*E. gracilis* G.A.Klebs	+	+
S. obtusiusculus Chodat	+	+	*E. polymorpha* P.A.Dang.	+	+
S. obtusus fo. *alternans* (Reinsch.) Comp.	+	+	*Euglena* sp.	+	+
S. producto-capitatus Schmula	+	+	*Euglena* sp.	+	+
S. quadricauda (Turpin) Bréb.	+	+	*Phacus acuminatus* A.Stokes	+	+
Tedraedron minimum (A.Braun) Hansg.	+	+	*P. pleuronectes* (O.F.Müll.) Dujard.	+	+
Desmidiales			*P. spirogyra* var. *maxima* Prescott	+	+
Arthrodesmus triangularis Lagerh.		+	*Trachelomonas varians* (Lemmerm.) Deflandre	+	
Closterium littorale F. Gay	+	+	*T. volvocina* Ehrenb.	+	+

(*) E: Epipelic El: Epilithic

27%, 11% and 5%, respectively. The *Bacillariophyta* were dominant in terms of species number and abundance during the study period. However, members of the *Cyanophyta*, especially *Anabaena aequalis* Borge and *Oscillatoria limnetica* Lemmerm., became dominant only at station II with a rapid increase in late summer and early autumn. *N. rhynchocephala* Kütz., *N. salinarum* Grun., *Cocconeis placentula* var. *euglypta* (Ehrenb.) Cleve and *Pinnularia borealis* Ehrenb. (*Bacillariophyta*) were dominant at all stations. *Hannaea arcus* (Ehrenb.) R.M.Patrick *Cymbella minuta* fo. *latens* (Krasske) Reimer and *Achnanthes lanceolata* (Bréb.) Grun. were dominant only at station I. *Nitzschia palea* (Kütz.) W. Sm. was abundant, and *Amphora ovalis* (Kütz.) Kütz., *Fragilaria ulna* (Nitzsch) Lange-Bert. *Oscillatoria limnetica* and *O. limosa* (Roth) C.Agardh ex Gomont were subdominant species at station II. *Cosmarium margaritatum* (Lund.) Roy & Biss., *Staurastrum longiradiatum* W.&G.S.West, *Closterium lunula* (O.F.Müll.) Nitzsch ex Ralfs, *C. parvulum* Näegeli, *Euglena polymorpha* P.A.Dang., *E. gracilis* G.A.Klebs and *Phacus acuminatus* A.Stokes were abundant at stations II and III.

The epipelic algae exhibited similar seasonal variations in 2000 and 2001; however, the ranges of distribution of the epipelic algal composition and dominant species differed from each other at all stations. A higher abundance of epipelic algae was recorded at stations II and III than at station I throughout the study.

During the spring, numbers of the epipelic algae were very low at station I, and members of the *Bacillariophyta* constituted almost 80% of the epipelic algal community in both years. *Hannaea arcus*, *Achnanthes lanceolata*, *Cocconeis placentula* Ehrenb., *Navicula rhyncocephala*, *N. salinarum* and *Fragilaria ulna* were dominant at station I. The composition and growth of the epipelic algae were similar at stations II and III during the spring. At these stations, the epipelic algae were mainly dominated by the *Bacillariophyta*; members of the *Chlorophyta* and *Cyanophyta* were found in very low numbers, and members of the *Euglenophyta* occurred rarely at that time. The dominant species were *Amphora ovalis* (only in 2001), *Navicula rhyncocephala*, *N. salinarum*, *Nitzchia palea*, *Pinnularia borealis*, *Cosmarium margaritatum*, *Closterium parvulum*, *C. lunula*, *Oscillatoria limosa*, *Phormidium formosum* (Gomont) Anagn. & Komárek (only in 2000), *Anabaena solitaria* Brunth. and *A. aequalis* (only in 2001). A result of long winter conditions, the spring peak of the epipelic algae was recorded in June 2000 and June 2001 (Figure 2).

During the summer (July and August) of 2000, while notable decreases in the total counts of epipelic algae were observed, there was a more gradual change in the abundance of the epipelic algae at the same time in 2001. The *Bacillariophyta* were dominant at station I, with 80% of the total individual counts of the epipelic algae. No changes in the numbers of members of the *Chlorophyta* and *Cyanophyta* were observed at station I in this period on comparing with the spring period. Whilst members of the *Bacillariophyta* decreased in number at stations II and III in summer, there were notable increases in the counts of the *Cyanophyta* and *Euglenophyta* members in summer. *Anabaena aequalis* (*Cyanophyta*) showed a rapid increase, especially in 2001, and reached about 3790 individuals per cm^2. Thus, the *Cyanophyta* became dominant together with the *Bacillariophya* at these stations. Almost all of the species dominating in spring were also dominant in summer at all stations (Figure 2).

The maximum number of epipelic algae was recorded in September of both years, followed by a steady decline to the end of the year. Members of the *Bacillariophyta* were found at higher numbers than the *Chlorophyta* and *Cyanophyta* at station I. *Anabaena aequalis*, *Oscillatoria limosa* (only in 2000) and *O. limnetica* (*Cyanophyta*) (only in 2001) grew rapidly in late summer and autumn at stations II and III. In particular, *Anabaena aequalis* increased very rapidly at station II in 2001 and appeared as a mat on the sediment surface. Some15380 individuals per cm^2 of this species were found at station II and constituted the majority of the epipelic community. The sediment of station III was mostly dominated by members of the *Bacillariophyta* and *Cyanophyta*. *Euglena polymorpha*, *E. gracilis* and *Phacus acuminatus* (*Euglenophyta*) were widespread at stations II and III in the summer and autumn, but they were observed rarely at station I (Figure 2).

Epilithic Algae

The epilithic algal flora was mainly dominated by diatoms at all stations, and the dominating species in the epilithic algal flora differed from each other at all stations. *Cocconeis placentula* var. *euglypta*, *Navicula rhyncocephala* and *N. salinarum* were the most abundant species at all stations. *Achnanthes lanceolata*, *Hannaea arcus* var. *amphioxys* (Rabenh.) Patrick, *Cymbella minuta*

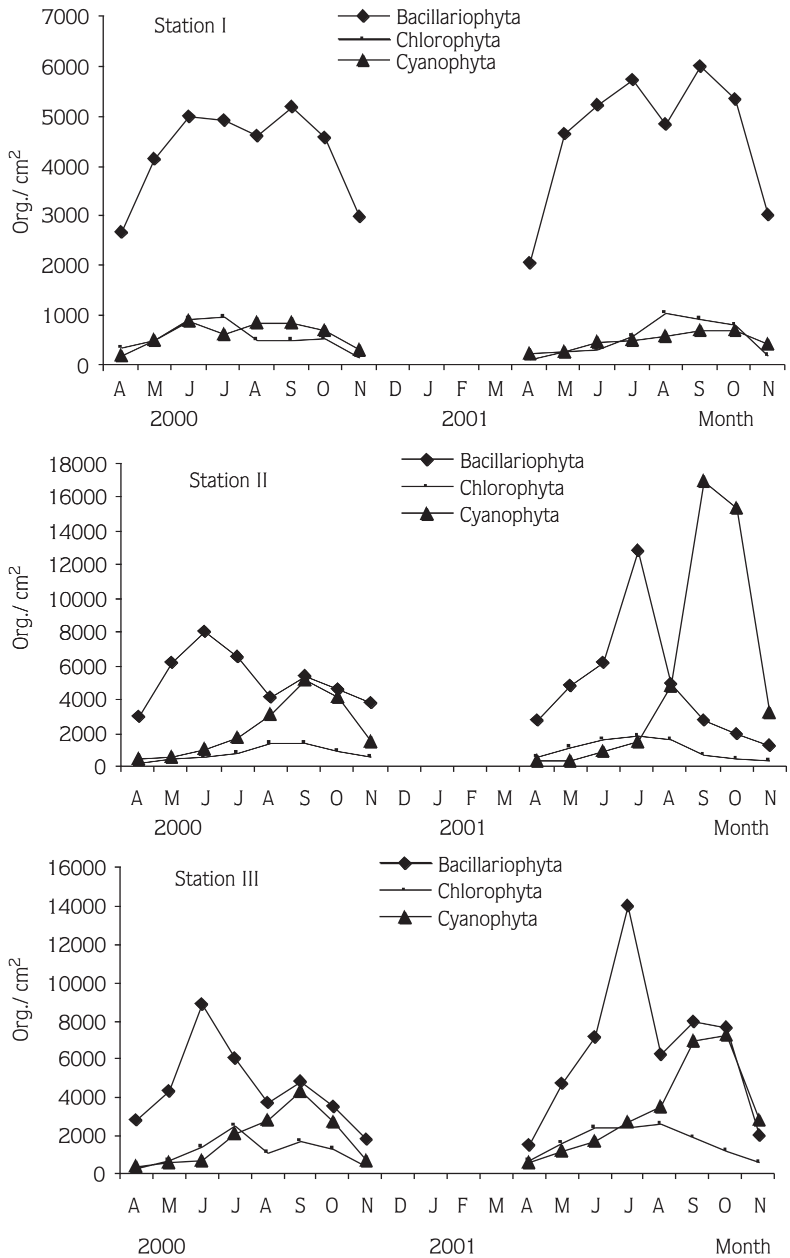

Figure 2. Seasonal changes in density of algal groups in the Demirdöven Dam Reservoir.

fo. *latens*, *Cymbella minuta* var. *silesiaca* (Bleisch ex Rabenh.) Reimer, *Epithemia adnata* (Kütz.) Bréb. and *Gomphonema olivaceum* (Lyngb.) Kütz. were common at stations I and III. *Gomphonema parvulum* (Kütz.) Kütz., *Epithemia adnata*, *Epithemia sor*ex Kütz. and *Nitzschia palea* were dominant at station II.

In the epilithic flora, while members of the *Chlorophyta* were abundant throughout the study period, members of the *Cyanophyta* and *Euglenophyta* were abundant only at stations II and III in the summer and autumn. *Cosmarium margaritatum*, *Closterium parvulum*, *Oedogonium* sp., *Ulothrix zonata* (Weber & D.Mohr) Kütz., *Staurastrum longiradiatum*, *Anabaena aequalis*, *Oscillatoria limosa*, *Euglena gracilis*, *E. polymorpha* and *Trachelomanas volvocina* Ehrenb. were abundant Table 3.

Table 3. Mean relative abundance of epilithic diatom taxa in the Demirdöven Dam Reservoir.

Taxa	StationI	Station II	Station III	Taxa	StationI	Station II	Station III
Centrales				*Gyrasigma acuminatum*	0.63	0.75	0.69
Aulacoseria distans	0.25	0.69	0.25	*Hannaea arcus*	5.56	1.56	4.31
Cyclotella kützingiana	0.94	1.31	1.44	*Hannaea arcus* var. *amphioxys*	4.06	1	2.31
C. kützingiana var. *radiosa*	0.56	0	0.44	*Hannaea arcus* var. *linearis*	1.81	0.56	0.63
Cyclotella ocellata	2.06	1.94	2.44	*Hantzschia amphioxys*	0.81	0.63	0.56
Meloseria varians	1.81	0.94	1.13	*Meridion circulare*	0.13	0.69	0.31
Pennales				*Navicula capitata*	0.63	0.25	0.25
Achnanthes lanceolata	4.94	0.94	3	*Navicula cryptocephala* var. *veneta*	1.88	2.88	1.44
Achnanthes lanceolata var. *dubia*	0	0.25	0	*Navicula cuspidata*	0.44	0	0.63
Amphora ovalis	1.13	0	1.25	*Navicula dicephala*	0	1.31	0
Amphora ovalis var. *pediculus*	0.5	2.5	0.31	*Navicula gastrum*	0.44	0.75	0.56
Asterionella formosa	0.25	0	0	*Navicula gracilis*	0.88	1.44	0.31
Caloneis silicula	0.69	0.5	0.38	*Navicula graciloides*	0.31	0	0.56
Caloneis ventricosa	0.31	0.5	0.19	*Navicula halophila*	0.69	0.81	0.38
Cocconeis placentula var. *euglypta*	4.13	3.81	5.19	*Navicula leavissima*	0	0.38	0
Cymatopleura eliptica	0.25	0.69	0.19	*Navicula mutica*	1.19	1.19	0
Cymatopleura solea	0.69	0.38	0.38	*Navicula mutica* var. *undulata*	1.5	0.75	1.38
Cymbella affinis	1.44	1.75	2.19	*Navicula rhyncocephala*	3.94	8	7.19
Cymbella cistula	1.25	1.94	2.56	*Navicula salinarum*	3.44	5.94	4.88
Cymbella cistula var. *maculata*	0	0	0.5	*Navicula viridula*	0.75	0	0.75
Cymbella cymiformis	1.25	1.63	1.38	*Neidium affine*	0.31	0	0.38
Cymbella lanceolata	1.06	2.06	1.63	*Neidium iridis*	0.19	0	0
Cymbella minuta fo. *latens*	5.94	2.88	3.44	*Nitzschia amphibia*	0.88	1.31	0.94
Cymbella minuta var. *silesiaca*	6.13	2.44	4.38	*Nitzschia dissipata*	2.19	1.56	2.13
Cymbella naviculiformis	0.69	0.56	0.25	*Nitzschia palea*	0.44	4.75	2.5
Cymbella sinuata	0.69	0	0.5	*Nitzschia sinuata* var. *tabellaria*	0.75	0.56	0.19
Cymbella tumida	0.94	0.88	1.5	*Pinnularia acrosphaeria*	0.19	0.31	0.25
Diatoma heimale var. *mesodon*	0.31	0.31	0.5	*Pinnularia biceps*	0	0	0.25
Didymosphenia geminata	0.5	0.38	0.38	*Pinnularia borealis*	1.38	1.19	0.56
Diploneis ovalis	0.19	0.19	0.38	*Pinnularia brebissoni*	0	0	0.25
Epithemia adnata	3	4.63	3.88	*Pinnularia microstauron*	0	0.81	0
Epithemia sorex	1.94	3.31	2	*Pinnularia stamotophora*	0.19	0.31	0.19
Eunatia diadon	0.13	0.38	0.31	*Pinnularia viridis*	0.81	0.69	0.75
Eunatia sp.	0.13	0	0	*Rhicosphenia curvata*	0.56	0.75	0.19
Fragilaria vaucheriae	1.25	0.81	1	*Rhopalodia gibba*	0.44	0.56	0.56
Fragilaria ulna	3.5	1.88	3.25	*Sellaphora pupula*	1.25	1.19	0.88
Gomphonema acuminatum	1.19	1.25	1.44	*Stauroneis anceps*	0.75	0.75	0.38
Gomphonema affine	0.31	1	0.19	*Stauroneis smithii*	0.31	0	0.19
Gomphonema angustatum	1.5	2.25	1.75	*Sureirella angustata*	0.81	0.88	1.13
Gomphonema consrictum var. *capitata*	0.5	0	0	*Surirella robusta*	0.25	0	0
Gomphonema gibba	1.06	0	0.81	*Synedra radians*	0.63	0	0.44
Gomphonema olivaceum	3.88	2.19	4.06	*Synedra rumpens*	0	0.44	0.25
Gomphonema parvulum	0.56	6.06	4.19	*Synedra ulna* var. *consracta*	0	1.13	0
Gomphonema turuncatum	0.81	0.75	0.5				

Discussion

Members of the *Bacillariophyta* dominated in the benthic algal flora of other lakes and reservoirs in Turkey and they were also dominant in that of the DDR, followed by the *Cyanophyta* and *Chlorophyta*. Similarly, species of *Cyanophyta* were subdominant in Tortum Lake (Altuner and Aykulu, 1987) and *Chlorophyta* were subdominant in Palandöken (Gürbüz, 2000) and 23 Temmuz Ponds (Gürbüz & Kıvrak, 2001), Tercan (Altuner & Gürbüz, 1996) and Çubuk-I Dam Lakes (Gönülol, 1985).

The composition of the epipelic algal flora is affected by a complex of factors, of which the chemical properties of the overlying water is the dominant one, interacting with the chemical and physical nature of the sediment and with the degree of water movement (Round, 1984). Seasonal variations and the composition of the epipelic algal flora of the DDR were observed to differ from each other at all stations. These results could be attributed to different environmental conditions such as the chemical and physical nature of the sediment at the stations. Whilst the *Bacillariophyta* were dominant at station I throughout the study period, they were dominant together with the *Cyanophyta* at stations II and III during the summer and autumn. *Navicula rhyncocephala*, *N. salinarum*, *Cocconesis placentula* and *Pinnularia borealis* were dominant at all stations. *Navicula* Bory species are known to be especially tolerant to changing environmental conditions (Nather Khan, 1990), which explains why they have been shown to be dominant in the epipelic algal flora of many lakes and reservoirs in Turkey (Gönülol, 1985; Elmalı & Obalı, 1998; Çetin et al., 2002; Gürbüz & Kivrak, 2003). *Hannaea arcus*, *Cymbella minuta* fo. *latens* and *Achnanthes lanceolata* were dominant only at station I with mud-sandy sediment.

Round (1960) reported that species of *Amphora* Ehrenb., *Caloneis* Cleve, *Cocconeis* Ehrenb., *Cymbella* C.Agardh, *Cymatopleura* W.Sm., *Epithemia* Bréb., *Navicula, Nitzschia* Hassall and *Rhopalodia* O.Müll. were common in calcareous and slightly alkaline water. The diatoms that grow well in calcareous and slightly alkaline water were also dominant in the benthic algal flora of the DDR. The results of chemical analyses of the reservoir water showed that it is slightly alkaline (Table 1). Diatoms growing in calcareous and alkaline water were also dominant in the benthic algal flora on the sediments of ponds, lakes and reservoirs in Turkey (Gönülol, 1985, 1987; Elmalı & Obalı, 1998; Gürbüz & Kıvrak, 2003).

Members of the *Cyanophyta* were subdominant at stations II and III, whereas they were not important at station I. *Anabaena aequalis*, *Oscillatoria limnetica* and *O. limosa* were recorded in high numbers in the DDR during the summer and early autumn. Round (1984) reported that these species grow in eutrophic water and on organically polluted sediments in summer and autumn. The dominance of *Nitzschia palea*, *Anabaena* Bory and *Oscillatoria* Vaucher species suggested that the sediments of these stations are very rich in organic matter.

Cosmarium margaritatum, *Staurastrum longiradiatum*, *Closterium lunula* and *C. parvulum* were found in low abundance on the sediments. *Staurastrum* Meyen species are known to be planktonic organisms, and *Staurastrum longiradiatum* may be transferred from the pelagic zone to sediments when common in reservoir waters during the summer.

Euglena polymorpha, E. gracilis and *Phacus acuminatus* were abundant at stations II and III in the summer and autumn. Round (1984) stated that members of the *Euglenophyta* were abundant in eutrophic water and on sediments polluted with organic matter.

Diatoms known as attached organisms, such as species of *Hannaea* R.M.Patrick, *Cymbella*, *Cocconeis*, *Epithemia*, *Gomphonema* C.Agardh and *Synedra* Ehrenb. were abundant in the epilithic algal community. Members of the *Chlorophyta* (especially *Oedogonium* sp. and *Ulothrix zonata*), *Cyanophyta* and *Euglenophyta* were abundant during the summer and autumn. The abundant species in the epilithic community of the DDR are similar to those of Çubuk-I Dam and Bayındır Dam Lakes (Gönülol, 1985; 1987), Akşehir Lake (Elmalı & Obalı, 1998) and Kuzgun Dam Reservoir (Gürbüz & Kıvrak, 2003). Round (1984) reported that filamentous algae and *Cymbella*, *Cocconeis*, *Epithemia*, *Gomphonema* and *Synedra* species were the most abundant organisms of the epilithic habitat.

The diatom taxa, thriving well in slightly alkaline water, became dominant in the benthic algal flora of the DDR. Seasonal variations and the growth of benthic algae were affected by environmental factors, especially water temperature. The abundance of benthic algae in the DDR was very low in early spring and late autumn (when water temperature is low) and high during the late spring, summer and early autumn.

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