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Seasonal Changes in Epipelic Diatom and Ionic Composition of a Karstic Lake, Todurge, in Central Anatolia, Turkey

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Abstract: The seasonal variations of epipelic diatoms and ionic composition in Tödürge Lake, the largest karstic lake of Anatolia, were investigated from October 2000 to October 2001. A total of 92 taxa belonging to 29 genera were identified. In all station, *Amphora*, *Achnanthidium*, *Cymbella*, *Gomphonema* and *Mastogloia genera* were dominant. *Amphora commutata*, *Achnanthidium minutissimum*, *Cymbella affinis*, *Cyclotella comensis*, *Cocconeis placentula* var. *euglypta*, *Gomphonema olivaceum*, *Mastogloia smithii*, *Mastogloia braunii*, *Cymbella sinuata*, *Cymbella silesiaca* and *Cymbella naviculaformis* were identified. The seasonal distribution of diatoms were affected by sulphate (311 mg L^{-1}) and calcium (489 mg L^{-1}) concentration.

Key words: Seasonal variation, diatom, Karstic lake, ionic composition, Tödürge

INTRODUCTION

Tödürge Lake, spread over an area of 35 km^2, is formed in one of the world's rare gypsum karsts in Anatolia, Turkey (Gunay, 2002). Karstic lakes are very sensitive to changes in temperature and rainfall because of the geomorphologic features of gypsum. They have the highest solubility of common rocks and fed by upwelling karstic springs. Seasonal cycles of temperature, ionic composition, rainfall and upwelling exert a pronounced control over the physiological and reproductive processes in diatom. Diatoms are abundant in all aquatic environments: oceans, lakes, rivers, wetlands and inland karstic lakes. It represents one of the key bio-indicators for limnological studies, particularly among the large number of biogenic residues in lake sediments. Diatoms are known to respond directly and sensitively to changes in physical and chemical environment (Stevenson and Pan, 1999), because of their short life-cycles, rapid dispersal, colonization and the large number of species with differing tolerances to physical and chemical variables (Battarbee *et al*., 1999; Lotter *et al*., 1999). There have been very few studies to establish diatom community composition and environmental condition in karstic lakes and ponds (Saros and Fritz, 2000; Jasprica and Hafner, 2005).

In Turkey, studies of diatom were begun by Yildiz (1985) in Meram stream and followed by others which mainly focused on algal flora and factors affecting them in mid-Anatolia (Kilinç and Sivaci, 2001; Marasliogiu *et al*., 2005; Sıvacı and Pabuccu, 2007).

Central Anatolia's Sivas region is characterized by a great amount of precipitation, average rainfall is 1500 mm $year^{-1}$, but there is a general lack of surface water, due to the porous nature of its karstic soil. Water thus accumulates below the surface where it flows often. The Tödürge Lake (39° 53′ N; 37°36′ E) consists of two interconnected parts having areas of 318 and 12 ha with total of 330 ha. The depth of the lake varies between 1.75 and 6 m Its elevation is 1334 m.

In this study, we aimed to investigate some environmental parameters of Tödürge Lake and study its effect on the composition of epipelic diatom.

MATERIALS AND METHODS

Eight stations (T1, T2, T3, T4, T5, T6, T7 and T8) were selected for the present study. Measurements of environmental variables were taken between October 2000 and October 2001 in sampling periods of once in approximately 15 days (no measurement available in February 2001 due to freezing), making up 19 samples. Only T4 and T5 stations could not sampled because of depth. The samples were collected by an 11 mm dia × 1 m glass pipe, which was lowered by hand to the surface of sediment while one end was closed with the thumb. It was

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then moved in a circular direction on the surface and the thumb was slightly loosened to scud the sediment into pipe. The sample were put into petri dishes and allowed to settle for 4 to 6 h. The supernatant was removed and cover glasses were placed over the sediment. After 24 h, the cover glasses were washed into beakers. To remove carbonates from diatoms, they firstly treated with HCl and then it was used H_2O_2 for oxidation following by repeated washing of resultant diatom frustules with demineralized water (Battarbee, 1986). Two or three permanent slides were prepared for each sample and 250-500 frustules per sample were identified and counted by using Olympus Vanox at 1600 X magnification. Number of total diatoms (per cm^2) was calculated by using Round's (1953) method. Species were identified according to John *et al.* (2003), Krammer and Lange-Bertalot (1991a, b and 1999a, b) and Patrick and Reimer (1966 and 1975).

Data from three replication of all count were subjected to analysis of variance using SPSS 8.0 for Windows for all statistical analysis. Differences between means at 5% ($p<0.05$) level were considered as significant.

It was measured water temperature (YSI 51B model) and pH (Orion 250-A model) in the field. Water was filtered through GF/C filters for analysis of ammonium, nitrate and soluble reactive phosphorus. Unfiltered water was used for other variables and all analyses were completed within 18 h of sampling. Soluble Reactive Phosphorus (SRP), Total Soluble Phosphorus (TSP), Total Phosphorus (TP), Silicate $(SiO_3)^4$, Chlorine (Cl^-), Calcium (Ca^{2+}), Sulphate (SO_4^{2-}), Ammonium (NH_4^+) were determined according to Mackereth *et al.* (1978). Nitrate was determined by the cadmium method. To determinate the chlorophyll a and carotene concentration, water volumes of 500 mL were filtered through GF/C glass fiber filters after the addition of 0.2 mL saturated $MgCO_3$. Filters were extracted in cold 90% acetone for 18-24 h. Following absorption measurements, the equations of Talling and Driver (1961) were used.

RESULTS AND DISCUSSION

During study periods, a total of 92 taxa belonging to 29 genera were identified in Tödürge Lake (Table 1). In all stations, *Amphora*, *Achnanthidium*, *Cymbella*, *Gomphonema* and *Mastogloia* were dominant; *Diatoma*, *Fragilaria*, *Nitzschia* and *Navicula* were co-dominant among the epipelic diatom genera. The lowest number of species was encountered in January and the highest number in May 2001 and June 2001 (Table 2) ($p<0.05$). Temporal and numerical variations of diatoms related to 6 stations are described in Table 2. Throughout the seasons, number of species was resembled at each stations and certain species, *Amphora commutata*, *Achnanthidium minutissimum*, *Cymbella affinis*, *Cyclotella comensis*, *Cocconeis placentula* var. *euglypta*, *Gomphonema olivaceum*, *Mastogloia smithii*, *Mastogloia braunii*, *Cymbella sinuata*, *Cymbella silesiaca* and *Cymbella naviculaformis* were determined more dense in all stations. The diatom main peak was observed in May 2001 and June 2001 at station T1 and T3. It was appeared late spring (Table 2) ($p<0.05$). The ionic composition of Tödürge Lake effected primarily the distribution of epipelic diatom. Some taxa were preferred to rich calcium and sulphate, especially, *Amphora*, *Achnanthidium*, *Cymbella* and *Mastogloia* genera. Krammer and Lange-Bertalot (1986 and 1988) indicated that the mentioned diatoms exist densely in waters which are rich in sulphate and calcium. These genera also were reported for karstic lakes in the Europe (Riera *et al.*, 2004) and in some Anatolian freshwater systems (Kilinç and Sivaci, 2001; Maraşlıoğlu *et al.*, 2005; Soylu and Gönülol, 2006; Sıvacı and Pabuccu, 2007).

When Gypsum ($CaSO_4.2\ H_2O$) dissolves in freshwater system, the ionic composition change and the intensity increase, especially in relation to Ca^{2+} and SO_4^{2-}. According to Wetzel (1983) in these lakes phosphorus was likely to be precipitated as calcium phosphate ($CaPO_4$) since Ca^{2+} is in abundance in the limestone bedrock. $CaPO_4$ is not a completely suitable source of phosphate for diatoms to use. Furthermore, concentration of divalent cations like Ca^{2+} is highly correlated with the amount of dissolved SO_4^{2-} and temperature. Kashima (2003) reported that the paleosalinity of some central Anatolian lakes were altered by climatic and temperature. Temperature is one of the most important factors in Tödürge Lake (Fig. 1). These factors have the greatest effect on the growth of diatoms in the study area.

Ionic composition affects diatom ecology, both directly (e.g., via their influence on physiological processes) and indirectly (e.g., via their influence on biogeochemical cycles). However, the actual mechanisms about of which one parameters influence diatom community structure in karstic lakes have not yet been understood. Of course the ability to withstand osmotic pressure may fully explain the correlation among salinity and diatom distributions.

Noting that, in the natural freshwaters, the expected value of the sulphate is between 3-30 mg L^{-1} and of the calcium 6-78 mg L^{-1} (Moss, 1973), the measured values of these ions in our lake can be considered

Table 1: Epipelic diatom taxa of Tödürge Lake

Divisio: Bacillariophyta
Class: Centrobacillariophycea
Cyclotella antigua W. Smith
C. bodanica Grunow
C. comensis Grunow
C. ocellata Pantocsek
C. meneghiniana Kütz.
Class:Pennatibacillariophyceae
Achnanthidium minutissimum (Kützing) Czarnecki
Amphora coffeaeformis (Agardh) Kütz.
A. commutata Grunow
A. ovalis Kütz.
A. veneta Kütz.
A. lineolata Ehr.
Caloneis silicula (Ehr.) Cleve
Campylodiscus bicostatus W.Smith
C. clypeus Ehr.
Cocconeis placentula var. *euglypta* Ehr.
Cymatopleura elliptica Brébisson
C. solea (Brébisson) W.Smith
Cymbella affinis Kütz.
C. amphicephala Näegeli
C. angustata (W.Smith) Cleve
C. naviculiformis Auersw.
C. cistula (Ehr.) Kirchner
C. lanceolata (Ehr.) Kirchner
C. subaequalis Grunow
C. tumida (Brébisson) Van Hustedt
C. turgidula Grunow
Diatoma tenuis Agardh
D. tenuis var. *elongatus* Lyngbye
D. vulgaris Bory
Diploneis elliptica (Kütz.) Cleve
D. interrupta (Kütz.) Cleve
D. parma Cleve
Entomoneis alata (Ehr.) Ehr.
Epithemia adnata (Kütz.) Bréb.
E. argus(Ehr.) Kütz.
E. sorex Kütz.
Encyonema caespitosum Kützing
E. silesiacum (Bleisch) D.G. Mann
Eucocconeis flexella (Kützing) Meister
Eunotia arcus Ehr.
Fragilaria biceps Kütz.
F. brevistriata var. *subcapitata* Grun.
F. capucina Desm.
F. capucina var.*rumpens* (Kütz.) Lange-Bertalot
F. tenera (W.Smith) Lange-Bertalot
E. tenella (Grunow) Hust.
F. ulna (Nitzsch) Lange-Bertalot
Gomphonema affine Kütz.
G. angustatum (Kütz.) Rabenh.
G. gracile Ehr.
G. olivaceum (Hornemann) Bréb.
G. parvulum (Kütz.) Kütz.
Hantzschia amphioxys (Ehr.) Grun.
Mastogloia braunii Grunow
M. grevillei W.Smith
M. smithii Thwaites
M. smithii var. *lacustris* Grunow
Navicula capitata.var *capita* Ehr.
N. cari Ehr.
N. cincta (Ehrenb.) Ralfs
N. cryptocephala Kütz.
N. cuspidata (Kütz.) Kütz.
N. elginensis (Gregory) Ralf
N. halophila (Grunow) Cleve.
N. pseudosilicula Hustedt
N. pupula Kütz.
N. radiosa Kütz.
N. splendicula Van Landingham
N. variostriata Krasske
Nitzschia acicularis (Kütz.) W.Smith
N. amphibia Grunow
N. brevissima Grunow
N. constricta (Gregory) Grunow
N. frustulum (Kütz.) Grunow
N. gracilis Hantzsch
N. linearis (Agart) W.Smith
N. macilenta Gregory
N. nana Grunow
N. palea (Kütz.) W.Smith
N. sigmoidea (Nitzsch.) W.Smith
N. sinuata (Thwaites?) Grunow
N. tryblionella Hantzsch
Rhopalodia gibba (Ehr.) O.Müll.
R. gibberula (Ehr.) O.Müll.
Pinnularia microstauron (Ehr.) Cleve
P. viridis (Nitzsch.) Ehr.
Pseudostaurosira brevistriata (Grun.) D.M. Will. and Round
Stauroneis anceps Ehr.
Staurosirella pinnata (Ehr.) D.M. Willi. and Round
Stephanodiscus sp. Ehr.
Surirella angusta Kütz.
Synedra ulna (Nitzsch.) Ehr.

Table 2: Seasonal variation of total diatom number (per cm^2) in stations. Abbreviation of sampling period used in Fig. 1 and 2

	Stations					
Sampling period	T1	T2	T3	T6	T7	T8
October 2000	1280	1754	985	720	420	960
November 2000	1426	1783	1020	985	850	2564
December 2000 (1)	1902	4897	4913	1025	2130	3520
December 2000 (2)	1886	3250	5026	1750	1230	3211
January 2001	346	486	921	523	657	820
March 2001	2026	1283	5034	1895	2355	2654
April 2001	4293	985	4252	1785	2030	2561
May 2001 (1)	4426	4325	6123	3260	1680	3560
May 2001 (2)	6620	3896	6204	4850	3250	2806
June 2001 (1)	6986	4410	4265	2560	3181	4950
June 2001 (2)	3373	4850	6234	5020	2430	3854
July 2001 (1)	4940	4582	4123	4320	2020	2656
July 2001 (2)	3646	2934	3658	3955	4560	1827
August 2001 (1)	2206	2304	2931	3300	2090	1784
August 2001 (2)	853	2010	3320	4120	1020	1503
August 2001 (3)	580	2120	2894	1853	1650	1257
September 2001 (1)	3036	785	1233	1680	1020	987
September 2001 (2)	4553	792	856	1321	850	652
October 2001 (1)	1420	521	785	654	480	93

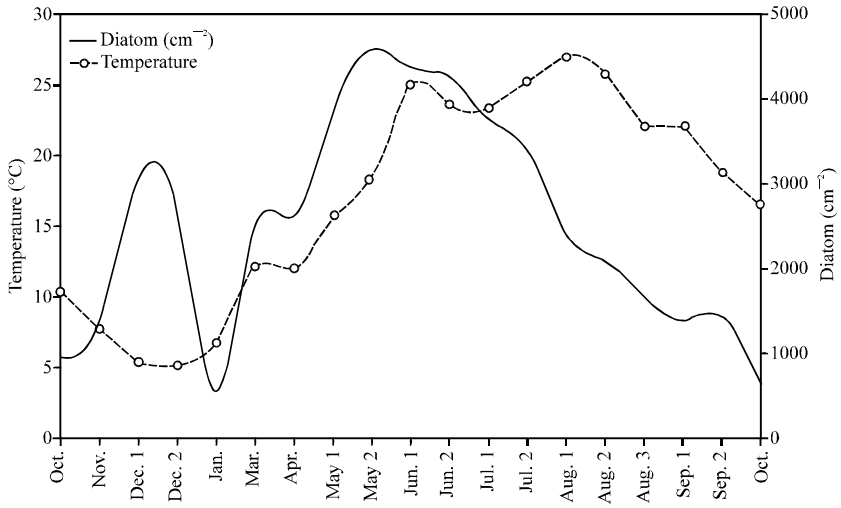

Fig. 1: Seasonal variation of diatom against temperature in Tödürge Lake

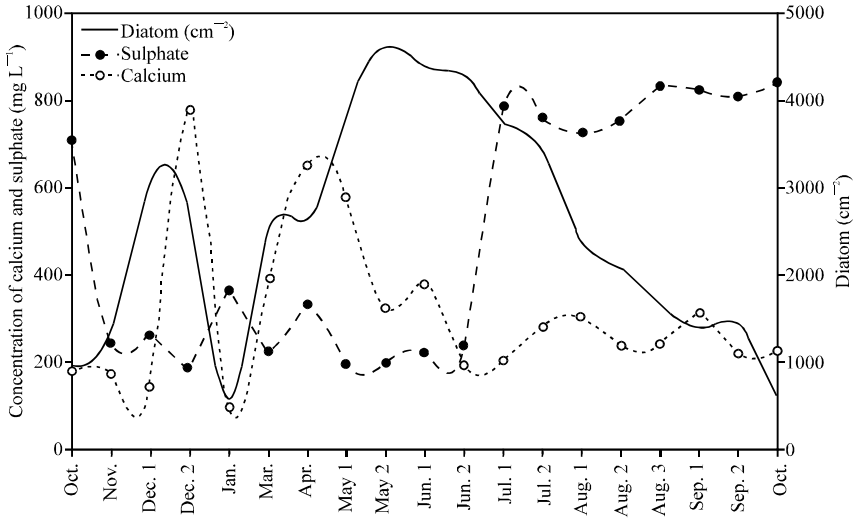

Fig. 2: Seasonal variation of diatom against sulphate and calcium concentration in Tödürge Lake

Table 3: Means of environmental variables in Tödürge Lake

Environmental variable	Mean±SE
Soluble reactive phosphorus (μg L^{-1})	46.70±4.850
Total soluble phosphorus (μg L^{-1})	52.80±6.950
Total phosphorus (μg L^{-1})	57.30±10.23
Ammonium (μg L^{-1})	215.30±24.30
Nitrate (μg L^{-1})	0.56±0.060
Silicate (mg L^{-1})	5.57±0.240
Sulphate (mg L^{-1})	311.00±34.60
Calcium (mg L^{-1})	489.00±33.60
Chlorine (mg L^{-1})	8.67±0.050
Chlorophyll-a (μg L^{-1})	0.38±0.090
Temperature (°C)	15.86
pH	8.53

as extreme as they were not below 100 and 600 mg L^{-1}, respectively in all samples (Fig. 2) (Table 3).

The physical (e.g., temperature) and chemical differences (e.g., SO_4^{2-}, Ca^{2+}) among stations of lake could naturally have effects on the seasonal development of diatoms ($p<0.05$). Temperature is known to be one of the most important factors in the seasonal distribution of diatoms (Fig. 1) and this study supports the above mentioned findings, since the diatoms showed their best growth in late spring and summer in Tödürge Lake.

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