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RESEARCH PAPER

Relationship of Epilithic Diatom Communities to Environmental Variables in Yedikır Dam Lake (Amasya, Turkey)

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Abstract

In order to evaluate the composition and seasonal variations of the epilithic diatoms in Yedikır Dam Lake were studied using samples collected from the stones in the barrier area between November 2004 and April 2006. The diatom communities were diverse; 88 taxa were found, belonging to the Bacillariophyta. *Cymbella minuta*, *Cyclotella ocellata* and *Encyonema silesiacum* have become the most abundant organisms in the epilithon.

Environmental variables together with biological data obtained during the monthly routine biomonitoring of epilithic samples in the dam were analysed to understand variability of epilithic diatom communities and their relationships with environmental variables. Moreover, cluster analysis was applied to the epilithic algal communities and the seasonal variations of the samples were classified according to their similarity levels. Speciess richness and shannon diversity of the samples which were counted were measured in monthly periods. The results of the diversity analysis and the counting did not exactly match up with each other.

Multivariate analyses indicated that both the regional distribution and seasonal variation of some epilithic diatoms (e.g. *Cymbella* spp., *Nitzschia* spp., *Amphora delicatissima*) are mainly driven by nutrient concentrations. Furthermore, epilithic diatoms are predominantly affected by geochemical characteristics including pH and total alkalinity ($CaCO_3$) levels.

Keywords: Benthic diatoms, species diversity, CCA, indicators.

Introduction

Diatoms are considerably important biological organisms because they are one of the sources of oxygen, like other algal divisions, and the first ring of food chains in aquatic systems. A complete picture of the lake ecosystem is necessary to understand the mechanisms regulating the nutrient content and biomass of benthic algae, because they can be dominant primary producers and are an important food resource (Wetzel, 1996). In addition, algae are used in textiles, paper, construction, cosmetics, fertiliser, food, and medical industries, and to produce single cell protein in biotechnology (Round, 1973). Some indicator algal species are also important criteria for determining water pollution. Waste waters come from domestic and industrial sources, consisting of organic and inorganic compounds (Atıcı, 1997). Diatoms have been used in a number of countries as indicators of water pollution (Ács, Szabó, Kiss, Tóoth, Záray, & Kiss, 2006; Gosselain *et al*., 2005). The natural structure of water pollution is such that a useful water source is destroyed by any harmful chemical or physical factor.

Epilithic diatoms are recognized worldwide as one of the most appropriate biological components for water quality assessment, due to their continuous presence along the aquatic system and their quick response to the environmental changes (Salomoni, 2004). Also, the WFD provides a general definition of ecological status as an 'expression of the structure and functioning of aquatic ecosystems' (Kelly, King, & Ni Chathain, 2009). Investigation of benthic diatoms is recommended by the Water Framework Directives (Water Framework Directive, European Parliament 2000 directive, 2000/60/EC). They are considered key organisms in ecological quality analyses of water courses and have been applied for more than a decade in several countries of Europe (Austria, Switzerland, Germany, Belgium, France, Poland, Finland, Luxemburg, United Kingdom, Spain, Portugal, Italy). One of the main goals of the WFD is, to assign the extent of difference to which ecosystems differ from high ecological status, where there are no or only very minor anthropogenic alterations (reference ecosystems) (Ács, Szabó, Tóth, & Kiss, 2004).

Studies conducted in Yedikır Dam Lake,

Amasya, Turkey, have been focussed on phytoplankton (Maraşlıoğlu & Gönülol, 2014), trophic status by using epipelic and epipsammic algae (Maraşlıoğlu, 2016), and biodiversity of the dam lake (Anonymous, 2012), but there is a gap in knowledge concerning epilithic diatoms. Also, similar epilithic studies were made in the middle Black Sea region of Turkey (Maraşlıoğlu, Soylu, & Gönülol, 2005; Bulut, 2012; Dönmez & Maraşlıoğlu, 2016; Bektaş, 2016; Maraşlıoğlu, Gönülol, & Pelit, 2016).

Epilithic diatom samples obtained in the present study have a wide spectrum of ecologically different types, including marine, brackish, and even freshwater affinities. In addition to this, samples also contained a mixture of forms growing on the stones themselves, on silt accumulated on the stones, and epiphytic forms on other algae, but here I will refer to this collective community as the epilithon. The aims of the present study were to describe the species composition of diatom assemblages, to determine which environmental factors explain the composition of epilithic diatoms and to assess the response of common diatom taxa to these environmental variables.

Material and Methods

Study Area

Yedikır Dam Lake (40°46′48″ N, 35°33′36″ E) is located in the North of Turkey and within the city of Amasya, between Suluova lowland and Merzifon lowland (Figure 1). The dam was built for irrigation purposes in 1985 on Tersakan Stream, a tributary of Ladik Lake and pours their water to Yeşilırmak river. The feeding of the dam occurs with the precipitation falling on the lake surface and the water given from the Tersakan stream. Water is provided to dam in a controlled way by the regulator built in Celtek region on Tersakan stream. The drainage of the dam lake is carried out with water taken from the lake for the purpose of irrigation and annual evaporation. The state of the amount of water in the dam at different seasons is given in Figure 2. It has a surface area of 5.93 km^2. The maximum depth is 25.2 m and the maximum water capacity is 6.3 hm^3. The dam irrigates about 7403 hectares of agricultural land. The structure of the bottom is thick, with a brown colour. Nevertheless, salt is widespread in the soil and the bottom deposits are extensively salty.

The climate regime in the area is characterised by the transition from the climate of the Middle Black Sea Region to that of Central Anatolia. Winter and autumn is generally rainy, and summer is cool. According to monthly average precipitation data obtained from Suluova District Directorate of Agriculture between 1995 and 2005, the highest precipitation in the region is seen in spring and the lowest in summer. Also, according to the evaporation values of the stations nearest to the dam site, the highest evaporation occurs in July and August. According to temperature data between 1995 and 2005 obtained from the Meteorological Station of Suluova, is a district nearest to the Dam Lake, annual temperature average is 14.04°C and maximum

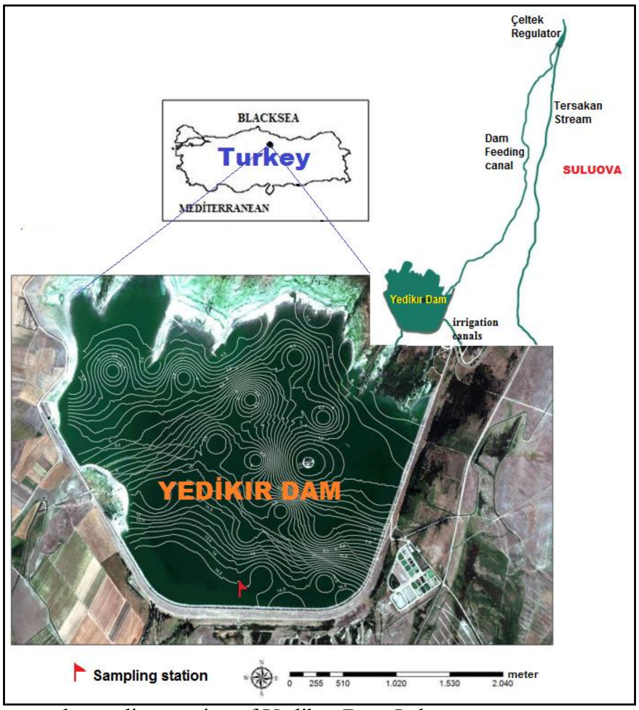

Figure 1. The bathymetry map and sampling station of Yedikır Dam Lake.

Figure 2. The state of the amount of water in the dam a) after summer and b) before summer (google earth).

temperature average is 26.67°C and minimum temperature average is 2.21°C (Anonymous, 2012).

Moreover, Yedikır Dam Lake is one of the most important dams on the middle Black Sea region of Turkey in terms of bird and plant diversity. For example, there are some endemic plant species (*Delphinium venulosum*, *Anthemis sintenisii*) around the dam lake. Also, in the bird observing studies conducted around the dam lake in 2012, a total of 71 different bird species have been identified. Because of its enormous species diversity and natural habitats, the dam was included in the important wetlands list in the Ramsar Convention. (Anonymous, 2012).

Water Sampling and Analysis

Water samples were taken monthly from the same station in order to determine the physico-chemical structure of Yedikır dam. Water temperature (°C), pH, conductivity (µmhos/cm) and dissolved oxygen concentration (mg/L) were measured *in situ* with Jenway 3040 model pH meter. Water transparency was measured on each sampling date using a Secchi disk. Water samples collected in 1 L plastic bottles for analyzing immediately transferred to the laboratory. Concentrations of nitrite nitrogen (NO_2-N), nitrate nitrogen (NO_3-N), ammonium nitrogen (NH_4-N), orthophosphate phosphorus (PO_4-P) and sulphate (SO_4) were measured spectrophotometrically according to the standard methods (APHA, 1995). To determine chlorophyll-a, water volumes of 500 mL were filtered through GF/C glass 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 Strickland and Parsons (1972) were used. The remaining variables were measured colorimetrically with Hanna C 200 multiparameter ion specific meter in laboratory.

Diatom Analysis

Sampling of epilithic diatoms were performed monthly from the one station in Yedikır Dam Lake between November 2004 and April 2006. We chosed only a station for epilithic sampling due to the presence of stones only in the dam barrier area. To define the species composition of epilithic diatoms, stones and pebbles 15 to 20 cm in diameter at least 40 cm depth in the littoral area were collected into a plastic container. Each stone was chosen as randomly as possible amongst those that were not covered with filamentous algae and with an evident film of diatoms. The entire surface area of each stone was scraped clean with a toothbrush in 150 ml of distiiled water and preserved with formaldehyde (4%). Before counting, the preserved sample was brought to a final volume of 200 ml with distilled water and homogenized at low speed until the sediment was throughly mixed (Winter & Duthie, 2000). At least 500 diatom valves per slide were counted at 600x magnification on Nikon microscope. In the evaluations, the average of three countings from the station was used (Sladeckova, 1962). Permanent slides were prepared for identifications of diatoms from the same sample after boiling in a 1:1 mixture of concentrated H_2SO_4 and HNO_3. Slurries were rinsed several times in distilled water until neutral pH was reached. Slurries were dried overnight on coverslips and permanent slides for identification of diatoms were prepared using Naphrax high refractive index medium (Round, 1953). Diatoms were identified to the species level at 1000x magnification by phase-contrast optics with oil-immersion objective following standard diatom preperation methods (Battarbee, 1986). Identifications were made following Krammer and Lange-Bertalot (1991a, b, 1999a, b); Krammer (2003); Round, Crawford, & Mann (1990) and the current accepted nomenclature has been checked with AlgaeBase (Guiry & Guiry, 2016).

Data Analyses

The Shannon-Wiener index (H'; log 10 base) (Shannon-Weaver, 1949) and Pielou's evenness index (J') were calculated from relative abundance values (RA, %). Diatom counts of all 37 samples were first converted into RA. The RA values were used in the multivariate analysis and were the means of 3 replicate samples. Only the taxa which had an RA of at least 1% in any single sample were taken into consideration. In total, 88 taxonomic entities were distinguished, of which 37 were used as active taxa in the numerical analysis. A similarity matrix was defined according to the Bray-Curtis similarity method (complete linkage mode) after the square-root transformation was applied on the phytoplankton abundance matrix. Both index types (H' and J') and cluster analysis were conducted using the PRIMER-E statistical package (Clarke & Warwick, 2001).

Canonical correspondence analysis (CCA) was used to identify statistically significant directions of variations within the 37 samples. CCA is a powerful, statistically robust procedure for analyzing complex biological data (e.g. diatom percantages) and their relation to environmental variables (e.g. pH, temperature). It provides a simultaneous low-dimensional representation of diatom taxa, samples, and environmental variables (Birks, Juggins, & Line, 1990). A code was assigned to the species used in the CCA analyses (see Figure 3). Species abundance data were log (x+ 1) transformed prior to the analysis. Canonical Correspondence Analysis (CCA) was carried out using Multi-Variate Statistical Package (MVSP) program version 3.1 (Kovach, 1998).

Results

Biological Characteristics

In the qualitative and quantitative study of Yedikır Dam Lake, 88 diatom species were identified. Of those, 25 belonged to *Navicula*, 21 to *Cymbella*, 13 to *Gomphonema*, 6 to *Nitzschia*, 4 to *Amphora*, 3 to *Pinnularia*, 2 to *Ceratonies*, *Cocconeis*, *Fragilaria*, and 1 to *Achnanthes*, *Brachysira*, *Cyclotella*, *Cymatopleura*, *Diatoma*, *Encyonema*, *Melosira*, *Rhoicosphenia*, *Stephanodiscus*, *Surirella*.

The total numbers of epilithic diatoms ranged between 1025 cells cm^{-2} in February 2005 and 11375 cells cm^{-2} in March 2006 (Figure 4). *Cyclotella ocellata* and *Cymbella minuta* were especially prominent diatoms during the year in the lake. *Encyonema silesiacum* (up to 86% of all algal cells) was important organism only in May 2005. Approximately half of the total number of epilithic organisms was recorded only once during the sampling period.

Physicochemical Characteristics

The average values of seasonal changes in the physicochemical features of Yedikır Dam Lake are given in Table 1.

Diversity, Evenness and Richness

Shannon diversity and evenness (relative species abundance) presented small variations during the study period. Evenness around 0 indicates high single-species dominance that *Encyonema silesiacum* and *Cymbella minuta* formed up to 80% of the all organisms in May 2005 and January 2006. The bloom pattern of this species with a resulting decrease of H',

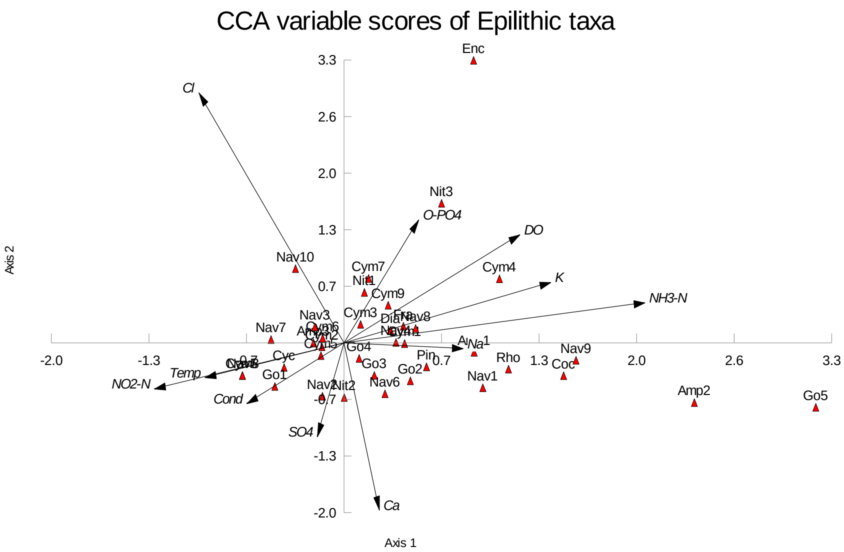

Figure 3. Results of the Canonical Corresponding Analysis (CCA) carried out in MVSP shown as a biplot environmental variables and 37 taxa. Abbreviations are: Temp-temperature, Cond-conductivity, DO-dissolved oxygen.
Amphora delicatissima (Amp1), *A.pediculus* (Amp2), *A.veneta* (Amp3), *Cocconeis placentula* (Coc), *Cyclotella ocellata* (Cyc), *Cymbella affinis* (Cym1), *C.brehmii* (Cym2), *C.cymbiformis* (Cym3), *C.elginensis* (Cym4), *C.gracilis* (Cym5), *C.minuta* (Cym6), *C.parva* (Cym7), *C.perpusilla* (Cym8), *C.prostrata* (Cym9), *Diatoma vulgaris* (Dia), *Encyonema silesiacum* (Enc), *Fragilaria ulna* (Fra), *Gomphonema minutum* (Go1), *G.olivaceum* (Go2), *G.olivaceum* var. *balticum* (Go3), *G.truncatum* (Go4), *G.vibrio* var. *pulvinatum* (Go5), *Navicula cari* (Nav1), *N.cryptonella* (Nav2), *N.gallica* (Nav3), *N.halophila* (Nav4), *N.minuscula* var. *muralis* (Nav5), *N.rhynchocephala* (Nav6), *N.tridentula* (Nav7), *N.tripunctata* (Nav8), *N.veneta* (Nav9), *N.vitabunda* (Nav10), *Nitzschia fonticola* (Nit1), *N.palea* (Nit2), *N.paleacea* (Nit3), *Pinnularia appendiculata* (Pin), *Rhoicosphenia abbreviata* (Rho).

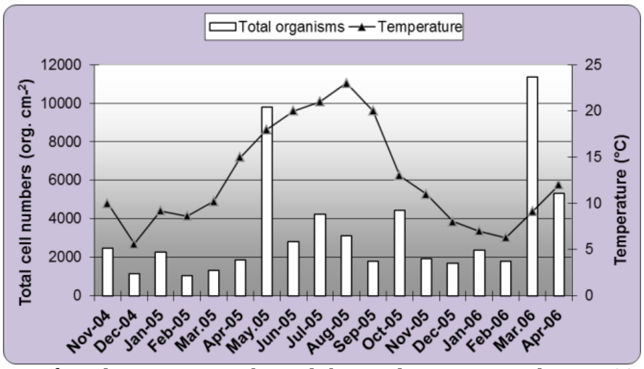

Figure 4. The seasonal variation of total organisms in the epilithon and temperature during 2004-2006.

Table 1. Seasonal averages of some physical and chemical properties in Yedikır Dam Lake

Parameters	2004-2005		2005			2005-2006	
	Autumn	Winter	Spring	Summer	Autumn	Winter	Summer
Temperature (°C)	10	7.8	14.4	21.3	14.7	7.1	10.6
pH	8.3	8.0	8.6	8.4	7.2	8.2	8.3
EC (μmhos/cm)	378	435	320	556	408	425	320
Cl (mg/L)	20	30	33	31	27	30	25
NH_3 (mg/L)	0.45	0.2	0.4	0.2	0.3	0.2	0.33
NO_2-N (mg/L)	0.00	0.01	0.01	0.04	0.01	0.01	0.01
NO_3-N (mg/L)	1.1	1.4	0.6	0.4	0.9	1.0	1.2
Total Alkalinity ($CaCO_3$) (mg/L)	155	159	177	152	158	168	193
DO (mg/L)	8.3	9.4	7.5	5.6	7.5	8.8	7.3
O-PO_4 (mg/L)	0.04	0.06	0.06	0.01	0.03	0.08	0.04
SO_4 (mg/L)	345	335	218	275	338	312	372
Na (mg/L)	13	14	10	9,3	12	13	11
K (mg/L)	4.9	4.8	4.2	3.9	4.8	4.6	4.2
Ca (mg/L)	85	69	57	69	63	85	82
Mg (mg/L)	11	15.3	14.3	8	13.7	18	16
Hardness (mg/L)	187	209	153	198	188	192	167
Fe (mg/L)	0.4	0.2	0.1	0.1	0.3	0.2	0.5
Chl-a (μg/L)	12	7	18	32	19	9	10
Turbidite (m)	2.1	2.4	2.0	1.7	2.2	2.5	2.2

also indicates low evenness. Yedikır Dam Lake wasn't presented low values of species richness. While the seasonal variations of species richness presented a decrease especially in summer period, the highest values of species richness were recorded in spring and autumn (Figure 5).

On the basis of comparative analysis of epilithic diatom communities investigated here, two groups of months were distinguished (Figure 6). The first cluster, formed by some spring samples (May 2005 and March 2006), is from the absolute prevalance of *Encyonema silesiacum* and *Cymbella minuta*. October and April months belong to group I whose diatom communities indicated the number of species dominance. Similarly, January 2006 and summer months were characterised by the at least the number of species during the study period. The 10 remaining months belonged to the second group, whose diatom communities did not indicate any species dominance, as it was confirmed by the scarcity of the number of organisms.

Correspondence Analysis

Multivariate statistical approaches were used to evaluate the relationship between biomass of epilithic assemblages and environmental variables in the dam lake. Fifteen variables (temperature, pH, conductivity, DO, Cl^-, NH_3-N, NO_3-N, NO_2-N, PO_4^-, SO_4^-, Na^+, K^+, Mg, Ca^{++} and $CaCO_3$) were chosen by the forward selection method from the environmental matrix (Table). The first two axes accounted for 37.9% of the variance (axis 1: 23.1%; axis 2: 14.8%). The eigenvalues indicated that abiotic factors were significantly correlated with both the first axis and second axis. The eigenvalues of the following canonical axes are lower, which implies a weaker gradient and a smaller percentage of the variance explained by an individual axis.

The diplot of the taxa and environmental variables according to the first two axes is shown in Figure 3. The taxa illustrated were selected taking in to account their abundance, frequency of occurence

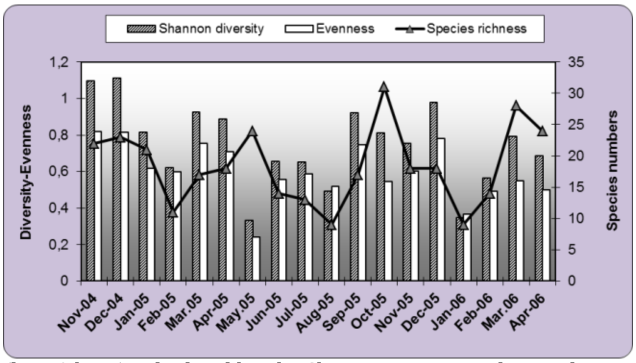

Figure 5. Shannon Diversity (log 10 base) calculated by the Shannon-Wiener index, Pielou's evenness and species richness in the epilithon.

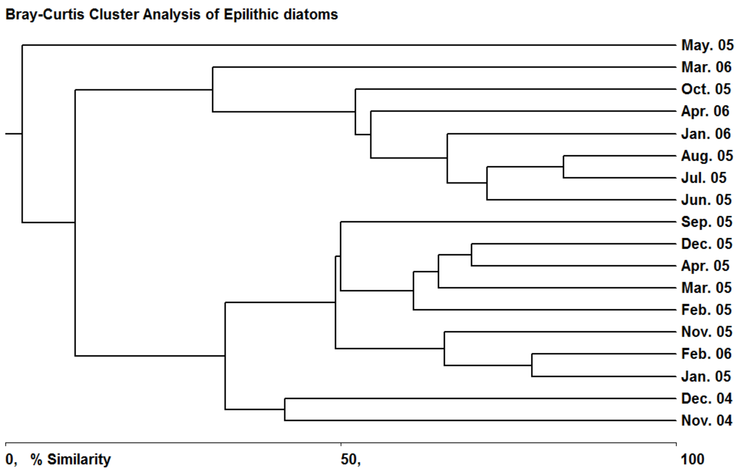

Figure 6. Dendrograms for hierarchical clustering of the months in Yedikır Dam Lake, using complete linking of Bray-Curtis similarities calculated in the epilithon abundance data during 2004-2006.

along the study period and their fitness to the environmental variables included in the model.

The first axis is mainly defined by a combination of NH_3-N and NO_2-N (intra-set correlation coefficients: r = 0.52; r = –0.33 respectively). Axis 2 is mainly correlated with Cl and Ca^{++} (intra-set correlation coefficients: r = 0.74; r = –0.50).

While the most of taxa located near the middle of the ordination diagram, some species such as *Encyonema silesiacum* (Enc), *Amphora pediculus* (Amp2) and *Gomphonema vibrio* var. *pulvinatum* (Go5) are plotted away from the center. There is an association between *Navicula halophila* (Nav4), *N. tripunctata* (Nav8), *Cymbella elginensis* (Cym4), *Diatoma vulgaris* (Dia), *Fragilaria ulna* (Fra) and K^+, NH_3-N. Also, *Navicula minuscula* var. *muralis* (Nav5), *Cyclotella ocellata* (Cyc) and *Cymbella perpusilla* (Cym8) species indicated an association with NO_2-N and temperature. In this analysis, *Encyonema silesiacum* (Enc), Amphora pediculus (Amp2) and *Gomphonema vibrio* var. *pulvinatum* (Go5) were not correlated with abiotic factors and other taxa (Figure 3).

Discussion

Diatoms are abundant and diverse in Turkish freshwaters. They form an important component of many benthic algal communities in streams and standing waters, but are generally less common in the phytoplankton. Diatoms are excellent ecological indicator species because their remains are preserved in many sedimentary environments. More research is needed to analyse the causes of the observed enormous variation in the nutrient status and biomass of benthic algae in lakes. The physicochemical parameters were evaluated and connected with diatoms.

Navicula and *Cymbella* genera with 46 taxa comprise of 52% of the total taxa found. Seasonal variations influenced by physical and chemical factors in the lake, and water flow can especially influence the diatom population density and thus the food chain. Whilst *Cyclotella ocellata*, *Cymbella minuta*, and *C. perpusilla* were the most abundant organisms in March 2006, *Encyonema silesiacum* peaked in May 2005. Generally, the total number of organisms increased in spring and autumn seasons. The species diversity of *Navicula*, and *Gomphonema* was high, but abundance was low. Generally, members of *Cyclotella, Cymbella, Gomphonema*, and *Navicula* were widespread in all months during the study period. Genera of *Achnanthes, Brachysira, Cyclotella, Cymatopleura, Diatoma, Encyonema, Melosira, Rhoicosphenia, Stephanodiscus* and *Surirella* were only represented by a taxon in the dam lake. In a study conducted on benthic diatoms (epipelic and epipsammic) in Yedikır dam (Maraşlıoğlu, 2016) *Navicula veneta*, *N. capitata* var. *hungarica*, and *Nitzschia fonticola* were recorded as dominant organisms. While in epipelic and epipsammic diatoms *Navicula* spp. (24 taxa) and *Nitzschia* spp. (12 taxa) were found dominant and subdominant respectively, at the present study (on epilithic diatoms) *Navicula* and *Cymbella* were dominant and subdominant genera respectively. The reason for abundance of the planktonic *C.ocellata* species only in epilitic diatom assemblages among benthic communities is the wind which blows in the direction of the dam's barrier area. Since this wind causes fluctuations in the dam water, some planktonic species such as *C. ocellata* in the dam lake are transported on the rocks in the barrier area. In benthic studies on epipelic and epipsammic diatoms (Maraşlıoğlu, 2016) we have seen that there is no such a water fluctuation in the areas where the dam's sand and mud samples are.

Sunlight, temperature, salinity, and physicochemical characteristics have a great influence on diatoms (Atıcı & Obalı, 2010). They all have showed an increase in spring and autumn. Temperature influences biological, chemical, and physical activities in the water. Thus, oxygen consumption increases. The oxygen level is related to temperature, salinity, current, photosynthetic activities (algae and macrophytes), and atmospheric pressure in natural waters. Water temperature ranged between 5.6 and 23°C in Yedikır Dam Lake (Figure 2). Water temperature increases in spring months, then decreases in winter months, depending on changes in the air temperature (Atıcı, 2003). Oxygen solubility differs based on the rate on photosynthesis and the level of nutrients in the aquatic environment. The monthly oxygen levels of Yedikır Dam Lake varied during the research period; the maximum was 10.2 mg/l and the minimum was 5.1 mg/L. Solubility of oxygen decreases in water when temperature increases (Wetzel, 1983). Generally, the concentration of oxygen is around 10 mg/L in natural oligotrophic waters (20°C) (DSİ, 1998). Temperature and conductivity, which were measured in the Lake, were related. Conductivity also increases with the temperature of the water. The conductivity was 269-628 µmhos/cm. Furthermore, particularly Cl^- and Na^+ determine conductivity. These and some other minerals are important sources of salinity. Generally, the salinity value increases with evaporation in shallow lakes (John, Whitton, & Brook 2003; Kolaylı & Şahin, 2009). In the Dam, the diversity of all diatoms decreased in summer due to increase of salinity. High levels of salinity restrict diatom diversity (Nagasathya & Thajuddin, 2008). The source of nitrogen compounds was atmospheric nitrogen and agricultural activity, such as domestic and industrial wastes in the lake water. The source of ammonia was the waste from fish and other organisms. Ca^{++} and Mg^{++} have vital importance in plants, which photosynthesise in the aquatic environment. Mg^{++} is in the structure of chlorophyll. The concentration of Mg^{++} has a great effect on algae growing in lakes. As a result, the trophic level is influenced (Wetzel, 1983). The concentration of Ca^{++} increases with rain in winter. Life became active with the increase in the temperature of the water and environment after April 2005, and consumption of Ca^{++} began in the lake. Therefore, a decrease of values of Ca^{++} was observed in the Dam Lake. Alkalinity, which shows that the water is gaining proton capacity, is formed by the reaction of CO_2 and water, producing H_2CO_3 and the disintegration of structure. These ions adjust the pH of the water and control the acidity (Hecky & Kling, 1987). According to the pH values (between 7.2 and 9.0) the lake is slightly alkaline. The ions carried by spring rains were the cause of that increase. pH values range between 6.0 and 9.0 in natural lakes and streams (Tanyolac, 2000). Furthermore, algal growth can decline with pH (e.g. Vinebrooke, 1996). However, the pH values reached high values in May 2005 and March 2006 when total cell numbers were also found to be high in these months in the study area. So, it should be kept in mind that other unmeasured variables such as physical mixing, day-length effects, grazing, parasitism and availability of microhabitats influence the distribution and the abundance of diatom taxa (Dixit, Smol, Kingston, & Charles, 1992). Precipitation waters arrive at the lake in short spans of time, because the plant cover is limited. Due to a pasture, organic material is also mixed with the lake water. These mixtures have an influence on the chemistry of the lake water, and then affects the turbidity. Some groups (such as the pennate diatoms *Cymbella*, *Encyonema*, *Navicula*, and the centric *Cyclotella*) were found to be abundant; they are tolerant to the environmental and other factors in Yedikır Dam Lake.

Species richness wasn't low for epilithic diatom community in our study than the other lake (Maraşlıoğlu *et al*., 2005; Sıvacı, Dere, & Kılınç, 2007) or dam/pond (Atıcı & Obalı, 2010; Dönmez & Maraşlıoğlu, 2016). This may be due to competition wasn't observed between epilithic diatoms and the other benthic diatoms because of the different diatom composition. Shannon diversity and evenness also presented small variations during the study period. In freshwater lakes, the diversity ranges between 1 and 2.5 cell/bits in eutrophic lakes and up to 4.5 bits/cell in oligotrophic and dystrophic lakes (Margalef, 1964). According to this criterions, Yedikır Dam Lake is an eutrophic lake for the whole year, as the diversity index (H') ranged from 0.3 to 1.1 cell/bits. High species diversity values usually indicate diverse, well-balanced communities, while low values indicate stress or impact. The lowest values for species diversity in Yedikır Dam Lake occured in May 2005 and January 2006. The potential for such a low species diversity indicates substantial pollution. The most important stresses on the Dam are organic enrichments (discharge of untreated sewage), nutrients, pesticides, herbicides and physical changes produced by canalisation. Higher species diversity index (H') were registered in November and December 2004, coinciding with the higher rainfall values, which, probably, caused the algal suspension of the sediment. Rain is possibly the main reason for the observed seasonal variation (Huszar and Reynolds, 1997).

CCA results indicated that pH and total alkalinity ($CaCO_3$) were the most important variables governing the seasonal succession of epilithic species. Multivariate analyses indicated that *Navicula* species (especially *N. veneta*) and *Cooconeis placentula* were mainly found in cooler water, while *Cymbella* species (especially *C. minuta* and *C. affinis* species) and *Cyclotella ocellata* preferred warmer water during study period. Species belonging to genus *Cymbella* and *Nitzschia* preferred higher PO_4 value than those of the other epilithic taxa. Furthermore, *Amphora delicatissima* species were found in high Na, comparing the other epilithic taxa. The use of multivariate analysis to explore the effects of multiple environmental variables on the epilithic community is, demonstrably, a powerful means of exploration of mechanisms and of isolation of the critical determinants.

In conclusion, the CCA showed that the dominance of certain species was closely related to pH and total alkanity ($CaCO_3$). Whilst water transparency and oxygen of high concentrations and also low chlorophyll concentration values indicate that the system was oligotrophic, the extremely low Shannon-Weaver species diversity value, especially during the summer, indicates that the system is under stress (in eutrophic state). Furthermore, the morphometric structure of the dam lake, other physical and chemical properties of the water, and composition of the epilithic diatoms are characteristic to mezotrophic water bodies. Based on all these results we can say that Yedikır Dam Lake is in a transition period from oligotrophy to eutrophy (mezotrophy).

Oligotrophic lakes support a high species of diversity and are generally dominated by species with small cells, with rapid nutrient uptake and turnover rates. These species, are well adapted to nutrient–poor systems, like *Cyclotella* or some *Navicula* species, a very abundant species seen during almost the whole investigated period on all benthic studies in Yedikır Dam Lake. High species diversity but low abundance seen such us *Navicula*, *Nitzschia* and *Cymbella* genera support mezotrophic structure in the dam lake. Among benthic studies carried out in the dam up to now (Maraşlıoğlu, 2016; the present study), the best reflection of the mesotrophic structure has been the epilithic diatoms. As in addition to the planktonic species such as *C. ocellata* reflecting the increase in the water level, benthic taxa of *Cymbella* and *Gomphonema* are also abundant in epilithon.

As a result, Yedikır dam lake sometimes has been polluting through organic organic contaminants carried from poultry farms waste depending on functioning of the regulator and pesticides/herbicides move out agricultural activities in the surrounding. The pollutans are usually moved from districts by the Tersakan stream to the dam. The reason why the dam water is not yet sufficiently polluted enough is that the dam water circulates every season for irrigation purpose. Whilst this circulate looks like an advantage for the not pollution of the dam, it occurs a disadvantage in terms of biodiversity in the dam lake. As, Yedikır dam lake is anymore very important area not only for the irrigation of agricultural lands in the region but also a residential area for waterfowl. Since, according to CCA results, pH and total alkalinity ($CaCO_3$) were major variables in the seasonal variation of epilithic taxa, organic pollutans and pesticides/herbicides did not make an effect on diatoms. Beacause have limited the abundance of most epilithic diatoms in the dam.

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