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Epilithic Diatom Community Structure and Physical-Chemical Interactions in Bolukcali Stream (Elazig/Turkey)

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Abstract: Epilithic diatoms of Bolukcali stream were studied from February-December 2009 using samples collected from two stations. Sampling was performed monthly. Temperature, pH, dissolved oxygen, nitrate, orthophosphate and silica values were measured over the entire study period. Epilithic diatoms of Bolukcali stream consisted most commonly of *Cyclotella*, *Cymbella*, *Navicula* and *Surirella* genera while other genera identified included *Epithemia*, *Nitzschia*, *Rhoicosphenia*, *Gomponema* and *Cocconeis*. The physical and chemical parameters of these diatom communities were studied along with their variations by stations and seasons.

Key words: Bolukcali stream, epilithic diatom, seasonal variation, parameter, dissolved oxygen, Elazig

INTRODUCTION

Besides being used as food by both humans and animals due to their high protein content, algae are also commonly utilized in the efforts to manufacture natural fertilizers and to obtain natural vitamins. Another reason why algae are among the most widely studied group of organisms is that they can be produced easily and inexpensively in culture media. As the importance of algae in stagnant waters and rivers has been better understood, there has been an increase in the studies about these organisms. Studies about algae started in 1987 in Turkey and were followed by research about diatoms and epilithic diatoms in particular (Yildiz, 1987; Altuner, 1988; Sahin, 2009). Kalyoncu recently focused on determining the water quality of Aglasun and Isparta streams through identification of epilithic diatoms.

There are studies about epilithic diatoms of rivers in other countries as well (Reavie and Smol, 1998; Dell'uomo *et al*., 1999). Identification of the development of algae communities and the physical and chemical factors affecting them is of utmost importance in increasing the usefulness of rivers.

Accordingly, the present study conducted in Bolukcali stream examined epilithic diatoms of benthic algae communities together with several physical and chemical factors. Identification of epilithic diatoms of Bolukcali stream shall also contribute to the formation of the genera list of epilithic diatoms in Turkish fresh waters.

MATERIALS AND METHODS

Bolukcali stream which originates from the Bolukcali village within the borders of the city of Elazig has a constant flow during both summer and winter. Its width occasionally reaches 2-3 m and its depth to 70 cm. Bolukcali stream flows into Keban Dam lake. The distance between two stations selected in Bolukcali stream was about 3 km.

Surface water temperature of the stream was measured using 1°C calibrated thermometer and dissolved O_2 values were quantified in the field using a Hanna 91410 model Ph/O_2 m while Nitrate (NO_3), Orthophosphate (PO_4) and Silica (SiO_2) values were determined by spectrophotometric method (APHA, 1985). Epilithic samples in both stations were collected by scraping off with a brush washed with pure water and placed into sterile nylon bags.

Continuous preparations of diatoms were used to identify their genera and their counts with a Nikon brand microscope. The counts in continuous preparations were based upon relative density and the results were expressed as % organism:

$$\text{Relative density (Nd)} = \frac{N_A}{N} \times 100$$

Where:
N_A = Total number of individuals in the genus A
N = Number of individuals of all genera

Relevant sources were employed in the identification of diatoms.

RESULTS

Several physical measurements and chemical analyses were conducted in the surface water of both

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Table 1: Values pertinent to the physical and chemical parameters recorded in the stations I and II selected in Bolukcali stream, Elazig

	1 station						2 station					
Months/ parameters	Temperature (°C)	Oxygen $mgO_2\ L^{-1}$	pH	Nitrate $mg\ L^{-1}$	Orthophosphate $mg\ L^{-1}$	Silica $mg\ L^{-1}$	Temperature (°C)	Oxygen $mgO_2\ L^{-1}$	pH	Nitrate $mg\ L^{-1}$	Orthophosphate $mg\ L^{-1}$	Silica $mg\ L^{-1}$
February 2009	7.0	8.5	8.4	0.9	0.3	0.3	8.0	8.6	8.0	0.7	0.5	0.4
March 2009	9.0	8.2	8.2	1.4	0.1	0.7	8.5	8.3	8.4	1.2	0.3	0.8
April 2009	10.0	8.0	8.2	1.5	0.1	0.7	9.5	8.0	8.3	1.3	0.1	0.9
May 2009	14.0	7.4	6.9	1.6	2.0	0.9	13.5	7.4	8.2	1.5	2.5	1.0
June 2009	16.0	6.2	6.9	1.7	3.5	0.5	15.0	6.4	8.0	1.6	4.0	0.6
July 2009	17.5	6.0	7.6	1.7	3.5	0.4	16.5	6.8	7.8	1.7	4.0	0.5
August 2009	17.0	6.1	8.2	1.8	4.2	0.2	16.0	6.5	7.0	1.8	5.2	0.5
September 2009	13.0	7.2	7.4	1.5	2.5	0.3	12.5	7.2	8.6	1.4	2.5	0.4
October 2009	13.0	7.4	7.8	1.4	2.0	0.3	12.0	7.0	8.6	1.3	2.3	0.4
November 2009	8.0	8.3	8.3	1.2	0.2	0.4	7.5	8.4	8.5	1.2	0.7	0.3
December 2009	7.5	8.4	8.4	0.9	0.3	0.3	7.5	8.6	8.4	1.0	0.5	0.3

Table 2: Epilithic diatom genera identified in the first and second stations in Bolukcali stream, Elazig

Species	1 station	2 station
Cyclotella meneghiniana Kutzing	+	+
Achnanthes minutissima Kutzing	+	+
Caloneis limosa (Kutz.) R.M.Patrick	-	+
Cocconeis placentula var. *lineata* (Ehrenberg) P. Cleve	-	+
Cymatopleura solea (Brebisson) W. Smith	+	+
Cymbella affinis Kutz.	+	+
Cymbella cuspidata Kutz.	+	+
Cymbella cymbiformis Agardh	+	+
Cymbella helvetica Kutz	+	+
Cymbella naviculiformis (Auerswald) Cleve	+	+
Encyonema triangulum (Ehrenberg) Kutzing	-	+
Epithemia turgida var. *westermannii* (Ehr.) Grun	+	+
Fragilaria ulna (Nitzsch) Lange-Bertalot	-	+
Gomphonema gracile Ehrenberg	-	+
Gomphonema olivaceum (Lyngbye) Kutz	+	+
Hantzschia amphioxys (Ehrenberg) Grunow	-	+
Navicula aurora Sovereign	+	+
Navicula bacillum (Ehrenberg)	-	+
Navicula cuspidata Kutzing	+	-
Navicula dicephala (Ehrenberg) W. Smith	+	+
Navicula lanceolata (C.Agardh) Kutzing	-	+
Navicula oblonga Kutzing	+	+
Navicula placentula (Ehrenberg) Grunow	+	-
Navicula reinhardtii Grunow	+	+
Navicula rostellata Kutzing	+	+
Navicula veneta Kutz	+	+
Neidium dubium (Ehrenberg) Cleve	+	+
Nitzschia linearis (Agardh) W. Smith	+	-
Nitzschia sigmoidea (Ehrenberg) W. Smith	+	-
Nitzschia tryblionella Hantzsch	-	+
Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot	+	+
Rhopalodia acuminata Krammer	+	+
Rhopalodia gibberula var. *minuens* O.F. Muller	+	+
Surirella birostrata Hustedt	+	+
Surirella linearis W. Smith	+	+
Surirella moelleriana Grunow	-	+
Surirella ovata Kutz	+	+

stations from January-December 2009 in the field and in the laboratory with a view to determining some physical and chemical characteristics of Bolukcali stream and their results are shown in Table 1. The highest surface water temperature over the study period in the first station was recorded in July (17.5°C) and the lowest in February (7.0°C) while in the second station the highest temperature was found in July (16.5°C) and the lowest in November-December (7.5°C). Dissolved oxygen values of the Bolukcali stream were the highest (8.4 $mgO_2\ L^{-1}$) in February-December and the lowest (6.9 $mgO_2\ L^{-1}$) in May-June in the first station and the highest (8.6 $mgO_2\ L^{-1}$) in September-October and the lowest (7.0 $mgO_2\ L^{-1}$) in August in the second station. As for pH, the highest pH value (8.5) was recorded in February and the lowest pH value (6.0) was recorded in May and June in the first station whereas the highest pH (8.6) was found in February and the lowest (6.4) in June in the second station.

The highest (1.8 $mg\ L^{-1}$) and the lowest (0.9 $mg\ L^{-1}$) nitrate values were recorded in August and February-March, respectively in the first station and the highest (1.6 $mg\ L^{-1}$) and the lowest (1.0 $mg\ L^{-1}$) nitrate values were found in June and December, respectively in the second station. Regarding orthophosphate, the highest value (4.2 $mg\ L^{-1}$) was found in August and the lowest value (0.1 $mg\ L^{-1}$) was found in March-April in station 1 and the highest (5.2 $mg\ L^{-1}$) and the lowest (1.0 $mg\ L^{-1}$) values were recorded in August and April, respectively in station 2. As for silica, the highest silica value (0.9 $mg\ L^{-1}$) was registered in May and the lowest value (0.3 $mg\ L^{-1}$) in February-March in the first station and the highest value (1.0 $mg\ L^{-1}$) was recorded in May and the lowest value (0.3 $mg\ L^{-1}$) in December in the second station. A total of 37 diatom genera were established in the samples taken from the two stations selected in Bolukcali stream. Genera which were represented with a single species in both stations were *Cyclotella*, *Achnantes*, *Caloneis*, *Cocconeis*, *Cymatopleura*, *Encyonema*, *Epithemia*, *Fragilaria*, *Hantzschia*, *Neidium* and *Rhoicosphenia*, while genera represented with multiple species included *Cymbella* (5 species), *Gomphonema* (2 species), *Navicula* (10 species), *Nitzschia* (3 species), *Rhopalodia* (2 species) and *Surirella* (4 species) (Table 2). Species which were recorded in all samples over the entire study period were *Cyclotella meneghiniana*, *Cymbella*

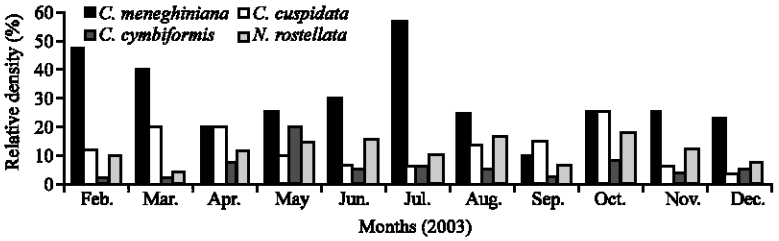

Fig. 1: Seasonal variations in the relative density of *Cyclotella meneghiniana*, *Cymbella cuspidata*, *Cymbella cymbiformis* and *Navicula rostellata* species in the first station

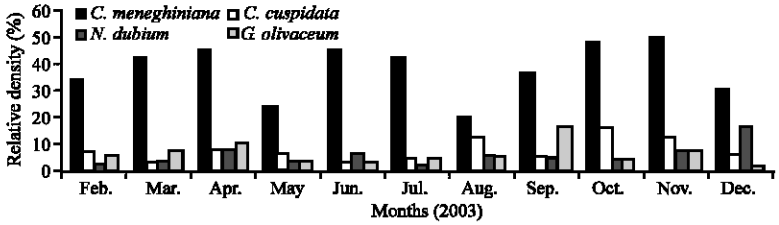

Fig. 2: Seasonal variations in the relative density of *Cyclotella meneghiniana*, *Cymbella cuspidata*, *Neidium dubium* and *Gomphonema olivaceum* species in the second station

cuspidate, *C. cymbiformis*, *C. naviculiformis*, *Gomphonema olivaceum*, *Navicula dicephala*, *N. rostellata* and *N. reinhardtii*. The most salient diatoms with respect to frequency of occurrence and relative density were *Cyclotella meneghiniana*, *Cymbella cuspidata*, *Cymbella cymbiformis* and *Navicula rostellata*.

The highest relative density of *Cyclotella menenghiniana* (57.1%) was registered in July and the lowest relative density (10%) in September in the first station (Fig. 1). As opposed to *Cyclotella memenghiniana*, the relative density of *Cymbella cuspidata* was found the highest (25.6%) in October ad the lowest (2.4%) in December. The relative density of *Cymbella cymbiformis* in May (20.5%) was its highest relative density while its lowest relative density (1.2%) was found in February. As for *Navicula rostellata* which had a continuous frequency of occurrence in the first station, the highest relative density of this diatom (17.9%) was found in October and its lowest relative density (4.1%) in March. Although, the relative densities of the other diatoms of the first station were found high (20-30%) in some months, these were not included in the figure due to the irregularity in their frequency of occurrence. *Navicula cuspidata*, *Nitzschia linearis* and *N. sigmoidea* that were recorded in the first station emerged in only a single sample. The most prominent diatoms in terms of their frequency of occurrence and relative density in the second station were *Cyclotella meneghiniana*, *Cymbella cuspidata*, *Neidium dubium* and *Gomphonema olivaceum* (Fig. 2). The highest relative density of *Cyclotella meneghiniana* (50%) was recorded in November and the lowest relative density (20.3%) in August in the second station. The relative density of this diatom in the month of November is the highest relative density recorded among other diatoms (*Cymbella cuspidata*, *Neidium dubium* and *Gomphonema olivaceum*) (Fig. 2). The second species that was noteworthy with regard to its frequency of occurrence and relative density in the second station was *Cymbella cuspidata*. The highest relative density of *C. cuspidata* (16%) was recorded in October and the lowest relative density (2.7%) in September. The relative density of this diatom increased in 1 month and decreased in the next (Fig. 2). Another species remarkable for its frequency of occurrence in this station was *Neidium dubium*. The highest relative density of this diatom (15.7%) was found in December and the lowest relative density (2.1%) was recorded in July.

A species which displayed a continuous frequency of occurrence but which did not have a high relative density like *Cymbella cuspidata* and *Neidium dubium* was *Gomphonema olivaceum*. The highest relative density of this diatom (16.1%) was recorded in September and the lowest relative density (1.9%) in December. The individuals belonging to the species of *Caloneis limosa*, *Cocconeis placentula* var. *lienata*, *Encyonema triangulum*, *Fragilaria ulna*, *Gomphonema gracile*, *Navicula bacillum*, *N. lanceolata*, *Nitzschia tryblionella* and *Surirella moelleriana* were encountered only in a single sample in the second station and these species were not among those recorded in the first station.

DISCUSSION

Epilithic diatoms of Bolukcali stream were examined from February-December 2009 and the epilithic diatoms that were found were compared with the results of other researchers who studied epilithic diatoms in Turkey. Diatoms which were notable with respect to frequency of occurrence and individual numbers in the epilithic diatom flora of Peri stream included *Achnanthes microcephala*, *Gomphonema angustatum*, *G. angustatum* var. *producta*, *Cymbella affinis*, *Cymbella laevis* and *Navicula phyllepta*. These exhibited similarity in terms of species with the exception of *Amphora* and *Nitzschia*. In their study of the algae flora of Samsun-Incesu stream, Gonulol and Arslan found that the dominant species among epilithic algae were *Cocconeis*, *Cymbella* and *Gomphonema*.

Cetin and Yavuz who studied the epipelic, epilithic and epiphytic flora of Cip stream (Elazig/Turkey) established that *Gomphonema olivaceum*, *Meridion circulare*, *Navicula cryptocephala*, *Nitzschia linearis*, *Nitzschia palea* and *Fragilaria ulna* were significant among other epilithic diatoms in terms of both frequency of occurrence and density. Studying algae communities in Altinapa Dam lake and Meram stream originating from this lake (Yildiz, 1987) determined that the diatoms were more common and dominant than other algae in both waters and found that the most common and most dense species found on plants and rocks in Altinapa Dam lake (Yildiz, 1987) included *Synedra delicatissima*, *Navicula cryptocephala*, *Nitzschia palea*, *Cymbella microcephala*, *C. amphicephala* and *Cyclotella ocellata* while the most common and dominant organisms in Meram stream (Yildiz, 1987) were *Diatoma vulgare*, *Fragilaria ulna*, *Cymbella verntricosa*, *C. amphicephala*, *Gomphonema olivaceum* and *Navicula cryptocephala*.

Altuner, 1988 who studied the diatom flora of the Aras river established that the most commonly found diatoms were *Achnanthes affinis*, *Fragilaria ulna*, *Gomphonema olivaceum*, *Navicula cryptocephala* var. *veneta*, *Nitzschia intermedia*, *N. subcapitellata* and *Surirella ovata*. The flora of epilithic diatoms were found similar in Aras river (Altuner, 1988), Sera stream (Sahin, 2009), Sana stream, Yanbolu river (Sahin, 2009), Akcay, Isparta stream, Upper Porsuk stream, Melendiz stream, Aksu stream and Dipsiz-Cine stream. The species which have the highest frequency of occurrence and density among the epilithic diatoms of Bolukcali stream are *Cyclotella meneghiniana*, *Cymbella cuspidata*, *Cymbella cymbiformis*, *Navicula viridula* var. *rostellata*, *Gomphonema olivaceum* and *Neidium dubium*. Achnanthes minutissima which was one of the diatoms established in the study was found in Porsuk stream and Kizilirmak river (Altuner, 1988) but not in Cubuk stream. Likewise, Rhoicosphenia abbreviata which was recorded in the study was found in Kizilirmak river (Altuner, 1988) and Cubuk stream but not in Porsuk stream. The epilithic diatoms of *Diatoma vulgare*, *Fragilaria ulna*, *Cocconeis placentula* var. *euglypta*, *Cymbella affinis*, *Caloneis ventricosa* and *Gomphonema olivaceum* which were registered in Cubuk stream were found to display the same prevalence and distribution in Porsuk stream and Meram stream (Yildiz, 1987). Similarly, *Fragilaria ulna*, *Cymbella amphicephala*, *Caloneis ventricosa* and *Gomphonema olivaceum* that were recorded in Cubuk stream were found abundantly and commonly among the epilithic algae of Kizilirmak river (Altuner, 1988). *Cymbella affinis* and *Gomphonema olivaceum* which were found among the epilithic diatoms of Bolukcali stream were also established among the epilithic diatoms in the studies carried out in Kizilirmak river (Altuner, 1988), Cubuk stream and Porsuk stream. *Navicula aurora* identified among epilithic diatoms in the study area is evaluated as a new registry entry for Turkish waters and *Navicula oblonga* as a new entry for the regional waters (it is not new in Turkey as it had been previously found in Hotamis Morass and Uyuz lake). *Fragilaria ulna*, *Cymbella helvetica* and *Nitzschia sigmoidea* which were registered among the epilithic diatoms of Bolukcali stream were also recorded in the study of the epilithic diatoms of Aglasun stream. *Surirella ovata* and *Fragiliara ulna* which were among the epilithic diatoms of Degirmendere and remarkable with a relative density of up to 59% were recorded in Bolukcali stream as well.

CONCLUSION

Although, several diatoms registered in Bolukcali stream were insignificant in terms of their frequency of occurrence among epilithic algae communities, they were noteworthy due to their high relative density in certain months. This finding suggests that there may be a succession among diatoms as long as conditions permit. When the continuous presence of diatoms in the epilithic algae communities is considered, it appears that diatoms are cosmopolitan can be among the most commonly encountered algae in all types of substrata and may be used as biological monitors (Round, 1981; Lowe and Pan, 1996).

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