Study on epilithic diatoms in the kozluk creek (Arapgir-Malatya, Turkey)

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Introduction

Being the most important members of phytoplankton and phytobenthos, both of which are the primary producers of surface water resources, algae play a very important role in the biological productivity of waters with their oxygen production through photosynthesis and they synthesize the organic materials. Furthermore, with their high levels of protein, algae are used as human and animal food as well as being used in the production of organic fertilizers and organic vitamins. Another reason for algae currently being among the most researched organisms is their easy and inexpensive productions in culture media.

With the recognition of the importance of algae in standing waters and streams, the number of studies conducted on these organisms has rapidly increased. In Turkey, the number of studies on algae in streams is quite high [(Altuner and Gurbuz (1989), Altuner and Gurbuz (1991) Yıldız (1991) , Yildiz and Ozkiran (1994), Ertan and Morkoyunlu (1998), Sahin (1998), Cetin and Yavuz (2001), Solak *et al*. (2012), Sivaci and Dere (2007), Mumcu *et al*. (2009), Pala and Caglar (2008)].

It is quite important to study the growth of algal communities and identify the physical, chemical and biological factors that affect them in order to make better and more use of streams. In line with this purpose, the epilithic diatoms within the benthic algal communities were researched along with certain physical and chemical factors within the context of this study conducted on Kozluk Creek. Identifying the epilithic diatoms will also contribute to creating the species list of Kozluk Creek.

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Materials and methods

A district in Malatya Province, Kozluk Creek is located at 39º01'25.85" N (latitude) and 38º 17' 26.81"E (longitude). Kozluk Creek originates in Saricicek Mountains and divides the Arapgir district into two parts (Fig. 1).

In this study, samples were collected periodically from two different stations from March 2015 to October 2015 in order to determine the epilithic algae of Kozluk Creek. The first station was chosen from the right side of Kozluk Creek where there are rocky areas, and the second station was chosen from approximately 1 km below the first station.

The temperature and pH values were measured in the field with an Electromagon-site pH meter; the electrical conductivity (E.C.µmhoscm^{-1}) was measured in the fieldwith a YSI Model 33 S-C-T meter; the dissolved oxygen was measured with a YSI Model 51B on-site oxygen meter during sampling; ammonium was measured following Nessler's method whereas nitrate was measured by the spectrophotometric method using salicylate, and chloride was measured in accordance with the Mohr method. The calibrations of the above mentioned portable devices were made with stable solutions before the field surveys (APHA, 1985).

The epilithic samples from both stations were collected by scraping them from mucilaginous big stones with the help of a brush and the epilithic diatoms stuck onto the brush were washed with purified water and placed in sterile sample jars. There was no pollution in the stations and the Creek water was very cold and clear.

Species identification and counting of the diatoms, for which permanent slides were prepared, were made with a Nikon microscope. For the species count performed on the permanent slides, relative density was taken as the basis and the results are given as "% organism.

Related sources were used for the identification of diatom species (Hustedt, 1932; Prescott, 1961; Bourelly, 1968; Bourelly, 1972; Germain, 1981;).

Results and discussion

Some hydrological results from each station on Kozluk Creek are given in Table 1.

During the study period, according to its average water temperature (11ºC), the water quality of the waterfall was classified as 1st class (Anonymous, 2004). According to the water pollution directive, waters with over 8 mg/L dissolved oxygen levels are classified as environments with 1st class quality; and even the lowest dissolved oxygen level at the waterfall was measured to be higher than this value (Anonymous, 2004). According to the directive waters intended for human consumption should have pH values within the range of 6.5 to 9.5 (Anonymous, 2004).

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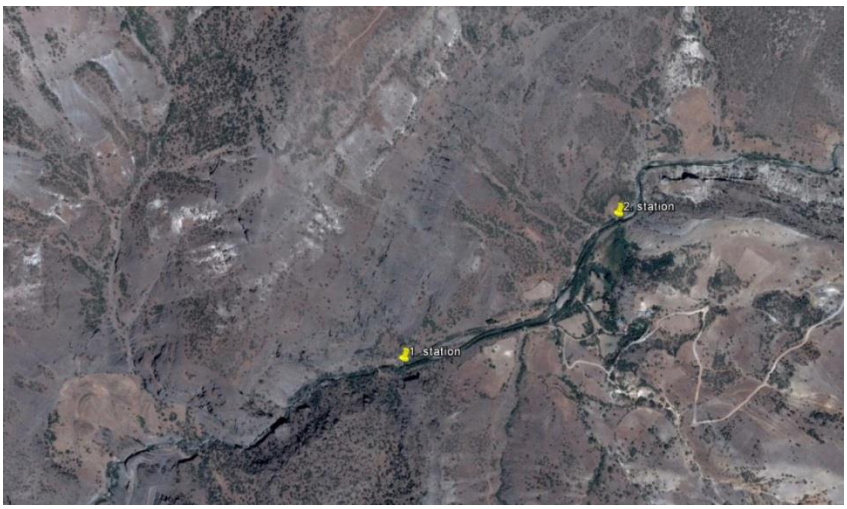

Figure 1: A general view of Kozluk Creek (URL 2).

Table 1: The hydrological variations in Kozluk Creek from March- October 2015.

	March	April	May	June	July	August	September	October	Average	St. dev.
Temperature										
1st Station.	9.0	9.0	10.0	11.0	12.0	12.0	13.0	12.0	11.00	1.511
2nd Station	9.0	10.0	9.0	13.0	13.0	14.0	13.0	13.0	11.75	2.052
Oxygen										
1st Station	9.6	9.5	9.8	9.7	9.5	9.4	9.5	9.7	9.58	0.135
2nd Station	9.7	9.6	9.9	9.8	9.6	9.7	9.5	9.8	9.70	0.130
pH										
1st Station	8.0	8.2	8.1	8.3	8.2	8.3	8.3	8.3	8.21	0.112
2nd Station	8.4	8.2	8.0	8.2	8.4	8.3	8.2	8.2	8.23	0.130
Conductivity										
1st Station	630	620	630	690	710	720	690	680	671.25	39.074
2nd Station	620	620	640	630	720	710	680	670	661,25	39.798
T.hardness										
1st Station	119	120	118	117	119	96	98	99	110.75	10.898
2nd Station	120	120	119	119	114	100	111	100	112.87	8.559
Salinity										
1st Station	0.69	0.66	0.65	0.63	0.64	0.50	0.52	0.51	0.60	0.076
2nd Station	0.67	0.64	0.62	0.63	0.61	0.52	0.54	0.53	0.59	0.056
Nitrite										
1st Station	0.09	0.10	0.11	0.10	0.09	0.11	0.10	0.10	0.10	0.007
2nd Station	0.12	0.12	0.11	0.10	0.10	0.12	0.11	0.10	0.11	0.009
Nitrate										
1st Station	1.0	1.0	1.0	1.4	1.8	1.6	1.8	1.7	1.42	0.364
2nd Station	1.3	1.3	1.5	1.6	1.9	1.8	1.7	1.7	1.60	0.220
Ammonium										
1st Station	0.18	0.18	0.17	0.18	0.17	0.17	0.18	0.17	0.175	0.005
2nd Station	0.19	0.18	0.18	0.17	0.19	0.18	0.16	0.53	0.222	0.124

The pH values of both stations in Kozluk Creek were within the range of 8.0 to 8.4. According to the water pollution control directive for quality

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criteria for inland water resources, pH value was within 1st class water quality levels (Anonymous, 2004).

According to the water pollution control directive on quality criteria for inland water resources, nitrite was within the 4th class water quality levels (Anonymous, 2004). According to the water pollution control directive on quality criteria for inland water resources, nitrate was within the 1st class water quality levels (Anonymous, 2004), According to the water pollution control directive on quality criteria for inland water resources, ammonium levels were within the range of 1st class water quality levels (Anonymous, 2004).

Taking Table 2 into consideration, the fact that some species were encountered in the environment and some were not could be taken as a sign for the adaptabilty of the existing species in different habitats. The most significant diatoms at the first station in terms of their frequency of appearance and relative density were *Navicymbula pusilla*, *Navicula tripunctata*, *Nitzschia amphibia* and *Nitzschia tryblionella* (Figs. 2a, b, c and d).

Table 2: The epilithic diatom species recorded at the 1st and 2nd stations in Kozluk Creek (Arapgir-Malatya).

Species	1st Station	2nd Station
Amphora ovalis Kützing	+	+
Amphora pediculus (Kütz.)Grunow &A.Schmidt	+	_
*Cyclotella meneghiniana*Kützing	+	_
Cymbella cymbiformis C. Agardh	+	_
*Cymbella affinis*Kützing	+	+
Cymbella cistula (Ehr.) O. Kirchner	-	+
Cymbella parva (W. Smith) Kirchner	+	+
*Cymbella porxima*Reimer	+	_
Cymbopleuralata(Grunow ex Cleve) Krammer	+	+
Lindaviaocellata (Pantocksek) T.Nakov et al.	+	+
Lindaviacomta (Kütz.)Nakov, Gullory, Julius, Alverson&Theriot	+	+
Navicula cincta(Ehrenberg) Ralfs	+	_
*Navicula cryptocephala*Kütz.	+	_
Navicula protracta (Grunow) Cleve	-	_
*Navicula salinarum*Grunow	+	+
Navicula tripunctata(O.F. Müller) Bory.	+	+
Navicymbulapusilla (Grunow) Krammer	-	+
*Nitzschia amphibia*Grunow	+	+
*Nitzschia gracilis*Hantzsch	+	+
Nitzschia palea(Kützing) W. Smith	+	+
*Nitzschia tryblionella*Hantzsch	+	+
Sellaphora bacillum (Ehrenberg) D.G. Mann	+	_
*Surirella ovalis*Brebisson	+	+
Surirella robusta Ehrenberg	+	_
Ulnariaacus (Kützing) M. Aboal	+	_
Ulnaria ulna (Nitzsche) P. Compere	+	+

+: found - :not found

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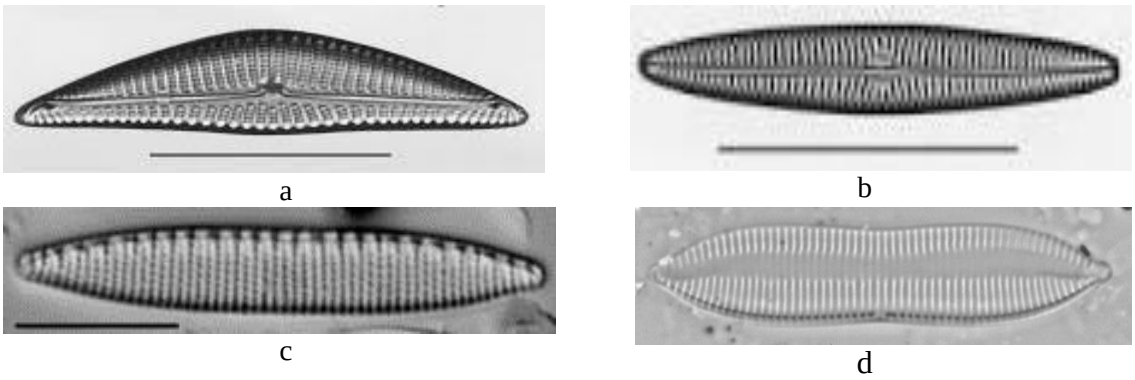

Figure 2: ***Navicymbula pusilla*****(a),** ***Navicula tripunctata*****(b),** ***Nitzschia amphibia*** **(c) and** ***Nitzschia tryblionella*** **(d) (URL 3).**

The highest relative density (3.08%) of *N. pusilla* at this station was recorded in April whereas its lowest relative density (1.68%) was recorded in September. At the first station, *N. tripunctata* reached its highest relative density (8.49 %) in October, and dropped to its lowest relative density (4.34%) in May; highest relative density (6.60%) for *N. amphibia* was in October whereas its lowest relative density (3.58%) was recorded in March; and the highest relative density (4.66%) for *N. tryblionella* was in March and its lowest relative density (1.68%) in September (Fig. 3).

Even though there were other diatoms in the first station with high relative densities during certain months, they could not be shown with figures due to their irregular frequencies of appearance.

The most significant species in the second station in terms of frequency of appearance and relative density were *Cymbopleura lata*, *Cymbella parva*, *N. tripunctata* and *Nitzschi agracilis*. At this station, *C. lata* reached its highest relative density (7.20%) in March and dropped to its lowest relative density (2.35%) in October; whereas for *C. parva*, highest relative density (9.01%) was recorded in March and its lowest relative density (4.57%) in September. Highest relative density (11.76 %) for *N. tripunctata* was recorded in October and its lowest relative density (6.57%) in April and June, while *N. gracilis* showed its highest relative density (9.15%) in the second station in September, and its lowest relative density (4.66%) was recorded in July (Fig. 4).

Another remarkable species at this station with regards to its frequency of appearance was *N. amphibia*. The relative density of this diatom in June (9.62%) was the highest relative density among other diatoms; whereas the relative density for *Ulnaria ulna* in the same month was the lowest relative density (1.88%) among all diatoms.

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The photographs of *C. lata, C. parva* and *N. gracilis*, which were significant in the second station in terms of their relative densities and frequencies of appearance, are given in Figs. 5a, b and c.

Another remarkable species at this station with regards to its frequency of appearance was *N. amphibia*. The relative density of this diatom in June (9.62 %) was the highest among other diatoms; whereas that for *U. ulna* in the same month was the lowest relative density (1.88 %) among all diatoms.

The photographs of *C. lata, C. parva* and *N. gracilis*, which were significant in the second station in terms of their relative densities and frequencies of appearance, are given in Fig. 5.

Other significant species in the second station with regards to their relative densities were *Nitzschia palea*, *N. tryblionela* and *U. ulna*. However, they were not shown with figures due to their irregular frequencies of appearance.

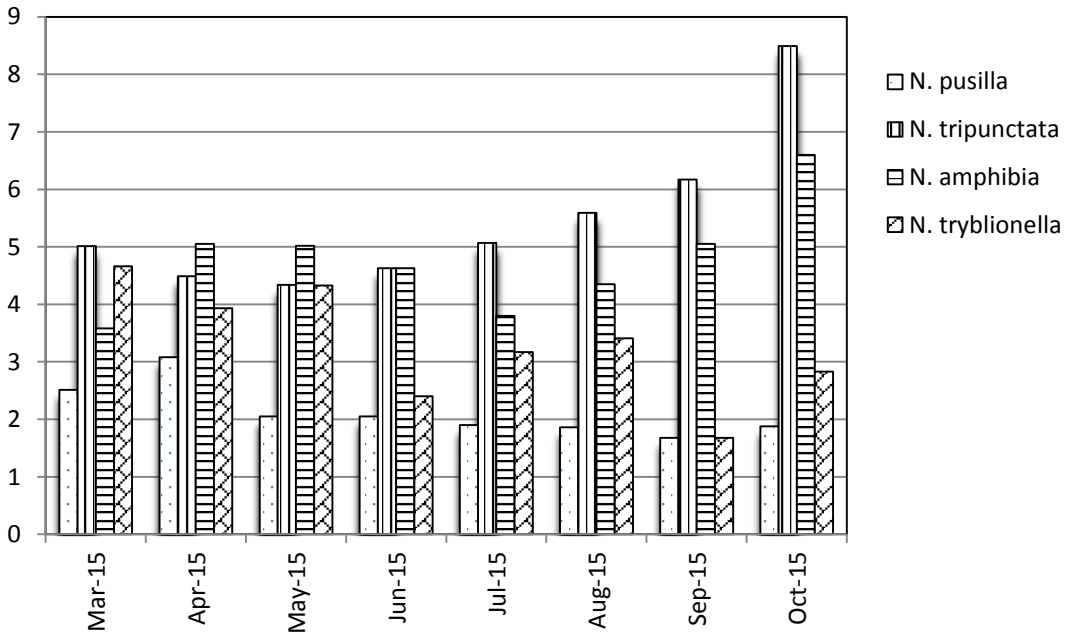

Figure 3: Relative densities of *Navicymbula pusilla, Navicula tripunctata, Nitzschia amphibia* and *Nitzschi atryblionella* during monthly samplings in the first station.

According to physical and chemical analyses, except for nitrite, Kozluk Creek has first class quality (Anonymus, 2004).

Throughout the study, 26 taxa of epilithic diatoms were recorded at Kozluk Creek. Other algae were not included in this study as diatoms are more dominant than other algae with regards to numbers of individuals and frequencies of appearance. This can be seen as a sign that means diatoms make better use of their surrounding conditions compared to other algal groups.

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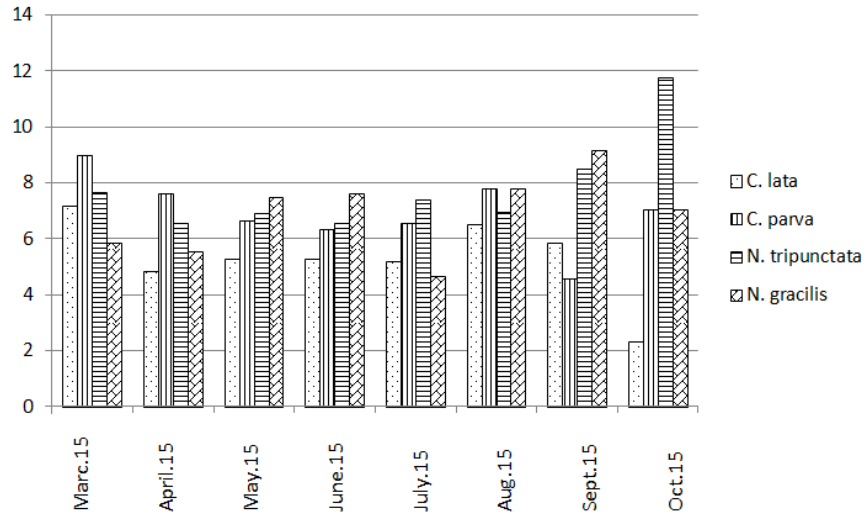

Figure 4: Monthly variations in the relative densities of *Cymbopleura lata*, *Cymbella parva*, *Navicula tripunctata* and*Nitzschia gracilis* in the second station.

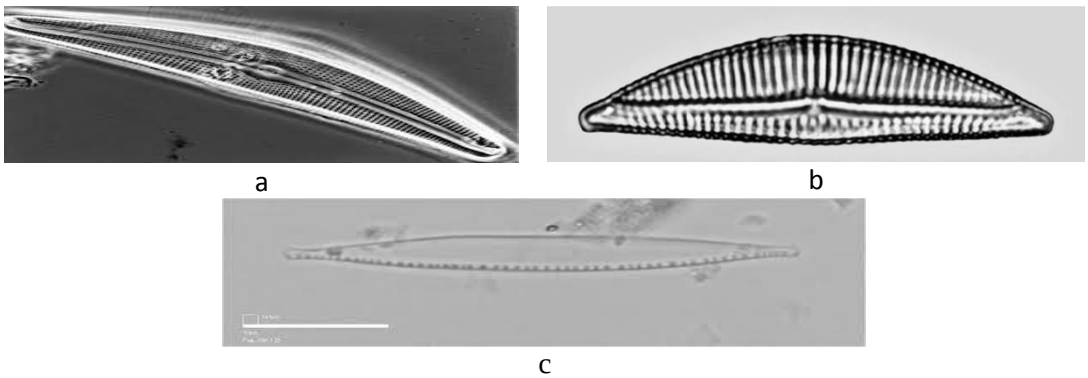

Figure 5: *Cymbopleura lata*(a), *Cymbella parva* (b)and *Nitzschia gracilis*(c) (URL 3).

This has been reported numerous times in other algae studies conducted on streams, as well. Some of those studies are mentioned below.

Diatoms were the dominant group in the study conducted on the epipelic algal flora of Karasu (Euphrates) River by Altuner and Gurbuz (1991), as well. *Navicula cryptocephala, Cymbella affinis, Cymbella ventricosa, Amphora ovalis, N. palea* and *Synedra ulna* were observed as the dominant species within this group. The significant diatoms in the epilithic diatom flora of Kozluk (Arapgir) Creek in terms of frequency of appearance and number of individuals were *Navicymbula pusilla, Cymbopleur alata, C. parva, N. tripunctata, N. amphibia, N. tryblionella* and *Nitzschia gracilis.* There were similarities among the diatoms in both studies on a specie-basis.

Gonulol and Arslan (1992) studied algal flora of Samsun-IncesuStream, and found that the dominant species among epilithic algae were *Cocconeis, Cymbella* and *Gomphonema*. Even

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though the *Cocconeis* and *Gomphonema* species were not encountered in Kozluk Creek, the *Cymbella* specie was among the dominant species of this Creek, as well.

In the research conducted by Yıldız (1987) on the algal communities of AltınapaDam Lake and Meram Creek, diatoms were more prevalent and dominant in both these waters compared to other algae. The dominant species among the epiphytic and epilithic diatoms of Altınapa Dam Lake were *Synedra delicatissima, Navicula cryptocephala, N. palea, Cymbella microcephala, Cymbella amphicephala, Gomphonema olivaceum* and *Navicula cryptocephala.* This finding does not show any species similarity with the findings of our study with the exceptions of *N. palea* and *Navicula cryptocephala* species.

In Altuner's (1988) study on the diatom flora of Aras River, the most encountered diatoms were *Achnanthes affinis, Fragilariaca pucina, Gomphonema olivaceum*, *Naviculacry ptocephala* var. *veneta, Nitzschia intermedia, N. subcapitellata* and *Surirella ovata*. None of these diatom species were encountered in Kozluk Creek.

In Pala and Caglar's (2008) study titled Epilithic diatoms in Peri Stream (Tunceli) and Their Seasonal Variations, 36 diatom species were recorded in total. *Gomphonema, Fragilaria, Cymbella* were the diatom genera represented with the highest number of species in the researched area whereas *Cymbella* spp., *Gomphonema* spp. and *Fragilaria* spp. were the most important diatoms in terms of frequency of appearance and populationsizes within the epilithic diatom community. In Kozluk Creek, on the other hand, the most significant diatom genera both in terms of representation rates and their frequencies of appearance and population sizes were *Cymbella* spp., *Navicula* spp. and *Nitzschia* spp.

Sivaci and Dere (2007) examined the monthly changes in the epilithic diatom communities of Melendiz Creek (Aksaray-Ihlara) and the effect of water flow on the organisms and stated that *Cocconeis placentula* var. *euglypta*, *Navicula cryptocephala*, *Navicula tripunctata*, *Encyonema minutum, N. amphibian* and *N. palea* diatoms were the dominant species within the communities of Melendiz Creek. This finding showed similarity with the findings of Kozluk Creek with the exclusions of *C. placentula* var. *euglypta* and *E. minutum.*

In Round's (1957) and Butcher's (1946) studies, the majority of the diatoms were described as species that favour alkaline waters. *C. placentula*, *Cymbella ventricosa*, *Gomphonema parvulum* and *Gomphonema olivaceum*, in particular, were found to be the dominant organisms in high alkaline waters. Even though Kozluk Creek's water displayed alkali

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characteristics, these diatoms were not found in it.

Cymbella spp., *Navicula* spp. and *Ulnaria* spp., which were identified among the epilithic diatoms of KozlukCreek, are generally reported as the typical benthic species of inland waters (Hutchinson, 1957).

Chessman (1986) stated that the species of *Navicula* and *Nitzschia* are cosmopolitan. The fact that the species of *Navicula* and *Nitzschia* were encountered at both of the stations in Kozluk Creek, as well, supports this finding.

Even though some of the diatoms encountered in Kozluk Creek (*S. ovalis, Navicula salinarum, U. ulna* and *N. palea)* were not significant within the epilithic algal community in terms of frequency of appearance, they were remarkable with the relative densities they reached during some months. This finding points to the possibility that given the appropriate conditions, there can be a succession among diatoms, as well.

The fact that diatoms are always present within the epilithic algal community shows that diatoms are cosmopolitan and that they are one of the algae encountered in all kinds of substratum.

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