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Research Article

Epilithic Diatoms of Lake Hazar (Elazığ-Türkiye)

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Abstract: In this study, the epilithic diatoms of Lake Hazar, one of the most important surface water resources in the Eastern Anatolian region of Türkiye, were investigated. As a result of the examination of the epilithic diatom flora, it was found that the diatom diversity is quite high and the epilithic diatoms are represented by 61 species belonging to 36 genera. *Navicula* (7 spp.), *Epithemia* (6 spp.) and *Cymbella* (3 spp.) were the most abundant genera. In Hazar Lake, centric diatoms were represented by *Stephanocyclus meneghinianus* and *Cyclostephanos dubius*. It was determined that a significant proportion of these species were cosmopolitan. It was found that some of the species found in Lake Hazar are ecologically oligotrophic species that prefer alkaline water.

Keywords: Bacillariophyta, Elazığ, Epilithic, Diatoms, Lake Hazar.

1. Introduction

Diatoms are one of the most important groups of algae found in freshwater. Together with other microscopic algae, they form a very important part of the food chain in almost all aquatic ecosystems. Diatoms are organisms of very important ecological importance, contributing 20-25% of primary production. They form the primary food source for other aquatic organisms that feed on them (Round, 1973).

This important group includes benthic and planktonic forms. Benthic forms are found attached to rock, stone and plant surfaces in the water table. Studies have shown that benthic diatoms differ according to the substrates they attach to. The temporal and spatial variation of diatom communities in aquatic environments has made these organisms a favorite of ecologists. Due to the environmental sensitivity of diatom species, they have been considered to be indicator organisms in the determination of the ecological status of water bodies (Round, 1984; Round et al., 1990).

Studies on the determination of algae in reservoirs in our country have intensified in the last forty years. These studies have focused on benthic and planktonic algae. The first limnological study in Lake Hazar, located in the Eastern Anatolia region, was conducted by Nüman (Nüman, 1955). In the following years, the physical and chemical structure and biological characteristics of the lake were revealed with the studies carried

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out in the lake (Solak et al., 2012; Sen et al., 2003; Ozmen et al., 2004; Sen and Canpolat, 2010; Sonmez and Sen, 2011; Kocer and Sen, 2014; Pala et al., 2018; Sonmez et al., 2018; Rashid et al., 2022). With this study conducted in Lake Hazar, it was aimed to contribute to the determination of the algal flora of our country by determining the epilithic diatoms of the lake.

2. Materials and Methods

2.1.Study area

Located in the Upper Euphrates section of the Eastern Anatolia region of Türkiye, Lake Hazar is an elliptical, 20 km. long, tectonic lake with an average width of 4.5 km. The lake is located 22 km southeast of Elazığ. The lake area is 81 km2 and the height of the lake above sea level is 1248 meters. The lake basin is very hilly and is a depression area within the Eastern Anatolian Fault Zone, with Çelemik Mountain (1747 m.) and Mastar Mountain (1724 m.) in the north and Hazar Baba Mountain (2347 m.) in the south (Tatar et al., 1995; Gunek and Yigit, 1995). Eight stations were determined to examine the epilithic diatoms of Lake Hazar. These stations were selected from the areas determined to best represent the lake and along the shoreline along the entire perimeter of the lake (Figure 1).

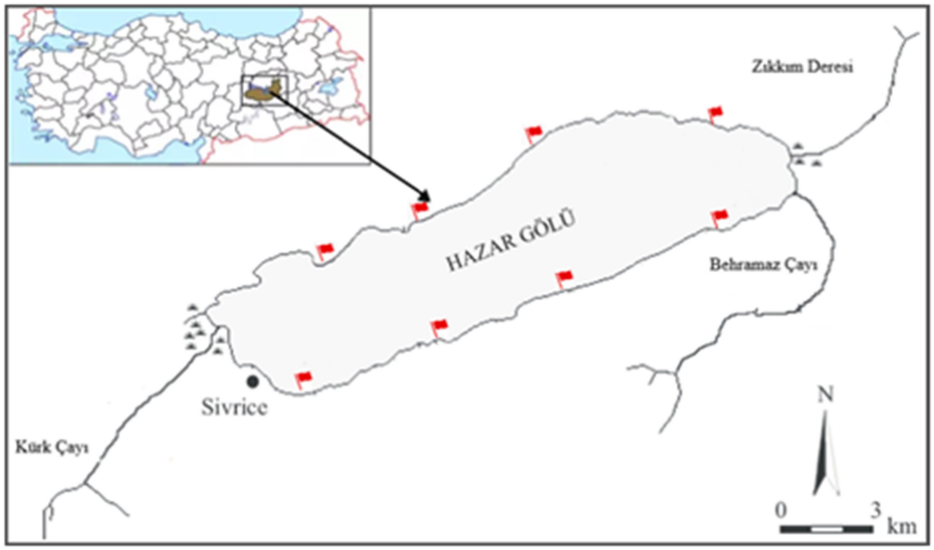

Figure 1. Sampling stations.

2.2.Field collection and laboratory analysis

Epilithic diatoms are algae that live in water by clinging to stones and rocks. Diatom samples on stones were collected by “brushing method” with the help of a brush at predetermined sampling stations in Lake Hazar. With this method, stone samples large enough to fit in the palm of the hand were taken and washed with a brush in jars containing lake water and the diomers on the stone surface were allowed to pass into the water in the jar (Round et al., 1990). The collected diatom samples were boiled in H_2O_2 and HCl to remove organic matter from the frustules. After washing three times in distilled water, the material was air-dried on a cover. A drop of the water containing the frustules was placed on a coverslip, allowed to dry and prepared with Naphrax. Diatoms were examined with an Olympus BX53 Light Microscope (LM). Diatoms were identified according to Bourelly, 1981; Krammer and Lange-Bertalot, 1986, 1991a; 1991b; 1999; 2003; Lange-Bertalot, 1978; Lange-Bertalot, 2001; Lange-Bertalot et al., 2017; Li et al., 2020; Patrick and Raimer, 1966; 1975.

3. Results

The epilithic diatoms of Lake Hazar were examined in samples taken from eight sampling stations selected in the coastal region of the lake and 61 species belonging to 36 genera belonging to the Bacillariophyta divisios were identified. The taxonomic order of these taxa identified in the Lake Hazar is given as a list based on the order of Round et al. (1990).

Table 1. Epilithic diatoms of Lake Hazar.

DIVISION : BACILLARIOPHYTA

Class : COSCINODISCOPHYCEAE

Ordo : Thalassiosirales

Family : Stephanodiscaceae Glezer & Makarova 1986

Genus : Stephanocyclus Skabitschevsky 1975

Species : ***Stephanocyclus meneghinianus*** (Kützing) Kulikovskiy, Genkal & Kociolek 2022

Genus : *Cyclostephanos* Round in Theriot, Håk., Kociolek, Round and Stoermer 1987

Species : ***Cyclostephanos dubius*** (Hustedt) Round 1988

Class : FRAGILARIOPHYCEAE

Ordo : Fragilariales

Family : Fragilariaceae Greville 1833

Genus : *Fragilaria* Lyngbye 1819

Species : ***Fragilaria capucina*** Desmaziéres 1830

Species : ***Fragilaria vaucheriae*** (Kützing) J.B.Petersen 1938

Genus : *Staurosira* Ehrenberg, 1843

Species : ***Staurosira venter*** (Ehrenberg) Cleve & J.D.Möller 1879

Genus : Pseudostaurosira Williams & Round 1988

Species : ***Pseudostaurosira brevisitriata*** (Grunow) D.M.Williams & Round 1988

Species : ***Pseudostaurosira elliptica*** (Schumann) Edlund, Morales & Spaulding 2006

Species : ***Pseudostaurosira medliniae*** D.M.Williams & E.A.Morales 2010

Genus : *Diatoma* Bory, 1824

Species : ***Diatoma ehrenbergii*** Kützing 1844

Species : ***Diatoma vulgaris*** Bory 1824

Genus : *Odontidium* Kützing, 1844

Species : ***Odontidium hyemale*** (Roth) Kützing 1844

Genus : *Hannaea* R.M.Patrick, 1966

Species : ***Hannaea arcus*** (Ehrenberg) R.M.Patrick 1966

Genus : *Meridion* C.Agardh, 1824

Species : ***Meridion circulare*** (Graville) C.Agardh 1831

Ordo : Tabellariales

Family : Tabellariaceae

Genus : *Tetracyclus* Ralfs, 1843

Species : ***Tetracyclus rupestris*** (Kützing) Grunow 1881

Ordo : Licmophorales

Family : Ulnariaceae

Genus : *Ulnaria* (Kützing) Compère, 2001

Species : ***Ulnaria acus*** (Kützing) Aboal 2003

Species : ***Ulnaria delicatissima*** (W.Smith) Aboal & P.C.Silva 2004

Class : BACILLARIOPHYCEAE

Ordo : Mastogloiales

Family : Mastogloiaceae
Genus : *Aneumastus* D.G.Mann & A.J.Stickle, 1990
Species : ***Aneumastus tusculus*** (Ehrenberg) D.G.Mann & A.J.Stickle 1990
Species : ***Aneumastus minor*** Lange-Bertalot 1993
Ordu : Cymbellales
Family : Rhoicospheniaceae
Genus : *Rhoicosphenia* Grunow, 1860
Species : ***Rhoicosphenia abbreviata*** (C.Agardh) Lange-Bertalot 1980
Family : Anomoeoneidaceae
Genus : *Anomoeoneis* E.Pfitzer, 1871
Species : ***Anomoeoneis sphaerophora*** Pfitzer 1871
Family : Cymbellaceae
Genus : *Placoneis* Mereschkowsky, 1903
Species : ***Placoneis clementis*** (Grunow) E.J.Cox 1988
Genus : *Cymbella* C.Agardh, 1830
Species : ***Cymbella helvetica*** Kützing 1844
Species : ***Cymbella parva*** (W.Smith) Kirchner 1878
Species : ***Cymbella tumida*** (Brebisson) Van Heurck 1878
Genus : *Cymbopleura* (Krammer) Krammer, 1999
Species : ***Cymbopleura inaequalis*** (Ehrenberg) Krammer 2003
Family : Gomphonemataceae
Genus : *Gomphonema* Ehrenberg, 1832
Species : ***Gomphonema angustatum*** (Kützing) Rabenhorst 1864
Species : ***Gomphonema staurophorum*** (Pantocsek) A.Cleve 1955
Genus : *Didymosphenia* Mart.Schmidt, 1899
Species : ***Didymosphenia geminata*** (Lyngbye) Mart. Schimidt 1899
Genus : *Gomphonella* Rabenhorst, 1853
Species : ***Gomphonella olivacea*** (Hornemann) Rabenhorst 1853
Ordo : Achnanthales
Family : Cocconeidaceae
Genus : *Cocconeis* Ehrenberg, 1836
Species : ***Cocconeis placentula*** Ehrenberg 1838
Ordo : Naviculales
Family : Neidiaceae
Genus : *Neidium* Pfitzer, 1871
Species : ***Neidium dubium*** (Ehrenberg) Cleve 1894
Family : Amphipleuraceae
Genus : *Halamphora* (Cleve) Levkov 2009
Species : ***Halamphora veneta*** (Kützing) Levlov 2009
Family : Sellaphorineae
Genus : *Sellaphora* Mereschowsky, 1902

Species : ***Sellaphora bacillum*** (Ehrenberg) D.G.Mann 2018
Family : Pinnulariaceae
Genus : *Pinnularia* Ehrenberg, 1843
Species : ***Pinnularia brebissonii*** (Kützing) Rabenhorst 1864
Family : Naviculaceae
Genus : *Navicula* Bory, 1822
Species : ***Navicula cryptotenella*** Lange-Bertalot 1985
Species : ***Navicula oblonga*** (Kützing) Kützing 1844
Species : ***Navicula pygmaea*** (Kützing) Pantocsek 1901
Species : ***Navicula reinhardtii*** (Grunow) Grunow 1880
Species : ***Navicula striolata*** (Grunow) Lange-Bertalot 1985
Species : ***Navicula subalpina*** E.Reichardt 1988
Species : ***Navicula virdula*** (Kützing) Ehrenberg 1838
Genus : *Caloneis* Cleve, 1894
Species : ***Caloneis bacillum*** (Grunow) Cleve 1894
Species : ***Caloneis silicula*** (Ehrenberg) Cleve 1894
Family : Pleurosigmataceae
Genus : *Gyrosigma* Hassall, 1845
Species : ***Gyrosigma acuminatum*** (Kützing) Rabenhorst 1853
Ordo : Thalassiophysales
Family : Catenulaceae
Genus : *Amphora* Ehrenberg ex Kützing, 1844
Species : ***Amphora libyca*** Ehrenberg 1841
Species : ***Amphora ovalis*** (Kützing) Kützing 1844
Ordo : Bacillariales
Family : Bacillariaceae
Genus : *Tryblionella* W.Smith, 1853
Species : ***Tryblionella apiculata*** W.Gregory 1857
Genus : *Nitzschia* Hassall, 1845
Species : ***Nitzschia commutata*** Grunow 1880
Species : ***Nitzschia linearis*** W.Smith 1853
Genus : *Grunowia* Rabenhorst, 1864
Species : ***Grunowia solgensis*** (A.Cleve) Aboal 2003
Genus : *Denticula* Kützing, 1844
Species : ***Denticula valida*** (Pedicino) Grunow 1885
Ordo : Rhopalodiales
Family : Rhopalodiaceae
Genus : *Epithemia* Kützing, 1844
Species : ***Epithemia adnata*** (Kützing) Brebisson 1838
Species : ***Epithemia gibba*** (Ehrenberg) Kützing 1844
Species : ***Epithemia paralella*** (Grunow) Ruck & Nakov 2016

Species : ***Epithemia sorex*** Kützing 1844
Species : ***Epithemia turgida*** (Ehrenberg) Kützing 1844
Species : ***Epithemia turgida*** var. ***westermannii*** (Ehrenberg) Grunow 1862
Ordo : Surirellales
Family : Surirellaceae
Genus : *Surirella* Turpin, 1828
Species : ***Surirella brebissonii*** Kramer & Lange-Bertalot 1987
Species : ***Surirella subsalsa*** W.Smith 1853
Genus : *Iconella* Jurilj, 1949
Species : ***Iconella amphioxys*** (W.Smith) D.Kapustin & O.Kryvosheia 2019
Species : ***Iconella linearis*** (W.Smith) Ruck & Nakov 2016

Lake Hazar, located in the Eastern Anatolia region, has an important value for the region in terms of its location and intended use. Lake Hazar is the second deepest lake in our country after Lake Van. In addition to its recreational use, Lake Hazar is one of the important inland water resources for the local people in terms of fishing. In today's world where global warming is effective, tectonic movements have been effective in our region in recent years, affecting aquatic habitats as well as the terrestrial environment. Lake Hazar, a tectonic lake, is also significantly affected.

Diatoms, one of the most important components of the aquatic flora, cannot be unaffected by these changes. For this purpose, the epilithic diatoms of Lake Hazar were examined in samples taken from the coastal region of the lake. In these samples, 61 species belonging to 3 classes, 12 orders, 2 families and 36 genus were identified. Among the epilithic diatom phyla of Hazar Lake, *Navicula* was the genus with the highest number of species. The genus *Navicula* is represented by *Navicula cryptotenella*, *Navicula oblanga*, *Navicula pygmaea*, *Navicula reinhardtii*, *Navicula striolata* and *Navicula subalpina*. The second important genus among the epilithic diatoms in terms of species diversity in the lake is *Epithemia*. *Epithemia* was represented by *Epithemia adnata*, *Epithemia gibba*, *Epithemia paralella*, *Epithemia sorex* and *Epithemia turgida* and constituted the second richest genus in terms of species number in Lake Hazar. Especially the species belonging to the genus *Navicula* are generally reported to be distributed in waters with oligotrophic characteristics. *Navicula cyrptotenella*, which we detected in the epilithic diatom flora of Lake Hazar, is defined as a cosmopolitan species. They are widely distributed in all oligotrophic and eutrophic freshwaters with very high and very low electrolyte levels. Ecologically, β-mesosaprobic and better character are reported to be used as indicators in determining water quality (Lange-Bertalot, 2001). *Navicula oblanga*, which was also found in Lake Hazar where the study was conducted, is expressed as a cosmopolitan species in the literature. *Navicula reinhardtii* is reported to be tolerant to β-mesosaprobic waters with moderate electrolyte levels, preferring primarily meso-eutrophic waters (Lange-Bertalot, 2001). The widespread detection of these species in Lake Hazar shows that the lake preserves its oligotrophic character. Patrick and Reimer, reported that *Navicula pygmaea* is ecologically distributed in freshwaters with high mineral content (Patrick and Reimer, 1975) and the detection of *N. pygmaea* in the epilithic diatoms of Lake Hazar reinforces the view that the amount of mineral matter in the lake water may be high. Sonmez and Sen emphasized that the lake has high conductivity (Sonmez and Sen, 2011).

Navicula striolata is described as a species found in calcareous rich oligosaprobic and relatively eutrophic waters (Lange-Bertalot, 2001). *Navicula subalpina* is a cosmopolitan species with a widespread distribution especially in northern hemisphere waters. Ecologically, it is found in calcareous rich oligotrophic to less β-mesosaprobic waters. Therefore, they are known as indicator organisms of β-mesosaprobic waters (Lange- Bertalot, 2001).

Epithemia adnata is a species that prefers alkaline waters containing moderate amounts of calcium. It is found epiphytically on lithoral substrates, especially on aquatic plants. *Epithemia gibba* is often found epiphytically, especially in waters with high conductivity (Patrick and

Reimer, 1966). *Epithemia sorex* is a cosmopolitan species and is reported to be commonly found in waters containing high electrolytes (Taylor et al., 2007).

Studies have also shown that a significant portion of the epilithic diatoms detected in Lake Hazar are observed in oligotrophic waters. Pala et al. (2018) reported that species belonging to the genera Navicula, *Gomphonema* and *Cymbella* in the epilithic diatom flora are important in terms of both population size and frequency of occurrence in the coastal region of the lake. In our study, *Navicula* was determined as the genus with the highest number of species in Lake Hazar. These results we obtained in this study are in parallel with the results of the study conducted by Pala et al. in Lake Hazar (Pala et al., 2018). Sönmez and Şen (2011) examined the distribution and seasonal changes of the epilithic diatoms of Hazar Lake and found a total of 67 taxa and stated that the species belonging to the genus *Navicula* were more numerous than other diatoms. They stated that following *Navicula*, species belonging to the genera *Cymbella*, *Epithemia* and *Gomphoneme* were the most important diatoms in terms of diversity (Sonmez and Sen, 2011). In our study, especially the species belonging to the genera *Navicula* and *Epithemia* attract attention in terms of species diversity and the results we obtained are in parallel with the results obtained by Sönmez and Sen. Similar results, especially in terms of species composition, are similar to the results of many studies conducted in different lakes in our country (Altuner and Gurbuz, 1996; Cetin et al., 2003).

A significant portion of the epilithic diatoms identified in Lake Hazar are cosmopolitan species, which were also identified in studies conducted in the lakes of our country (Altuner and Gurbuz, 1996; Cetin et al., 2003; Atıcı et al., 2005; Papuçcu et al., 2010; Sıvacı et al., 2013; Gumus and Gonulol, 2018; Maraslıoglu and Soylu, 2017). Lake Hazar is an alkaline lake and some of the species found in the lake have also been reported in other alkaline waters. Round stated that *Amphora ovalis* shows a wide distribution in waters with high alkaline character (Round, 1984). It has been stated in different studies that the lake water shows alkaline properties in the analyzes conducted in Lake Hazar (Sonmez and Sen, 2011; Kocer and Sen, 2014; Sonmez et al., 2018; Rashid et al., 2022) . The fact that both *Amphora ovalis* and some other alkaline species were recorded in this study in Hazar Lake strengthens the idea that the alkalinity of the lake water is preserved and some species can be used as indicator organisms in the use of alkalinity.

Sonmez et al., *Achnanthidium exile, Amphora affinis, Aneumastus tuscula, Caloneis ventricosa, Cymbella helvetica, Cympleura cuspidata, Epithemia adnata* var. *saxonica*, *Staurosira construens*, *Gomphonema angustatum*, *Gomphoneme intricatum*, *Navicula dicephala*, *Navicula decussis* and *Platessa salinarum* are the most common oligotrophic diatoms in Lake Hazar (Sonmez et al., 2018). The species such as *Cymbella helvetica, Cymbopleura inaequalis, Gomphoneme angustatum, Epithemia adnata* that we detected in Lake Hazar in our study are similar to the diatoms detected in the study by Sönmez et al.

4. Conclusions

In this study conducted to determine the epilithic diatom flora of Hazar Lake, 61 species belonging to Coscinodiscophyceae, Fragilariophyceae and Bacillariophyceae families were identified. A significant portion of the species detected in Lake Hazar are alkaline species found in oligotrophic waters. It is seen that the diatom flora of Hazar Lake, which is intensively used for tourism purposes especially in summer months, does not show a significant change compared to previous studies.

Conflicts of Interests
Authors declare that there is no conflict of interests

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Statement contribution of the authors
This study's sampling, idendification and writing, etc. all steps were made by the authors.

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