Water Quality Assessment Based on the Phytoplankton Composition of Buyukcekmece Dam Lake and its Influent Streams (Istanbul), Turkey

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Introduction

- Generally physical, chemical and biological parameters are examined together to reveal the water quality of aquatic ecosystems.

- Especially phytoplankters, one of the biological parameters are frequently used as functional groups.

- Buyukcekmece Dam Lake, the most affected reservoir by anthropogenic pollution in Istanbul, is also the second largest drinking water source.

- Istanbul Metropolitan Municipality is planning works to allow new residential areas, industrial and commercial activities in the Buyukcekmece Basin.

- Consequently, an increase is expected in the pollution load of the dam lake. Therefore, it has become compulsory to plan and implement the protection of the Buyukcekmece Dam Lake Basin.

- The phytoplankton composition of Buyukçekmece Dam Lake was carried out by Temel (2002) in an earlier study and Aktan et al. (2009) investigated the effect of environmental factors on the growth and size structure of two dominant phytoplankton species in this reservoir.

- It is known that poured streams to the lakes, constitute a serious pollution load. There isn't any detailed studies including the phytoplankton community and related environmental variables of the influent streams of Buyukcekmece Dam Lake.

Objectives

- The aim of this study is to determine the pollution level which were brought by the streams to the lake by using phytoplankton composition and some physicochemical parameters and create mitigation plans to take necessary precautions against the ecological problems in this lake ecosystem.

Study Area

Figure 1: Map of Buyukcekmece Dam Lake and sampling stations

- Buyukcekmece Dam Lake is located in the south of the Thrace peninsula, within the boundaries of Istanbul and near to the Sea of Marmara.
- The dam was built on Karasu River in 1985 and it is the second largest drinking water reservoir of Istanbul with a volume of 160 million m^3.
- The lake is exposed to the effects of the use of pesticides and artificial fertilizers originating from agricultural activities.

St.1:Karasu Stream (41°08'28.2"N 28°29'06.8"E)

This stream constitutes the main water source of the lake and there are many agricultural activities (wheat, barley, oats, and corn) around it.

View of Karasu Stream

- A total of 23 taxa were identified belonging to 7 divisions in Karasu Stream. Bacillariophyta was recorded the dominat group and Euglenozoa was the subdominant division in station 1. *Nitzschia acicularis* of diatoms was found the dominant species.

St.2:İzzettin Stream (41°08'46.1"N 28°31'13.5"E)

The second important feeding stream of the lake.

View of İzzettin Stream

- A total of 12 taxa were identified belonging to 5 divisions in İzzettin Stream. Cyanobacteria was recorded the dominat group and Chlorophyta was the subdominant division in station 2. *Anabaena spiroides* of blue-green algae was found the dominant species both in spring and summer seasons.

St.3:Eskice Stream (41°09'04.1"N 28°31'22.3"E)

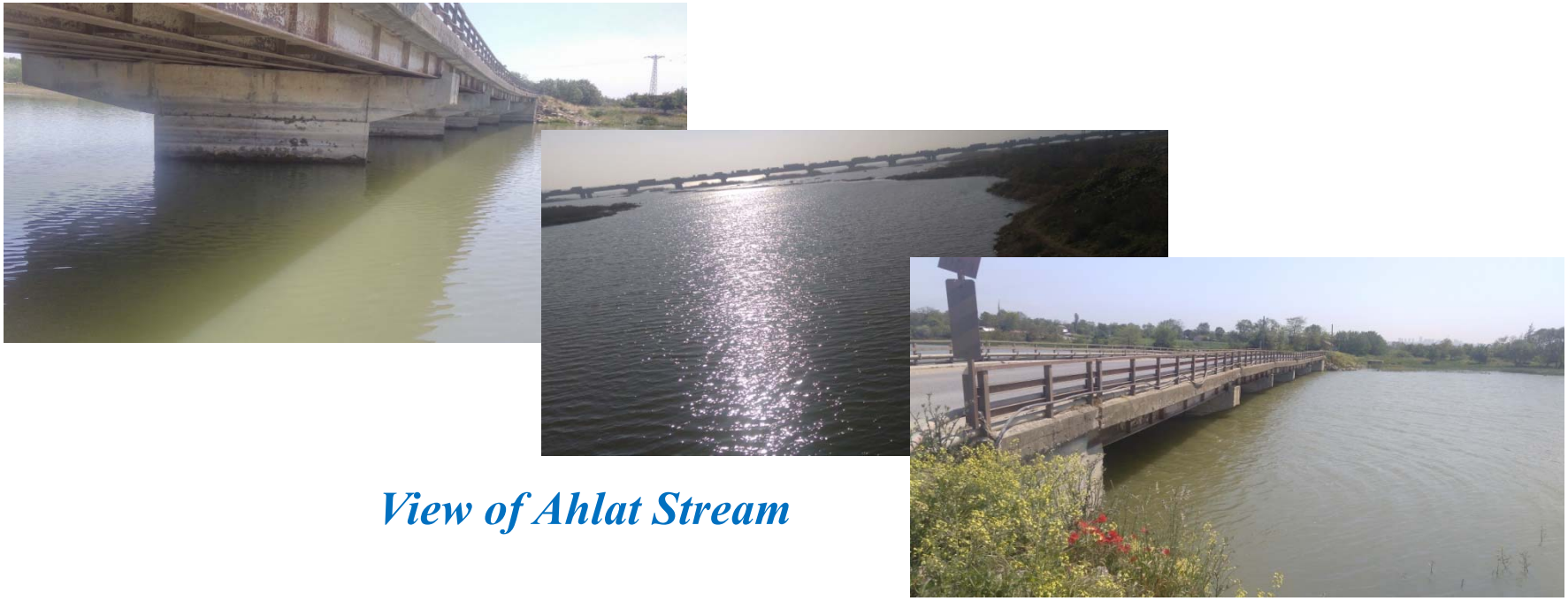
Shallow creek with low water flow.

View of Eskice Stream

- A total of 38 taxa were identified belonging to 7 divisions in Eskice Stream. Cyanobacteria was recorded the dominat group and Chlorophyta was the subdominant division in station 3. *Anabaena spiroides* was the dominant and *Merismopedia glauca* was the subdominant species.

St.4:Ahlat Stream (41°06'37.5"N 28°32'08.6"E)

Shallow creek with low water flow.



View of Ahlat Stream

- A total of 17 taxa were identified belonging to 6 divisions in Ahlat Stream. Bacillariophyta was recorded the dominat group; Euglenozoa and Cryptophyta were the subdominant divisions in station 4. While *Cyclotella meneghiniana* was the dominant species; *Nitzschia acicularis*, *Cryptomonas ovata*, *Euglena acus* and *E. viridis* were recorded as important species.

St.5:Beylikçayı Stream (41°06'15.9"N 28°33'33.1"E)

This effective water source is located in the north-east of the lake.

View of Beylikçayı Stream

- A total of 33 taxa were identified belonging to 7 divisions in Beylikçayı Stream. Cyanobacteria was recorded the dominat group and Chlorophyta was the subdominant division in station 5. *Oscillatoria tenuis* was the dominant and *Sphareocystis* sp. was the subdominant species.

St.6:Çekmece Stream (41°03'31.4"N 28°34'52.7"E)

There are situated agricultural areas around this very small creek.

View of Çekmece Stream

- A total of 15 taxa were identified belonging to 5 divisions in Çekmece Stream. Cyanobacteria was recorded the dominat group and Bacillariophyta was the subdominant division in station 6. *Aphanizomenon flosaquae* was the dominant and *Aulocoseira italica* was the subdominant species.

St.7: Çakmaklı Stream (41°03'22.8"N 28°35'14.8"E)

Shallow creek with low water flow.

View of Çakmaklı Stream

- A total of 14 taxa were identified belonging to 5 divisions in Tahtaköprü Stream. Bacillariophyta was recorded the dominat group and Cyanobacteria was the subdominant division in station 7. *Nitzschia acicularis* was the dominant and *Merismopedia glauca* was the subdominant species.

St.8:Tahtaköprü Stream 41°03'22.8"N 28°35'14.8"E

It is located in the west part of the lake.

View of Tahtaköprü Stream

- A total of 33 taxa were identified belonging to 7 divisions in Eskice Stream. Bacillariophyta was recorded the dominat group and *Cyclotella meneghiniana* was recorded as the dominant species. *Scenedesmus quadricauda* of Chlorophyta, *Cryptomonas ovata* of Crytophyta and *Euglena viridis* of Euglenozoa was recorded in high numbers in station 8.

St.9:Buyukcekmece Dam Lake (41°04'28.1"N 28°32'49.2"E

It is selected from the centre of the lake.

View of Buyukcekmece Dam Lake

- A total of 26 taxa were identified belonging to 7 divisions in Buyukcekmece Lake. Cyanobacteria was recorded the dominat group and *Anabaena spiroides* was recorded the dominant species. *Aphanizemenon flosaquae* and *Oscillatoria tenuis* of blue-green algae were recorded subdominant species.

Sampling and Analyses

- This study was carried out at 9 sampling sites including the lake and its feeding streams in May 2017 (spring), Agust 2017 (summer), November 2017 (autumn) and February 2018 (winter).

- Samples were collected seasonally by using Nansen bottles from each sampling points and were fixed with Lugol's iodine solution. Phytoplankton were identified in reference to the literature, including several comprehensive reviews on the subject.

- Water temperature, dissolved oxygen, pH, salinity and electrical conductivity were measured with the WTW Multi 340i /set made multiparameter in the field.

Nitrite, nitrate and orthophosphate analysis at the laboratuary.

- Chlorophyll- *a* were estimated according to Parsons and Strickland (1963); nitrite, nitrate and orthophosphate concentrations were determined according to standard methods (Greenberg, 1995) at the laboratory.

Results

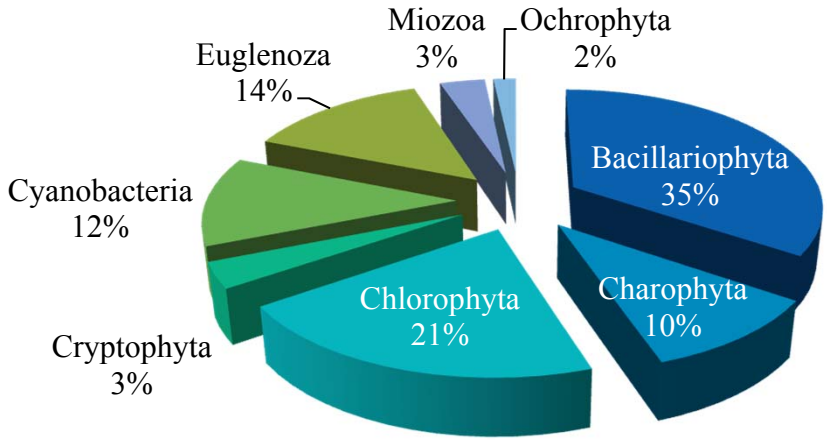


Figure 2. The percentage distribution of phytoplankton groups.

- A total of 58 taxa belonging to Bacillariophyta (20), Charophyta (6), Chlorophyta (12), Cryptophyta (2), Cyanobacteria (7), Euglenozoa (8) Miozoa (2) and Ochrophyta (1) divisions were identified.

- According to the species diversity Bacillariophyta division was found the richest group and *Anabaena spiroides* of Cyanobacteria was recorded the dominant species in terms of phytoplankton density.

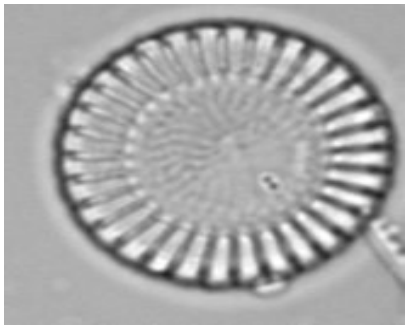
Table 1. List of recorded taxa of phytoplankton.

DIVISIO: BACILLARIOPHYTA	**DIVISIO: CYANOBACTERIA**	**DIVISIO: CHAROPHYTA**
Amphora ovalis (Kütz.) Kützing	*Anabaena spiroides* Klebahn	*Cosmarium formosulum* Hoff
Aulacoseira italica (Ehr.) Simonsen	*Aphanizmenon flosaquae* Ralfs ex Bornet & Flahault	*Closterium acutum* Brebisson
Cocconeis placentula Ehrenberg	*Chroococcus limneticus* Lemmermann	*Closterium incurvum* Brebisson
Cyclotella atomus Hustedt	*Merismopedia glauca* (Ehr.) Kützing	*Closterium strigosum* Brebisson
Cyclotella ocellata Pantocsek	*Microcystis aeruginosa* (Kütz.) Kützing	*Staurastrum brachiatum* Ralfs ex Ralfs
Cyclotella meneghiniana Kützing	*Oscillatria princeps* Vaucher ex Gomont	*Staurastrum crenulatum* (Nägeli)Delponte
Cymbella affinis Kützing	*Oscillatora tenuis* C.Agardh ex Gomont	
Cymbella tumida (Brebisson) Van Heurck		**DIVISIO: EUGLENOZOA**
Cymbella ventricosa (C.Agardh) C.Agardh	**DIVISIO: CHLOROPHYTA**	*Euglena acus* (O.F.Müller) Ehrenberg
Diatoma vulgaris Bory	*Ankistrodesmus falcatus* (Corda) Ralfs	*Euglena ehrenbergii* G.A. Klebs
Fragilaria crotonensis Kitton	*Coelastrum microporum* Nägeli	*Euglena gracilis* G.A. Klebs
Melosira varians C.Agardh	*Kirchneriella* sp.	*Euglena viridis* (O.F.Müller) Ehrenberg
Meridion circulare (Greville) C.Agardh	*Scenedesmus arcuatus* (Lem.) Lemmermann	*Phacus orbicularis* K.Hübner
Navicula cryptocephala Kützing	*Scenedesmus dimorphus* (Turpin) Kützing	*Trachelomonas hispida* (Perty) Stein
Navicula cuspidata (Kütz.) Kützing	*Scenedesmus ecornis* (Ehr.) Chodat	*Trachelomonas volvocino* (Ehr.) Ehr.
Navicula lanceolata Ehrenberg	*Scenedesmus quadricauda* (Turpin) Brebisson	*Strombomonas* sp.
Nitzschia acicularis (Kütz.) W.Smith	*Scenedesmus* sp.	**DIVISIO: MIOZOA**
Pleurosigma sp.	*Sphaerocystis* sp.	*Peridium bipes* Stein
Ulnaria acus (Kütz.) Aboal	*Pandorina morum* (O.F.Müller) Bory	*Prorocentrum micans* Ehrenberg
Ulnaria ulna (Nitzch) Compere	*Pediastrum boryanum* (Turpin) Meneghini	**DIVISIO: OCHROPHYTA**
DIVISIO: CRYPTOPHYTA	*Pediastrum duplex* Meyen	*Dinobryon sertularia* Ehrenberg
Cryptomonas ovata Ehrenberg		
Plagioselmis nannoplanctonica Skuja		

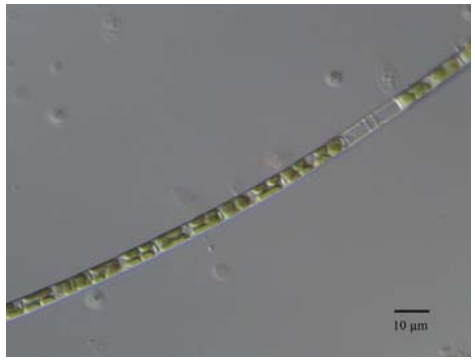
- According to previous studies carried out in the freshwaters of Turkey, Bacillariophyta members were found to be the dominant group in terms of species number as in the presented study.

- Bacillariophyta was represented by 20 taxon and most common diatoms were recorded as *Amphora ovalis*, *Aulacoseira italica*, *Cyclotella meneghiniana* and *Nitzschia acicularis*.

- *Aulocoseira italica* and *Cyclotella* spp. of centric diatoms are recorded usually in vertical mixed mesotrophic small- medium lakes with tolerance to light deficiency and sensitive to a rise in pH.



Cyclotella meneghiniana

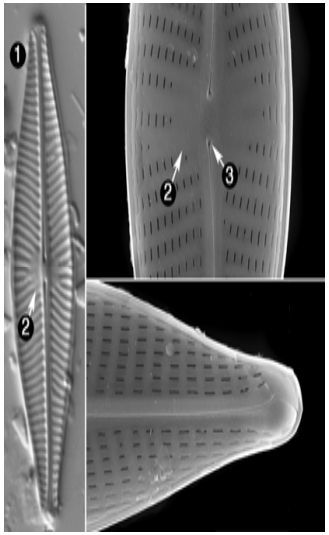


Aulocoseira italica

- *Nitzschia acicularis* and *Ulnaria acus* of pennate diatoms are habitants of shallow enriched waters and streams with sensitivity to nutrient deficiency.

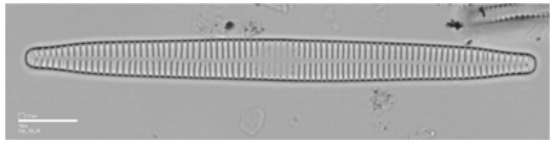
Nitzschia acicularis

Ulnaria acus



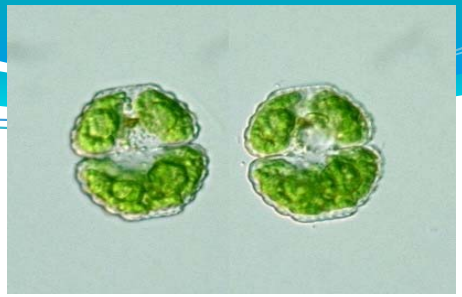
Navicula cryptocephala

- While *Navicula cryptocephala* and *Ulnaria ulna* were usually present in mixed inorganically shallow lakes, *Melosira varians* is known as a lotic habitat member.



Ulnaria ulna

- Charophyta was represented by 6 taxon. *Cosmarium formosulum* and *Closterium acutum* of desmids were recorded frequently during the study.



Cosmarium formosulum

- While *Cosmarium formosulum* is a habitant of mesotrophic epilimnia, *Closterium acutum* is found generally in eutrophic epilimnia of waters.

Closterium acutum

- Chlorophyta was represented by 12 species. It was stated that *Scenedesmus dimorphus* and *S. quadricauda* of green alga are sensitive to low light and presents in shallow, highly enriched ponds, lakes and rivers (Reynolds et al., 2002; Padisak et al., 2009).

Scenedesmus quadricauda

Scenedesmus dimorphus

- Cryptophyta was represented by *Cryptomonas ovata* and *Plagioselmis nannoplanctonica.*

- *Cryptomonas ovata* is presented in small enriched lakes (Reynolds et al., 2002; Padisak et al., 2009). This cryptomonads have been reported as dominant species in Buyukcekmece Dam Lake by Aktan et al. (2009).

- *Plagioselmis nannoplanctonica* was recorded rarely in low numbers. This is a difference with the earlier study conducted by Aktan et al. (2009).

Cryptomonas ovata

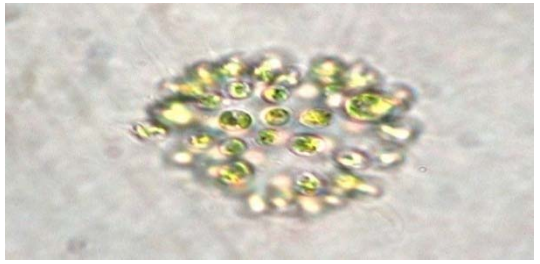
Plagioselmis nanoplanctonica

- Cyanobacteria was represented by 7 species. It is reported that *Anabaena spiroides*, *Merismopedia glauca*, *Microcystis aeruginosa* and *Oscillatoria tenuis* of blue-green algae are indicated eutrophic conditions.

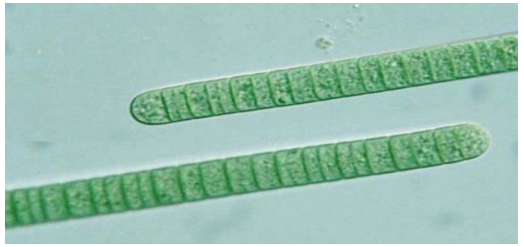
- Particularly, *Anabaena spiroides* and *Microcystis aeruginosa* show high organic matter level and agricultural enriched eutrophic and also hypereutrophic waters (Reynolds et al., 2002; Padisak et al., 2009).

- Additionally, toxin-producing Cyanobacteria like *Microcystis aeruginosa* , pose a big threat both to the lake ecosystem and public health. Also, they could be very dangerous for migratory birds.

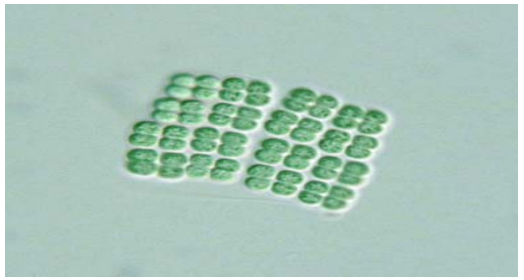
Anabaena spiroides



Microcystis aeruginosa



Oscillatoria tenuis



Merismopedia galauca

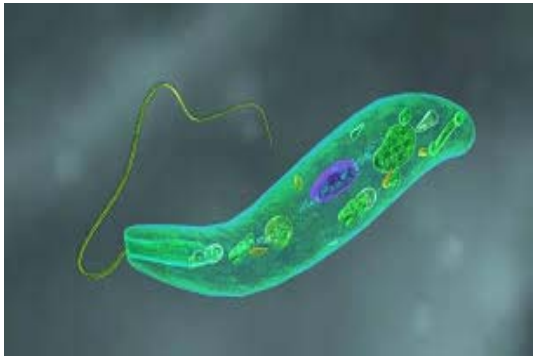
- Euglenozoa was represented by 9 species.

Trachelomonas hispida

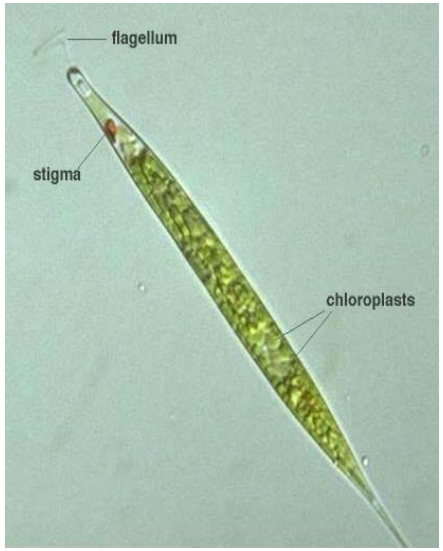
- It was stated that species of *Euglena* genus are found commonly in shallow mesotrophic and polluted lakes (Reynolds et al., 2002; Padisak et al., 2009).

Euglena gracilis

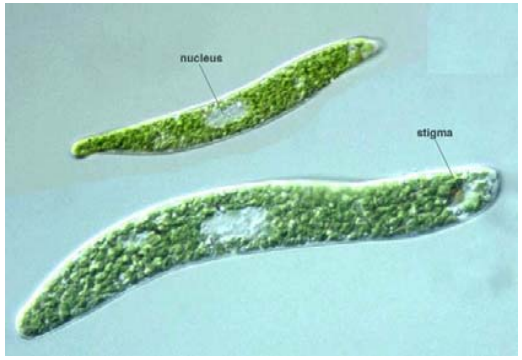
- *Euglena gracilis* was determined as a subdominant species in eutrophic featured Kuçukcekmece Lagoon (Yilmaz et al., 2015).



Euglena viridis



Euglena acus



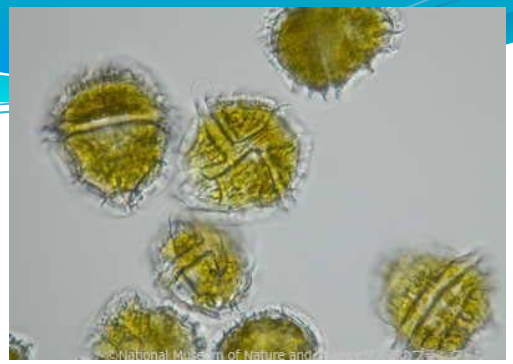
Euglena ehrenbergii

- Miozoa was represented by *Prorocentrum micans* and *Peridiniim bipes* which are found both in freshwaters and marine systems.

- It was expressed that these dinoflagellates are presented from oligotrophic to eutrophic waters in a wide range.

- Also, this species are considered to be harmful algae because of they cause excessive blooms under appropriate conditions and cause red-tides (Ignatiades et al., 2010). This species recorded frequently but in low numbers in the presented study.

- Ochrophyta was represented only by *Dinobryon sertularia* a member of small, oligotrophic, poor based lakes and heterotrophic pools (Reynolds et al., 2002; Padisak et al., 2009).



Peridinium bipes

Prorocentrum micans

Dinobryon sertularia

Water Quality Parameters

- Electrical conductivity values were higher (623- 1817 µS/cm) than the standard limits (150-500 µS/cm) of the protocols assigned for protection of surface water sources against pollution (Uslu and Türkman,1997).

- According to the measured pH values, the water of the lake and its feeding streams have slightly alkaline characteristics and indicated I and II water quality classes.

- The average of dissolved oxygen concentrations were measured as 6.21 mg/L (in normal limits) and shows class of II water quality according to water pollution control regulations of Turkey.

- Nitrite (NO_2) and orthophosphate (PO_4) concentrations show that the streams and the lake have class of IV water quality.

- Chlorophyll-*a* distribution is an important indicator of pollution and primary production. It is also used for determining the algal biomass (Uslu and Türkman, 1987).

- Chlorophyll-*a* concentrations were estimated between 0.20 µg/L and 82.91 µg/L. The average of the lake was 3.95 µg/L and the average of the streams was 13.44 µg/L.

- Sokomoto (1966) was expressed that, chlorophyll-*a* concentrations between 5- 140 µg/L indicates eutrophic lakes (Cirk and Cirik, 1991).

- High levels of chlorophyll-*a* concentrations which shows eutrophic conditions, were measured in st.3 (82.91 µg/L), st.8 (40.21 µg/L), st.1 (39.17 µg/L) and st.4 (36.89 µg/L) in summer.

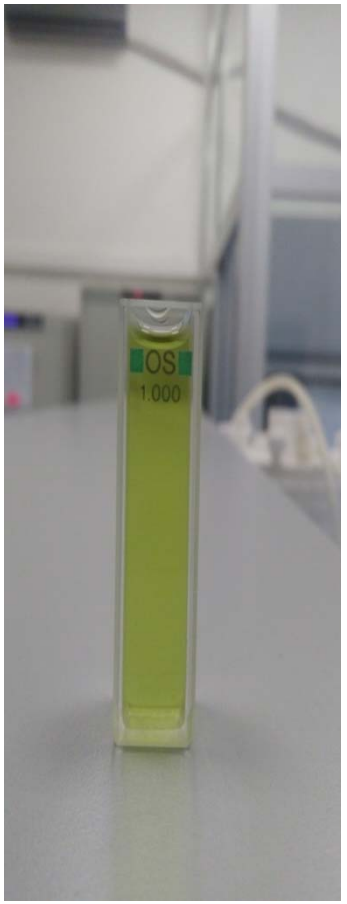


Table 2. Water quality classes in the feeding streams of Buyukcekmece Dam Lake according to Water Pollution Control Regulation in Turkey.

	Class I	Class II	Class III	Class IV	Min.-Max.	Average	Water Quality
Temp. (°C)	25	25	30	>30	8.0-27.9	17.39	Class I-II
pH	6.5- 8.5	6.5- 8.5	6.0- 9.0	6.0- 9.0 except	7.32-8.85	8.09	Class I-II
Dis. O_2 (mg/L)	8	6	3	<3	2.01-8.17	6.15	Class II
NO_2(mg/L)	0.002	0.01	0.05	>0.05	0.014-3.382	0.432	Class IV
NO_3 (mg/L)	5	10	20	>20	0.000-4.134	0.853	Class I
PO_4 (mg/L)	0.02	0.16	0.65	>0.65	1.069-69.726	12.665	Class IV

Table 3. Water quality classes in Buyukcekmece Dam Lake.

	Class I	Class II	Class III	Class IV	Min.-Max.	Average	Water Quality
Temp. (°C)	25	25	30	>30	8.2-27.5	17.15	Class I-II
pH	6.5- 8.5	6.5- 8.5	6.0- 9.0	6.0- 9.0 except	8.16-8.47	8.24	Class I-II
Dis. O_2 (mg/L)	8	6	3	<3	4.75-8.42	6.67	Class II
NO_2(mg/L)	0.002	0.01	0.05	>0.05	0.030-0.108	0.056	Class IV
NO_3 (mg/L)	5	10	20	>20	0.202-2.906	0.942	Class I
PO_4 (mg/L)	0.02	0.16	0.65	>0.65	0.846-1.495	1.189	Class IV

Conclusion

- Eventhough in general physicochemical parameters indicated that the lake has mesotrophic characteristics, high orthoposphate and chlorophyll-*a* concentrations showed that the lake is close to eutrophic features.

- Also recorded species of Euglenozoa which are important organic pollution indicators and dominance of cyanobacterium *Anabaena spiroides* which indicates eutrophic conditions, showed that the lake has eutrophic characteristics.

- The water quality of the lake is affected negatively by the discharges from domestic, industrial wastewaters, and also inputs from agricultural areas.

- Especially, it was determined that the pollution load carried by the streams was effective on the trophic level of the lake.

- When compared the streams in terms of carrying pollution loads to the lake, respectively Eskice (st.3), Karasu (st.1), Çekmece (st.6), Beylikçayı (st.5), İzzettin (st.2), Tahtaköprü (st.8), Ahlat (st.4) and Çakmaklı (st.7) streams affected the lake negatively.

- It is required that Buyukcekmece Dam Lake and its inflowing creeks should be taken under protection for improving its water quality by relevant authorities.

- It is need to carrying out more detailed studies, both at the lake and its influent streams, on physicochemical variables, nutrient concentrations and seasonal changes of phytoplankton for monitoring the lake's water quality.

Thank you for listening…