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Water quality assessment based on the phytoplankton composition of Buyukcekmece Dam Lake and its influent streams (Istanbul), Turkey

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ABSTRACT

In this study, water quality and pollution status of Buyukcekmece Dam Lake, which is the second largest drinking water resources of Istanbul (Turkey), and its influent streams (Karasu, Izzettin, Eskice, Ahlat, Beylikçayı, Çekmece, Çakmaklı and Tahtaköprü) were analyzed. For this purpose, some physicochemical parameters, nutrient concentrations and phytoplankton composition were investigated at the lake and its streams. Water samples were collected seasonally from nine sampling sites by using Nansen bottles in May 2017, August 2017, November 2017 and February 2018. Phytoplankton was identified in reference to the literature, including several comprehensive reviews on the subject. Phytoplankton composition of the lake and its feeding streams consists of Bacillariophyta (22), Charophyta (6), Chlorophyta (14), Cryptophyta (2), Cyanobacteria (8), Euglenozoa (8), Miozoa (2) and Ochrophyta (1) division members. As a result of measurements, the minimum and maximum values of some physicochemical parameters and nutrients were as follows; dissolved oxygen (2.01–8.42 mg L^{-1}), pH (7.32–8.85), nitrite (0.014–2.790 mg L^{-1}) and orthophosphate (0.846–69.726 μg L^{-1}). The results indicated that the basin of Buyukcekmece Dam Lake shows close feature to eutrophic conditions. It is required that, Buyukcekmece Dam Lake and its creeks should be taken under protection continuously for improving its water quality by relevant authorities.

Keywords: Phytoplankton; Physicochemical parameters; Nutrients; Water pollution; Buyukcekmece Dam Lake; Influent streams

1. Introduction

Generally physical, chemical and biological parameters are examined together to reveal the water quality of aquatic systems. Especially phytoplankton as one of the biological parameters is frequently used as functional groups [1,2]. Forming the first ring of the food chain and responding very fast to changes in waters are the reasons for preferring this group as bioindicators in many studies [3–6].

Buyukcekmece Dam Lake, the most affected reservoir by anthropogenic pollution in Istanbul, is the second largest drinking water source. Due to the lake is used for providing irrigation water to cultivated areas, run off from these areas is the additional source of anthropogenic nutrient load of the lake [7]. Also, Buyukcekmece Dam Lake and its surroundings are used as a recreational area. Istanbul Metropolitan Municipality has planning works to allow new residential areas, industrial and commercial activities in the Buyukcekmece Basin. In parallel with this planning, 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 [8].

The phytoplankton composition of Buyukçekmece Dam Lake was carried out by Temel [7] in an earlier study and Aktan et al. [9] investigated the effect of environmental factors on the growth and size structure of two dominant phytoplankton species in the reservoir. It is known that poured streams to the lakes constitute a serious

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pollution load. There are no detailed studies including the phytoplankton community and related environmental variables of the influent streams of Buyukcekmece Dam Lake. The aim of this study is to determine the pollution level which was brought by the streams to the lake by using phytoplankton composition and some physicochemical parameters and create consideration for taking necessary precautions against the ecological problems in this lake ecosystem.

2. Materials and methods

2.1. Study area

Buyukcekmece Dam Lake is located in the south of the Thrace peninsula, within the boundaries of Istanbul and near to the Sea of Marmara (Fig. 1). It is 50 km away from the center of Istanbul Metropolitan. The dam was built on Karasu River by ISKI (Water and Sewerage Administrative Center of Istanbul) in 1985. Buyukcekmece Dam with a total drainage area of 620 km^2, has a lake surface area of 28.5 km^2. It is the second largest drinking water reservoir of Istanbul with a volume of 160 million m^3. This shallow dam lake has an average depth of 6 m and it is the most affected reservoir in Istanbul by the anthropogenic pollution [9]. Maximum depth of Buyukcekmece Lake is 8.6 m and it meets approximately 17% of Istanbul's daily water needs. [10]. It was stated that,

Fig. 1. Map of Buyukcekmece Dam Lake and sampling stations.

Buyukcekmece Lake is one of the most polluted drinking water reservoirs in Istanbul due to its settlement, agricultural areas and nearly 800 industrial establishments [8]. The lake, which bordered on industrial and residential areas, is exposed to the effects of the use of pesticides and artificial fertilizers originating from agricultural activities. Also, it is under threat with the most intensive traffic of the main arteries in Istanbul, such as TEM and E5 [8,9].

The lake is feeding by Çekmece, Hadımköy, Kayan, Kavuk, Hamzalı, Örcünlü, Eski, Tahtaköprü, Köy, Kesliçiftliği, Kızılcaali, Damlı, Ayvalı, Şeytan, Karasu, Tavşan, İnter, Delice, Akalan, Tepecik, Kadınlar, Kestanelik, İnceğiz, Gökçeali and İzzettin creeks. Kavuk and Tepecik creeks combine to constitute the Karasu River near to the lake. Especially Karasu Creek has an important amount of water flow to the lake and the others have a very low flow rate [8].

2.2. Climate

Marmara climate, with rainy winters and hot summers, is dominant in the region. Unlike the typical Mediterranean regime, it is seen that the summer drought has lost its severity due to its close proximity to the Black Sea. Temperatures range from an average of 23°C in July–August to 5°C in January–February. According to 14-year evaluation between 1967 and 1981 of DSI, the annual average rainfall was 573.1 mm. The effect of Azor anticyclone in summer changes the wind direction in winter due to the effects of Siberian high-pressure center and temporary barometer depressions [8].

2.3. Sampling and analyzes

The presented study was carried out at nine sampling sites including the lake and its feeding streams in May 2017 (spring), August 2017 (summer), November 2017 (autumn) and February 2018 (winter) (Table 1). Samples were collected from surface seasonally by using Nansen bottles. The samples were fixed with Lugol's iodine solution for phytoplankton identification and counting. Samples were taken to glass tubes of 50 cc and it was added 2–3 drops

Table 1
Coordinates and characteristics of sampling stations

Stations		Coordinates	Characteristics
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.
2	İzzettin Stream	41°08′46.1″N 28°31′13.5″E	The second important feeding stream of the lake.
3	Eskice Stream	41°09′04.1″N 28°31′22.3″E	Shallow creek with low water flow.
4	Ahlat Stream	41°06′37.5″N 28°32′08.6″E	Shallow creek with low water flow.
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.
6	Çekmece Stream	41°03′31.4″N 28°34′52.7″E	There are situated agricultural areas around this very small creek.
7	Çakmaklı Stream	41°03′22.8″N 28°35′14.8″E	Shallow creek with low water flow.
8	Tahtaköprü Stream	41°03′22.8″N 28°35′14.8″E	It is located in the west part of the lake.
9	Büyükçekmece Dam	41°04′28.1″N 28°32′49.2″E	It is selected from the center of the lake.

of Lugol's iodine on the samples. Phytoplanktonic organisms were left to stand for 24 h to be sunk to the bottom. The remaining 5 cm^3 of samples were taken in counting chambers. After waiting for a period of time (4 h) for the collapses of the organisms, the counts were made with a Nikon TMS inverted microscope at a magnification of 400 according to Lund et al. [11]. Water samples were filtered through Whatman GF/A glass fiber filter and these filters were stored in petri dishes for phytoplankton identification. The identifications of algae, except the diatoms, were made by examining these filter papers from temporary preparations prepared by scraping the surface of a filter with a light microscope. The diatoms in the water samples were boiled for 10 to 15 min in a heat-resistant glass beaker by adding a mixture of HNO_3-H_2SO_4. After a few drops of material taken on a slide were evaporated from water on a heating plate, a permanent preparation was prepared and the identification was carried out [12].

The taxonomic identification of phytoplankters was done in reference to Hustedt [13,14], Desikachary [15], Prescott [16,17], Patrick and Reimer [18,19], Huber-Pestalozzi [20], Krammer and Lange-Bertalot [21] and John et al. [22]. All the recorded species were checked in algabase cite [23]. Water temperature, dissolved oxygen, pH, salinity and electrical conductivity were measured with the WTW Multi 340i/set multiparameter in the field. Nitrite (NO_2), nitrate (NO_3) and orthophosphate (PO_4) concentrations in the water were analyzed at the laboratory according to standard methods [24] and the chlorophyll-*a* concentrations were estimated according to Parsons and Strickland [25]. The classification of water quality of the lake was done according to water pollution control regulations of Turkey [26].

2.4. Statistical analysis

In this study, statistical applications were made for predicting the related acquaintances of the input parameters used for an adequate understanding of the subject. The investigated input parameters were the chlorophyll-*a*, DO, pH, temperature, nitrite, nitrate, orthophosphate, salinity and electrical conductivity.

The resolution of the multivariate analysis is to envisage the intra-regression potentials among the water quality parameters estimated along with the current research. Principle Component Analysis (PCA) is performed to transform a set of likely correlated variables with unlikely correlated variables. Principal components number is less/equal to the variables original number. Following Anderson [27] and Gabriel [28], PCA fundamental equations are:

First vector $w_{(1)}$ should be answered as follows:

$$w_{(1)} = \arg\max_{\|w\|=1}\left\{\sum_i (t_1)^2_{(i)}\right\} = \arg\max_{\|w\|=1}\left\{\sum_i (x_i.w)^2\right\} \quad (1)$$

The matrix form of the above equation gives the following:

$$w_{(1)} = \arg\max_{\|w\|=1}\left\{\| Xw \|^2\right\} = \arg\max_{\|w\|=1}\left\{w^T X^T Xw\right\} \quad (2)$$

$w_{(1)}$ should be answered as follows:

$$w_{(1)} = \arg\max\left\{\frac{w^T X^T Xw}{w^T w}\right\} \quad (3)$$

Originated $w_{(1)}$ suggests that the first component of a data vector $x_{(i)}$ can then be expressed as a score of $t1_{(i)} = x_{(i)} \cdot w_{(1)}$ in the transformed coordinates, or as the corresponding vector in the original variables, $(x_{(i)} \cdot w_{(1)})\, w_{(1)}$.

3. Results and discussion

3.1. Physicochemical parameters and chlorophyll-a concentrations

As a result of measurements, the minimum and maximum values of some physicochemical parameters and nutrients were as follows; water temperature (8.0°C–27.9°C), dissolved oxygen (2.01–8.42 mg L^{-1}), pH (7.32–8.85), salinity (0.1‰–0.7‰), electrical conductivity (623–1817 µS cm^{-1}), nitrite (0.014–2.790 mg L^{-1}), nitrate (0.010–4.134 mg L^{-1}) and orthophosphate (0.846–69.726 µg L^{-1}). Measured chlorophyll-*a* concentrations varied between 0.20 and 82.91 µg L^{-1} (Table 2). The average of dissolved oxygen concentrations was measured as 6.21 mg L^{-1} (in normal limits) and shows the class of II water quality according to water pollution control regulations of Turkey [26]. In terms of pH values, the water of the lake and its feeding streams has slightly alkaline characteristics and indicated I and II water quality classes. Electrical conductivity values were measured higher than the standard limits of the protocols assigned for the protection of surface water sources against pollution [29]. Because of the inflows were passed through many agricultural lands, the electrical conductivity and salinity values determined in the streams were higher than the lake. Also heavy precipitation has an important effect on this situation.

According to nitrite concentrations, the water is of class I water quality. Maximum concentrations of orthophosphate were measured in İzzettin Stream (St. 2), except February 2018. Because of station 2 is located in the residential area, the main source of phosphate load stems from the inputs of domestic waste and sewage. According to chlorophyll-*a* concentrations (0.202–82.919 µg L^{-1}) with an average of 9.50 µg L^{-1}, the lake has mesotrophic characteristics. Especially; measured high chlorophyll-*a* concentrations at Eskice (St. 3) and Tahtaköprü streams (St. 8), indicated that the lake is changing to eutrophic conditions. Although, there isn't any comprehensive study of the lake and its feeding streams, when compared the physicochemical variables and nutrients with earlier studies, values were found almost in similar levels [8,30]. According to some physical and chemical parameters Buyukcekmece Dam Lake was classified as III and IV water quality classes by Baykal et al. [31]. It was reported that in earlier studies, intensive agricultural activities around the lake is the main reason of high nitrogen and phosphorus concentrations at the lake [32,33].

3.2. Phytoplankton composition

A total of 63 taxa belonging to Bacillariophyta (22), Charophyta (6), Chlorophyta (14), Cryptophyta (2),

Table 2
Some measured physicochemical parameters, nutrients, and chlorophyll- *a* concentrations

Months	Stations	Temperature (°C)	pH	DO (mg L^{-1})	Salinity (‰)	Conductivity (µS cm^{-1})	Chl-*a* (µg L^{-1})	NO_2^--N (mg L^{-1})	NO_3^--N (mg L^{-1})	PO_4^{3-}–P (µg L^{-1})
May 2017	St. 1	22.8	8.37	5.22	0.1	780	2.190	0.101	2.089	13.330
	St. 2	21.5	8.43	6.69	0.4	1,191	3.261	0.014	0.083	36.422
	St. 3	20.8	7.55	2.01	0.1	701	1.523	0.015	0.033	9.434
	St. 4	21.2	8.06	4.08	0.3	1,008	1.380	0.634	2.945	23.253
	St. 5	23.3	8.25	4.67	0.4	1,193	0.214	1.716	1.465	18.987
	St. 6	24.2	8.15	4.53	0.5	1,340	1.511	0.050	4.134	18.059
	St. 7	21.8	8.47	4.90	0.1	646	6.712	0.036	1.260	1.737
	St. 8	23.8	8.85	7.00	0.2	883	22.122	0.030	0.776	10.640
	St. 9	21.6	8.47	4.75	0.1	634	3.653	0.051	2.906	1.366
August 2017	St. 1	27.0	7.53	3.40	0.2	875	39.175	0.278	0.387	5.539
	St. 2	26.4	7.32	6.43	0.5	1,464	6.390	0.028	0.037	69.726
	St. 3	27.4	7.86	6.26	0.1	650	82.919	0.020	0.010	1.069
	St. 4	27.2	7.90	5.45	0.1	623	36.890	0.030	0.010	1.403
	St. 5	27.6	8.06	6.10	0.1	648	5.629	0.030	0.254	1.282
	St. 6	25.6	7.53	4.41	0.6	1,636	1.119	2.790	0.670	27.093
	St. 7	26.6	7.90	5.89	0.5	1,374	0.976	0.410	3.295	1.523
	St. 8	27.9	8.09	5.56	0.1	659	40.210	0.023	0.248	2.933
	St. 9	27.5	8.16	6.16	0.1	655	6.807	0.030	0.393	0.846
November 2017	St. 1	10.3	7.90	7.35	0.3	987	0.678	0.341	0.603	10.046
	St. 2	10.5	7.59	5.77	0.6	1,576	0.417	0.288	0.903	24.570
	St. 3	10.2	8.24	7.80	0.1	761	1.190	0.064	0.779	4.575
	St. 4	10.9	8.11	6.81	0.3	996	1.833	0.320	1.384	5.743
	St. 5	11.4	8.02	7.33	0.3	981	1.369	0.035	0.111	1.496
	St. 6	13.4	7.94	6.78	0.6	1,601	0.202	1.224	1.299	24.524
	St. 7	12.3	8.27	7.47	0.5	1,396	1.142	0.934	1.548	10.084
	St. 8	11.6	8.17	6.72	0.3	1,105	56.501	0.188	2.589	24.459
	St. 9	11.3	8.19	7.35	0.1	682	3.451	0.037	0.267	1.4956
February 2018	St. 1	8.8	8.34	7.69	0.2	938	0.690	0.270	0.067	5.419
	St. 2	8.2	8.54	8.17	0.1	715	1.761	0.117	0.127	2.191
	St. 3	8.0	8.35	8.08	0.1	712	1.202	0.108	0.103	1.839
	St. 4	8.2	8.35	7.80	0.2	819	1.785	0.206	0.130	3.573
	St. 5	8.1	7.85	4.50	0.1	751	3.011	0.154	0.183	6.569
	St. 6	10.5	8.20	6.97	0.7	1,817	0.226	0.862	0.147	16.344
	St. 7	9.6	8.32	7.09	0.5	1,481	0.405	0.541	0.138	10.417
	St. 8	9.4	8.55	7.96	0.3	1,030	1.809	0.324	0.207	11.030
	St. 9	8.2	8.17	8.42	0.1	686	1.871	0.108	0.202	1.050

Cyanobacteria (8), Euglenozoa (8) Miozoa (2) and Ochrophyta (1) divisions were identified. The list of recorded taxa of phytoplankton was given in Table 3 and the distribution of phytoplankton groups was shown in Fig. 2. According to the species diversity, Bacillariophyta division the richest group and *Anabaena spiroides* of Cyanobacteria was recorded as a dominant species in terms of phytoplankton density.

Bacillariophyta was represented by 22 taxa 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. *Nitzschia acicularis* of pennate diatoms are habitants of shallow enriched waters and streams with sensitivity to nutrient deficiency [1,2]. Charophyta was represented by 6 taxa. *Cosmarium formosulum* and *Closterium acutum* of desmids were recorded frequently during the study. While *C. formosulum* is a habitant of mesotrophic epilimnia, *C. acutum* is found generally in eutrophic epilimnia of waters [1,2]. Chlorophyta was represented by 14 species. It was stated that *Scenedesmus dimorphus* and *S. quadricauda* of green algae are sensitive to low light and presents in shallow, highly enriched ponds, lakes and rivers [1,2]. Cryptophyta was represented by *Cryptomonas ovata* and *Plagioselmis nannoplanctonica. C. ovata* is presented in small enriched lakes [1,2]. These cryptomonads have been reported as the dominant species in Buyukcekmece Dam Lake by Aktan et al. [9]. In the presented study, *P. nannoplanctonica* was recorded rarely in low numbers. Cyanobacteria were represented by eight species. It is reported that *Anabaena spiroides, A. affinis, Merismopedia glauca*, *Microcystis aeruginosa* and *Oscillatoria tenuis* of blue-green algae are indicated eutrophic conditions [1,2]. Particularly, *A. spiroides* and *M. aeruginosa* show high organic matter level and agricultural enriched eutrophic and also hypereutrophic waters [1,2]. Additionally, toxin-producing Cyanobacteria like *M. aeruginosa*, pose a big threat both to the lake ecosystem and public health [1,2]. Also, they could be very dangerous for migratory birds [12]. Euglenozoa was represented by eight species. It was stated that species of *Euglena* genus are found commonly in shallow mesotrophic and polluted lakes [1,2]. *Euglena gracilis* was determined as a subdominant species in eutrophic featured Kuçukcekmece Lagoon [34]. Miozoa was represented by *Prorocentrum micans* and *Peridinium 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, these species are considered to be harmful algae because of they cause excessive blooms under appropriate conditions and cause red-tides [35]. These species are 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 [1,2].

If the stations were compared according to the number of species diversity, the richest have detected respectively as Eskice Stream (St. 3), Buyukcekmece Lake (St. 9), Karasu (St. 1), Beylikçayı (St. 5), Tahtaköprü (St. 8), İzzettin (St. 2), Ahlat (St. 4), Çekmece (St. 6) and Çakmaklı (St. 7) streams (Table 2). Bacillariophyta division was dominant in terms of species diversity and density in stations of 1, 4, 7 and 8. However Cyanobacteria division members have recorded as dominant in stations 2, 3, 5, 6 and 9. During the study period, *Nitzschia acicularis* of pennate diatoms has been determined as the dominant species in stations 1 and 7. *Cyclotella meneghiniana* of centric diatoms has found the dominant species in stations 4 and 8. While the cyanobacterium *Anabaena spiroides* has recorded the dominant species in stations 2 and 9; *Anabaena affinis* was the dominant in station 3. Also, *Oscillatoria tenuis* of blue-green algae has been found the dominant species in station 5 and *Aphanizomenon flosaquae* was the dominant species in station 6.

The functional groups represented by the phytoplankton in Buyukcekmece Dam were B, D, N, P, X1, Y, F, J, H1, Lo, M, MP, TB, W1 and W2 groups. In terms of phytoplankton functional groups Buyukcekmece Dam shows similarities to eutrophic characterized Yedikır Dam (B, C, D, N, NA, P, MP, TB, X1, Y, E, F, J, H1, Lo, LM, W1, W2), Kucukcekmece Lagoon (B, C, D, N, X1, Y, F, J, Lo, M, MP, W1, W2) and Elmalı Dam (B, D, N, P, X1, Y, F, J, H1, Lo, M, MP, TB, W1, W2) [34, 36, 37]. Also, it was recorded similar functional groups with mesotrophic characterized Sazlidere Dam Lake (B, D, N, P, T, S2, X1, Y, E, F, J, H1, Lo, LM, M, MP, R, W1, W2) [38].

3.3. Statistical analyzes

According to statistical analyzes, there was determined a strong positive correlation between salinity and electrical conductivity in all seasons. Seasonality variations were expected in the current research due to the alteration of microclimate temperatures and its effect of the photosynthetic activities [39,40]. In May 2017, there was positive correlations among temperature and electrical conductivity ($r = 0.502$); pH and chlorophyll-*a* ($r = 0.682$). Also there was a strong positive correlation between pH and dissolved oxygen concentration ($r = 0.914$). Additionally, there are positive relations between orthophosphate concentration, both salinity and electrical conductivity (Fig. 3). In August 2017, there was a strong negative correlation between temperature and both salinity and electrical conductivity. It was found positive correlations among nitrite concentrations and both electrical conductivity and salinity. The correlation between electric conductivity and the salinity was discussed in other scholarly work [41] and showed a robust correlation. Also, it was presented with a linear correlation between orthophosphate concentrations and pH in summer (Fig. 4). Positive relations between salinity and both nitrite ($r = 0.742$) and orthophosphate concentrations ($r = 0.720$) were found in November 2017. Also it was presented a positive correlation among chlorophyll-*a* and nitrate concentrations ($r = 0.746$) in autumn (Fig. 5). In February 2018, it was found highly strong positive correlations between salinity and both nitrite($r = 0.992$) and orthophosphate ($r = 0.910$) concentrations (Fig. 6). Statistically, water quality parameters responded differently to the microclimate conditions and showed a seasonality pattern that could be used for better understanding and also forecasting the intrarelationships among the investigated parameters [40].

Table 3
List of recorded taxa of phytoplankton species according to the sampling stations in Buyukcekmece Dam Lake (+ = present; – = not present)

Recorded taxa	Stations								
	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9
Division: Bacillariophyta									
Amphora ovalis (Kütz.) Kützing	+	+	+	+	+	+	+	+	+
Aulacoseira italica (Ehr.) Simonsen	+	+	+	–	–	+	–	–	–
Cocconeis placentula Ehrenberg	–	–	+	–	+	–	–	+	+
Bacillaria paradoxa J.F. Gmelin	+	–	–	–	–	–	–	–	–
Cyclotella atomus Hustedt	+	–	+	+	–	–	–	+	+
Cyclotella ocellata Pantocsek	+	–	+	+	+	–	–	+	+
Cyclotella meneghiniana Kützing	+	+	+	+	+	+	+	+	+
Cymbella affinis Kützing	–	–	+	–	+	–	–	+	–
Cymbella tumida (Brebisson) Van Heurck	+	–	+	–	–	–	–	–	–
Cymbella ventricosa (C.Agardh) C.Agardh	+	–	+	–	–	–	–	–	+
Diatoma vulgaris Bory	+	–	+	–	–	–	+	+	–
Fragilaria crotonensis Kitton	–	–	+	–	–	–	–	–	–
Melosira varians C.Agardh	–	–	+	+	–	–	–	–	+
Meridion circulare (Greville) C.Agardh	–	–	+	+	–	+	–	–	–
Navicula cryptocephala Kützing	+	+	+	–	+	+	+	+	+
Navicula cuspidata (Kütz.) Kützing	+	–	–	–	–	–	–	–	–
Navicula lanceolata Ehrenberg	–	–	–	–	+	–	+	–	–
Navicula radiosa Kützing	–	–	–	–	–	–	+	–	–
Nitzschia acicularis (Kütz.) W.Smith	+	+	+	+	+	+	+	+	+
Pleurosigma sp.	–	–	–	–	+	–	–	–	+
Ulnaria acus (Kütz.) Aboal	+	+	+	+	+	–	+	+	+
Ulnaria ulna (Nitzch) Compere	+	+	+	+	+	–	+	+	+
Division: Charophyta									
Cosmarium formosulum Hoff	+	+	+	+	+	+	+	+	+
Closterium acutum Brebisson	+	–	+	–	+	–	+	+	+
Closterium incurvum Brebisson	+	–	+	–	+	–	–	–	+
Staurastrum crenulatum (Nägeli)Delponte	–	–	+	–	–	–	–	–	–
Staurastrum brachiatum Ralfs ex Ralfs	–	–	+	–	–	+	–	–	–
Closterium strigosum Brebisson	+	–	–	–	+	–	–	–	+
Division: Chlorophyta									
Ankistrodesmus falcatus (Corda) Ralfs	+	–	+	–	+	–	–	+	+
Coelastrum microporum Nägeli	+	–	+	–	+	+	–	–	+
Kirchneriella sp.	–	–	–	–	+	–	–	+	–
Oocystis borgei J.W. Snow	–	+	–	–	–	–	–	–	–
Scenedesmus arcuatus (Lemm.) Lemmermann	–	–	–	–	+	–	–	–	–
Scenedesmus communis E. Hegewald	–	+	–	+	–	–	–	–	–
Scenedesmus dimorphus (Turpin) Kützing	+	–	+	–	–	–	–	+	–
Scenedesmus ecornis (Ehr.) Chodat	–	+	+	–	+	+	–	–	+
Scenedesmus quadricauda (Turpin) Brebisson	+	+	+	+	+	–	–	+	+
Scenedesmus sp.	–	+	+	+	+	+	–	+	+
Sphaerocystis sp.	+	–	+	–	+	+	–	+	+
Pandorina morum (O.F.Müller) Bory	+	+	–	+	–	+	–	–	+

(*Continued*)

Table 3 (*Continued*)

Recorded taxa	Stations								
	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	St. 8	St. 9
Pediastrum boryanum (Turpin) Meneghini	–	–	+	–	–	–	–	–	+
Pediastrum duplex Meyen	–	–	–	–	–	–	–	+	+
Division: Cryptophyta									
Cryptomonas ovata Ehrenberg	+	–	+	+	+	+	+	+	+
Plagioselmis nannoplanctonica (Skuja) G.Novarino, I.A.N.Lucas and Morrall	+	–	–	–	+	–	–	–	–
Division: Cyanobacteria									
Anabaena affinis Lemmermann	+	+	+	–	+	+	–	+	+
Anabaena spiroides Klebahn	–	+	–	–	–	–	–	–	
Aphanizmenon flosaquae Ralfs ex Bornet and Flahault	–	–	+	–	–	+	–	–	+
Chroococcus limneticus Lemmermann	–	+	–	–	–	+	+	+	+
Merismopedia glauca (Ehr.) Kützing	–	+	+	–	+	–	+	+	+
Microcystis aeruginosa (Kütz.) Kützing	+	–	–	–	–	–	–	+	–
Oscillatria princeps Vaucher ex Gomont	–	–	+	–	–	–	–	+	+
Oscillatora tenuis C.Agardh ex Gomont	–	+	+	–	+	+	–	+	+
Division: Euglenozoa									
Euglena acus (O.F.Müller) Ehrenberg	+	+	+	+	+	+	+	+	+
Euglena ehrenbergii G.A. Klebs	+	–	+	+	+	–	–	–	–
Euglena gracilis G.A. Klebs	+	+	+	+	+	+	+	+	+
Euglena viridis (O.F.Müller) Ehrenberg	+	+	+	+	+	–	+	+	+
Phacus orbicularis K.Hübner	–	+	+	–	+	–	–	+	+
Strombomonas sp.	+	–	+	–	+	–	–	+	+
Trachelomonas hispida (Perty) Stein	+	+	+	+	+	+	+	+	+
Trachelomonas volvocino (Ehr.) Ehrenberg	+	–	+	+	+	–	–	+	+
Division: Miozoa									
Peridium bipes Stein	+	–	+	+	+	–	–	+	+
Prorocentrum micans Ehrenberg	–	–	–	–	–	–	–	+	–
Division: Ochrophyta									
Dinobryon sertularia Ehrenberg	+	–	–	–	–	–	–	+	+
Total taxa number	37	24	45	22	37	21	18	37	41
Total division number	8	5	7	6	7	7	5	8	8

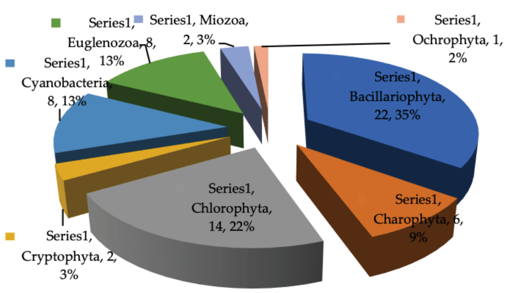

Fig. 2. Percentage distribution of phytoplanktın groups in Buyukcekmece Dam Lake.

4. Conclusion

Even though in general physicochemical parameters indicated that the lake has mesotrophic characteristics, high orthophosphate and chlorophyll-*a* concentration 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 condition, 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 is known that the pollution load carried by

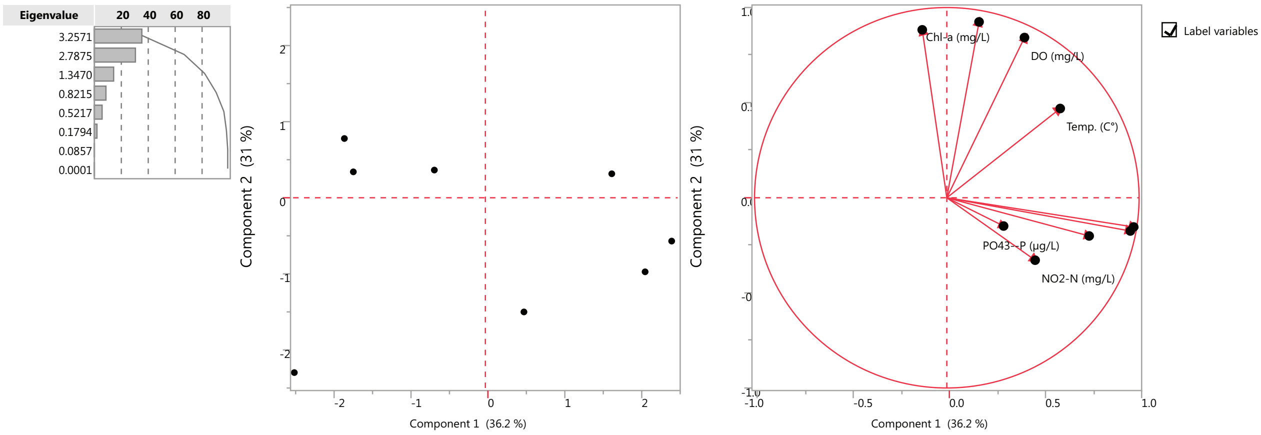

Fig. 3. Statistical relations between the variables in May 2017.

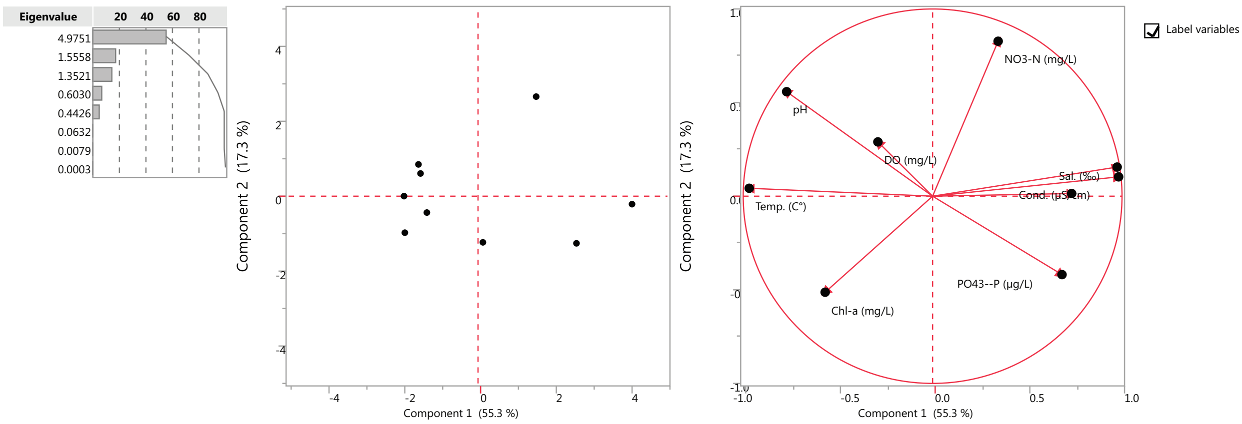

Fig. 4. Statistical relations between the variables in August 2017.

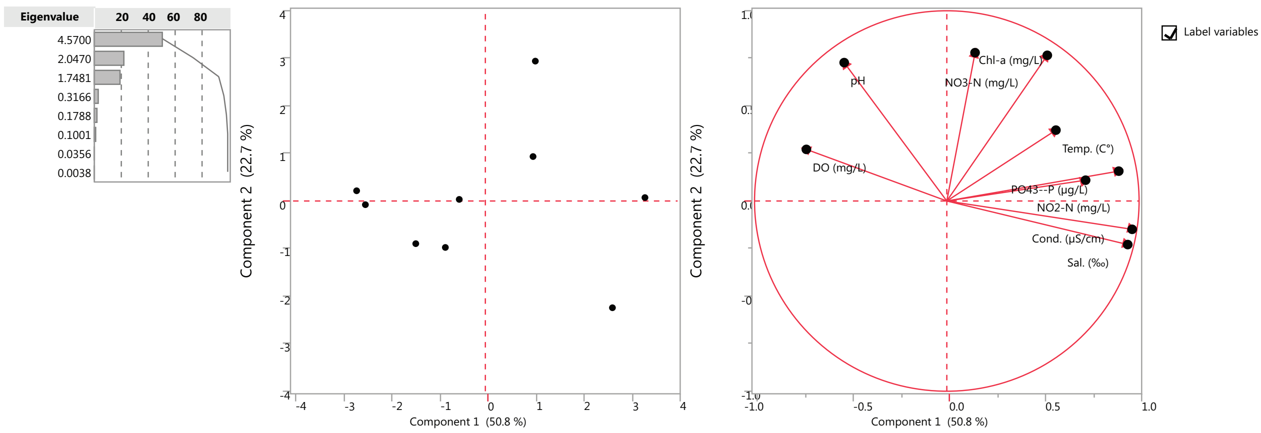

Fig. 5. Statistical relations between the variables in November 2017.

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, Karasu, Çekmece, Beylikçayı, İzzettin, Tahtaköprü, Ahlat, and Çakmaklı streams affected the lake negatively. For this reason, designation of the usage areas and amounts of this creek's water again has an important role in its trophic status. It is required that Buyukcekmece Dam Lake and its creeks should be taken under protection for improving its water quality by relevant authorities. It needs to carry out more detailed studies, both at the lake and

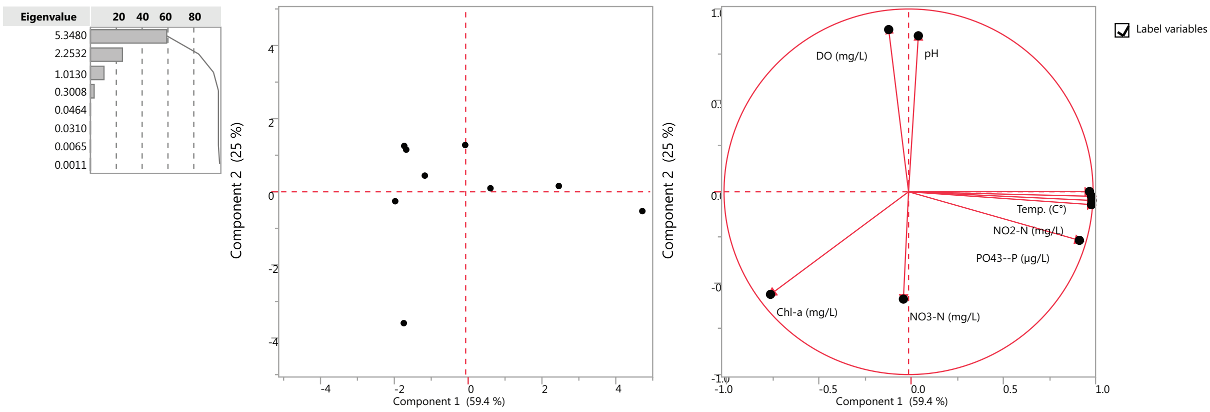

Fig. 6. Statistical relations between the variables in February 2018.

its influent streams, on physicochemical variables, nutrient concentrations and seasonal changes of phytoplankton for monitoring the lake's water quality.

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