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An investigation on phytoplankton composition and bacterial load relationship in a drinking water resource: Büyükçekmece Dam Lake (Istanbul, Türkiye)

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ABSTRACT

Bacterial and phytoplankton communities, which are important components of lakes, are affected by both abiotic and biotic factors, especially each other. The relationship between phytoplankton communities and the bacteriological load was investigated in Büyükçekmece Dam Lake and selected 8 influent streams. In accordance with this purpose, water samples were collected seasonally from 9 sampling stations. The phytoplankton composition of Büyükçekmece Dam Lake and its streams constitutes 63 taxa belonging to Bacillariophyta, Charophyta, Chlorophyta, Cryptophyta, Cyanobacteria, Euglenozoa, Miozoa and Ochrophyta divisions. Minimum and maximum load of total heterotrophic aerobic bacteria, total and fecal coliforms were determined as $1 \times 10^2 - 1{,}330 \times 10^2$, $1 \times 10^2 - 378 \times 10^2$ and $9 \times 10^2 - 551 \times 10^2$ CFU/mL, respectively. Especially Karasu and Çekmece streams' bacteriological load was found above the acceptable amounts in terms of bacteriologic pollution. The maximum nutrient concentrations were measured in parallel to the stations where the bacteriological load was detected at the highest density. The maximum bacteriological load was determined at Çekmece Stream (st.6) which is passing through the agricultural areas and has a low flow. Also, the water bloom-forming cyanobacterium *Aphanizomenon flos-aquae* Ralfs ex Bornet et Flahault was recorded as dominant. The lake basin, which shows mesotrophic characteristics according to physicochemical variables, has been defined as close to eutrophy since it has high nutrient salt and chlorophyll-*a* concentrations. Büyükçekmece Lake is the second largest drinking water source and the most affected reservoir by anthropogenic pollution in Istanbul. The water quality of the lake is affected negatively by the discharges from domestic, industrial wastewaters, and also inputs from agricultural areas. Continuing limnological studies on phytoplanktonic and bacteriologic organisms, which are accepted bioindicators in waters, have a vital role in monitoring and protecting the water of Büyükçekmece Dam Lake and its feeding streams.

Keywords: Phytoplankton; Bacteria; Water pollution; Büyükçekmece Dam Lake; Türkiye

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1. Introduction

Water, which constitutes approximately 70% of the human body, is the main element necessary for the realization of all metabolic activities [1,2]. Although three-fourths of the earth is made up of water, the amount of usable freshwater is only a very small fraction of 3% [3]. In recent years, climatic changes together with population growth, unplanned construction, and uncontrolled industrialization in the world have put great pressure on our water resources [4–6]. Drinking water pollution, which has become a global problem, poses a serious threat to human health [7]. Our access to clean and reliable water for the continuity of life on Earth depends on the conscious and planned use of our water resources. In today's scientific world, studies on water pollution have a great place in the main research areas and are supported, especially for the protection of our usable water resources. First of all, determining the flora and fauna of our freshwater resources forms the basis of these studies. Evaluation of physical and chemical water quality parameters and biological variables together is the most preferred method for determining the trophic status of aquatic systems.

Especially bacteria and phytoplanktonic organisms are among the most used bioindicators in waters [8–10]. Phytoplankton as one of the biological parameters is frequently used as functional groups in aquatic systems. Forming the first ring of the food chain and responding very fast to changes in water are the reasons for preferring this group as bioindicators in many studies [11–13]. Bacterial communities form an important part of the biochemical cycle along with biodiversity in aquatic ecosystems. Bacteria with short biological cycles and genetic changes are affected by environmental changes in waters [14]. Therefore, the presence of these microorganisms is used to evaluate and monitor water quality [8]. It is known that there is a close relationship between the phytoplankton community and the bacterial community in waters, directly or indirectly, including mutualism, commensalism, parasitism, amensalism, and competition. While phytoplanktonic organisms create habitats for bacteria with the special substances they secrete, bacteria have the ability to support the growth of phytoplankton through nutrient cycling. Competition between phytoplankton and bacterial communities leads to important biological interactions controlled by limiting nutrient salts [8,14,15].

Bacteria can reproduce more easily in freshwaters than in marine environments. For this reason, it requires more attention to maintain the sustainable productivity of freshwater ecosystems in terms of ecological and public health. The presence of bacteria with an optimum growth temperature of 37°C, which enters the environment as a result of human activities, indicates external contamination outside of the natural environment bacteria. The density of total coliforms (TC) and fecal coliforms (FC) are also used as indicators of fecal pollution in waters since they are always found in high amounts in the feces of humans and warm-blooded animals [9]. In order to determine the microbiological quality of water, the first of the hygienic controls is the examination of coliform microorganisms.

Büyükçekmece Dam Lake is the second largest drinking water source and the most affected reservoir by the anthropogenic pollution of Istanbul. Because the lake is used for providing irrigation water to cultivated areas, runoff from these areas is the additional source of an anthropogenic nutrient load of the lake. Also, Büyükçekmece Lake and its surroundings are used as a recreational area. Istanbul Metropolitan Municipality has planning works to allow new residential areas and industrial and commercial activities in the Büyükçekmece Lake Basin. In parallel with this planning, an increase in the pollution load of the dam is expected. Therefore, it has become compulsory to implement the plans for the protection of the lake basin [16]. When the literature is scanned, it is seen that the previous researches mostly cover only the lake. The research topics are mostly about fish species living in the lake, physicochemical properties of the lake, modeling studies that have become the trend of the age, and a small number of phytoplankton, zooplankton, and invertebrates. The study we presented is the only study in which phytoplankton was studied simultaneously with bacteria in Büyükçekmece Lake and its creeks. Since phytoplankton and bacteria are important groups of microorganisms affected by abiotic and biotic factors in lakes, it is important to reveal their interactions and relationships with each other.

The influent streams to the lakes bring an important pollution load [17–19]. For a better understanding of the pollution status of the study area, the most correct way is to take samples also from influent streams. Therefore, we selected our sampling stations from the center of the lake and also eight feeding streams which are Karasu, İzzettin, Eskice, Ahlat, Beylikçayı, Çekmece, Çakmaklı and Tahtaköprü. This study aimed to reveal the relationships and competition of phytoplankton and bacteria, which are the leading organism groups in aquatic systems, that are most affected by the pollution inputs and react quickly, and also create consideration for taking necessary precautions against the ecological problems that occur in Büyükçekmece Lake and its selected streams.

2. Material and methods

2.1. Information about the study area and sampling

Büyükçekmece Dam Lake is located in the south of the Thrace Peninsula, 50 km away from the city center of Istanbul and near the Sea of Marmara. It was built on Karasu River, which has an important amount of water flow, by the Water and Sewerage Administrative Center of Istanbul (ISKI) in 1985. Büyükçekmece Lake is fed by many large and small creeks. The dam has a lake surface area of 28.5 km^2, with a total drainage area of 620 km^2 and an average depth of 6 m. The lake, which has a volume of 160 million m^3, is very close to the industrial, agricultural, and residential areas, meeting approximately 17% of Istanbul's daily water needs [16].

This work was conducted at 9 sampling stations including the lake and 8 feeding streams Karasu, İzzettin, Eskice, Ahlat, Beylikçayı, Çekmece, Çakmaklı and Tahtaköprü between May 2017 and February 2018. The map of

Büyükçekmece Dam Lake and sampling points are given in Fig. 1.

2.2. Measurements of physico-chemical variables and chlorophyll-a concentration

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^{3-}) concentrations were analyzed in the laboratory according to standard methods [20]. The classification of the water quality of the lake was done according to water pollution control regulations of Turkey (2004). Chlorophyll-*a* concentrations were estimated according to Parsons and Strickland [21].

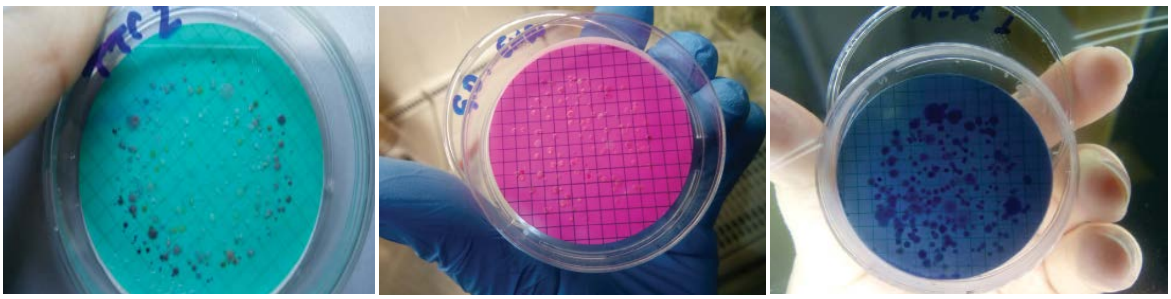
2.3. Identification and counting of phytoplankton and bacterial load estimation

Samples were collected by using Nansen bottles and fixed with Lugol's iodine solution for phytoplankton identification and counting. Phytoplankton counting was made with a Nikon TMS inverted microscope at a magnification of 400 according to Lund et al [22]. Taxonomic identification of phytoplankton was done in reference to the literature including several comprehensive reviews on the subject [23–32]. All of the identified species were checked from the Cite AlgaeBase according to Guiry and Guiry [33]. Water samples were collected in triplicates into sterile bottles by using the membrane filtration technique to determine the total heterotrophic aerobic bacteria (THAB), total (TC), and fecal coliform (FC). TTC medium was used to determine the total heterotrophic aerobic bacterial load, and M-Endo medium was used for total coliform and kept in an oven at 37°C. To calculate the fecal coliform load, m-FC medium was used and incubated in an oven at 42°C for 24–72 h (Fig. 2). After incubation, the diluted plates containing countable bacterial colonies were calculated and reported as colony-forming units (CFU/mL) [34].

2.4. Statistical analyses

A multivariate correlation was applied between chlorophyll-*a*, total coliforms (TC), fecal coliforms (FC), and total

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



(a) **(b)** **(c)**

Fig. 2. Diluted plates containing countable bacterial colonies for THAB (a), TC (b), and FC (c).

heterotrophic aerobic bacteria (THAB) [35]. The correlations are estimated by Row-wise method.

3. Results and discussion

The minimum and maximum values of physicochemical variables, nutrients, and chlorophyll-*a* concentrations in Büyükçekmece Dam Lake and its feeding streams were given in Table 1 [16]. As a result of the measurements made in the study area, while the Büyükçekmece Lake and streams show the class of II water quality in terms of dissolved oxygen, they have classes of I and II water quality features in terms of pH and temperature according to water pollution control regulations of Turkey [36]. The pH (7.32–8.85) indicated that the water of the lake has slightly alkaline characteristics. Measured electrical conductivity values (623–1,817 μS/cm) have been detected more than the standard limits (classes II and III) of the protocols assigned for the protection of surface water sources against pollution. The reason why the electrical conductivity and salinity values measured in streams are higher than in the lake is that the basin receives heavy rainfall and the streams pass near agricultural lands. In terms of measured nitrate (an average of 1.133 mg/L) and orthophosphate (an average of 11.391 μg/L) concentrations, the water indicates classes of I and II, while nitrite (an average of 0.344 mg L) concentrations show the first class. The average chlorophyll-*a* concentrations were measured as 9.50 μg/L. Especially at stations, 1 (39.18 μg/L), 3 (82.92 μg/L), 4 (36.89 μg/L), and 8 (56.50 μg/L) very high values indicating eutrophication were detected in the August samples.

Turkey's water pollution control regulation [36] was used to classify the lake and its streams according to water quality. According to these regulations, first-class water is defined as surface waters with high potable water potential, water that can be used for recreational purposes, water that can be used for trout and animal production, and farm needs. The second class of water defines the less polluted waters that have the potential to be drinking water, can be used for irrigation and recreation purposes and can be used for fish production other than trout. Class of III water, contaminated water means water and industrial water that can be used for aquaculture after appropriate treatment, excluding facilities requiring qualified water such as food and textiles.

Table 1
Minimum and maximum values of measured variables, nutrients and chlorophyll-*a* concentrations in Büyükçekmece Dam Lake and its feeding streams

Parameters	Minimum	Maximum
Temperature (°C)	8.0	27.9
Dissolved oxygen (mg/L)	2.01	8.42
pH	7.32	8.85
Salinity (‰)	0.1	0.7
Electrical conductivity (μS/cm)	623	1817
Nitrite (mg/L)	0.014	2.790
Nitrate (mg/L)	0.010	4.134
Orthophosphate (μg/L)	0.846	69.726
Chlorophyll-*a* (μg/L)	0.20	82.92

The phytoplankton community of Büyükçekmece Dam Lake and its influent streams constituted of 63 taxa belonging to 8 divisions: Bacillariophyta (22), Charophyta (6), Chlorophyta (14), Cryptophyta (2), Cyanobacteria (8), Euglenozoa (8) Miozoa (2) and Ochrophyta (1). The sampling stations are listed as follows, from the richest to the poorest in terms of species diversity: Eskice Stream (st.3), Büyükçekmece 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 [16].

All bacteria that use organic nutrients for growth are called total heterotrophic aerobic bacteria (THAB). They are found in all types of water, food, soil, vegetation, and air. This group of bacteria encompasses a broad range of bacteria that uses organic carbon sources to grow [37]. While total coliforms (TC) include bacteria found in the soil, in water that has been influenced by surface water, and in human or animal wastes, fecal coliforms (FC) are the group of the total coliforms that are considered to be present specifically in the gut and feces of warm-blooded animals [9]. Minimum and maximum load of total heterotrophic aerobic bacteria (THAB), total (TC) and fecal coliform (FC) were determined as 1×10^2 – $1{,}330 \times 10^2$, 1×10^2 – 378×10^2 and 9×10^2 – 551×10^2 CFU/mL respectively (Figs. 3–5). According to Environmental Protection Agency,

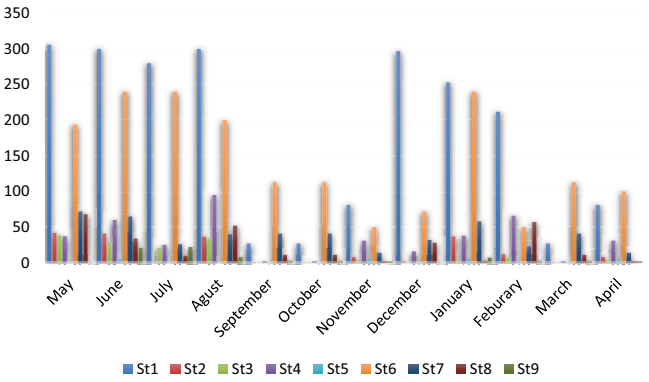


Fig. 3. Total coliform bacteria load (×10^2 CFU/mL) by sampling stations.

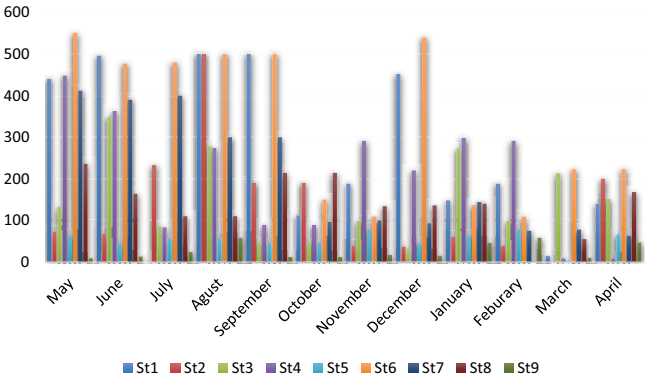


Fig. 4. Fecal coliform bacteria load (×10^2 CFU/mL) by sampling stations.

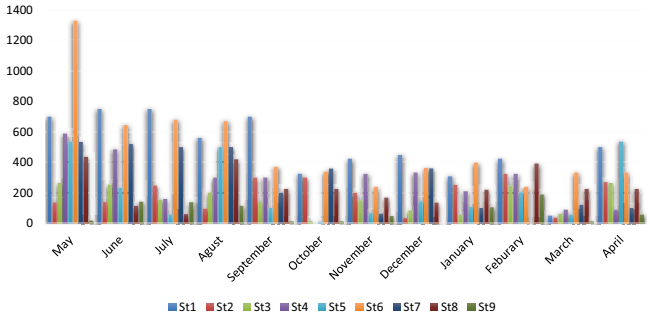


Fig. 5. Total heterotrophic aerobic bacterial load (×10^2 CFU/mL) by sampling stations.

the maximum contamination level for bacteria in drinking waters is established as 0 total coliform colonies/100 ml of water. In water sources used for irrigation, a maximum of ≤ 235 cfu *Escherichia coli* per 100 ml is acceptable. *E. coli* is the most well-known member of the fecal coliforms [38]. In terms of fecal coliforms load, Karasu (st.1), Çekmece (st.6), Ahlat (st.4), and Çakmaklı (st.7) streams were found to be above the acceptable level, respectively.

Phytoplanktonic and bacterial organisms used as bioindicators in waters, mainly show changes according to sampling points, flow rate, and nutrient salts concentrations. The maximum nutrient concentrations were measured in parallel to the stations where the bacteriological load was detected in the highest density. The maximum bacteriological load was determined at Çekmece Stream (st.6) which is passing through the agricultural areas and has a low flow. Also, the water bloom-forming cyanobacterium *Aphanizomenon flos-aquae* Ralfs ex Bornet et Flahault was recorded as dominant at this sampling point. While minimum bacteriological load was determined at station 9, which is located in the middle of the lake, *Anabaena spiroides* Klebahn of Cyanobacteria was the dominant species. In Lake Erhai, China abiotic factors have been reported to have a greater effect on bacterial community density than phytoplankton. Phytoplankton only played an important role in certain periods, similarly only when genera of *Microcystis* and *Psephonema* were dominant during algal blooms [14]. Also, station 9 ranks second among the stations with the highest phytoplankton density. This can be explained by the fact that closely related phytoplankton species can produce similar metabolic products and support similar bacterial communities. In many studies, it has been reported that there is a relationship between certain toxin cyanobacteria species and bacterial community structure [15].

The total coliform load is very high in stations 1 (Karasu Stream) and 6 (Çekmece Stream). Although human-induced fecal coliform is intense at most stations, except for stations 5 (Beylikçayı Stream) and 9 (middle of the lake), it draws attention throughout the year when it is highest at stations 1 (Karasu Stream) and 6 (Çekmece Stream). Periodically, it is high at the 2nd station. The maximum nutrient concentrations were measured in parallel to the stations where the bacteriological load had the highest density. The Çekmece Stream (st.6) where intensive agricultural activities are carried out, was also the station where the maximum bacterial load was recorded. In San Pedro Lake, Mexico, the density of bacteria was found to be high where settlements are located close to the San Pedro river mouth and in areas where livestock is constantly made [9].

Chlorophyll-*a* concentration is a useful expression of phytoplankton biomass in waters [39]. It is also widely used to assess the state of aquatic ecosystems and possible human impacts [40]. When chlorophyll-*a* concentrations were measured at a minimum at Çekmece Stream (st.6), the bacteriological load was counted in the highest numbers. The load amount of heterotrophic aerobic bacteria increases when the phytoplankton diversity shows decreases. Since phytoplankton and bacteria both use the nutrient salts in the aquatic environment, they have an antagonistic effect on each other. According to the multivariate correlation analysis applied, no significant relationship was found between chlorophyll-*a*, TC, FC, and THAB. It was concluded that chlorophyll-*a*, which shows the phytoplankton biomass, does not affect bacterial load in our study (Fig. 6).

3.1. Dynamics of phytoplankton and bacterial load at sampling stations

Recorded dominant/subdominant and important species of phytoplankton and bacteriologic load according to the sampling stations are given in Table 2. Karasu Stream (St.1), located in the coordinates of 41°08′28.2″ N and 28°29′06.8″ E, the main water source, has many agricultural activities around. Phytoplankton composition constituted of 23 taxa belonging to 7 divisions. *Nitzschia acicularis* Kützing W.Smith of pennate diatoms was recorded as the dominant species. This species is densely found in shallow, nutrient-rich waters and streams [41].

Chlorophyll-*a* concentration, which is accepted as an indicator of algal biomass [40], was very high (39.18 μg/L) only in August at the 1st station, and it was very low in other months. Karasu Stream is one of the important stations where the maximum bacteriological load (THAB: 424 – 780 × 10^2 CFU/mL, TC: 81 – 306 × 10^2 CFU/mL, FC: 188 – 500 × 10^2 CFU/mL) is detected in the research area. Also, in a study carried out by Aykut et al. [42] on the epiphytic diatoms of Büyükçekmece Reservoir, eutrophic conditions were reported close to Karasu Stream.

İzzettin Stream (St.2), with coordinates 41°08′46.1″N and 28°31′13.5″E, is the second important feeding stream of the lake. Phytoplankton composition constituted of 12 taxa belonging to 5 divisions. *Anabaena spiroides* of Cyanobacteria was recorded the dominant species. *A. spiroides* is an inhabitant of the eutrophic, stratified as well as shallow lakes with low nitrogen content. It is also found dominant in Lake Terkos, a drinking water resource in Istanbul [12]. This station, where chlorophyll-*a* and therefore algae biomass was low during the research, is among the stations with high bacteriological load (THAB: 137 – 324 × 10^2 CFU/mL, TC: 1 – 42 × 10^2 CFU/mL, FC: 33 – 73 × 10^2 CFU/mL).

Eskice Stream (St.3), is a shallow creek with low water flow located at 41°09′04.1″ N and 28°31′22.3″ E. Phytoplankton composition constituted of 38 taxa belonging to 7 divisions. *Anabaena affinis*, dominant species and *Merismopedia glauca* (Ehrenberg) Kützing was

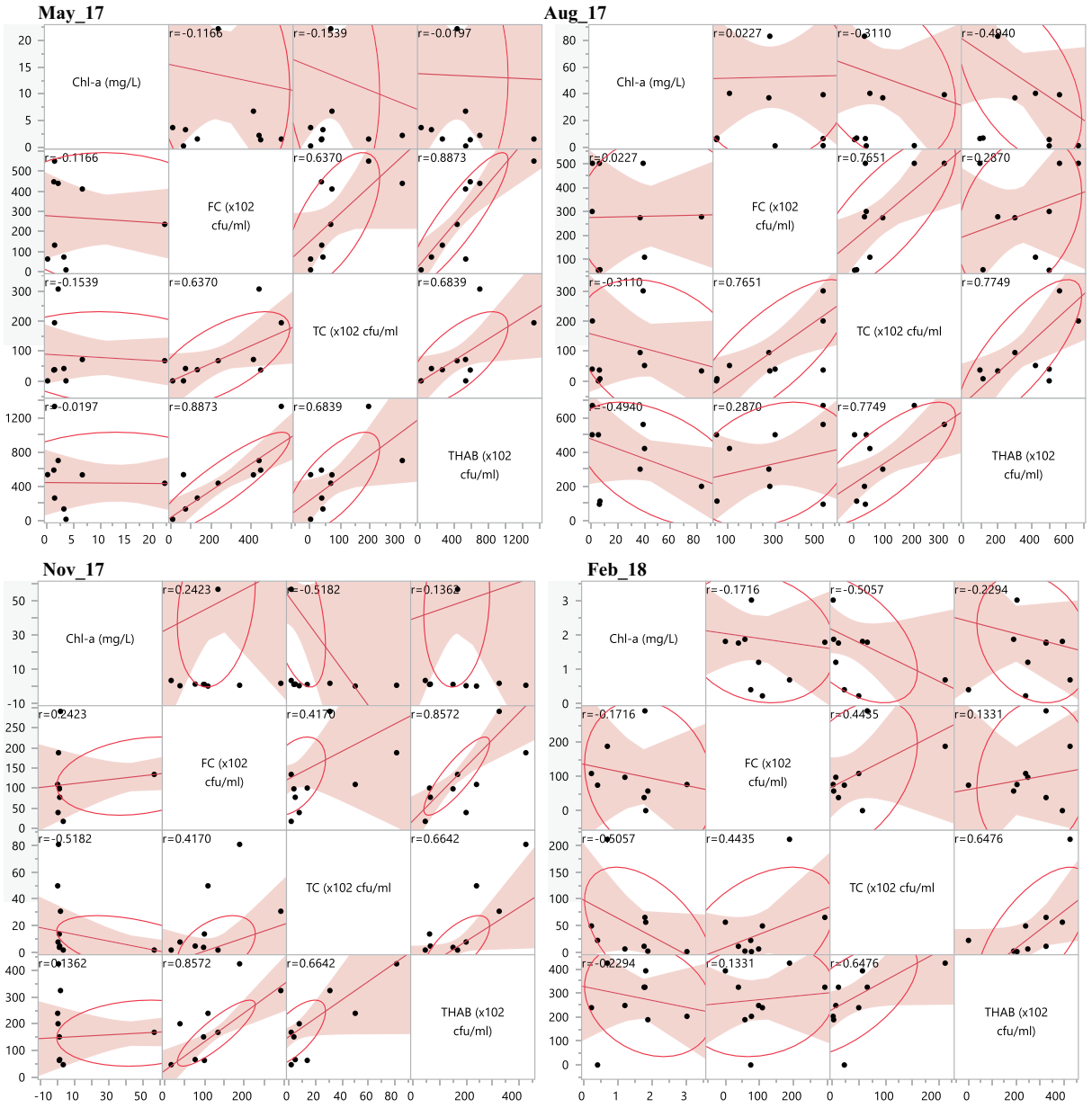


Fig. 6. Multivariate correlation analyses between chlorophyll-*a* (Chl-a) (mg/L), total coliforms (TC) (×10² CFU/mL), fecal coliforms (FC) (×10² CFU/mL), and total heterotrophic aerobic bacteria (THAB) (×10² CFU/mL).

subdominant species. *M. glauca*, is characteristic of summer epilimnia in mesotrophic lakes [43]. Members of Cyanobacteria found at this station were quite important. It was observed that the bacteriological load did not reach very high values (THAB: 151 – 264 × 10² CFU/mL, TC: 4 – 38 × 10² CFU/mL, FC: 84 – 132 × 10² CFU/mL) at this station, where the highest chlorophyll-*a* was measured as 82.92 μg/L in August throughout the study.

Ahlat Stream (St.4), one of the shallow creeks with low water flow to the lake, is located at 41°06′37.5″ N and 28°32′08.6″ E. Phytoplankton composition constituted of 17 taxa belonging to 6 divisions was recorded the dominant species. It has been observed that a significant part of the phytoplankton community was composed of *Cyclotella meneghiniana* Kützing and *Nitzschia acicularis* from diatoms, *Cryptomonas ovata* Ehrenberg from crytophyts, and *Euglena acus* (O.F. Müller) Ehrenberg and *Euglena viridis* (O.F. Müller) Ehrenberg from euglenophyts. In August, algal biomass was high and chlorophyll-*a* increased up to 36.89 μg/L. The intense detection of euglenophytes in this station indicates organic pollution in Ahlat Creek.

Beylikçayı Stream (St.5), the effective water source is located at 41°06′15.9″ N and 28°33′33.1″ E in the north-east of the lake. Phytoplankton composition constituted of 33 taxa belonging to 7 divisions. *Oscillatoria tenuis* C. Agardh ex Gomont, the dominant species, and *Sphaerocystis* sp. subdominant. Station 5 has the minimum total coliform load during the study. The fact that both the bacteriological pollution

Table 2
Recorded dominant/subdominant and important species of phytoplankton (D: Dominant, SD: Subdominant, I: Important species) and bacteriologic load (THAB: Total heterotrophic aerobic bacteria, TC: Total coliform, FC: Fecal coliform)

Sampling stations	Phytoplankton (D: Dominant, SD: Subdominant, I: Important)			Bacteriological load ($\times 10^2$ CFU/mL)		
	Division/Taxa numbers	Species	Chl-a (μg/L) min. – max.	THAB min. – max.	TC min. – max.	FC min. – max.
St.1 Karasu Stream	7/23	*Nitzschia acicularis* D	0.68–39.18	424–780	81–306	188–500
St.2 İzzetin Stream	5/12	*Anabaena spiroides* D	0.42–6.39	137–324	1–42	33–73
St.3 Eskice Stream	7/38	*Anabaena affinis* D *Merismopedia glauca* SD	1.19–82.92	151–264	4–38	84–132
St.4 Ahlat Stream	6/17	*Cyclotella meneghiniana* I *Nitzschia acicularis* I *Cryptomonas ovata* I *Euglena acus* I *Euglena viridis* I	1.38–36.89	159–589	25–378	83–448
St.5 Beylikçayı Stream	7/33	*Oscillatoria tenuis* D *Sphaerocystis* sp. SD	0.21–5.63	58–536	1–5	56–77
St.6 Çekmece Stream	5/15	*Aphanizomenon flos-aquae* D *Aulacoseira italica* SD	0.20–1.51	239–1,330	50–240	109–551
St.7 Çakmaklı Stream	5/14	*Nitzschia acicularis* D *Merismopedia glauca* SD	0.41–6.71	1–534	14–72	75–412
St.8 Tahtaköprü Stream	7/33	*Cyclotella meneghiniana* I *Scenedesmus quadricauda* I *Cryptomonas ovata* I *Euglena viridis* I	1.81–56.50	110–436	2–68	18–236
St.9 Büyükçekmece Dam	7/26	*Anabaena spiroides* D *Aphanizomenon flos-aquae* SD *Oscillatoria tenuis* SD	1.87–6.81	17–189	1–22	9–58

load and the phytoplankton biomass are low in this station is due to the low amount of nutrient salt in the environment.

Çekmece Stream (St.6), a very small creek is situated around the agricultural areas at 41°03′31.4″ N and 28°34′52.7″ E. Phytoplankton composition constituted of 15 taxa belonging to 5 divisions. The cyanobacterium *Aphanizomenon flos-aquae* was the dominant species and the diatom *Aulacoseira italica* (Ehrenberg) Simonsen was the subdominant species. In this station, where the highest bacteriological pollution load was detected, chlorophyll-*a* was found to be quite low. Water rich in nutrient salts from agricultural lands allowed bacteria to grow well.

Çakmaklı Stream (St.7), located at 41°04′28.1″ N and 28°32′49.2″ E is a shallow creek having low water flow. Phytoplankton composition constituted of 14 taxa belonging to 5 divisions. *Nitzschia acicularis* of pennate diatoms was the dominant species and *Merismopedia glauca* subdominant. Due to its poor nutrient salt concentrations, both groups of organisms could not develop well in the Çakmaklı Stream.

Tahtaköprü Stream (St.8) is located in the western part of the lake at 41°02′59.1″ N and 28°33′00.2″ E. Phytoplankton composition constituted of 33 taxa belonging to 7 divisions. *Cyclotella meneghiniana*, *Scenedesmus quadricauda* Chodat, *Cryptomonas ovata*, and *Euglena viridis* were detected as important species. Especially the species showing organic pollution were found intensively [41,43]. In August, chlorophyll-*a* was detected at a very high concentration of 56.50 μg/L, and accordingly, it was observed that bacteria could not reach very high numbers.

Büyükçekmece Lake (St.9) is located at 41°04′28.1″N 28°32′49.2″E in the center of the lake. Phytoplankton composition constituted of 26 taxa belonging to 7 divisions. While the cyanobacterium *Anabaena spiroides* was the dominant species also the cyanabacteria *Aphanizomenon flos-aquae* and *Oscillatoria tenuis* were subdominant species. Since these species have the ability to secrete toxins, the control of their sudden and excessive increases is of a great importance in order to prevent undesirable situations that may occur in the future. Station 9 has the minimum fecal coliform load during the study period. It was observed that the low nutrient concentrations in the samples taken from the lake did not allow both groups of organisms to develop well. It is thought that macrophytes, which are aquatic plants in the lake, are also effective in the current situation.

4. Conclusion

In our research, the most polluted stations in terms of bacteriology are Karasu and Çekmece streams; Büyükçekmece Dam and Beylikçayı Stream have the lowest pollution load. In the formation of algal blooms, not only the nutrient salts

in the environment but also other microbial community components play an active role. In stations where a high bacteriological pollution load is detected, the dominance of phytoplankton species belonging to the cyanobacteria group is striking. As it is known, both groups of organisms use the nutrient salts in the environment to develop, which explains the decrease detected in the phytoplankton biomass during the periods when bacteria are well developed. The stations with the highest algal biomass were Eskice, Tahtaköprü, Karasu, and Ahlat streams. Karasu Stream, in addition to being the mainstream feeding the Büyükçekmece Dam Lake, has also been determined as the most important station in terms of high phytoplankton biomass and bacteriological pollution load. Consequently, due to Büyükçekmece Dam being the second largest drinking water source of Istanbul Metropolitan, continuing limnological studies on monitoring and protection of the water of the lake and its feeding streams have great importance. In the pollution studies conducted in aquatic systems, it was concluded that the simultaneous study of phytoplankton and bacteria, which are competitive with each other, will provide much more efficient results.

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Declaration of conflicting interests

The authors declare that they have no conflict of interest.

Informed consent

This manuscript did not involve human or animal participants; therefore informed consent was not collected.

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