Relationship Between Phytoplankton Composition and Bacterial Load Dynamics in Buyukcekmece Dam Lake (Istanbul, Turkey), a Drinking Water Resource

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Introduction

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

- Because of 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.

- Also, Buyukcekmece Lake and its surroundings are used as a recreational area.

- Phytoplankton as one of the biological parameters are frequently used as functional groups in aquatic systems.

- 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.

- 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 an external contamination outside of the natural environment bacteria.

- In order to determine the microbiological quality of water, the first of the hygienic controls is the examination of coliform microorganisms.

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

- In parallel with this planning, an increase is expected in the pollution load of the dam. Therefore, it has become compulsory to implement the plans for the protection of the lake basin.

- It is known that poured streams to the lakes constitute a serious pollution load.

- Therefore, studies examining the physicochemical parameters with phytoplankton and bacterial density, which are accepted as biological indicators in waters, should be carried out not only in the lake but also in feeding streams of the lake.

Objectives

The aim of this study is to determine the relationship between phytoplankton communities and bacteriological load of Buyukcekmece Dam Lake and its selected 8 influent streams (Karasu, İzzettin, Eskice, Ahlat, Beylikçayı, Çekmece, Çakmaklı and Tahtaköprü) and create consideration for taking necessary precautions against the ecological problems.

Material and Methods

Study Area

- Buyukcekmece Dam Lake is located in the south of the Thrace Peninsula, 50 km away from the city center of Istanbul and near to Sea of Marmara.
- Buyukcekmece Dam with a total drainage area of 620 km^2, has a lake surface area of 28.5 km^2.
- It was built on Karasu River, which has an important amount of water flow, by Water and Sewerage Administrative Center of Istanbul in 1985.

Study Area

- The lake, which has a volume of 160 million m^3 is fed by many large and small streams.
- The lake is the most suffering reservoir in Istanbul, affected by anthropogenic pollution, due to it is exposed to the effects of the use of pesticides and artificial fertilizers originating from agricultural activities. Also it is close to the industrial and residential areas.
- This shallow dam lake has an average depth of 6 m. Maximum depth of the lake is 8.6 m and it meets approximately 17% of Istanbul' s daily water needs.

Sampling and Analyses

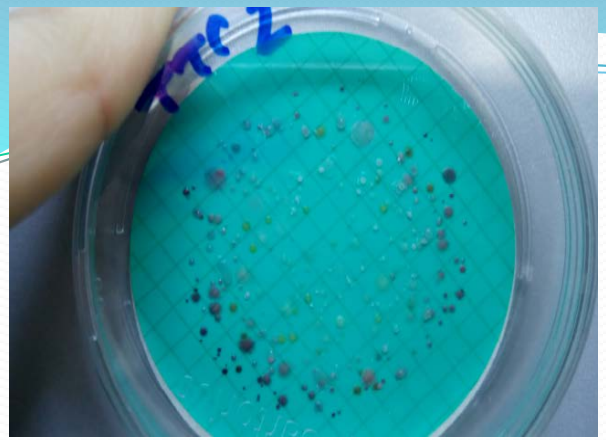
- Sampling was carried out between May 2017 and February 2018 from 9 sampling stations (Fig. 1 and Tab. 1).

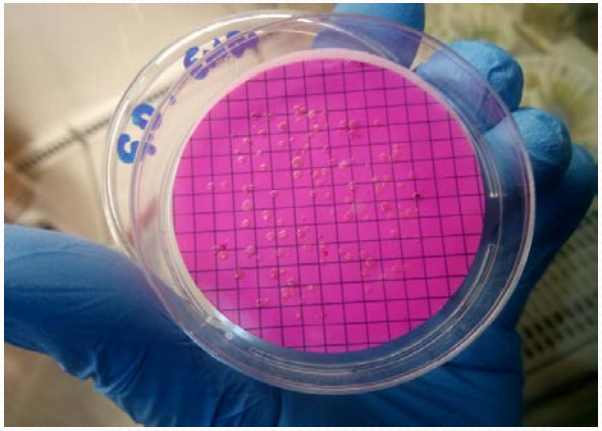
Figure 1. Map of Buyukcekmece Dam Lake

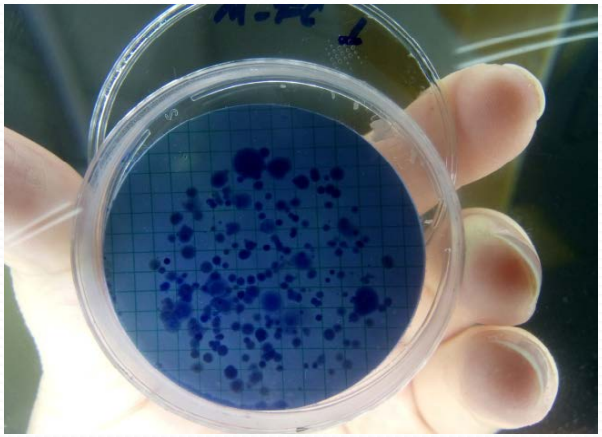
Table 1. Coordinates and characteristics of sampling stations.

Stations	Coordinates	Characteristics
1. Karasu Stream	41°08'28.2"N 28°29'06.8"E	Main water source has agricultural activities.
2. İzzettin Stream	41°08'46.1"N 28°31'13.5"E	Second important feeding stream.
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	Effective water source located in the north-east.
6. Çekmece Stream	41°03'31.4"N 28°34'52.7"E	Very small creek situated around agricultural areas.
7. Çakmaklı Stream	41°04'28.1"N 28°32'49.2"E	Shallow creek with low water flow.
8. Tahtaköprü Stream	41°02'59.1"N 28°33'00.2"E	Located in the west of the lake.
9. Buyukcekmece Dam	41°04'28.1"N 28°32'49.2"E	Selected from the center of the lake.

- 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* (1958).
- Taxonomic identification of phytoplankton was done in reference to the literature including several comprehensive reviews on the subject.







- Water samples were collected in triplicates into sterile bottles by using membrane filtration technique to determinate the total heterotrophic aerobic bacteria, coliform and fecal coliform (Goldreich *et al*, 1955).

- After incubation, the diluted plates containing countable bacterial colonies were calculated and reported as colony forming units (CFU/ml).

- 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 were analyzed at the laboratory according to standard methods (Greenberg, 1985).
- Chlorophyll-*a* concentrations were estimated according to Parsons and Strickland (1958).
- The classification of water quality of the lake was done according to water pollution control regulations of Turkey (2004).

Results and Discussion

Physicochemical Parameters, Nutrients and Chlorophyll-a Concentrations

Table 2. Minimum and maximum values of some physicochemical parameters, nutrients and chlorophyll-*a* in Buyukcekmece Dam and its influent creeks.

Parameters	Minimum	Maximum
Temperature	8.0°C	27.9°C
Dissolved Oxygen	2.01 mg L^{-1}	8.42 mg L^{-1}
pH	7.32	8.85
Salinity	0.1 ‰	0.7 ‰
Electrical Conductivity	623 µS cm^{-1}	1817 µS cm^{-1}
Nitrite (NO_2)	0.014 mg L^{-1}	2.790 mg L^{-1}
Nitrate (NO_3)	0.010 mg L^{-1}	4.134 mg L^{-1}
Orthophosphate (PO_4)	0.846 µg L^{-1}	69.726 µg L^{-1}
Chlorophyll-*a*	0.20 µg L^{-1}	82.91 µg L^{-1}

- 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 (2004).

- 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.

- 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.

Phytoplankton and Bacteriological Load

- Phytoplankton community of Buyukcekmece 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) (Yilmaz, 2019).

- 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.

- Minimum and maximum load of total heterotrophic aerobic bacteria, total and fecal coliform were determined as $1x10^2$-$1330x10^2$, $1x10^2$- $378x10^2$ and $9x10^2$- $551x10^2$ cfu/ml respectively (Figures 2-4).

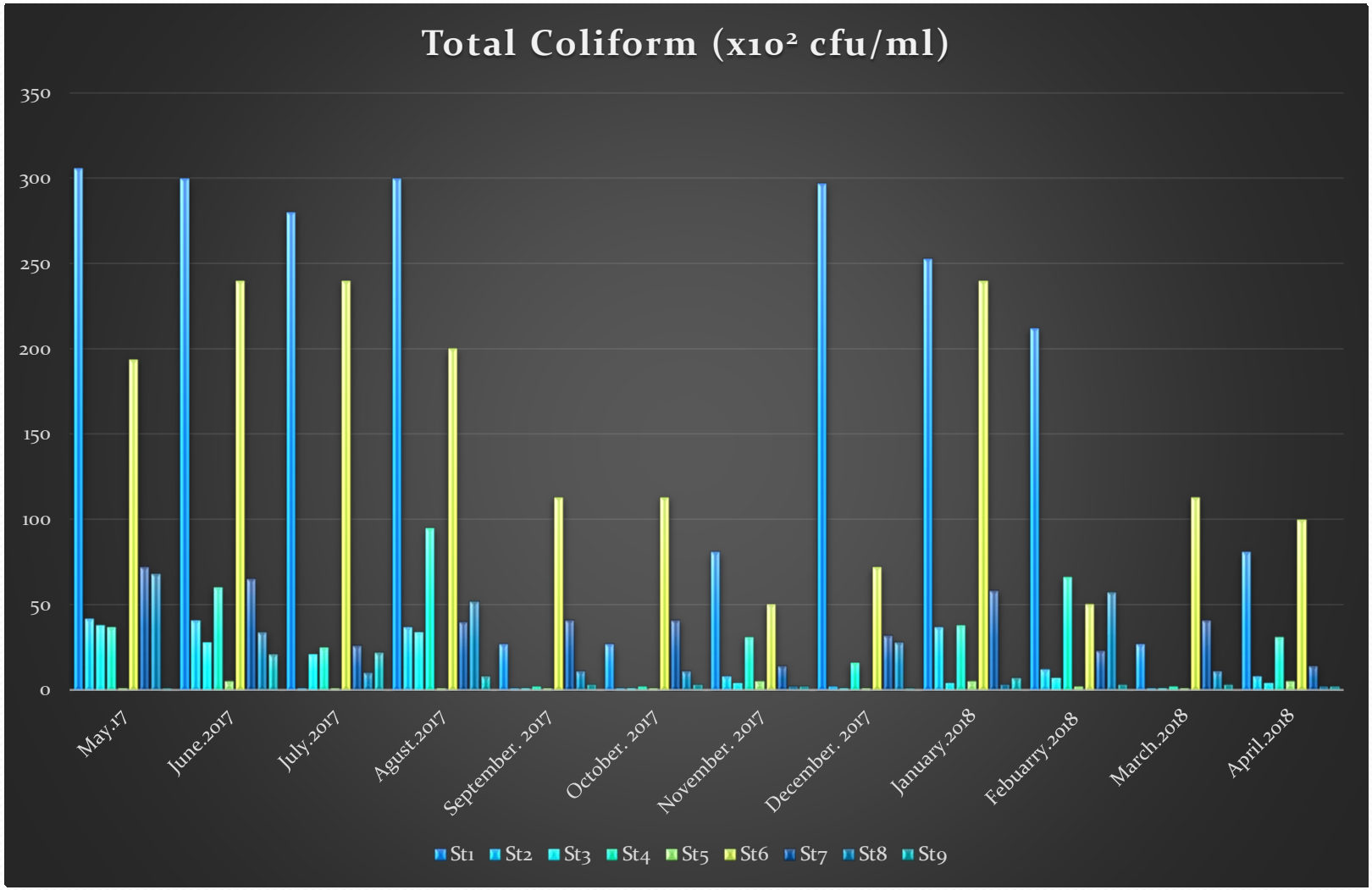


Figure 2. Total coliform bacteria load according sampling stations.

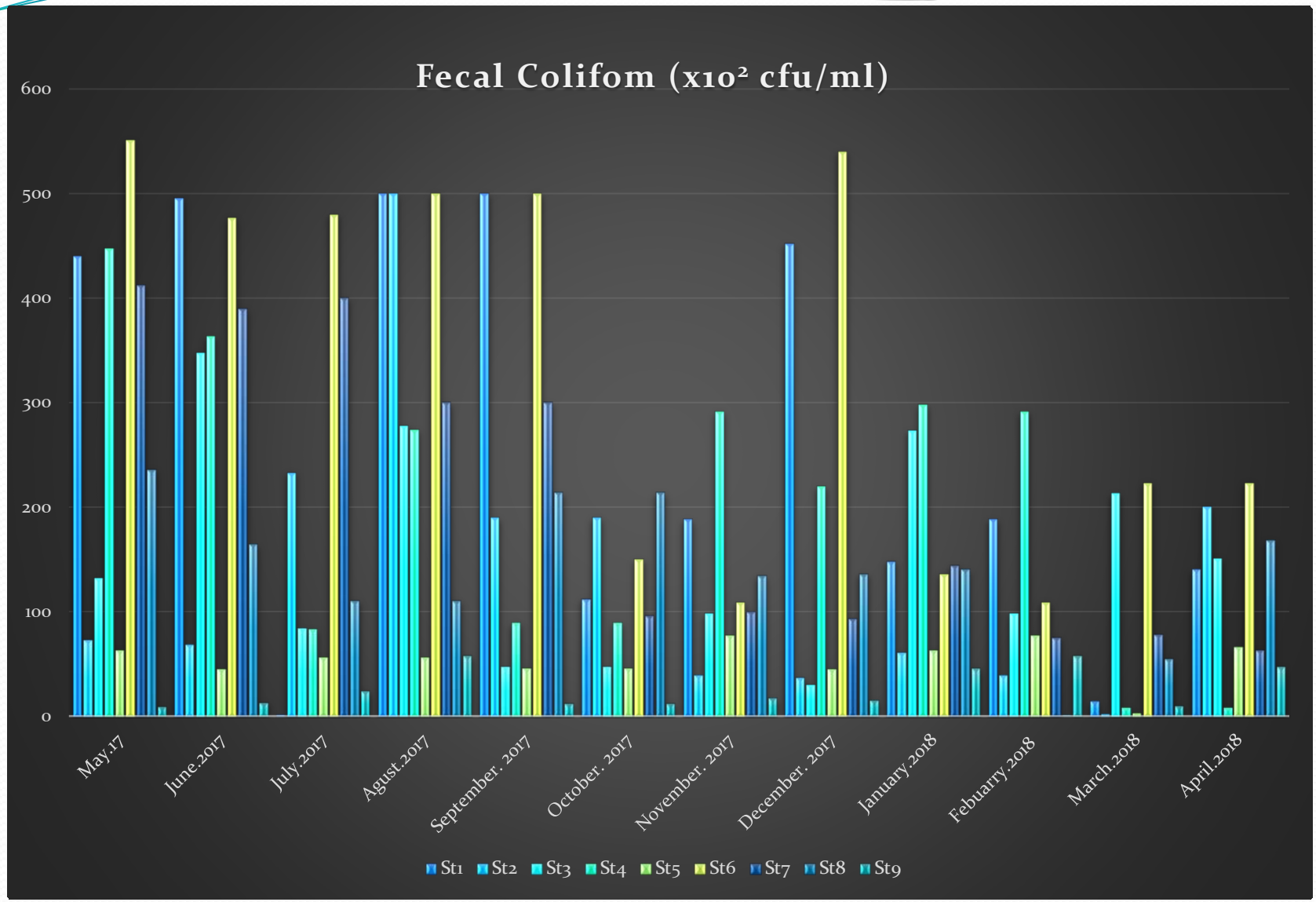


Figure 3. Fecal coliform bacteria load according sampling stations.

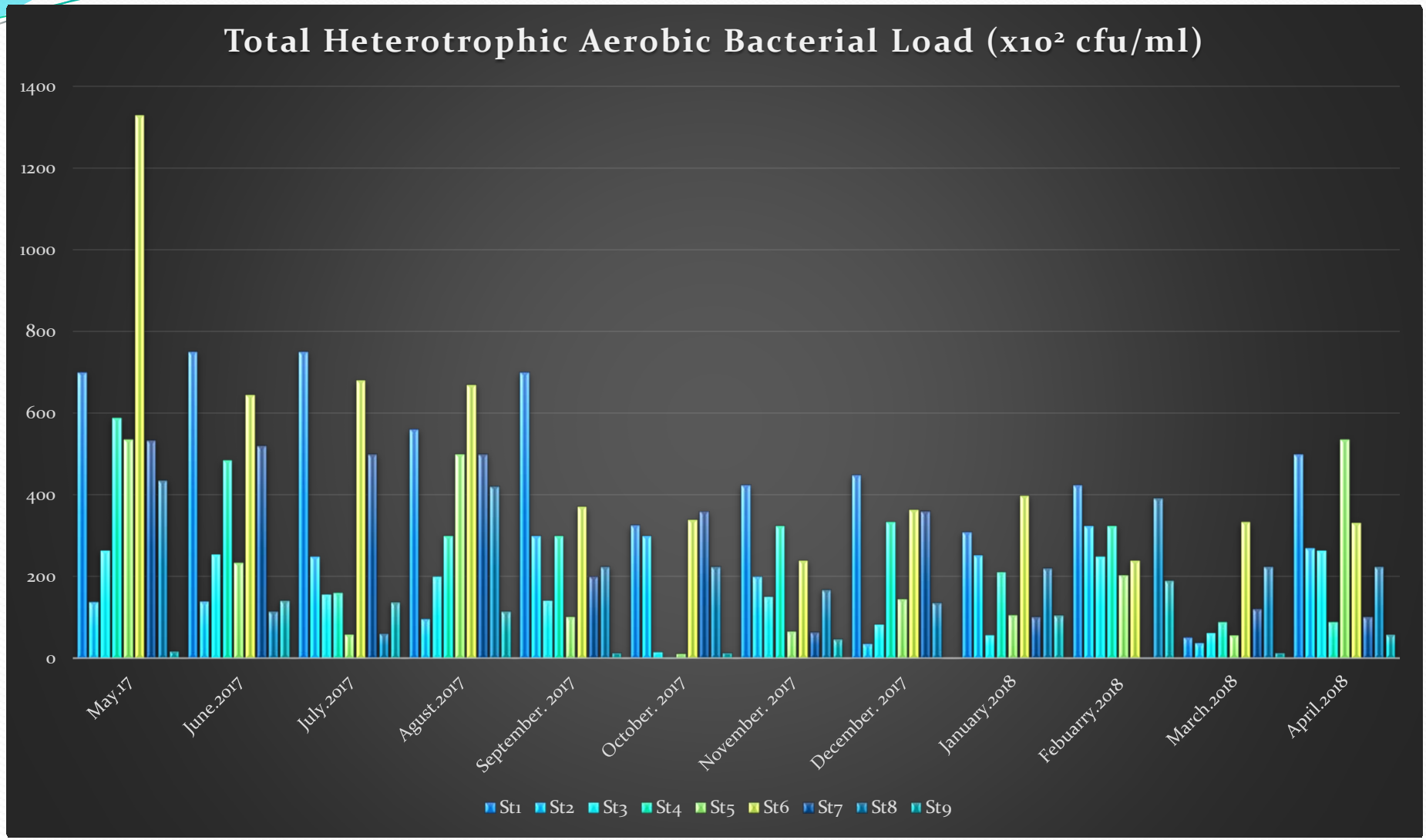


Figure 4. Total heteretrophic aerobic bacterial load according sampling stations.

Table 3. 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).

N. acicularis

A. spiroides

SAMPLING STATIONS	PHYTOPLANKTON		BACTERIOLOGICAL LOAD ($x10^2$cfu/ml)		
	Divisio / Taxa Numbers	Species	THAB Min.-Max.	TC Min.-Max.	FC Min.-Max.
1. Karasu Stream	7 / 23	*Nitzschia acicularis* (D)	424 - 780	81 - 306	188 - 500
2. İzzettin Stream	5 / 12	*Anabaena spiroides* (D)	137 - 324	1 - 42	33 - 73
3. Eskice Stream	7 / 38	*Anabaena affinis* (D) *Merismopedia glauca* (SD)	151 - 264	4 -38	84 - 132
4. Ahlat Stream	6 / 17	*Cyclotella meneghiniana* (I) *Nitzschia acicularis* (I) *Crytomonas ovata* (I) *Euglena acus* (I) *Euglena viridis* (I)	159 - 589	25 - 378	83 - 448
5. Beylikçayı Stream	7 / 33	*Oscillatoria tenuis* (D) *Sphaerocystis* sp. (SD)	58 - 536	1 - 5	56 - 77
6. Çekmece Stream	5 / 15	*Aphanizomenon flosaquae* (D) *Aulocoseira italica* (SD)	239 - 1330	50 - 240	109 - 551
7. Çakmaklı Stream	5 / 14	*Nitzschia acicularis* (D) *Merismopedia glauca* (SD)	1 - 534	14 - 72	75 - 412
8. Tahtaköprü Stream	7 / 33	*Cyclotella meneghiniana* (I) *Scenedesmus quadricauda* (I) *Cryptomonas ovata* (I) *Euglena viridis* (I)	110 - 436	2 - 68	18 - 236
9. Buyukcekmece Dam	7 / 26	*Anabaena spiroides* (D) *Aphanizomenon flosaquae* (SD) *Oscillatoria tenuis* (SD)	17 - 189	1 - 22	9 - 58

A. flosaquae

E. viridis

E. acus

- Phytoplanktonic and bacterial organisms used as bioindicators in waters and they 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 detected in highest density.

- 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 flosaquae* Ralfs ex Bornet et Flahault was recorded as dominant at this sampling point.

- While minimum bacteriological load was determined at st.9, which is located in the middle of the lake, *Anabaena spiroides* Klebahn of Cyanobacteria was found the dominant species. Also, station 9 ranks second among the stations with the highest phytoplankton density.

- Chlorophyll-*a* concentration is a useful expression of phytoplankton biomass in waters. When chlorophyll- *a* concentrations were measured in minimum at Çekmece Stream (st.6), bacteriological load was count in 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 antagonistic effect on each other.

Conclusion

- 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 the streams was effective on the trophic level of the lake.

- It is known that the phytoplankton density in streams is lower than in stagnant waters such as lakes.

- Therefore, the highest bacteriological pollution load was detected in stations where phytoplankton could not develop well, with the effect of nutrient salts carried by rivers.

- In this study, it was determined that the phytoplankton density and the density of bacteria varied inversely at the sampling stations, except for the middle of the lake.

- **It needs to continuing limnological studies including phytoplanktonic and bacteriologic organisms the bioindicators in waters, for monitoring and protecting the water of Buyukcekmece Dam Lake and its feeding streams.**

Thank you for listening…

Acknowledgements

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