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Some Physicochemical Characteristics of Yarseli Lake, Hatay, Turkey

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Abstract

Lakes are sometimes subjected to wastewater discharges originating from different sources. Chemicals such as nitrogen, phosphorus and carbon in certain concentrations might distort and disrupt aquatic ecosystems. Eutrophication of inland bodies of water has become synonymous with the deterioration of water quality, which interferes with most of its beneficial uses. This study, purposing to determine water quality characteristics of Yarseli Lake, located in Antakya, Hatay, began in April 2003 and was carried out for 12 months by taking monthly water samples from two different stations. Water quality parameters of pH, dissolved oxygen, temperature, salinity, chemical oxygen demand (COD), total alkalinity and hardness, ammonia, nitrite, nitrate, phosphate, sulphite, sulphate, chloride, potassium, sodium and silica analyses were done. Changes in water quality parameters of Yarseli Lake by months were determined. This study indicates that Yarseli Lake has not reached the eutrophic stage yet.

Key Words: Water Quality, Oxygen, Nitrate, Phosphate, Antakya.

Introduction

Agriculture is the largest user of water in Turkey with 75 percent of the total consumption. Turkey has irrigated 50 percent of total irrigable land so far. Water is a limiting factor for agriculture throughout the whole country. The amount and distribution of precipitation is quite uneven. Turkey, like many countries today, faces challenges in efficiently developing and managing its agricultural water resources while trying to protect water quality and the environment (Çakmak *et al.*, 2004)

Yarseli Lake is located on White Creek (Bohsin) between Yarseli and Avsuyu villages, 30 km east of the Antakya city centre, south of Turkey. The main water source of the Lake is Orontes River and one of its branches, White Creek. Orontes River, born in Lebanon and passing through Syria and joining the Mediterranean Sea in Turkey, is one of the largest rivers with 380 km in length in the Middle East. Yarseli is an artificial lake, constructed in 1991 for agricultural irrigation. The Lake, which is located in the middle of the large agricultural fields supports three to four different crops per year and irrigates an area about 7,300 ha. At mean water level, the surface area is 3.98 km^2, the height from riverbed is 37 m, and the volume is 5.4×10^6 m^3. Olive is the main agricultural product of the area and the Lake is surrounded with olive trees. This region provides 34.372 tons of olives, which is more than half of the total olive production (60,785 ton) of the city.

The main water quality degradation comes from olive processing plants around the Lake. Acute fish kill has been reported from the Lake in the past several years. Olive oil, contaminated from these processing plants, causes surface scum and reduces oxygen concentration in the Lake.

Water quality degradation by various sources becomes an important issue around the world. Usage of more land for agricultural purposes, soil salinization, increase in the use of agricultural fertilizers, common pesticide use, and erosion have become problems threatening natural water source (Zalidis *et al.*, 2002). The purpose of the present study is to observe water quality of Yarseli Lake by physico-chemical procedures and to determine the changes in water quality parameters by seasons and stations.

Material and Methods

Study Area

Yarseli Lake is located in the town of Altınözü, province of Hatay. Orontes River and White Creek are the main water sources of the Lake. The Lake is constructed for irrigation purpose and was started to use for agricultural irrigation in 1991. The surface area is 3.98 km^2 at the mean water level and the height from riverbed is 37 m. The total volume of the Lake is 5.4×10^6 m^3. The largest length of the Lake is 930 m and the flow rate, when it is at full level, is 888 m^3/min. Water samples were collected from stations. Station 1 was located nearby the entrance of White Creek. Station 2 was across the Station 1 and close by the set (Figure 1).

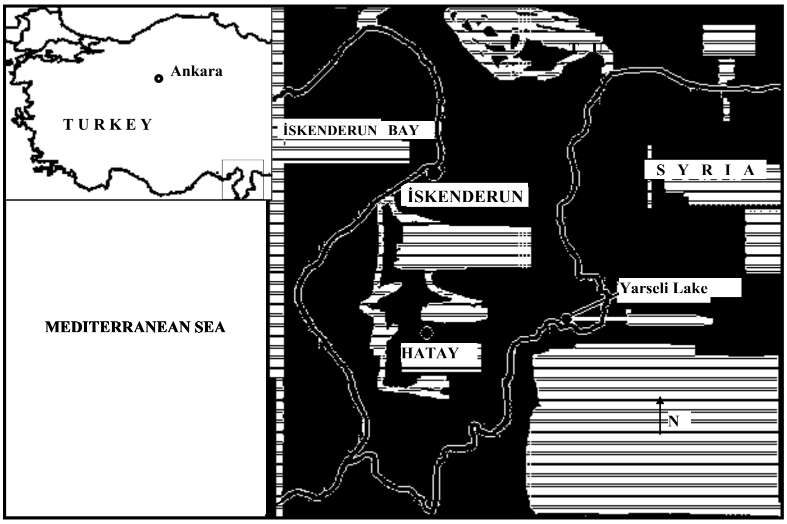

Figure 1. Location map of Yarseli Lake.

Water Analyses

The study was carried out for a year between April 2003 and April 2004 by collecting water samples monthly. Sampling bottles were acid washed a day before sampling day. 1-2% HCl solution was used for acid wash and sampling bottles, which then were rinsed through distilled water, were dried in the drying oven (Boyd and Tucker, 1992). Water samples were taken from 10 cm depth from the surface by holding the bottles upward and immediately transferred to the laboratories for analyses. Oxygen, temperature, pH and salinity were measured directly at the field by means of digital instruments. Oxygen and temperature were measured by YSI model 52 oxygenmeter, pH by Orion model 420A pHmeter and salinity by YSI model 30 salinometer.

Other water quality parameters such as chemical oxygen demand (COD), total alkalinity and hardness, ammonia, nitrite, nitrate, phosphate, sulphite, sulphate, chloride, potassium, sodium and silica analyses were done on the same day in Mustafa Kemal University, Faculty of Aquaculture and Fisheries Laboratories. Titration methods were used for total alkalinity and total hardness and the results from both analyses were expressed as mg/L $CaCO_3$. Chloride (Cl_2) analyses were done by titration method with $Hg(NO_3)_2$. Chemical oxygen demand (COD) analyses were carried out by titration method with Ferrous Ammonium Sulphate, which basically calculates the amount of oxygen spent to oxidize all organic matters in water. Nitrate (NO_3), nitrite (NO_2^-) and total ammonia nitrogen (TAN) (NH_3 + NH_4^+) and phosphate (PO_4^{-3}) measurements, which require photometric measurements, were done according to the standard procedures by using Shimadzu brand UV-1601PC model spectrophotometer. Water analyses were done according to procedures described by Boyd and Tucker (1992).

Statistical Analyses

Statistical analyses were performed with Sigma Stat for Windows (SPSS 1997). The probability level (α) for rejection of the null hypothesis was 0.1. Monthly difference of each parameter was compared by using one-way ANOVA, and Tukey test was applied to see which month is different (Steel and Torrie, 1960).

Results

Water temperature ranged from a low of 9.2ºC in January to a high of 29.1ºC in August over the year. In contrast with seasons, water temperature did not change as much by stations. The average water temperature was 19.8ºC and 19.6ºC for Station 1 and Station 2, respectively (Figure 2).

pH values were ranged between 7.7 and 8.7 during the study. Throughout the study period, no statistical difference was found in pH values between the stations. pH values increased month by month starting from December to March. Annual mean pH values were 8.20 and 8.17 for the Station 1 and Station 2, respectively (Figure 2).

Dissolved oxygen levels were stagnant for the first 9 months of the study and averaged 6.10 mg/L and 6.28 mg/L for Station 1 and Station 2, respectively. Dissolved oxygen levels, however, increased up to 11.29 mg/L in January (the 10th month) and averaged 9.14 mg/L and 10.14 mg/L during the last three months for Station 1 and Station 2, respectively (Figure 3).

Chemical oxygen demand (COD) at the beginning of the study in April was 18 mg/L at both stations and increased month by month until October up to 36 mg/L. After October, COD levels decreased in last four months down to 24 mg/L (Figure 3). Annual mean COD levels were 25.3 mg/L and 27.17

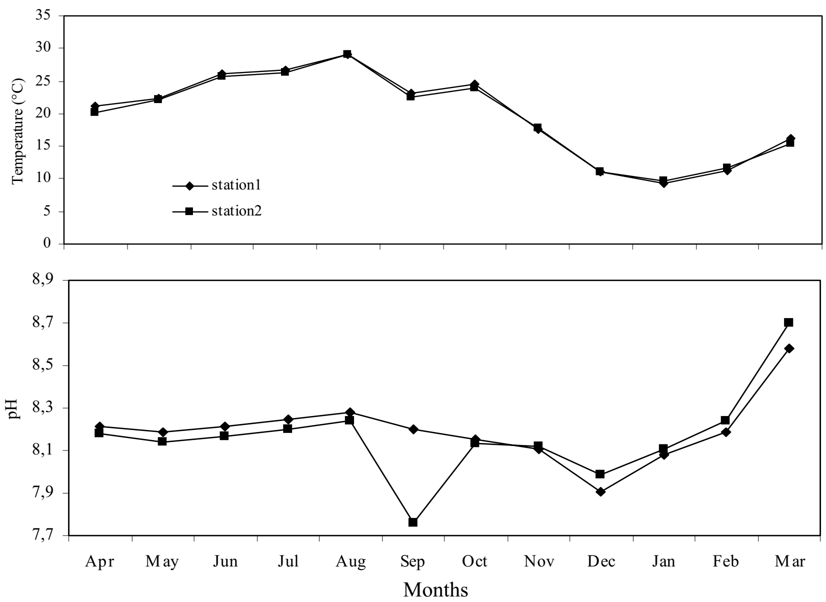

Figure 2. Temperature and pH levels by months by stations.

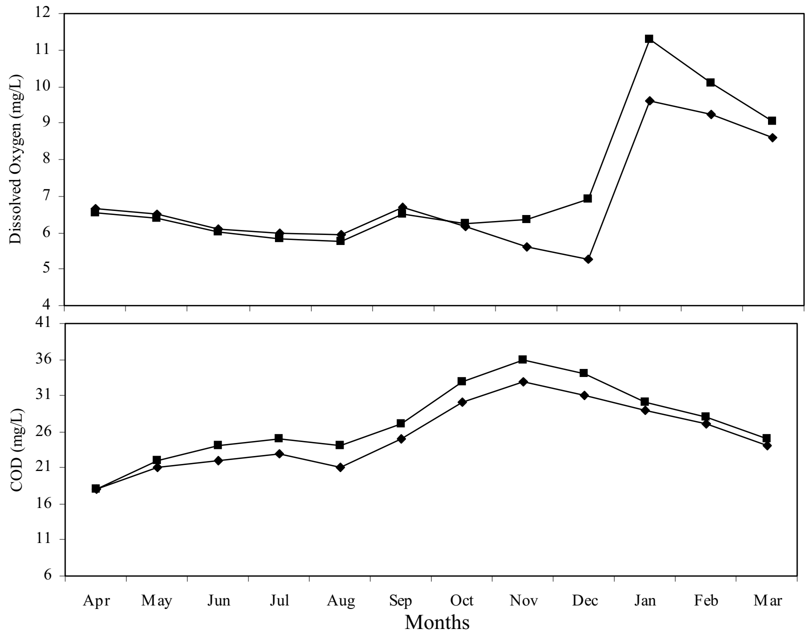

Figure 3. Dissolved oxygen (mg/l) and Chemical Oxygen Demand (COD) (mg/l) levels by months by stations.

mg/L for Station 1 and Station 2, respectively.

Nitrate, and nitrite levels showed similar patterns during the study period and max levels were recorded in January. Nitrogen derivatives did not show seasonal change by stations. Although the average measurements of all nitrogen derivatives from Station 1 were higher than those from Station 2, there was no statistical difference found. The average nitrate, nitrite levels measured from Station 1 were 13.42 mg/L and 0.023 mg/L. These values were 11.99 mg/L and 0.018 mg/L respectively, for Station 2. Fluctuations for another nitrogen derivative, ammonia over the year, were different than those for nitrate and nitrite. Ammonia concentration was minimum in August with 0.03 mg/L for both stations. The mean ammonia measurements were 0.20 mg/L for Station 1 and 0.15 mg/L for station 2, respectively (Figure 4).

Salinity, as expected, did not change from station to station and month to month and averaged about 0.3 ppt for both stations.

Fluctuations in total alkalinity and total hardness were similar but the amount of the total hardness was significantly greater than that of the total alkalinity. Over the study period, Station 1 had significantly higher measurements of both total alkalinity and total hardness than Station 2 ($p < 0.05$). The average total alkalinity and total hardness values were 273 mg/L and 418 mg/L for Station 1, respectively. These values were 208 mg/L and 375 mg/L for Station 2 for the total alkalinity and total hardness, respectively (Figure 5).

Considering phosphate, the most vital nutrient

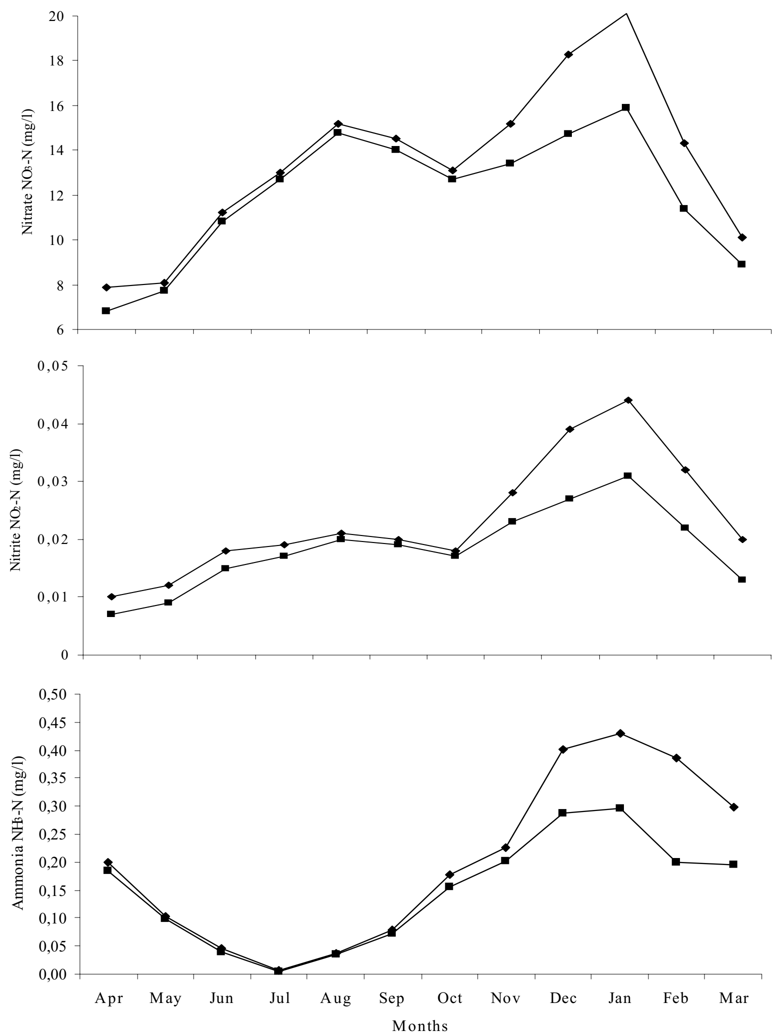

Figure 4. Monthly nitrate (NO_3), nitrite (NO_2^-) and ammonia (NH_4^+) (mg/L) levels by stations.

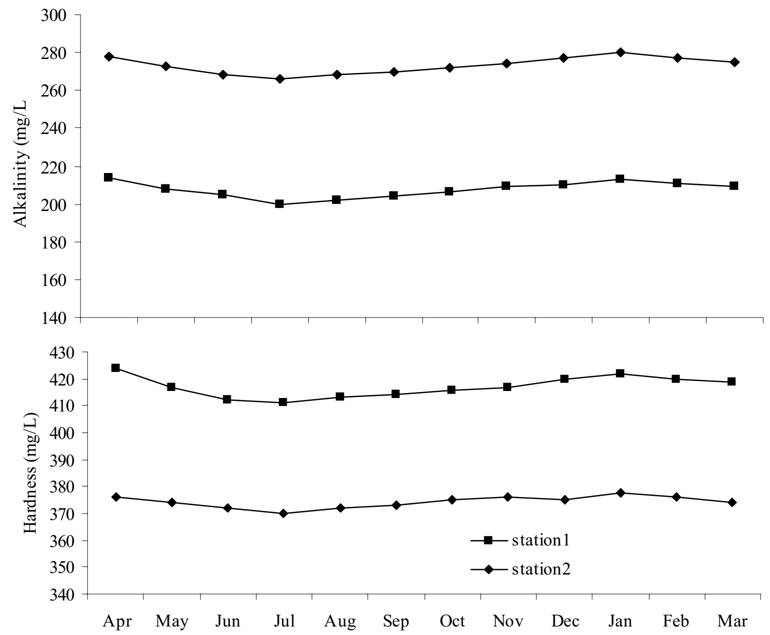

Figure 5. Monthly alkalinity and hardness (mg $CaCO_3$/L) levels by stations.

effecting productivity of natural water resources, the measurements averaged 0.34 mg/L in Station 1. Phosphate measurements in Station 2 were significantly lower than Station 1 and averaged 0.28 mg/L. Phosphate levels increased during summer in both stations. Levels increased until August and gradual decrease was seen after this month. Phosphate levels reached to 0.6 mg/L and 0.5 mg/L in August for Station 1 and 2, respectively. Phosphate levels did not change by stations and by months (Figure 6).

Silica levels were not significantly different by stations and by months. The average silica levels were 13.22 mg/L and 13.18 mg/L for Station 1 and Station 2, respectively. Starting with 9.7 mg/L and 9.9 mg/L in April, silica levels gradually decreased down to 9.2 mg/L and 9.4 mg/L in August for Station 1 and Station 2, respectively. Silica levels then increased each month until January in both stations (Figure 6).

Potassium levels started from 4.4mg/l in April and increased gradually each month until January up to 18 mg/L and 17 mg/L and then dropped back to 9.5 mg/L and 7.6 mg/L in March for Station 1 and Station 2, respectively. The average potassium levels were 9 mg/L and did not change by stations and by months. As potassium, sodium and chlorine levels also did not change by stations and by months. The maximum sodium level of 44 mg/L was recorded in January from both stations. The average sodium concentrations were 37 and 38 mg/L for Station 1 and Station 2, respectively. Chloride levels were 0.07 mg/L at the beginning of the study and increased each month until December. The average chloride levels were 0.183 mg/L and 0.153 mg/L for Station 1 and Station 2, respectively (Figure 7).

Sulphite and sulphate measurements were not different by stations and months over the year. Sulphite readings from Station 1 were significantly lower than those from Station 2 from the beginning of the study in April until December. No statistical difference between stations, however, was reported during the last six months of the study. Sulphate concentrations showed the maximum values in October with 329 mg/L and 342 mg/L for Station 1 and Station 2, respectively. The average sulphate concentrations were 208 mg/L and 210 mg/L for Station 1 and Station 2, respectively (Figure 8).

Discussion

The mean values of the water quality parameters of the present study that run for a year in Yarseli Lake in the town of Altınozü, province of Hatay, were given in Table 1.

Most natural water has pH values between 5 to 10, with the greatest frequency of values falling between 6.5 and 9. Natural waters with high or moderate alkalinity usually have lower pH change during the day because of the buffering capacity afforded by higher alkalinity. The total alkalinity of the Lake is quite high to buffer pH to increase too high (Boyd, 1990).

Dissolved oxygen concentrations were above 5 mg/L, which was adequate enough to support aquatic life. The increase in dissolved oxygen levels might be the result of runoffs accounted for by winter rains (Tepe and Mutlu, 2004).

The carbonate system provides acid buffering through two alkaline compounds: bicarbonate

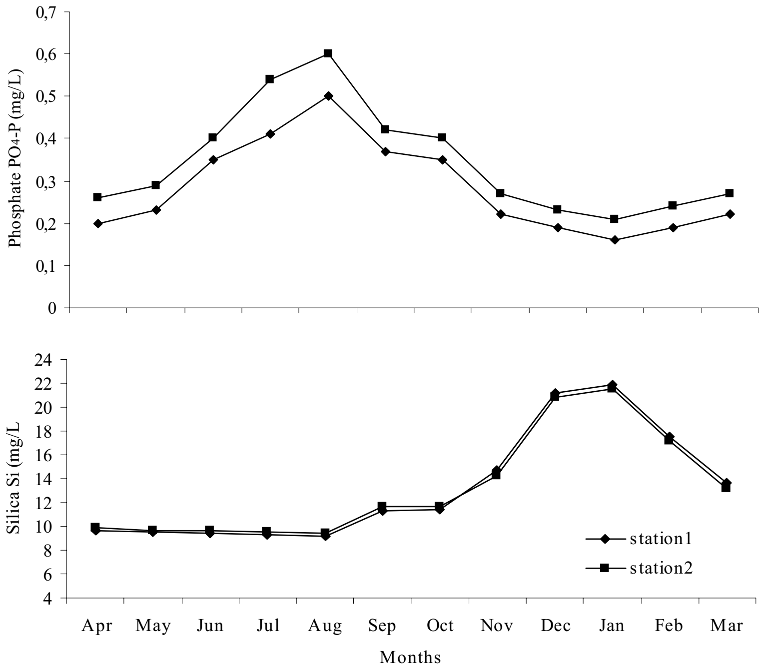

Figure 6. Monthly phosphate (PO_4^{-3}) and Silica (mg/L) levels by stations.

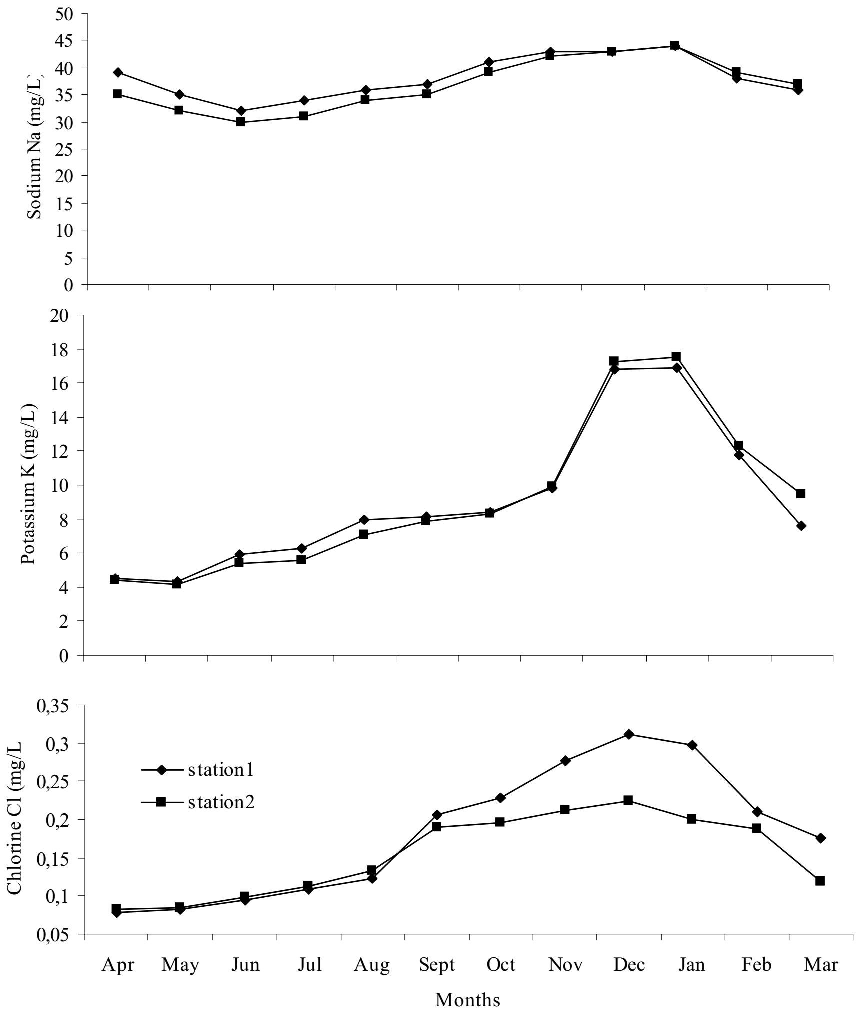

Figure 7. Monthly potassium and chlorine (mg/L) levels by stations.

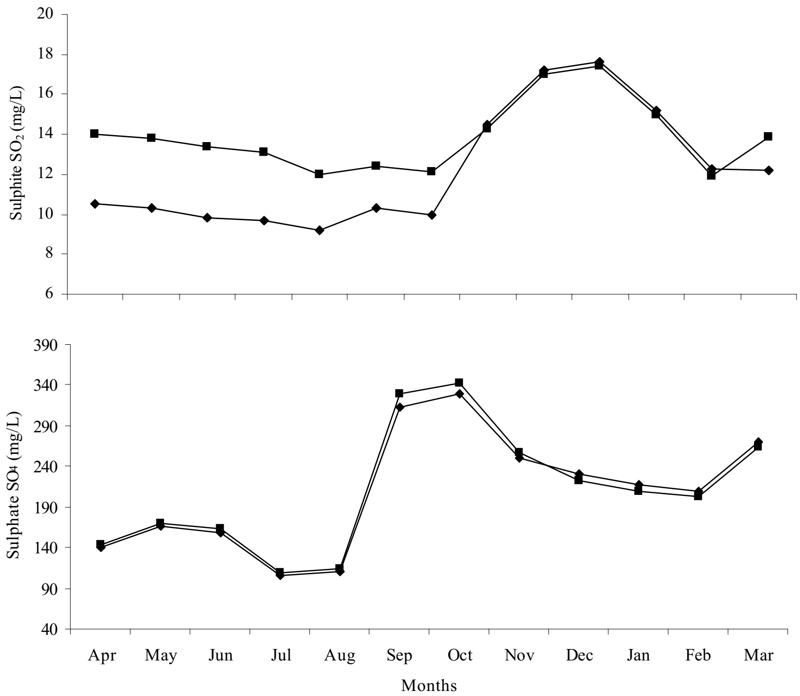

Figure 8. Monthly sulphite (Na_2SO_3) and sulphate (SO_4^{-2}) (mg/L) levels by stations.

Table 1. The annual mean values of water quality parameters by stations

Parameter	Station 1	Station 2
pH	8.20	8.17
Dissolved Oxygen (mg/L)	6.86	7.25
COD (mg/L)	25.3	27.17
Nitrate NO_3-N (mg/L)	13.42	11.99
Nitrite NO_2-N (mg/L)	0.023	0.018
Ammonia NH_3-N (mg/L)	0.20	0.15
Salinity (ppt)	0.36	0.33
Total Alkalinity (mg/L)	273*	208
Total Hardness (mg/L)	418*	375
Phosphate PO_4-P (mg/L)	3.4	2.8
Sulphite SO_2 (mg/L)	12.21	13.87
Sulphate SO_4 (mg/L)	208.5	210.58
Silica Si (mg/L)	13.225	13.183
Temperature (°C)	19.8	19.6
Potassium K (mg/L)	9	9

* There is a statistically significant difference between the stations (P <0.001).

(HCO_3^-) and carbonate (CO_3^{--}). These compounds are usually found with two hardness ions: calcium (Ca^{++}) and magnesium (Mg^{++}).

The highest COD was carried to Yarseli Lake via White River (36 mg/L) in November. Possible cause of this high value could be the illegal discharge by olive processing plants to this creek by the villages around the Lake.

Assessment of seasonal changes in COD loads showed insignificant changes in Orantes and White Creeks. They exhibited a general increase in COD in winter months. This is an indication of increased organic loads due to the increased household wastewater or olive processing plants waste discharges (Karakoç *et al*., 2003).

A lake's hardness and alkalinity are affected by the type of minerals in the soil and watershed bedrock, and by the amount of lake water coming into contact with these minerals. If a lake gets groundwater from aquifers containing limestone minerals such as calcite ($CaCO_3$) and dolomite ($CaMgCO_3$), hardness and alkalinity shall be high.

Natural waters of Hatay region have more than 50 mg/L of total alkalinity and are assumed as alkaline waters. Total hardness of Yarseli Lake is greater than the total alkalinity, probably as a result of calcium and magnesium in the water associated with sulphate, chloride, silicate, or nitrate instead of bicarbonate.

Nitrogen does not occur naturally in soil minerals, but is a major component of all organic matter (both plant and animal). Decomposing organic matter releases ammonia, which is converted to nitrate if oxygen is present (Boyd and Tucker, 1998). This conversion occurs more rapidly at higher water temperatures (Emersson *et al*., 1975). All inorganic forms of nitrogen (NO_3^-, NO_2^- and NH_4^+) can be used by aquatic plants and algae. If these inorganic forms of nitrogen exceed 0.3 mg/L (as N) in spring, it means there is sufficient nitrogen to support summer algae blooms.

Nitrogen comprises 78% of gas in the atmosphere. Like other gases, it is more soluble at cooler temperatures. Most aquatic plants do not derive nutritional value from nitrogen gas, though blue-green algae are an exception. Nitrogen gas is important in lakes containing such algae.

Some bacteria convert nitrate back to nitrogen gas under anaerobic conditions when soluble organic matter is present. This reaction, called denitrification, is one of the main ways by which nitrogen is lost from certain lakes and some soils. This reaction is being investigated as the means of reducing pollution from septic systems.

The high total P levels in Yarseli Lake environs could possibly result from agricultural fertilizer runoff reaching surface waters by rain drainage or irrigation return reaching White Creek. High levels in Gölcük Creek in summer months are due to agricultural activities. Total phosphate levels in this study were generally found higher than the eutrophication values in the Turkish Environmental Legislation (SSKY, 1988)

The presence of chloride (Cl^-), where it does not occur naturally, indicates possible water pollution. Chloride does not affect plant and algae growth and is not toxic to aquatic organisms at most of the levels found in Hatay. Chloride is not common in Hatay soils, rocks or minerals, except in areas with limestone deposits.

Sulphate in lake water is primarily related to the types of minerals found in the watershed and acid rain. Industries and utilities that burn coal release sulphur compounds into the atmosphere that are carried into lakes by rainfall.

Since natural levels of sodium and potassium ions in soil and water are very low (Tepe and Mutlu, 2004), their presence might indicate lake pollution caused by human activities. Sodium is often associated with chloride. It finds its way into lakes from road salt, fertilizers, and human and animal waste. Potassium is the key component of commonly used potash fertilizer, and is abundant in animal waste.

Soils retain sodium and potassium to a greater degree than chloride or nitrate. Therefore, sodium and potassium are not as useful as pollution indicators. Increase in sodium and potassium values over time can mean there are long-term effects caused by pollution. Although not normally toxic themselves, these compounds strongly indicate possible contamination from more damaging compounds.

The primary purpose of this study is to help people understand the elements affecting lake water quality. Another goal is to show the benefits of keeping a long-term record of water quality data. Such a record documents changes and helps to distinguish between a lake's natural variability and the impacts of human activity.

Lake water quality changes over time, so interpreting data based on one or two samples is not enough. Data collected during spring and fall overturn represent a lake's most uniform water quality conditions and are most valuable for comparing year-to-year changes. More extensive sampling provides additional information. A long-term commitment to continue a modest sampling program is better than an extensive program, which cannot be sustained because of lack of funds or volunteers.

Acknowledgement

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