



Assessment of Physico-Chemical Parameters of Water of Çatalan Dam Lake, Turkey

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The physico-chemical parameters of the water of Çatalan Dam Lake, which supplies drinking water for Adana, have been investigated. Monthly surface water samples were collected from eleven stations between November 2006 and June 2008. Çatalan Dam Lake, whose mean values of water temperature, pH, dissolved oxygen, saturated oxygen, electrical conductivity, total dissolved matter, suspended solids, alkalinity, nitrate nitrogen, nitrite nitrogen and ammonia nitrogen were 18.99 ± 7.37 °C, 8.33 ± 0.15 , 8.19 ± 2.67 mg/L, 90.86 ± 16.11 %, 446.55 ± 172.98 μ S/cm, 328 ± 107 mg/L, 2.4 ± 2.1 mg/L, 164.02 ± 10.57 mg/L, 0.503 ± 0.158 mg/L, 0.010 ± 0.003 mg/L, 0.055 ± 0.079 mg/L, 14.90 ± 2.59 mg/L, 42.16 ± 9.17 mg/L and 18.95 ± 1.72 mg/L, respectively. Orthophosphate and chemical oxygen demand were less than 0.002 and 5 mg/L, respectively. As a result of the comparison with recommended water quality standards, it has been found that the water is suitable for both drinking and fresh water biota.

Keywords: Çatalan Dam Lake, Drinking water, Physico-chemical parameters, Water quality.

INTRODUCTION

Fresh water covers only a tiny part of the Earth's surface, which is about 1 %. Lakes, reservoirs and rivers constitute the main inland water resources for the purpose of domestic, industrial and irrigational uses. The conventionally friendly correlation between lakes and humankind, is now being jeopardized by unbalanced development of the man-made civilization [1]. The chemistry of water provides information regarding geo-climatic, hydrophysical and hydrobiological processes as well as the human impact on the water [2].

Nowadays, surface water quality has become a matter of serious concern all around the world. There are some certain factors causing degradation surface waters and thus impairing their use. Moreover, anthropogenic influences such as urban, industrial and agricultural activities and increasing consumption of water resources and natural processes like erosion, weathering of crustal materials and contribute negative effects on this process [3]. Not only do such problems include eutrophication leading to a significant loss of amenity in terms of water supply, fisheries and recreation, but also increases water treatment costs [4].

Çatalan Dam Lake, which filled the reservoir at the end of May 1996, was designed and planned in upstream of Seyhan Dam Lake with an effective storage capacity of 2.1 km³ and a reservoir surface area of 14.387 km². The zoned earthfill embankment dam has a crest length of 894 m, a maximum

height above the riverbed of 60 m and a volume of 14 million m³. The purpose of the dam is to provide energy, irrigation and drinking water besides having a control over flood.

The aim of this work is to determine the surface physico-chemical parameters of Çatalan Dam Lake and encourage the development of a lake management program for sustainable use and conservation of the dam ecosystem.

EXPERIMENTAL

Eleven sampling stations were selected and designed to cover a wide range of the dam, which reasonably represents 3 reservoir zones (fluvial, transitional and lacustrine) of the lake. Coordinates of the sampling stations are depicted in Table-1. Water samples were collected between November 2006 and June 2008 at the surface at monthly intervals. Sampling, preservation and transportation of the water samples to the laboratory were performed according to standard methods [5]. Water temperature, pH, dissolved oxygen, saturated oxygen, electrical conductivity and total dissolved matter were measured *in situ* using an YSI 6600 Multi Probe System. The samples including alkalinity (titration method), suspended solids (gravimetric method), nitrate nitrogen (cadmium reduction method), nitrite nitrogen (NED method), ammonia nitrogen (phenate method), chemical oxygen demand (dichromate reflux method) and orthophosphate phosphorus (ascorbic acid method) were analyzed according to standard methods [5].

TABLE-1
COORDINATES OF THE SELECTED
STATIONS IN ÇATALAN DAM LAKE

| | | |
|------------|------------|------------|
| Station 1 | 37°16'23"N | 35°13'46"W |
| Station 2 | 37°13'55"N | 35°14'49"W |
| Station 3 | 37°12'46"N | 35°15'55"W |
| Station 4 | 37°12'18"N | 35°17'00"W |
| Station 5 | 37°13'26"N | 35°17'22"W |
| Station 6 | 37°15'18"N | 35°20'06"W |
| Station 7 | 37°15'34"N | 35°21'41"W |
| Station 8 | 37°15'16"N | 35°24'20"W |
| Station 9 | 37°17'11"N | 35°25'45"W |
| Station 10 | 37°19'06"N | 35°27'46"W |
| Station 11 | 37°13'12"N | 35°19'23"W |

One-way ANOVA test were applied to find differences in variables. Differences among means were determined at the $p < 0.05$ level. These tests were conducted after testing the pre-conditions of normality, homoscedasticity and autocorrelation.

RESULTS AND DISCUSSION

Monthly variation in different water physico-chemical parameters are presented in Figs. 1-5. Guidelines for Drinking Water Quality [6], Turkish Water Pollution Control Regulation [7] and A Guide to Use of Biota, Sediments and Water in Environmental Monitoring [8] are used for this comparison. Water quality is classified into four classes in Turkish Water Pollution Control Regulation (TWPCR) [7]. Water quality of class 1 is considered to be clean and used as drinking water supply after disinfection, for recreational activities and for fish (trout) production, water quality of class 2 corresponds to low pollution status and used for drinking water supply after treatment process, for recreational activities, fish production (other than trout), water quality of class 3 corresponds to pollution status and used for industrial water supply, other than food and textile industry, but not for irrigation and water quality of class 4 is considered to be with high pollution status and not used for irrigation; used for industrial water supply.

In the statistical analysis of the data, differences of all water physico-chemical parameters depending on months are significant as statistical ($p < 0.05$) while as for the differences depending on the stations are significant for total dissolved solid, suspended solid and alkalinity.

The water temperature of Çatalan dam lake water varies depending on the seasonal atmospheric temperature (Fig. 1). While the highest temperature was measured as 30.96 °C in August 2007 at station 1, the lowest was measured as 8.28 °C in February 2008 at station 9. The lake remained slightly alkaline during the study period having pH of 8.32 ± 0.06 and sampling sites showed similar pH values (Fig. 1). The pH is an important variable in water quality assessment as it influences many biological and chemical processes within a water body and all processes are associated with water supply and treatment. The pH of most natural waters is between 6.0 and 8.5 [6]. The pH values of most of the water samples fell within the permissible limits of WHO [6] and are placed in class 1 water pursuant to TWPCR [7].

The lowest dissolved oxygen (DO) was measured in February 2007. Except February, oxygen level increased at low temperatures, decreased at high temperatures (Fig. 2). While the highest dissolved oxygen was measured as 12.50 mg/L in March 2008 at station 11, the lowest level was measured as 4.85 mg/L in February 2007 at station 10. Lake average was 8.19 ± 0.95 mg/L for dissolved oxygen, 90.86 ± 16.11 % for saturated oxygen. The amount of dissolved oxygen in water is essential for respiratory metabolism of most aquatic organisms and has an effect on the solubility and availability of many nutrients and thus determining the productivity of aquatic ecosystems [9]. As in present case, the oxygen level measured at station 10-shallow and situated at the entrance of the river Seyhan in February 2007 failed to satisfy the TWPCR [7]. According to the regulation, water quality criteria for class 2 water in which dissolved oxygen should be ≥ 5 mg/L. According to the regulation, water quality criteria for class 2 water in which dissolved oxygen and saturated oxygen should be ≥ 5 mg/L and 70-90 %.

The monthly variation of electrical conductivity (EC) is shown in Fig. 3. During the study, electrical conductivity measurements changed between 301 and 1739 $\mu\text{S}/\text{cm}$. The lake average was 446.55 ± 58.48 $\mu\text{S}/\text{cm}$. The electrical conductivity is an indicator of the amount of dissolved material in water [6] and signifies the concentration of biogenic and abiogenic impurities [4]. The electrical conductivity levels were found to be above average at all the stations in May and June 2008. The conductivity of most freshwaters is between 10 and

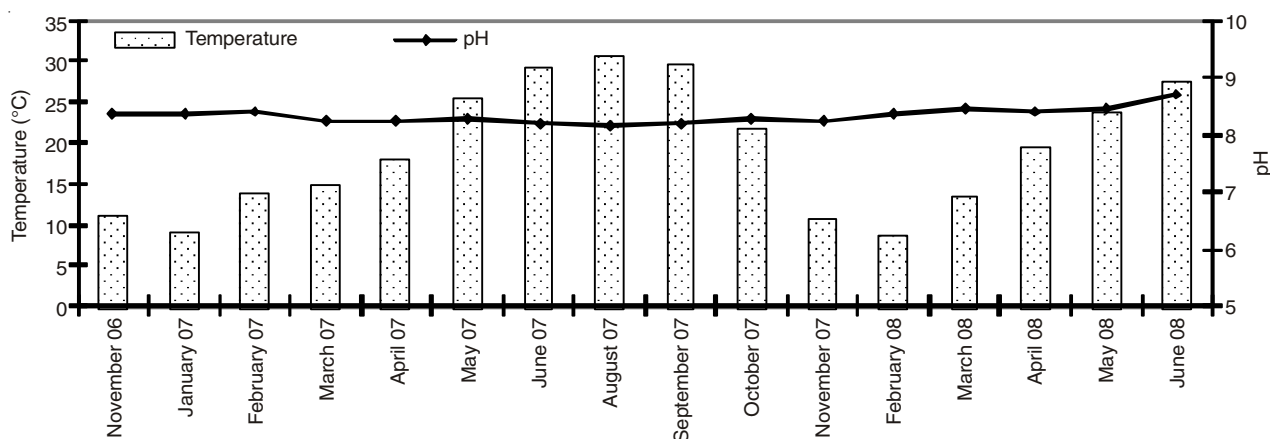


Fig. 1. Changes in temperature and pH of the water of Çatalan Dam Lake during sampling season

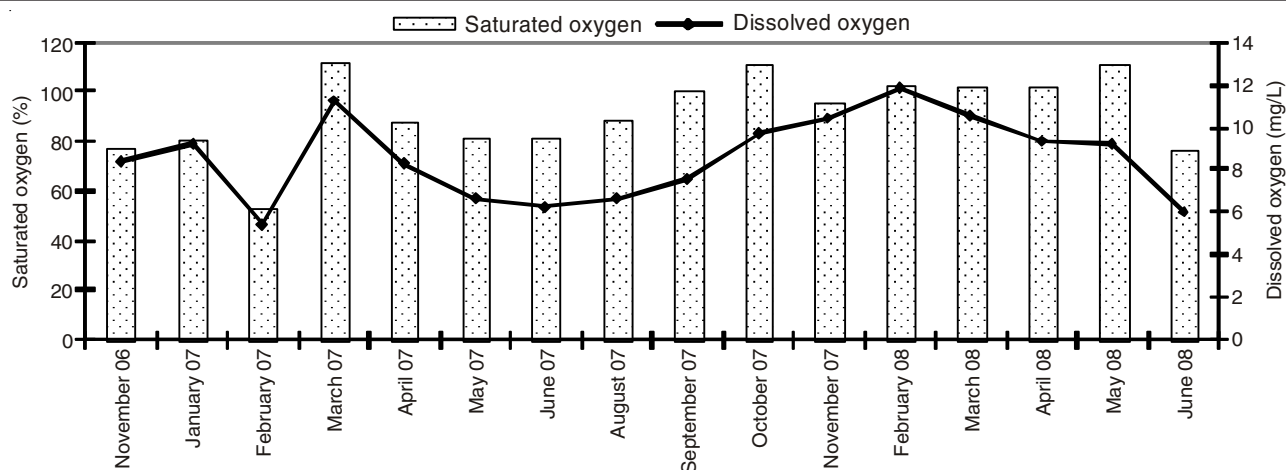


Fig. 2. Changes in saturated and dissolved oxygen of water of Çatalan Dam Lake during sampling season

1.000 iS/cm [6]. In Çatalan Dam Lake, the ranges, except June 2008 at station 1 and 2, are at that level.

Lake average of total dissolved solid (TDS) was 328 ± 41 mg/L. While the highest total dissolved solid value measured was 1064 mg/L in June 2008 at station 1, the lowest one was 251 mg/L in June 2007 at station 2. Differences among stations are statistically significant with $p < 0.05$. As was the case of electrical conductivity, total dissolved solid started to increase by February 2008 (Fig. 3). Total dissolved solid concentration for drinking water is below 1 mg/L [6]. The values water of Çatalan Dam Lake, except June 2008 at station 1 and 2, are below at that level. According to the TWPCR [7], water quality criteria for class 1 water in which total dissolved solid should be 500 mg/L, for class 2 water in which total dissolved solid should be 1500 mg/L. Total dissolved solid average of Çatalan Dam Lake are placed in class 1 water pursuant to TWPCR [7].

The monthly variation of suspended solid (SS) is shown in Fig. 4. Average value of suspended solid was 2.4 ± 2.1 mg/L. While the maximum suspended solid value (3.34 mg/L) occurred in December 2006 at station 10, the minimum value (0.2 mg/L) occurred in March 2007 and February 2008 at station 1 and 3, respectively. Differences among stations are statistically significant ($p < 0.05$). No matter how low level was measured in February 2008, at station 1, suspended solid

was higher at station 1 and station 10 than those at the other stations, which is not surprising as station 1 is situated the stream Eglence and station 10 is situated at entrance of the river Seyhan. Suspended solid level for fisheries and aquatic life is 25 mg/L [8]. Suspended solid of Çatalan Dam Lake, except at station 1 and 2, is at that level.

Alkalinity fluctuated within the range of 115-225.5 mg/L. Average alkalinity was 164.02 ± 10.57 . While the highest alkalinity was obtained in February 2008 at station 1, the lowest value was recorded in July 2007 at station 7. Differences among stations are statistically significant ($p < 0.05$). The monthly variation of alkalinity is shown in Fig. 4. Alkalinity in water acts as a buffer that tends to stabilize and prevent fluctuations in pH. If the alkalinity of less than 80 mg/L, pH can be rapid fluctuations. Low alkalinity also contributes to water's corrosive tendencies high alkalinity (> 200 mg/L) results in the water being too buffered. Alkalinity can be used as a measure of water fertility. Because it serves as a pH buffer and reservoir for inorganic carbon, thus helping to determine the ability of a water to support algal growth and other aquatic life [10].

Typically nitrate ($\text{NO}_3\text{-N}$), nitrite ($\text{NO}_2\text{-N}$) and ammonia nitrogen ($\text{NH}_4\text{-N}$) are at highly low levels in lakes or reservoirs unless there are some relatively recent loadings of manure or fertilizer present in run off from the watershed. These forms are rapidly used by algae and aquatic plants or converted to

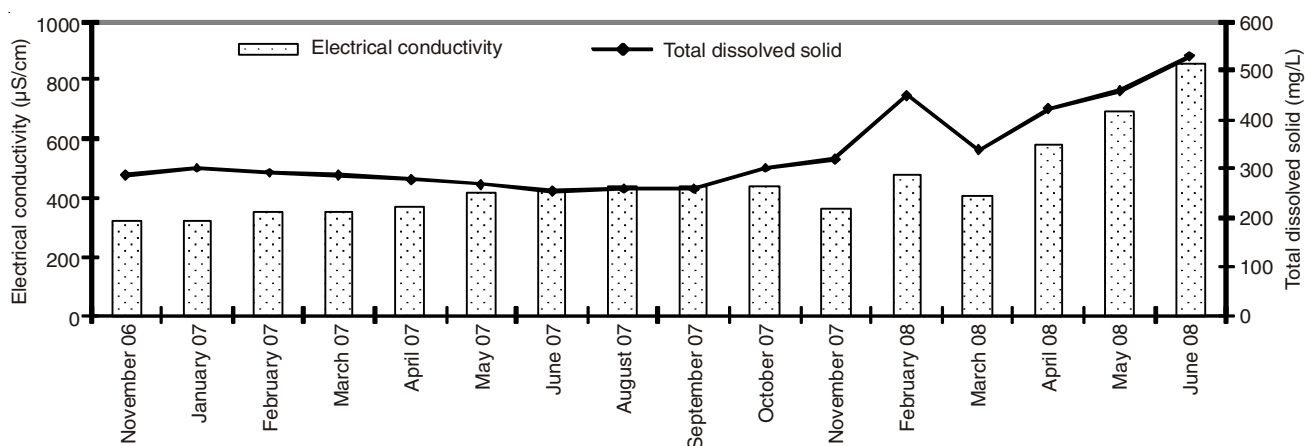


Fig. 3. Changes in electrical conductivity and total dissolved solid present in water of Çatalan Dam Lake during sampling season

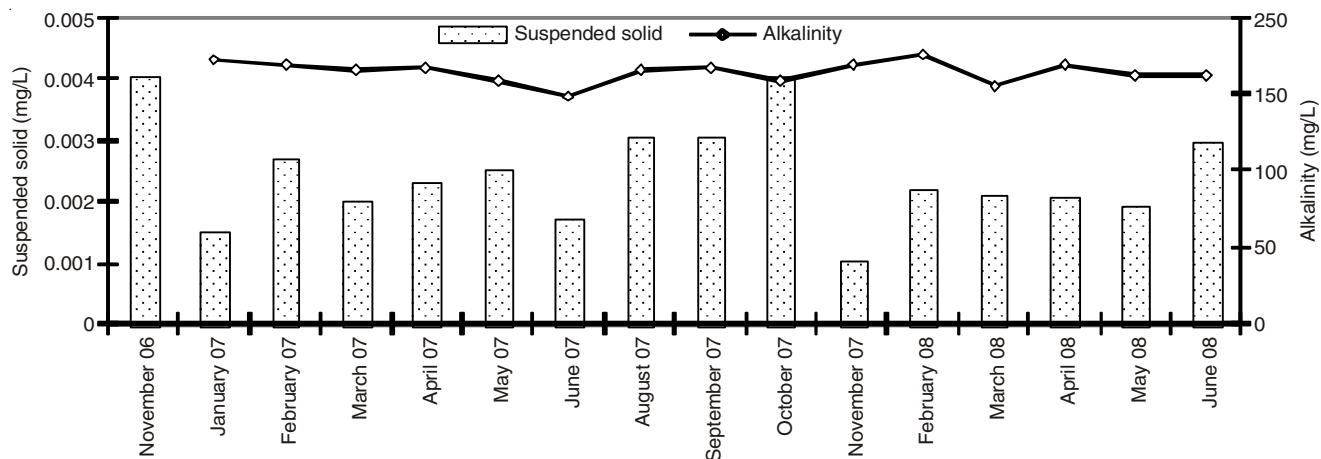


Fig. 4. Changes in suspended solid and alkalinity in Çatalan Dam Lake water during sampling season.

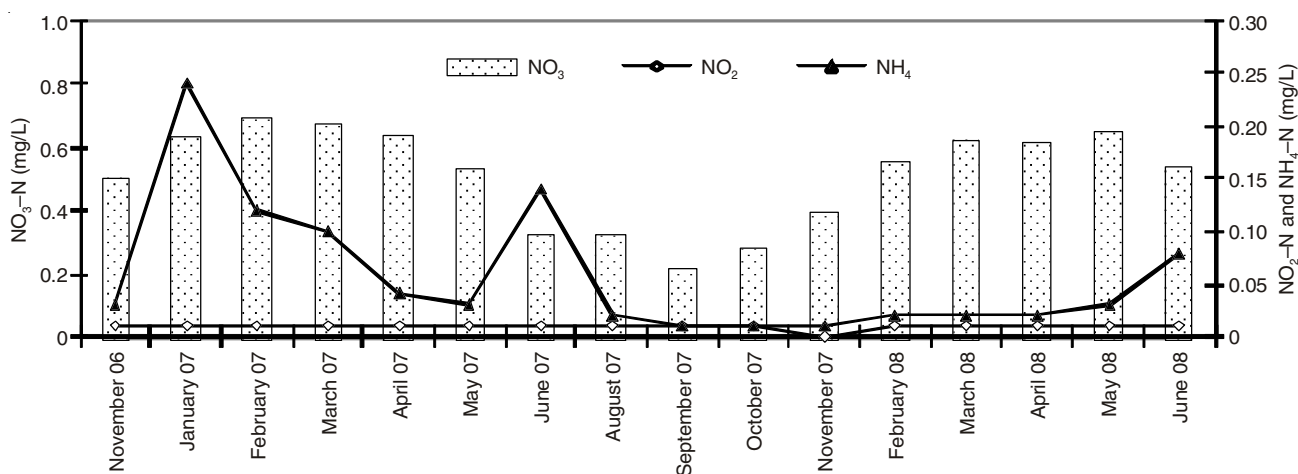


Fig. 5. Changes in nitrate, nitrite and ammonia nitrogen in Çatalan Dam Lake water during sampling season

other forms of nitrogen [11]. In Çatalan Dam Lake, mean values of NO₃-N, nitrite and ammonia nitrogen were 0.503 ± 0.045 , 0.009 ± 0.0017 and 0.055 ± 0.032 , ranged from 0.889-0.101, 0.0007-0.016 and 0.002-0.552 mg/L, respectively. In lakes, levels in excess of 0.2 mg/L NO₃-N indicate possible eutrophic conditions [8]. WHO recommended maximum limit for NO₃-N in drinking water should be 50 mg/L and waters with higher concentrations can represent a significant health risk [6]. Although Çatalan Dam Lake water does not expose a health hazard, nitrate levels are so close to eutrophication. Because of that, it should be closely monitored. According to TWPCR [7], NO₃-N values of lake water are placed in class 1.

In usual case, NO₂-N in freshwater is below 0.001 mg/L, which is rarely higher than 1 mg/L NO₂-N. High concentrations of nitrite are often associated with unsatisfactory microbiological water quality [8]. NO₂-N values of Çatalan Lake exceeded that level and are placed in class 2 pursuant to TWPCR [7].

Although it is typical of total ammonia concentrations measured in surface waters, which are less than 0.2 mg/L, it may reach 2-3 mg/L. It is likely that higher concentrations are an indication of organic pollution caused by such factors as domestic sewage, industrial waste and fertilizer run-off [8]. There should be close monitoring in Çatalan Dam Lake, especially at 1 and 10 station, entrance of the Stream Eglence and the river Seyhan.

In most surface waters, the concentration of orthophosphate ranges from 0.005 to 0.020 mg/L, so that a high concentration is largely responsible for eutrophication [8]. Orthophosphate and chemical oxygen demand levels were very low during the study. All orthophosphate and COD concentrations were less than 0.002 mg/L and 5 mg/L, respectively and are placed in class 1 water pursuant to TWPCR [7].

Water temperature, pH, electrical conductivity, total dissolved matter, suspended solids, alkalinity, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen and orthophosphate of Seyhan Dam Lake which located on the Seyhan river after Çatalan Dam Lake were 26.43 °C, 7.41, 349.87 μS/cm, 220 mg/L, 0.550 mg/L, 0.007 mg/L, 0.080 mg/L and 0.006 mg/L, respectively [12]. Compared to water quality of these dam lakes is close to each other.

According to guidelines [6-8], Çatalan Dam Lake water is considered as high-quality water depending on the levels of the most physico-chemical parameters. However our results revealed the water quality in some areas where the rivers (Eglence stream and Seyhan river) entered the lake. Therefore, it is assumed that the water quality of Çatalan Dam Lake may change in following years. Thus, a continuous monitoring programme should be conducted to be able to control the changes in water quality.

This study also showed that selection of the water sampling stations is very important to make correct observations on the

water quality. Although there is hardly any human settlement around the lake, there are some settlements along the rivers, which supply water to the lake as well as farmlands. Regarding the sustainable use and conservation of the dam ecosystem, there should be a management plan as to it provides drinking water, which signifies its value.

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