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Water Quality and Its Relation with Chlorophyll-*a* in Dry Season, in a Reservoir of Mediterranean Region

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This study was carried out between June 2004 and August 2004, in Seyhan dam, Adana, Turkey. This lake is under severe anthropogenic pressure and region has a typical Mediterranean climate. Water samples were taken weekly from two stations in littoral and pelagic zones. The temperature, pH and conductivity were measured by a CTD. Chlorophyll-*a*, NO_2-N, NO_3-N, NH_4-N, SRP and SRSi were analyzed according to the standard methods. Differences among weeks for water quality variables were statistically significant ($p < 0.01$). Chlorophyll-*a* showed significant positive linear correlation with temperature, NH_4-N and conductivity while NO_2-N, NO_3-N and TDS were inversely related ($p < 0.01$). Results show that Seyhan dam has not yet reached the eutraphic stage. Consequently, more extensive studies are needed because the lake is thought to be the most changing site in region as a result of the increasing agricultural, aquacultural and human population. A water quality program should be established to conservation of lake quality.

Key Words: Seyhan dam, Chlorophyll-*a*, Water quality, Pollution, Trophic state.

INTRODUCTION

The quality of surface water is very sensitive issue. Anthropogenic influences as well as natural processes degrade surface waters and impair their use for drinking, industrial, agricultural, recreation or other purposes. Eutrophication is recognized as a pollution problem, caused by increases in levels of nutrients (usually phosphorus and nitrogen compounds) and has caused deterioration in the aquatic environment and serious problems for water use.

Whenever conditions of temperature, light and nutrient status are conducive, surface waters may host increased growth of primer producers. If water contain high concentrations of toxic cyanobacteria (prokaryotic algae) or their toxins, using of this water present high risks to human health[1]. In some water bodies in Turkey, cyanobacterial toxins have been reported[2,3].

Algae are central to the pelagic ecosystem since they trap almost all the energy used by the ecosystem[4]. Chlorophyll-*a* is a photosynthetic pigment that present in all species of algae, including eukaryotic (algae) and prokaryotic organisms and thus, it is a reliably and commonly used proxy for algal and cyanobacterial biomass and water quality[1,4-6].

Nutrients especially phosphorus are essential in the formation of algal biomass which is expected in most temperate zone lakes[7]. There are many studies about chlorophyll-*a* and nutrient relationships[8-14]. The biological, chemical and hydrodynamic conditions of lakes are influenced by changes in the catchment and also show a response to local, regional and global climate processes[15].

Seyhan dam was chosen in this study since it is heavily influenced by human actions creating domestic and agricultural pollution sources and it is also major recreation area serving Adana city. Major land use in the common watershed of lake is agriculture and urban settlement. A typical Mediterranean climate prevails in the study region. This research was aimed to study the water quality of Seyhan dam and its relation with chlorophyll-*a* in summer season in order to increasing of quality and quantity of light and temperature.

EXPERIMENTAL

Seyhan Dam Lake, one of the most important reservoirs in the Mediterranean Region in Turkey was built for flood, irrigation and energy production. It has been operating since 1956 and was built across the River Seyhan. The lake, with an average width of 4 km and average length of 23 km, reaches its maximum depth of 45 meters in spring. It covers a maximum of 9200 hectares. The average height from the sea is 67 meters. The Seyhan Dam Lake is classified as a mesotrophic lake[16].

Sampling and analyses of data

Sampling was conducted at two stations, from June 1st 2004 to August 31st 2004, once a week. The temperature (Temp), pH, conductivity (Cond) and total dissolved solid (TDS) were measured by a CTD (YSI model). Water samples were collected at 5, 7.5, 10, 15, 20, 25 m depths with a Nansen Bottle (Hydrobios). Additionally, surface water samples were also taken. Secchi depth (SD) was used for the estimation of light penetration. The water samples taken from different depths and surfaces were used for the analysis of nutrients and chlorophyll-*a*. For nutrient analyses the nitrite-nitrogen (NO_2-N) was measured by the colorometric method using sulfanilamide, nitrate-nitrogen (NO_3-N) by the cadmium reduction method, ammonium nitrogen (NH_4-N) by the phenate method, soluble reactive phosphorus (SRP) by the ascorbic acid method and soluble reactive silica (SRSi) by the molibdosilicate method. Chlorophyll-*a* (Chl-*a*) was determined with the acetone extraction method[17].

All data were checked for normality before statistical distributions before statistical analyses. Some variables, chlorophyll-*a*, SRP, NO_2-N, NO_3-N and NH_4-N, deviated from normality. For these parameters, we obtained an approximately normal distribution with a $\log_{10}$ transformation and one-way Anova was applied to determine whether difference among depths and weeks. Correlation analyses were used for finding relationships between variables. Statistical analyses of data were performed out using the SPSS statistical package programs[18].

RESULTS AND DISCUSSION

According to one-way Anova, while differences among weeks for variables are significant as statistical ($p < 0.01$), differences among depths are significant for temperature, conductivity, TDS, pH ($p < 0.01$) and NO_2 ($p < 0.05$).

When the station and depth means are concerned, the temperature was high in August weeks, decreasing towards lower depths in all weekly measurements (Fig. 1). It fluctuated between 29.9 (in surface water in thirth week of July) and 17.7ºC (in 25 meter in first week of May) during sampling period. The pH varied between 7.41 and 7.77, showing a general stability but a slight decreasing tendency on August 16th (Fig. 1).

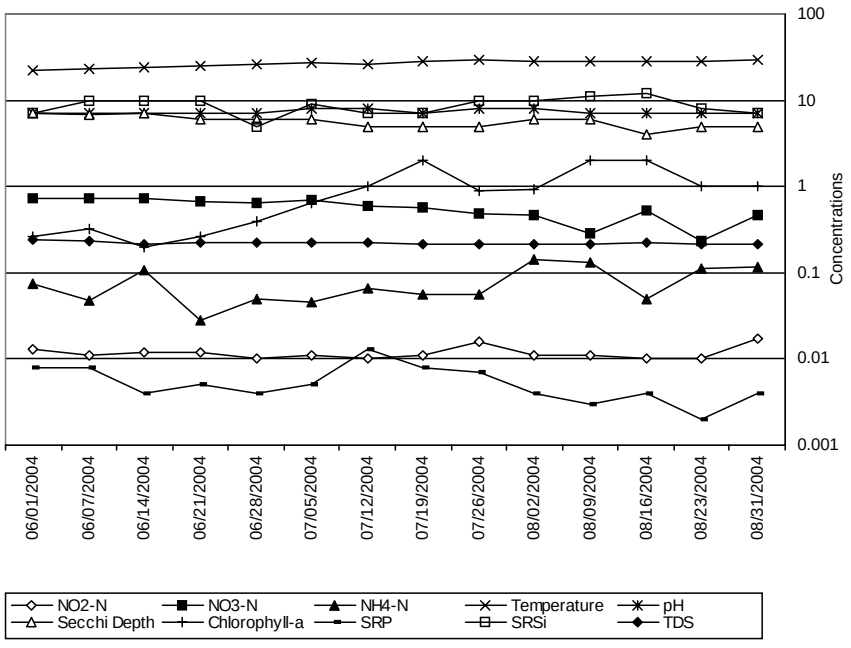

Fig. 1. Changes in Physico-chemical Variables of Seyhan Dam during sampling season

Chl-*a* level increased relatively until July 19th. A slight decrease was observed starting from this date. The second increase was observed on August 9th and then a decreasing tendency was recorded. Chl-*a* ranged from 0.10 to 2.90 mg L^{-1}. Generally, the Secchi depth was measured high when chl-*a* level was low and low when chl-*a* level was high (Fig. 1).

While the SRP level was normal at surface water, on July 12th when the SRP was the highest, this level increased with depth and observed as 0.013 mg L^{-1} at 25 m. In general, a decrease towards the end of June, an increase at the mid July and then a decrease, again, was observed. While the higher levels of SRSi were found at mid August, minimum levels were recorded at the end of June (Fig. 1).

The lower levels, among nitrogen forms, were observed in NO_2-N. The values ranged from 0.006 to 0.085 mg L^{-1}. The NH_4-N levels were low in July and higher in August than June. The NO_3-N level began to relatively decrease until the second week of August, but at the third and the fifth weeks some increases were observed (Fig. 1). The mean conductivity and total dissolved solid were 349.87 µScm^{-1} and 0.22 g L^{-1}, respectively.

The correlative relationships between Chl-*a* and water quality variables in dam are presented in Table-2. Chl-*a* showed significant positive linear correlation with temperature, NH_4-N, conductivity while NO_2-N, NO_3-N and TDS were inversely related ($p < 0.01$). The temperature is related to Chl-*a*, NH_4-N and conductivity positively and NO_2-N, NO_3-N and TDS negatively ($p < 0.01$).

In surface waters, the temperature is influenced by atmospheric conditions and depth of the water body[19]. The temperature of Seyhan dam varies weekly and vertically. Temperature in turn affects physical, chemical and biological processes in surface waters. In fact, differences among weeks for water quality variables were significant as statistically ($p < 0.01$). Because of the differences among vertical measurement for temperature, we concluded that Seyhan dam has stratification.

The pH and conductivity of most freshwaters are between 6.0 and 8.5, 10 and 1.000 µScm^{-1}, respectively[19]. In Seyhan dam the ranges are in that level (Table-1).

In natural water, nitrate and ammonium nitrogen concentrations are low and this is a limiting factor for aquatic plants and since nitrite is a by-product it is found in lower concentrations than ammonium and nitrate[20]. Usually nitrite concentration is below 0.001 mg L^{-1}. High concentrations of nitrite are often associated with unsatisfactory microbiological water quality and industrial effluents[19]. However, in Seyhan dam the range exceeded that level. Permissible level of ammonium in drinking water is 0.5 mg L^{-1}. Levels in excess of 0.2 mg L^{-1} nitrate indicate possible eutrophic conditions in lakes[19]. In this study, several sampling time exceeded

TABLE-1
MEAN, MAXIMUM, MINIMUM AND STANDARD DEVIATIONS OF CHLOROPHYLL-*a* AND SOME PHYSICO-CHEMICAL VARIABLES OF SEYHAN DAM

Variables	Mean	Maximum	Minimum	Standard Deviation
Chlorophyll-*a* (µg L^{-1})	0.894	2.900	0.100	0.660
Secchi depth (m)	5.600	7.000	4.000	0.890
Temperature (^{o}C)	26.430	29.890	17.660	2.570
pH	7.410	7.770	6.770	0.190
Soluble reactive phosphorus (mg L^{-1})	0.006	0.013	0.002	0.002
Soluble reactive silicate (mg L^{-1})	8.700	13.140	3.930	2.240
Nitrite-Nitrogen (mg L^{-1})	0.007	0.085	0.006	0.006
Nitrate-Nitrogen (mg L^{-1})	0.550	3.280	0.090	0.340
Ammonium-Nitrogen (mg L^{-1})	0.080	0.870	0.010	0.080
Conductivity (µScm^{-1})	349.870	373.000	329.000	10.250
Total dissolved solid (g L^{-1})	0.220	0.250	0.006	0.002

these values (Table-1). In most surface waters, the concentration of PO_4-P ranges from 0.005 to 0.020 mg L^{-1} and a high concentration is largely responsible for eutrophication[19]. In Seyhan dam, PO_4-P range was 0.002-0.013 mg L^{-1}.

The silica content of rivers and lakes usually varies within the range[19] 1-30 mg L^{-1}. Wetzel[21] reports that the silica concentration has a regulator role for diatom communities and the world average is about 13 mg L^{-1}. Soluble reactive silica was lower than world average in this study.

While concentrations nutrient of water body fluctuate seasonally depending on environment conditions, concentrations of chlorophyll also fluctuate seasonally and even daily, so that the growth of planktonic algae in a water body is related to the presence of nutrients (principally nitrates and phosphates), temperature and light. While water bodies with low levels of nutrients have low levels of chlorophyll (< 2.5 µg L^{-1}), waters with high nutrient contents have high levels of chlorophyll (5-140 µg L^{-1}) and sometimes the levels in excess of 300 µg L^{-1} also occur[19]. Concentrations of chl-*a* in dam were low.

Determinations of trophic state of lakes are made from examination of several diverse criteria. For example, the composition of the phytoplankton or of bottom fauna, concentrations of nutrients and chl-*a*[22]. In this study, Chl-*a* and nutrients concentrations and Secchi depths indicate that eutrophication is not present in this dam.

Çevik[16] stated that the level of nutrients decreased with respect to the increase in organisms in spring and summer months. In this work, it has been shown that, in the correlation analysis (Table-2), there are negative relationships with nutrients (except NH_4-N) and chl-*a*. In fact, Kufel[23]

reports that in mesotrophic lakes summer chlorophyll was not related to nutrients while in eutrophic lakes it was well correlated with nitrogen and phosphorus.

TABLE-2
CORRELATION COEFFICIENTS OF PHYSICO-CHEMICAL VARIABLES IN SEYHAN DAM. BOLD CELLS SHOW SIGNIFICANT CORRELATION

Variables	Chl-*a*	SD	Temp	pH	SRP	SRSi	NO_2-N	NO_3-N	NH_4-N	Cond	TDS
Chl-*a*	1.00										
SD	-0.62	1.00									
Temp	0.69**	-0.73**	1.00								
pH	0.11	-0.19	0.40**	1.00							
SRP	-0.08	0.04	-0.28**	0.05	1.00						
SRSi	-0.003	-0.04	-0.09	-0.21**	-0.08	1.00					
NO_2-N	-0.23**	-0.01	-0.26**	-0.20**	-0.04	-0.04	1.00				
NO_3-N	-0.58**	0.70**	-0.49**	0.14	0.23**	-0.09	0.17*	1.00			
NH_4-N	0.31**	-0.19	0.28**	-0.02	-0.09	-0.09	-0.01	-0.36**	1.00		
Cond	0.23**	0.72**	0.57**	-0.03	-0.22**	-0.08	0.07	-0.20**	0.18*	1.00	
TDS	-0.20**	-0.13	-0.36**	-0.24**	0.11	-0.01	0.21**	0.15	-0.10	-0.06	1.00

(n = 175, **p < 0.01, *p < 0.05)

After the Seyhan dam was constructed, the scenery and bioclimate at the dam recently attracted urbanization and hence changed the environment. Since the 1950s Adana has become an important agricultural, industrial and transportation centre. Population growth between 1985 and 2000 was 22.5 per cent. Areas around the dam are the only available semi-natural areas in the vicinity[24]. Apparently, the control of wastewater discharge from the catchment area by the local authorities seemed to have effectively conserved mesotrophic character of the lake.

The design of compatible and efficient management strategies for inland waters require a sound knowledge of structure and function of the aquatic ecosystem and watershed area. Data of this study are very important as a background for the estimation of the future impact of anthropogenic activity and lake management. The deterioration in lake quality can be faster than expected for other regional lakes. At present, Seyhan Dam supports an increasing human population, aquaculture and is undergoing cultural eutrophication. It is clear that lake management could play a key role in the conservation of lake quality.

Finally a water quality program should be established to detect changes in some key water variables such as water transparency (Secchi depth), form of phosphorus and nitrogen, total phosphorus and total nitrogen and chlorophyll-*a*.

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