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Heavy Metal Contents of Lake Sapanca*

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The heavy metal pollution of Lake Sapanca located in the Marmara region (Turkey), was investigated over time. The lake is the drinking water source of the city of Adapazarı and its environs. The D-80 (TEM) motorway passes about 5 km along the lake's zero point in the Sapanca district. The motorway's wastewater drainages have been connected to the lake without having been subjected to any wastewater treatment. The motorway was opened to service in October 1990. Analyses were performed in 1991 and were repeated in 1999 in order to observe changes in Pb, Fe and Zn contents. Samples were collected from the ends of the drainage channels opening into the lake and metals were determined using flame atomic absorbtion spectrophotometry (FAAS). According to the results obtained, Zn levels were found to be lower than the limits. However, Pb and Fe concentrations increased significantly at all points and exceeded the limit values. The concentrations of Pb and Fe may be rising in the lake, and hence there is a need for continued monitoring of the levels of toxic heavy metals in the lake.

Key Words: Drinking water, Natural lakes, Motorway, Metal pollution

Introduction

Lake Sapanca is situated in the Marmara region (Turkey) (Figure l). It has a surface area of 46.8 km^2 and a volume of about $1.0.10^9$ m^3water. Its catchment area is 209 km^2 and the maximum depth is 52 m. Several streams and ground water entering from the bottom feed the lake. There is only one stream draining the lake[1−3].

Lake Sapanca is used as a source of drinking and process water by the city of Adapazarı and several important industries in the İzmit area. The majority of pollutants entering the lake originate surface run-off from domestic and agricultural sources. No sewerage or wastewater treatment systems have so far been established for the small towns in the drainage area of the lake[2].

Besides the domestic and agricultural pollutants, another serious pollution factor is the vehicular traffic. The D-l00 highway is to the north and the D-80 (TEM) motorway to the south of the lake. Heavy metal discharges into the lake originate mainly from this traffic. The Kınalı (Trakya)-Sakarya motorway (D-80,TEM) passes about 5 km along the lake's zero point in the Sapanca district. The motorway's wastewater

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drainages have been connected to the lake without having been subjected to any wastewater pre-treatment. The motorway was opened to service in October 1990[3]. An investigation lasting one year was started in 1991 to determine metal pollution from the motorway[3]. In the present study, the same analyses were repeated to observe the changes in metal contents in 1999.

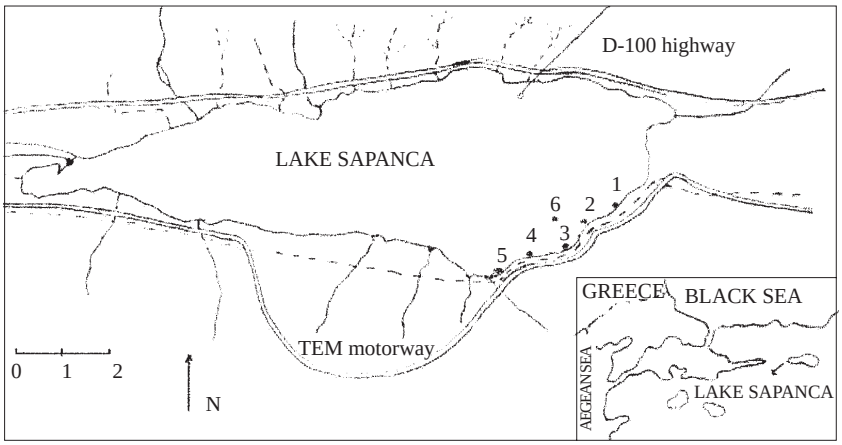

Figure 1. Sampling stations in Lake Sapanca

Experimental

The samples were collected from the ends of the drainage channels opening into the lake (between 121 and 125 km from İstanbul) and were taken just below the water surface (0.5 m depth) at five stations. The sixth sampling was performed station was at a cleaner part of the lake. The sampling was performed between January and November 1999. The samples were taken every other month from all stations (six samplings). Three parallel samples were investigated to obtain a mean value at all the stations. The method of grab sampling was used. The locations of sampling points are shown in Figure 1.

Water temperatures and pH values were recorded at the site. Water samples were collected using l liter glass bottles that had been cleaned by soaking in 10% nitric acid and rinsed with distilled water. At the sampling site the bottles were rinsed twice with the water to be sampled prior to filling. The conductance of the distilled water was 0.5 micromhos/cm. The samples for heavy metal analyses were filtered immediately upon arrival at the laboratory using 0.45 μm cellulose nitrate filter paper mounted on a Pyrex filter holder and the filtrates acidified to pH 2 with ultrapure grade nitric acid (Merck, Germany) in order to minimize precipitation and adsorption on the walls of the container.

Heavy metal levels were determined using a flame atomic absoption spectrophotometer (FAAS)[4] (Shimadzu AA-6701 F). The analyses for lead, iron and zinc were performed at the 283.3, 248.3 and 213.8 nm resonance lines, respectively. Solutions were aspirated into the air-acetylene flame. For the determinations of metals were used background correction and the D_2 method (Deuterium lamp method). This method is used for measurements at wavelengths between 190 and 430 nm by the instrument.

Results and Discussion

The annual mean values with standard deviations of the parameters measured in water samples are presented in the Table. In the first column, analysis results that were obtained by the Turkish State Water Works in

1982 are given[5]. In the second column, the analyses results that were obtained in 1991 are given[3]. Sampling point 6 was far from the wastewater drainages and was chosen for comparison. At this point, the lake's water is not polluted directly by channels. For comparison purposes, the limits for the measured parameters in drinking water, according to Turkish Standard TS 266, were taken into account[6].

The detection limits for Fe, Pb and Zn were improved significantly with precision of determination in the range of 0.91-2.22% RSD (relative standard deviation) for Fe, 1.57-2.85% RSD for Pb and 0.70-1.56% RSD for Zn. Relative errors for Fe, Pb and Zn were 0.033-0.081%, 1.27-2.30% and 0.034- 0.076%, respectively. Reproducibility was acceptable. r values of the determinations varied from 0.012 to 0.078 with 95% probability. Iron, lead and zinc were satisfactorily determined at concentrations accepted as meeting the drinking water standards. Direct determination of these metals was also possible.

Table The annual mean values of the parameters measured in the water of Lake Sapanca

Parameter	State Water Works Results	Sampling Points											Turkish Drinking Waters Standard TS 266
		1		2		3		4		5		6	
Years	1982	1991	1999	1991	1999	1991	1999	1991	1999	1991	1999	1999	
T (°C)	18	18.0	18.5	18.3	17.5	18.2	17.6	18.0	18.1	19.2	17.4	18.5	-
pH	8.3	6.6	7.0	6.8	7.6	6.7	7.3	6.8	7.4	6.7	7.2	6.7	6.5-8.5
Fe (mg/l), x±SD	0.057	0.084± 0.004	0.237± 0.003	0.080± 0.005	0.415± 0.004	0.084± 0.004	0.434± 0.004	0.089± 0.005	0.480± 0.005	0.088± 0.004	0.425± 0.004	0.090± 0.002	0.3-1.0
Pb (mg/l), x±SD	-	0.026± 0.003	0.140± 0.004	0.022± 0.001	0.118± 0.002	0.029± 0.003	0.127± 0.002	0.023± 0.001	0.134± 0.003	0.024± 0.001	0.138± 0.003	0.043± 0.001	0.0-0.05
Zn (mg/l), x±SD	-	1.430± 0.02	1.425± 0.01	0.570± 0.006	0.543± 0.004	0.430± 0.004	0.350± 0.003	0.390± 0.003	0.385± 0.004	0.560± 0.006	0.564± 0.006	0.192± 0.003	5-15

x= mean value (n=18)
SD= standard deviation

The water temperature in the wastewater drainage opening to the lake ranged from 17.4 to 18.5°C. These values conform to the standards.

The measured pH values were between 7.0 and 7.6. These values are in the suggested pH range of TS 266.

While the metals iron and zinc are characterized as undesirable substances, lead is characterized as a toxic substance. The distributions of metal concentrations in surface sediments near the sampling stations were determined by Tuğrul and Morkoç[2]. The metal concentrations in the sediments were 4.7% (Fe), 36.5 mg/kg (Pb), 105 mg/kg (Zn). These high concentrations in the sediment can also cause metal pollution in the lake.

The values of iron were between 0.237 and 0.480 mg/l. These values are higher than those reported in our previous study. Figure 2 shows the remarkable increase observed in iron concentrations. The highest concentration of iron was observed at sampling point 4. The lowest concentration for iron, 0.237 mg/l, was recorded at sampling point 1. Fe concentrations were a little above the range (0.3-1.0 mg/l) given in the Turkish Standards.

Lead concentrations increased significantly at all points, compared with the values reported during the previous study and substantially exceeded the limit (0.05 mg/l). Figure 3 shows the increases observed in lead concentrations. Sampling point 1 exhibited a higher level of lead pollution than the others. The concentrations of lead were between 0.118 and 0.140 mg/l.

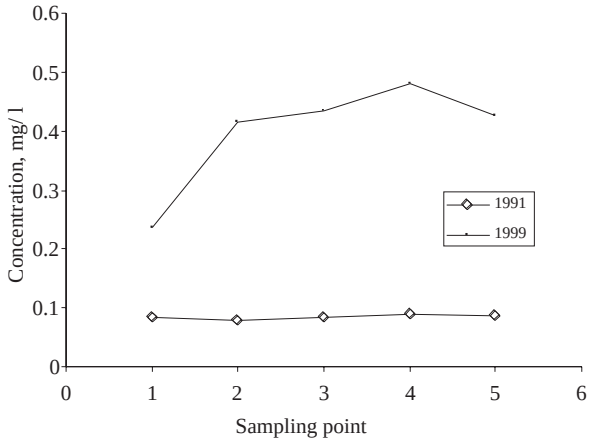

Figure 2. The annual variations in iron concentration at the sampling points

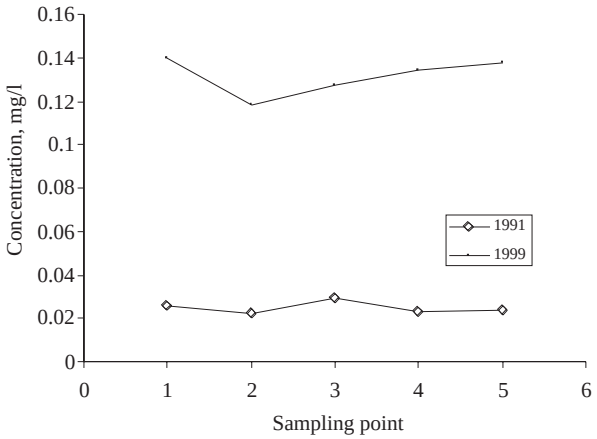

Figure 3. The annual variations in lead concentration at the sampling points

The levels of zinc at the sampling points varied between 0.350 and 1.425 mg/l. Zinc concentrations were found to be below the limit set by Turkish Standard TS 266 (5-15 mg/l) at all points. Zinc contents were found to be approximately at the same level compared to the previous study. Figure 4 shows the levels of zinc at sampling points. The highest concentration of zinc was observed at sampling point 1. This can most probably be attributed to a local source of pollution.

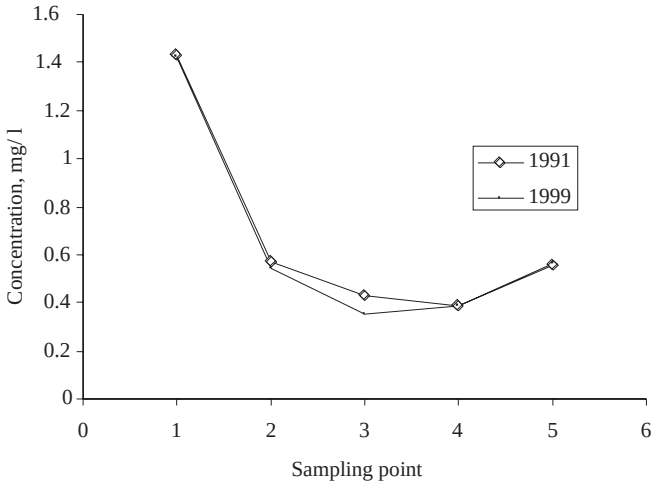

Figure 4. The annual variations in zinc concentration at the sampling points

Sampling point 6 values were measured in the lake water for comparison. The levels of heavy metals measured at this point were found to be lower. Its values were within the limits of Turkish Standard, TS 266.

The heavy metal content in the five locations studied may be presented in order of decreasing concentrations as follows:

1: Zn> Fe> Pb
2: Zn> Fe> Pb
3: Fe> Zn> Pb
4: Fe> Zn> Pb
5: Zn> Fe> Pb
Lake water : Zn> Fe> Pb

At the sampling points, the concentrations of Fe and Pb increased substantially while the changes in the concentration of Zn are not significant.

Conclusions

This study provides information on the extent of heavy metal pollution in Lake Sapanca over time. It is evident from the experimental results that the locations under study present serious problems to the ecosystem.

The levels of heavy metals measured were compared with those found in our previous study. The concentrations of Zn was found to be approximately the same. Fe and Pb concentrations increased significantly at all points and exceeded the limits. The elimination of the major pollution sources such as the motorway's wastewater drainages, and annual monitoring in order to follow the course of pollution will be the main steps for improving the water quality.

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