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Examination of Heavy Metal Levels in The Water and Sediment Samples Taken From Suğla Lake (Konya/Turkey)

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Abstract

This research has been conducted to determine the heavy metal accumulation in the water and sediment samples taken from Suğla Lake, which is one of the most important water sources of the Konya region. In this study, maintained in 2009-2010, the heavy metal accumulation has been examined seasonally within the time span of a year. At the end of the reseach it was concluded that the heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) accumulations in the samples of water and sediment show significant differences statistically between the seasons($p < 0.05$). The heavy metal measurement values in the water and sediment samples have been found to be under the level of the acceptable limits.

"Key words: Heavy metal, Konya, Sediment, Suğla Lake, Water;"

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Introduction

Environmental problems come at the top of the significant problems, threatening the ecological balance in today's conditions. Environmental pollution which emerged after urbanization, has increased in the parallel direction with the industrial development. The increasing environment pollution in the second half of the twentieth century as a result of the rapid increase in the population in recent years have resulted in the pollution of the life sources and as result, the breakdown of the ecosystem has dramatically taken a serious shape (Kaya et al. 1998; Yarsan et al., 2000). The release of the unrefined or insufficiently refined industry wastes along with urban wastes to the streams, lakes, and seas, have resulted in the pollution of the water sources. With the wastes, including heavy metals in their structures, produced by the industrial organizations, there has been a pollution in the aquatic environments (Bryan, 1976).

The greatest amount of the metals accumulate in the living beings. These metals, so long as accumulated more than some certain levels in the living beings, might cause to serious illnesses and even to death (Şengül, 1993; Kargı, 1995; Beyazıt & Peker 1998). Because of various reasons, the density of the heavy metal is increasing gradually in the natural water sources (Görmez, 1997). This heavy metals pollution in these sources have been the subject of many researches besides being perceived as a serious environment problem (Dural et al., 2007). In this study, the aim is to examine the pollution degree of some heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn) seasonally in the water and sediment samples taken from Suğla Lake and thereby to determine the reasons lying behind this pollution.

Materials and Methods

Suğla Lake, which is our research area, is in the 85 km distance of Konya's southwest. While in the rainy years the lake widens, in the dry years it dramatically narrows and the alluvial lake bottom comes to the surface. Suğla Lake, which is tectonic-based and a fresh water source, is an important source in terms of aquaculture and watering.

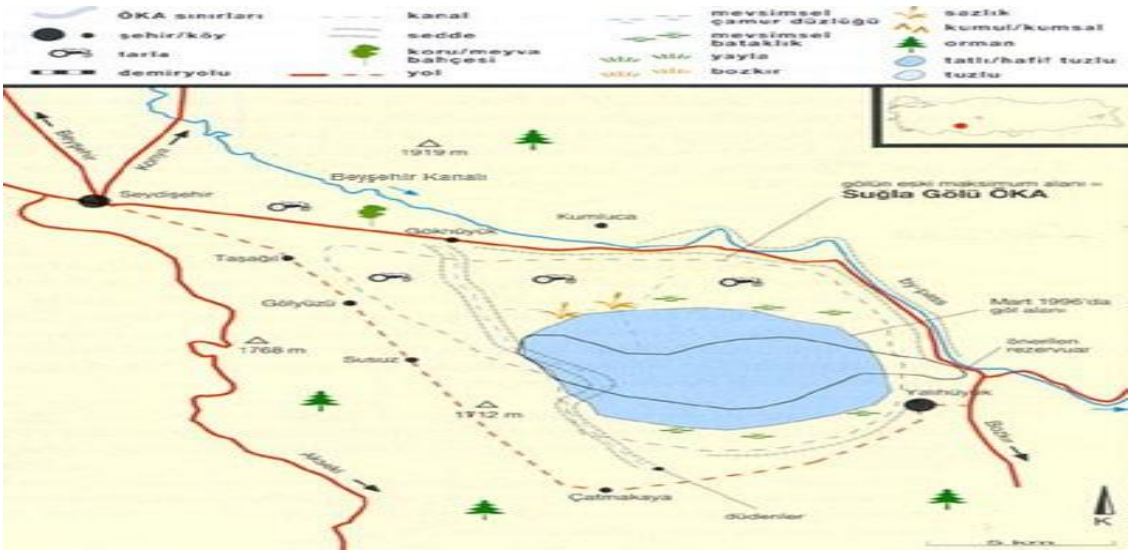

Figure 1. The map of Suğla Lake

Consisting of shallow water, the lake spreads to an area consisting of 18 600 ha. 145 million m3 water comes to the lake on average per year. A 4000 ha of the lake is restricted to the project, while the remaining 14 600 ha has been turned into a reliable agricultural area.

The study was conducted in 4 different stations chosen from Suğla Lake, to take the water and sediment samples. For each season, water and sediment samples were taken in April, July, October and January months.

In the previously determined station areas, nearly 5 m distant from the shore, water samples were taken and put into plastic bottles in the size of 500 ml. HNO3 in the proportion of 65% were added to the samples that had been taken (Cataldo et al., 2001).

The sediment samples taken with plastic shovels from the stations determined before distant from the shore about 5 m were put into plastic boxes and they were acided with HNO3 with the percentage of 65 %. The samples, by being put into transport containers, which include ice masses, were protected from the outer factors such as day light and heat, and they were brought to the laboratory in this manner within the same day. While the samples of the sediments were kept frozen at -18 ºC till they are analyzed, the samples of water were kept at refrigerators (Ünsal, 1998).

Heavy Metal Analysis in the Water Samples

First and foremost, so that there will be no infection, the materials that will be used in the study, were washed in the water prepared with 0.69% HNO3 and deioneized water, and then they were dried in the drying oven. The samples of the water were poured from the 100 mm blue band filter paper, and after this procedure, the

sample was made to be ready for the analysis by being put inside the falcon tubes after each sample was measured with tape measure as 25 ml.

Heavy Metal Analysis in the Sediment Samples

First of all, the sediment samples were sifted with a plastic sifter in the size of 63 µm. Some of the sediment samples were put into glass petri plates after they had been sifted, and they were dried by being kept in the drying oven at 102 ºC for 12 hours. The materials that had been dried were put to the glass erlenmayers which were temperature compensated, after they had been taken out of the drying oven and measured as 0.5 g in precision scales. Then, HC1: HNO3(King's water) was added over it in the amount of 3:1 and they were made to wait for 24 hours in the acid. After this procedure, over the hot plate watch crystal was put to the brims of the erlenmayer, and they were vaporized at 120 ºC till the white smoke came. After the crystalized samples had been cooled and filtered with 100 mm blue band filter paper, their volumes were made to reach to 25 ml with the deionized water (Unep, 1984).

Statistical Analyses

SPSS 15 program was used in the calculation of the statistical calculations. To determine the differences between seasons and stations in the samples of water and sediment, and also to determine the differences between tissues taken from the fish samples, One-Way Anova Post-Hoc test (Duncan) was used.

Results

Heavy Metal Concentrations in the Water Samples

According to the results of the analyses done in the water sediments, without taking into consideration the difference of season and stations, the average values of heavy metals concentrations for Cr, Cu, Fe, Mn, Ni, Pb and Zn are determined as 0.013, 0.006, 0.422, 0.039, 0.003, 0.0003, 0.021 mg l^{-1} respectively per year. Cd and Co metals were not found in any station in any season in this study. In the following tables, the seasonal station averages (Seasonal Averages) and station annual averages (Stational Averages) of the determined metals are given.

Table 1. The level of heavy metal in the water samples *ULA: Under the limit of analysis (mg l^{-1})

METAL	SEASON	STATION				Seasonal Mean±SD
		I.Station	II. Station	III. Station	IV.Station	
	Spring	ULA	ULA *	ULA	0.0002	0.00005±0.0001
	Summer	ULA	ULA	0.02	0.0442	0.016±0.021
Cr	Fall	ULA	0,0007	0.0006	ULA	0.0003±0.0004
	Winter	0.0212	ULA	0,009	ULA	0.007±0.010
	Mean±SD	0.0053±0,010	0.0001±0,0003	0.0074±0,009	0.011±0,022	0.013±0.02
	Spring	0.0049	0.0039	0.0067	0.0052	0.005±0.001
	Summer	0.0125	0.0056	0.0166	0.0115	0.011±0.004
Cu	Fall	0.0039	0.0027	0.0031	0.0016	0.002±0.0009
	Winter	0.0044	0.0032	0.0114	0.0044	0.006±0.004
	Mean±SD	0.006±0.004	0.003±0.001	0.009±0.005	0.005±0.004	0.006±0.003
	Spring	0.1916	0.108	0.3413	0.2257	0.216±0.096
	Summer	0.6704	17.712	13.398	0.3571	1.034±0.639
Fe	Fall	0.0835	ULA	0.276	ULA	0.089±0.130
	Winter	ULA *	0.2081	0.5188	0.6762	0.350±0.304

	Mean±SD	0.236±0.299	0.521±0.837	0.619±0.491	0.314±0.282	0.422±0.29
	Spring	0.0199	0.0036	0.0143	0.019	0.014±0.007
	Summer	0.1421	0.0647	0.0565	0.0243	0.071±0.049
Mn	Fall	0.0119	0.0529	0.0479	0.0375	0.037±0.018
	Winter	0.053	0.0072	0.0638	0.0123	0.034±0.028
	Mean±SD	0.056±0.059	0.032±0.031	0.045±0.021	0.023±0.010	0.039±0.018
	Spring	0.001322	ULA *	0.0017	ULA	0.0007±0.0009
	Summer	0.0017	0.0056	0.0048	0.02	0.008±0.008
Ni	Fall	0.0018	ULA	0.0015	ULA	0.0008±0.0009
	Winter	0.0094	ULA	ULA	0.0087	0.004±0.005
	Mean±SD	0.003±0.004	0.0014±0.0028	0.002±0.002	0.007±0.009	0.0033±0.0027
	Spring	0.0003	ULA *	ULA	ULA	0.00007±0.0001
	Summer	0.0010	ULA	0.0044	ULA	0.001±0.002
Pb	Fall	ULA	ULA	ULA	ULA	ULA
	Winter	ULA	ULA	ULA	ULA	ULA
	Mean±SD	0.0003±0.0004	ULA	0.001±0.002	ULA	0.0003±0.0004
	Spring	0.0065	0.0084	0.0096	0.0241	0.012±0.008
	Summer	0.0276	0.0189	0.0522	0.0696	0.042±0.023
Zn	Fall	0.0084	0.0078	0.0082	0.0059	0.007±0.001
	Winter	0.0388	0.0062	0.0426	0.0122	0.025±0.018
	Mean±SD	0.020±0.015	0.010±0.005	0.028±0.022	0.027±0.028	0.021±0.011

Heavy Metal in the Sediment Samples

According to the results of the analyses done in the samples of the sediments, without taking into consideration the differences of seasons and stations, the average annual values of heavy metals concentrations for Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn are found as 0.05, 13.03, 11.46, 10989.1, 231.7, 14.66, 5.30 and 31.22 μg g^{-1} dry weight

respectively. Co metal was not found in any season in any station in this study done on the sediment of Suğla Lake. In the following tables, the seasonal station averages (Seasonal Average) and station annual averages (Stational Average) of the determined metals are given.

Table 2. Heavy metal level in the sediment samples *ULA: Under the limit of analysis (mg l^{-1})

METAL	SEASON	STATION				Seasonal Mean±SD
		I.Station	**II. Station**	**III. Station**	**IV.Station**	
	Spring	0.1005	0.0427	0.0695	0.0412	0.06±0.02
	Summer	0.0497	0.0559	0.0569	0.0119	0.04±0.02
Cd	Fall	0.0502	0.0838	0.1012	0.1381	0.09±0.03
	Winter	0.0223	0.1448	0.1415	ULA*	0.07±0.05
	Mean±SD	0.05±0.03	0.08±0.04	0.09±0.03	0.04±0.06	0.06±0.02
	Spring	138.708	129.071	113.011	112.313	12.32±1.28
	Summer	105.153	109.859	79.788	89.886	9.61±1.38
Cu	Fall	142.395	128.389	13.332	128.643	13.31±0.65
	Winter	112.547	116.934	101.835	93.321	10.61±1.06
	Mean±SD	12.47±1.86	12.106±0.93	10.69±2.23	10.604±1.8	11.46±1.25
	Spring	12059.37	11084.07	10718.26	11603.58	11366.32±587.7
	Summer	8.558.143	7.819.273	8.363.831	8.130.112	8217.84±318.1
Fe	Fall	14633.18	14814.88	15280.36	14369.21	14774.4±383.7
	Winter	9.230.292	9.775.437	9.982.876	9.465.432	9613.5±332.3
	Mean±SD	11120±2790	10873±2950	11086±2964	10892±2724	10989.1±1846.4
	Spring	3.494.857	1.828.332	1.713.606	1.848.631	222.13±85.10
	Summer	2.090.584	2.354.927	1.723.343	1.961.727	203.26±26.32

Mn	Fall	2.450.497	2.061.749	2.302.562	2.931.964	243.66±36.69
	Winter	2.719.236	3.348.696	233.597	1.906.241	257.75±61.20
	Mean±SD	268.87±59.59	239.84±66.91	201.88±34.71	216.21±51.52	231.7±24.78
	Spring	178.951	139.661	14.459	146.825	15.25±1.788
	Summer	128.821	133.367	115.597	119.397	12.42±0.821
Ni	Fall	147.059	146.021	180.061	172.826	16.14±1.752
	Winter	148.879	169.861	15.192	122.378	14.85±1.958
	Mean±SD	15.092±2.076	14.72±1.594	14.804±2.648	14.035±2.489	14.66±1.08
	Spring	58.631	36.482	38.814	54.461	4.709±1.108
	Summer	39.469	68.856	37.883	59.304	5.13±1.519
	Fall	5.384	4.094	77.197	61.386	5.83±1.514
Pb	Winter	61.177	80.164	65.124	56.354	6.57±1.028
	Mean±SD	5.32±0.969	5.66±2.125	5.47±1.957	5.78±0.307	5.55±0.55
	Spring	325.209	372.945	31.393	296.016	32.7±3.288
	Summer	214.862	249.479	239.951	239.542	23.59±1.479
Zn	Fall	277.888	262.509	427.523	37.05	33.46±7.818
	Winter	378.418	416.589	347.544	263.946	35.16±6.491
	Mean±SD	29.9±6.956	32.53±8.225	33.22±7.781	29.25±5.690	31.22±3.63
	Spring	123.244	148.086	117.130	131.680	13.003±1.34
	Summer	97.445	86.078	111.299	123.149	10.44±1.61
Cr	Fall	159.184	148.271	160.367	178.131	16.14±1.23
	Winter	1.263.542	124.096	115.908	136.423	12.56±0.84
	Mean±SD	12.65±2.53	12.66±2.93	12.61±2.29	14.23±2.44	13.03±1.62

Discussion

As can be deduced from the analyses done, in water, Cd, Co, Ni and Pb were not found in any season. While Mn was found in all the seasons excluding spring, Mn, Fe and Zn were found in all the seasons. According to the results of the measurements done in water, Cr at summer (0.013mg l^{-1}), Cu at summer (0.006mg l^{-1}), Fe in the Summer (1.03 mg l^{-1}), Mn at summer (0.7mg l^{-1}), and Zn in the fall (0.3mg l^{-1}) reached to the highest rates. Besides, it was determined that, Fe was the metal found at the highest level in water.

Morel and Hering, in a study done in 1993 (Morel & Hering, 1993) determined that the concentrations of the heavy metals in water was influenced by the pH value of the environment, and thereby as they will be in the dissoluble condition in an acidic environment, they will be found more, whereas when the pH of water is basic, it gets difficult for the metals to depart from the ions that they had united. In the measurements done in this study, the pH of water was measured between 8.45-8.72. In this pH ranges, as the metals were not in the dissolved position, the metals in the water were either not found, or found very little. This condition shows that the studies done before and these new results support each other.

In a study done in the Habbaniya Lake in Irak in 2002 (Al-Saadi et al., 2002), Al-saadi et.al. stated that in Habbaniya Lake, Zn is the most accumulated metal and is followed by Cu, Pb, Ni, Mn and Cd. They stated that Cd, Co, Hg, Mo and Pb were under the AAS analysis limit. In the reseach done in New Calabar Lake in Nigeria in 2003 (Odokuma & Ijeomah, 2003), Odokuma and Ijeomah stated that the heavy metal concentration in the water of New Calabar River is higher at summer and winter seasons when compared with the spring and fall seasons. In a study in 2004 (Özmen et al.,

2004), Özmen et.al. determined Zn, Fe, Mn, Ni, Cu and Pb in the water of Hazar Lake. In the evaluation which is done seasonally, they determined that the highest heavy metal accumulation was in the spring season. In a research done in 2004 (Özmen et al., 2004), Tekin-Özan et. al. found Fe, Zn and Mn in the water of Kovada Lake, and determined that Cu, Cr, Pb and Cd were under the limit of AASS analysis limit. Besides, they stated that the highest heavy metal accumulation occurs in the summer season.

In this research, it is determined that the heavy metal concentration in the lake water increases in the summer months and decreases in the spring months. This shows that the researches done before supports our study. It is believed that the dense evaporation in the summer months causes the increases in the amount of metals. Also it is believed that in the spring months the density of raining along with the union of the melting snow water in the lake, makes the water of the lake more concentrated and thereby leads to the decrease in the amounts of the metals.

In a research done in 1998 (Abdel-Baky et al., 1998)) in the water samples taken from 5 different stations from Manzalah Lake and analysed, Abdel-Baky et.al found that the heavy metal concentrations are as Zn>Pb>Cd>Cu . The same researches also stated that though there was not an important difference among the stations, there was significant seasonal variations in the metal concentrations that were under research. In Liza ramada, Liza aurata, Mugil cephalus, Dicentrarchus labrax, Dicentrarchus punctata, Sparus auratus and Therapon theraps tissues, mg kg^{-1} wet weight was determined as Zn (2.25-9.29)>Cu (0.026-0.305)>Cd (0.026-0.059). In the samples of water, as mg l^{-1} this range is determined as Zn (0.06-0.995)>Cd (0.096-0.162)>Cu (0-0.22) . According to the data provided from this research, while the amount of Zn is again in the top rank, in the concentrations of Cu, Pb and Cd there were not significant

variations. While the amount of Pb and Cd metals were under the measurement limit, Zn concentration was determined as 0.3 mg l^{-1}, and Cu as 0.006 mg l^{-1}.

Sediment is the place where the heavy metals accumulate densely. Cd metal which was not found in the water, and also Cr and Pb metals which were rarely found in the water in this study, were found in the sediment samples. According to Hadring et. al. (1978) (Hadring & Whitton, 1978), this condition is related with the fact that the sediment particles absorb the metals in the water and the metals with high molecular weight fall down to the bottom.

Zhou et.al. (1998) (Zhou et al., 1998) stated that Cd is the metal which accumulates least in the sediment. Besides, they determined Ni, Cr, Cu, Pb and Zn in their study. Baron et.al. (1990) (Baron et al., 1990) stated that Cd was found in low level in the compound of the organic materials present in the sediment. The fact that in the research in Suğla Lake Cd was the the least accumulated metal in the sediment proved these researches true. Akköz and Yılmaz (2009) (Akköz & Yılmaz, 2009), in the water samples taken from Suğla Lake from 4 distinct stations through six months, tried to determine the levels of Fe, Cr, Cu, Ni and Zn metals and some chemical parameters. And at the end of the research they had done, they concluded that respectively, Cr metal was in the highest level at 1st station in 2006 July as 0.29 mg/l, Cu metal was in the highest level in the 2nd station in 2006 May as 0.31 mg/l, Ni metal was the highest level in the 3rd station in 2006 March as 0.53 mg/l.

The heavy metal concentrations measured in the water samples taken from four different stations seasonally from Suğla Lake in this research, were determined as Cd; 0, Co; 0, Cr; 0.013, Cu; 0.006, Fe; 0.422, Mn; 0.039, Ni; 0.003, Pb; 0.0003 and Zn; 0.021. The most accumulated metal in the water was stated to be Fe and besides, it was stated

that accumulation occurs mostly in the summer season. As Cd, Co were under the measuring range, they were not found in any season. As it was under the measuring range, Cr was not found in the spring in the 1st, 2nd and 3rd stations, and at summer, in the 1st and 2nd stations, in the fall in 1st and 4th stations, in the winter 2nd and 4th stations. As it was under the measuring range, Fe was not found in the fall in the 1st station and in the winter in 2nd and 4th stations. As it was under the measuring range, Ni was not found in the spring in the 1st and 2nd stations, in the fall in the 2nd and 4th stations, in the winter in the 2nd and 3rd stations. As it was under the measuring range, in the spring in the 2nd, 3rd, and 4th stations, at summer in the 2nd and 4th stations, and in all the stations in the the fall and winter seasons, Pb was not found.

The accumulation in sediment when compared with water is observed to be higher in terms of all the metals excluding Zn. Zn levels were found highest in Carp. Though in general, the listing of the accumulation is as water < fish < sediment, in terms of Zn it is found to be water <sediment< fish.

As a result, it has been determined that the heavy metal concentrations in the lake water is within acceptable limits for EPA. Heavy metal pollution in the lake water is not dangerous, and thereby there is no risk in their irrigation.

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