DETERMINATION OF SOME METAL LEVELS IN WATER, SEDIMENT AND FISH SPECIES OF TERCAN DAM LAKE, TURKEY

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Abstract. This study aimed to determine the metal (Al, As, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) levels in the gill, liver, and muscle tissues of some fish species, water and sediment samples taken from Tercan Dam Lake (Erzincan, Turkey). Initially, some physico-chemical parameters of the water such as temperature, pH, and dissolved oxygen were measured, and the relationship was determined between these parameters and the metal levels detected in the water. According to the analysis conducted on the water and the sediment, the most frequent metal was determined to be Fe. During the analyses conducted in the water, Pb and Zn metals were not detected, and all metals were detected in the sediment. It was determined that metals accumulated to a higher degree in the liver and gill tissues compared to muscle tissues. The harmfulness of the metal amounts determined in the water, sediment, and fish tissues was evaluated by comparing them to the acceptable values determined by national and international institutions.
Keywords: *accumulation, toxicity, Tercan Dam Lake, water contamination, physico-chemical parameters*

Introduction

The aquatic ecosystem, being part of the biosphere, is a receiver and carrier environment for the waste water and used water in the system, it is more exposed to contamination compared to air and soil (Yarsan et al., 2000). Water, which is in a constant cycle on the earth, loses its environment as a result of mostly human activities. Consequently, the water contamination occurs. Undoubtedly, the leading contaminators are the metals, which are common in today's aquatic ecosystem and which cause high rates of toxicity in aquatic organisms. Metals in general have a particular significance among other chemical contaminators since they can emerge from very different sources, cause a vast amount of contamination, continuously affect the biological systems, and—entering the food chain—can simply accumulate in developed living beings with increasing intensities (Erdoğrul and Ates, 2006).

Metals are carried towards waters by rock fragments through erosion, dust particles carried by the wind, volcanic activities, and forest fires. Metals dissolved in the water merge into the sediment by precipitating to the bottom, and thus, the metals accumulate at the sediment (Fergusson, 1990). The concentration of the metals accumulating at the sediment varies based on the ratio of the sediment particles, the size of the particles, and based on whether there are organic substances in the sediments. Since the sediment is an important accumulation environment for the metals, it is used in determining the metal contamination of the aquatic environments (Salomans et al., 1987).

The fish take the metals through nutrition, water, gills and skin from the external environment. The amount of the metals accumulating at different tissues of the fish vary according to the amount of metal in the environment, the type of the metal, the interaction duration of metal and the fish, the age and metabolic activities of the fish, the phase of its development, the physico-chemical characteristics of the water, tissues, and organs (Köse and Uysal, 2008). The metals received by the fish reach to the tissues and organs via blood path bonded to the carrier protein, and they reach high concentration levels through being bonded by the metal bonding proteins (Sönmez et al., 2016). Metals show their toxic effects on cell membranes, enzymes, and cell organelles in general (Kirici et al., 2017a). The toxicity of metals involves the interaction between the toxicological target and the free metal ions. Additionally, the cells (liver, renal tubular, gastrointestinal), which make metal transfer during their tasks, are the most toxic-effect-sensitive cells (Elbeshti et al., 2018).

Numerous studies have been conducted on the accumulation of metals in water, sediments, and fish (Moiseenko and Kudryavtseva, 2001; Al-Saadi et al., 2002; Özmen et al., 2004; Tekin-Özan et al., 2007; Tao et al., 2011; Tekin-Özan and Aktan, 2012; Başyiğit and Tekin-Özan, 2013; Kirici et al., 2013a, 2016a, 2017b). In this study, it was aimed at determining the metal (Al, As, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) concentrations in the gills, livers, and muscle tissues of Grass carp (*Ctenopharyngodon idella*), Caner fish (*Barbus capito*), Common carp (*Cyprinus carpio*) and Tigris scraper (*Capoeta umbla*), which live in the Tercan Dam Lake—within the borders of Erzincan province—water, sediment, and lake; it was also aimed at determining the relationship between metal levels in the water and the measured certain physico-chemical parameters of the water.

Materials and methods

Research area

Tercan Dam Lake is located 3 km to the Tercan district of Erzincan province (Turkey). The Dam Lake was inaugurated in 1988 for irrigation and energy. The lake has a surface area of 8.85 km^2, a drainage volume of 178 million m^3, and an irrigation area of 29725 ha. It is located between 39°44’2” north latitude and 40°26’40” east longitudes (*Fig. 1*). Tercan Dam Lake is fed by Tuzla Brook, Çirkiz Brook, Bülbül Brook and Pırnaşil Brook.

Field studies

The research study was conducted through samples taken from 3 stations between March 2018 - May 2018. The water (500 mL water samples were taken from each station) and sediment samples (3 g sediment samples were taken from each station) were taken from each station 3 times in different days, which was repeated 3 times per-month. As per the fish samples (grass carp (n = 22), Caner fish (n = 21), Common carp (n = 25) and Tigris scraper (n = 29)), they were obtained by means of fishermen fishing in the area. During the study, the temperature, pH, and dissolved oxygen amount of the water were measured through the Jenco 6010 (Jenco Instruments Co. China) brand portable multi-parameter. The water, sediment, and fish samples taken from the lake

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were brought to the laboratories after being contained in sample containers under cold storage conditions. The water samples were treated with HNO_3 with a 2% concentration ratio. The water samples were kept at +4 °C until (24 h) they were analyzed. The sediment samples were taken through ekman spoonnet, being brought to the laboratory within propylene containers.

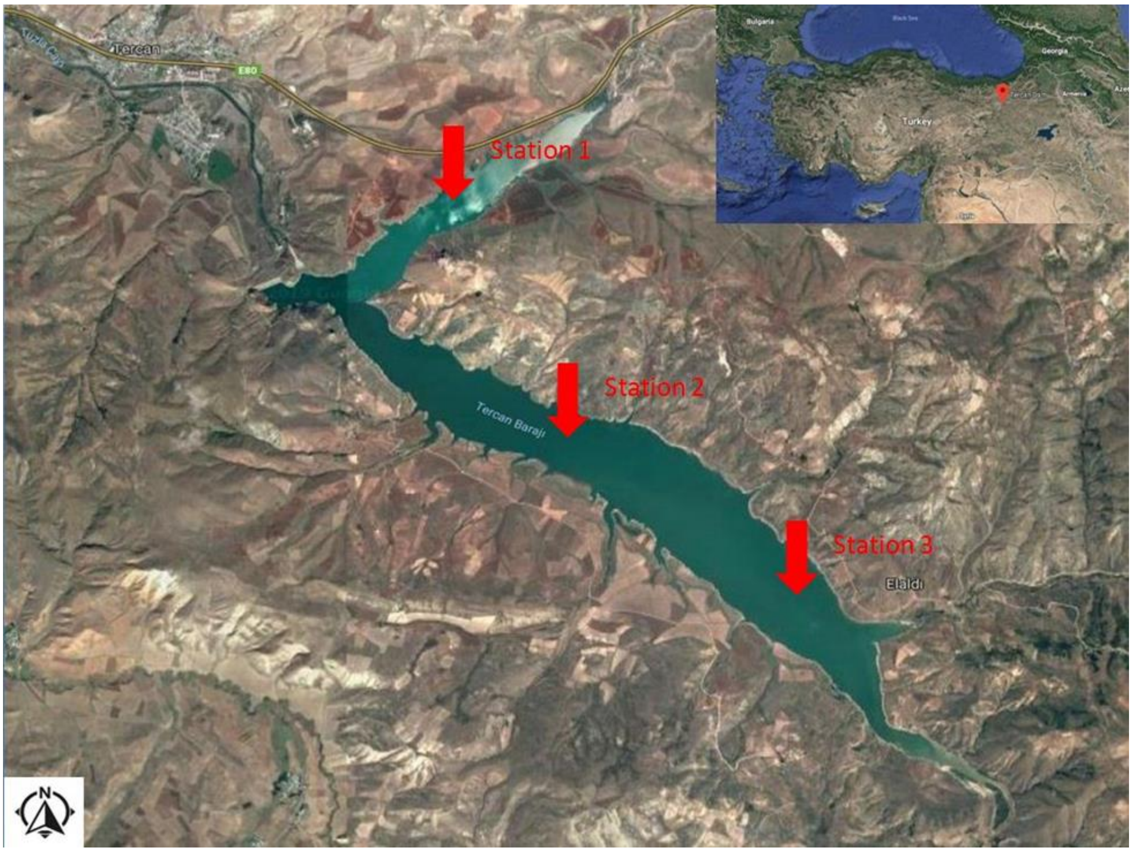

Figure 1. *Tercan Dam Lake*

Laboratory studies

The samples of water, sediment, and fish were brought to the Chemistry Laboratory of Erzincan University Basic Sciences Research and Application Center for laboratory studies. The weights of the fish were measured via scales and their total lengths were measured via measuring board with ± 1 mm precision. Subsequently, muscle, liver, and gill tissue samples of the fish were taken.

In order to determine the Al, As, Cr, Cu, Fe, Mn, Ni, Pb, and Zn accumulation concentrations in the muscle, gill, and liver tissues of the fish, 3-5 g samples were taken from each tissue. The tissue samples were put into heat-proof glass bottles and kept under 105 °C for 24 h in the Drying Oven for drying, and subsequently they were left for cooling down for 24 h. After pulverizing each sample and limiting them to 0.5 g via the precision scale, they were placed into teflon microwave tubes. Adding 7 ml HNO_3 and 1 ml H_2O_2, they were kept at ambient temperature for 24 h. The samples were shaken in the vortex for 10 min, thus, they were mineralized. Placed into microwave tubes, the samples were burnt at 110 °C at 700 W for 45 min. After opening the samples in the fume cupboard, their weights were increased to 200 ml by adding deionized

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water. Filtered through a teflon filter, the samples were made ready for the analysis. The metal analyses of the prepared samples were measured through ICP-MS device (Sökmen et al., 2018).

The sediment samples to be analyzed were taken from the lake via ekman spoonnet and placed into containers, and they were kept in deepfreeze until the analysis. For the measurement, 1 g was taken from each sample and placed into microwave solubilization tubes. Adding 5 ml HNO_3 and 1 ml H_2O_2 into each tube, they were exposed to solubilization process in a microwave oven (Milestone Ethos Plus 2000). Taking the tubes out from the oven, they were cooled down at the ambient temperature and the solutions in the tubes were transferred into 25 ml polypropylene volumetric flasks. The solution amounts in the volumetric flasks were completed to 25 ml by adding distilled water. The metal analysis of the samples was conducted in the (Perkin Elmer, 5300 DV model) ICP-OES device. The metal analyses of the water samples were directly conducted. The detection limits of the elements were Cd 0.0012 ppm, Cr 0.0027 ppm, Cu 0.0069 ppm, Fe 0.0381 ppm, Mn 0.001 ppm, Pb 0.0078 ppm, Zn 0.0015 ppm, Al 0.0057 ppm, and Ni 0.0048 ppm (Tekin-Özan and Kır, 2005).

Statistical analyses

The minimum-maximum values, arithmetic means, and standard deviation values of the results obtained in the study were calculated. Pearson Test was applied to determine the relationship between the physico-chemical parameters (temperature, pH, and dissolved oxygen) of the water and metal amounts. All of the statistical calculations were conducted through SPSS 17 package program.

Results and discussion

In this study, the metal (Al, As, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) concentrations were determined in the gill, liver, and muscle tissues of grass carp, Caner fish, common carp and Tigris scraper fish living in the water, sediment, and lake of the Tercan Dam Lake. Additionally, the relationship between the physico-chemical parameters and metal levels in the water was determined.

During the study, the water temperature, pH value, and dissolved oxygen amounts of the Tercan Dam Lake were measured and given in the *Table 1*. According to the *Table 1*, the highest temperature is 14.2 °C, while the lowest is 8.3 °C, and the mean temperature is 11.4 °C.

The results of the metal analyses conducted in the Tercan Dam Lake are given in the *Table 2*. As the conclusion of the metal analyses conducted in the water, it was determined that the highest accumulated metal in the water was Fe metal. Besides, the Pb and Zn metals were under the analysis limitations. The ranking of the mean values of the accumulation in the water was determined as Fe > Al > Ni > As > Cu > Mn > Cr. Reporting that the highest accumulated metal in the Habbaniyah Lake (Iraq) was Zn, Al-Saadi et al. (2002) stated that it was followed, respectively, by Cu, Pb, Ni, Mn and Cd metals. It was also mentioned that the Cd, Co, Hg, Mo, and Pb were under the AAS analysis limitations. In a study conducted in the Texoma Lake by An and Kampbell (2003) it was mentioned that the highest metal concentrations in the water were Na and Ca, and subsequently Mg and K. In a study conducted in the Kovada Lake by Tekin-Özan et al. (2004), Fe, Zn, and Mn were determined in the waters of the lake, and it was also determined that the levels of Cu, Cr, Pb and Cd were under the AAS analysis

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limitations. Similarly, in a study conducted in the Kovada Lake by Kır et al. (2007), it was determined that the most frequent metal encountered in the water was Fe. In a study conducted in the Taihu Lake (China), it was determined that the highest accumulated metal in the water was Zn, while the least accumulated one was Cd (Tao et al., 2012). Similarly, in a study conducted in the Panjkora River (Pakistan), the highest accumulated metal in the water was Zn, while the least accumulated metal was Cd (Ahmad et al., 2014).

Table 1. *Maximum, minimum, mean and standard deviation values of the temperature, pH, and dissolved oxygen values in the Tercan Dam Lake*

	Temperature	pH	Dissolved oxygen (mg/L)
Minimum	8.3	7.7	8.3
Maximum	14.2	8.1	9.2
Mean	11.4	7.9	8.7
Standard deviation	2.42	0.17	0.39

Table 2. *Maximum values, minimum values, mean values (ppb), and standard deviation values of the metal concentrations measured in the Tercan Dam Lake*

	Al	As	Cr	Cu	Fe	Mn	Ni	Pb*	Zn*
Minimum	2.167	1.430	0.003	0.112	4.737	0.045	0.459	-	-
Maximum	4.152	2.219	0.143	0.460	7.016	0.316	4.568	-	-
Mean	3.466	1.811	0.037	0.268	5.703	0.139	1.896	-	-
Standard deviation	0.921	0.229	0.024	0.089	0.965	0.023	0.743	-	-

*Below the analysis limitations

As the conclusion of the metal analyses conducted in the waters of the Tercan Dam Lake and comparing the metal levels of the study to the acceptable heavy metal amounts in the water determined by the World Health Organization (WHO), Turkish Standards Institute (TSI), and Turkish Ministry of Food, Agriculture, and Livestock (MFAL), and United States Environmental Protection Agency (USEPA), it was determined that all metal levels were under the acceptable values.

Using the Pearson Test, the relationships were determined between the temperature, pH, and dissolved oxygen amounts and the metal levels determined in the water, which are all given in the *Table 3*. According to this, there is a negative relationship between the temperature and the Ph, and there is a positive relationship between temperature and dissolved oxygen. In other words, while the temperature increases, pH value decreases, and the dissolved oxygen amounts increase. There is a negative relationship between the pH and dissolved oxygen, in other words, while pH increases, the dissolved oxygen amounts decrease. The pH value has a negative relationship with Cr, Cu, and Ni; while it has a positive relationship with Al, As, Fe, and Mn. While the dissolved oxygen has a negative relationship with Al, Cr, Cu, and Fe, it has a positive relationship with As, Mn, and Ni. Moreover, there are statistically significant differences between dissolved oxygen and As, between dissolved oxygen and Cu, and between Al and Ni (< 0.05).

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Table 3. *Values of some physico-chemical parameters and metals measured in the waters of Tercan Dam Lake determined via Pearson test*

	Temperature	pH	Dissolved oxygen	Al	As	Cr	Cu	Fe	Mn	Ni
Temperature	1	-0.569	0.457	-0.403	0.433	-0.049	-0.267	-0.221	0.380	0.491
pH		1	-0.035	0.519	0.367	-0.258	-0.106	0.591	0.213	-0.249
Dissolved oxygen			1	-0.647	0.753*	-0.509	-0.731*	-0.473	0.280	0.402
Al				1	-0.211	0.029	0.291	0.656	-0.183	-0.695*
As					1	-0.404	-0.602	0.046	0.421	0.353
Cr						1	0.467	-0.226	0.065	-0.002
Cu							1	0.243	0.050	0.058
Fe								1	0.182	-0.095
Mn									1	0.563
Ni										1

*0.05 significance level

The metal amounts determined in the sediment samples taken from the Tercan Dam Lake are given in *Table 4*. As the conclusion of the metal analyses on the sediment, it was determined that the highest accumulated metal in the lake waters was Fe, and the lowest one was As. According to the ranking of the mean values of the accumulation in the water, it was determined as Fe > Al > Mn > Cr > Ni > Zn > Cu > Pb > As. In the study conducted in the Texoma Lake (USA), An and Kampbell (2003) determined that the metal accumulation mean values ranking was Ca > Al > Fe > K > Mg > Na. Özmen et al. (2004) conducted a research about some certain heavy metal accumulations in the Caspian Sea (Zn, Fe, Mn, Ni, Cu, Cr, Co and Pb). As the conclusion of the study, it was determined that the ranking of the major elements and heavy metal concentrations in the sediment was Fe > Mg > Ca > Mn > Zn > Ni > Cr > Cu > Co > Pb. In another study conducted in Uluabat Lake, Kurtoğlu (2006) detected that the heavy metals had a ranking such as Pb > Cu > Cr > Ni > Cd > Zn in the sediment samples. In another study conducted in the Cauvery River (India), Venkatesha et al. (2012) examined heavy metals such as Fe, Zn, Ni, Mn, Pb, Cu, Co, Cd and Cr in the sediment samples. As the conclusion of the study, it was determined that the highest accumulated metal in the sediment was Fe. It was followed by, respectively, Mn, Cr, Zn, Ni, Cu, Pb, Co, and Cd metals. In a different study conducted in Odiel River (Spain) by Usero et al. (2003), it was determined that the highest accumulated metal in the sediment was Fe. Usero et al. (2003) explained the reason that the metal that existed in the earth's crust at the highest level was Fe, that was why it was at higher levels in the lake, river, and sea sediment compared to other metals.

When the analysis results of the sediment samples taken from the Tercan Dam Lake were compared to the data of the American National Oceanic and Atmospheric Administration (NOAA), it was determined that all the metals were below the acceptable levels.

The number, total length, and weights of the fish caught by the help of the fishermen fishing in the region are given in *Table 5*. In the study, 22 grass carp fish were used with a length of 29.6 ± 1.02 cm, and weighting 409.4 ± 13.64 g, 21 Caner fish fish were used with a length of 43.2 ± 5.11 cm, and weighting 648.6 ± 15.70 g, while 25 common carp fish were used with a length of 31.2 ± 1.46 cm, and weighting 337.2 ± 10.88 g, and 29 Tigris scraper were used with a length of 32.8 ± 2.48 cm, and weighting 385.1 ± 13.5 g.

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Table 4. *Maximum values, minimum values, mean values (mg/kg), and standard deviation values of the metal concentrations measured in the Tercan Dam Lake sediment*

	Al	As	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Minimum	799.091	0.001	2.931	2.149	863.582	31.474	1.169	2.426	1.550
Maximum	1131.294	0.041	66.099	14.533	7731.094	153.228	42.461	7.783	39.148
Mean	936.438	0.015	39.362	5.979	3816.004	102.253	17.944	4.588	17.701
Standard deviation	16.593	0.006	1.684	0.460	22.766	7.160	3.724	0.306	3.948

Table 5. *Weight and length averages of the fish caught*

Fish species	Total length (cm)	Weight (g)	Fish number
Grass carp (*Ctenopharyngodon idella*)	29.6 ± 1.02	409.4 ± 13.64	22
Caner fish (*Barbus capito*)	43.2 ± 5.11	648.6 ± 15.70	21
Common carp (*Cyprinus carpio*)	31.2 ± 1.46	337.2 ± 10.88	25
Tigris scraper (*Capoeta umbla*)	32.8 ± 2.48	385.1 ± 13.53	29

The amounts of metal (Al, As, Cr, Cu, Fe, Mn, Ni, Pb, and Zn) concentrations determined in the gill, liver, and muscle tissues of the Caner fish, Tigris scraper, grass carp and common carp that were caught in the Tercan Dam Lake are given in the *Tables 6, 7, 8* and *9*, respectively.

Table 6. *Maximum, minimum, mean values (mg/kg), and standard deviation values of the metals measured in muscle, liver, and gill tissues of the Caner fish (Barbus capito)*

Tissue	MUSCLE				LIVER				GILL			
Metal	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.
Al	-	-	-	-	0.906	7.817	2.953	0.126	0.145	3.804	1.375	0.144
As	-	-	-	-	0.021	0.187	0.057	0.009	0.032	0.394	0.124	0.028
Cr	0.087	0.192	0.106	0.034	0.031	0.304	0.084	0.005	0.027	1.136	0.398	0.052
Cu	0.008	4.284	0.882	0.013	0.435	57.114	15.888	0.216	0.744	60.003	11.119	2.187
Fe	8.270	124.041	43.638	1.020	16.496	918.684	420.160	8.320	16.496	679.166	195.062	5.792
Mn	0.017	0.571	0.343	0.044	0.562	18.523	7.662	0.672	0.529	16.656	5.714	0.544
Ni	-	-	-	-	0.004	0.173	0.042	0.006	0.028	0.741	0.213	0.016
Pb	-	-	-	-	0.016	0.227	0.090	0.017	0.008	0.067	0.032	0.008
Zn	21.048	237.530	77.936	4.050	0.334	241.328	88.507	3.074	0.334	241.328	91.691	1.935

Table 7. *Maximum, minimum, mean values (mg/kg), and standard deviation values of the metals measured in muscle, liver, and gill tissues of the Tigris scraper (Capoeta umbla)*

Tissue	MUSCLE				LIVER				GILL			
Metal	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.
Al	7.613	57.754	20.009	4.270	37.087	215.078	90.044	11.670	44.105	199.086	96.595	7.749
As	-	-	-	-	0.087	0.479	0.160	0.077	0.045	0.601	0.186	0.091
Cr	0.009	0.054	0.023	0.006	0.753	8.715	2.088	0.723	0.317	12.593	2.455	0.613
Cu	0.108	1.091	0.239	0.082	49.347	358.440	141.470	6.078	0.447	1.928	0.378	0.170
Fe	1.795	43.138	8.986	1.708	117.448	1512.825	486.326	14.719	27.623	122.437	74.916	6.471
Mn	3.186	29.138	9.149	3.485	26.678	120.188	61.528	3.271	9.873	45.415	19.671	2.483
Ni	-	-	-	-	0.953	6.910	2.278	0.240	0.523	7.812	1.667	0.754
Pb	0.316	2.281	0.640	0.150	0.520	3.739	2.074	1.141	0.364	1.733	0.547	0.050
Zn	3.832	54.958	11.703	2.165	3.180	69.201	34.972	5.659	12.385	75.248	37.777	3.762

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Table 8. *Maximum, minimum, mean values (mg/kg), and standard deviation values of the metals measured in muscle, liver, and gill tissues of the Grass carp (Ctenopharyngodon idella)*

Tissue	MUSCLE				LIVER				GILL			
Metal	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.
Al	1.598	8.021	3.069	0.740	2.003	40.217	19.322	3.161	2.714	19.357	10.136	5.983
As	-	-	-	-	-	-	-	-	0.190	1.675	0.774	0.543
Cr	-	-	-	-	0.009	1.136	0.458	0.052	0.012	0.075	0.049	0.026
Cu	0.321	1.723	0.792	0.157	1.122	7.248	4.185	0.251	0.132	2.014	0.882	0.694
Fe	4.170	39.071	27.350	5.412	26.966	104.672	59.277	2.833	7.745	53.402	23.452	3.025
Mn	0.003	0.441	0.014	0.001	0.617	6.218	2.859	0.202	4.021	11.116	7.349	2.596
Ni	-	-	-	-	-	-	-	-	0.019	0.205	0.122	0.065
Pb	0.030	0.991	0.318	0.026	0.013	0.624	0.455	0.146	0.017	0.256	0.116	0.011
Zn	8.763	40.137	18.922	1.257	5.823	61.673	23.709	0.193	79.397	259.631	164.827	5.676

Table 9. *Maximum, minimum, mean values (mg/kg), and standard deviation values of the metals measured in muscle, liver, and gill tissues of the Common carp (Cyprinus carpio)*

Tissue	MUSCLE				LIVER				GILL			
Metal	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.	Min	Max	Mean	St. dev.
Al	13.294	266.814	193.973	12.270	456.053	1120.483	807.121	9.627	7.575	97.435	39.624	2.092
As	-	-	-	-	0.057	0.449	0.265	0.146	0.057	0.923	0.383	0.083
Cr	0.198	1.336	0.592	0.445	0.078	2.608	1.409	0.011	0.314	2.692	0.918	0.042
Cu	-	-	-	-	17.069	100.169	46.023	2.831	0.789	6.045	2.695	0.517
Fe	10.766	194.636	87.463	7.210	450.917	1098.847	764.449	4.261	26.848	742.849	330.265	7.924
Mn	6.273	24.114	15.193	6.603	1.749	39.443	26.754	5.254	7.760	104.033	34.735	0.903
Ni	0.025	0.854	0.326	0.092	0.326	3.091	2.584	1.133	0.398	1.300	0.569	0.131
Pb	-	-	-	-	0.279	0.988	0.534	0.253	0.534	1.370	0.962	0.253
Zn	4.219	11.731	8.301	2.490	23.148	109.507	52.752	7.153	11.007	0.945	4.264	1.327

It was determined that the metal accumulation in the muscle tissues of Caner fish was Zn > Fe > Cu > Mn > Cr, while the accumulation in the liver tissues of the same species was Fe > Zn > Cu > Mn > Al > Pb > Cr > As > Ni, and the accumulation in its gill tissues was Fe > Zn > Cu > Mn > Al > Cr > Ni > As > Pb. Additionally, it was determined that the accumulation of Al, As, Ni, and Pb metals in the muscle tissues of the Caner fish were lower than the analysis limitations (*Table 6*). It was determined that the metal accumulation in the muscle tissues of Tigris scraper was Al > Zn > Mn > Fe > Pb > Cu > Cr, while the accumulation in the liver tissues of the same species was Fe > Cu > Al > Mn > Zn > Cr > Ni > Pb > As, and the accumulation in its gill tissues was Al > Fe > Zn > Mn > Cr > Ni > Pb > Cu > As. Additionally, it was determined that the accumulation of As and Ni metals in the muscle tissues of the Tigris scraper were lower than the analysis limitations (*Table 7*). It was determined that the metal accumulation in the muscle tissues of grass carp was Fe > Zn > Cu > Al > Pb > , while the accumulation in the liver tissues of the same species was Fe > Zn > Al > Cu > Mn > Cr > Pb, and the accumulation in its gill tissues was Zn > Fe > Al > Mn > Cu > As > Ni > Pb > Cr. Additionally, it was determined that the accumulation of As, Cr, and Ni metals in the muscle tissues of the grass carp, and those of As and Ni metals in the liver tissues of it were lower than the analysis limitations (*Table 8*). It was determined that the metal accumulation in the muscle tissues of

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common carp was Al > Fe > Mn > Zn > Cr > Ni, while the accumulation in the liver tissues of the same species was Al > Fe > Zn > Cu > Mn > Ni > Cr > Pb > As, and the accumulation in its gill tissues was Fe > Al > Mn > Zn > Cu > Pb > Cr > Ni > As. Additionally, it was determined that the accumulation of As, Cr, and Ni metals in the muscle tissues of the common carp were lower than the analysis limitations (*Table 9*).

There have been numerous research studies conducted in various parts of the world on the accumulation of metals in fish tissues and their detrimental effects on the tissues (Moiseenko and Kudryavtseva, 2001; Uysal et al., 2008; Kirici et al., 2013b, 2016b; El-Moselhy et al., 2014; Baharom and Ishak, 2015; Bosch et al., 2016; La Colla et al., 2017, 2018). For instance, in a study conducted on Avşar Lake (Turkey), Öztürk et al. (2009) examined the metal accumulation concentrations in the muscle, liver, and gill tissues of the Carp, and as the conclusion of the study, it was determined that the Fe metal had the highest accumulation level while Cd had the least. The ranking of metal accumulation in the tissues was determined as Fe > Cu > Pb > Ni > Cr > Cd in the muscle, and Fe > Cu > Ni > Pb > Cr > Cd in the gill and liver. Malik et al. (2010) determined the seasonal changes of some certain heavy metals (Cd, Cr, Cu, Hg, Ni, Pb, Zn) in the muscle, liver, gill, and kidneys of *Labeo rohita* and grass carp species in the Bhopal Lake (India). It was determined that, for the both fish species, the metals accumulated mostly in the livers and at the least levels in the muscles. While the highest accumulated metal in the fish was Zn, it was determined that Hg had the lowest level of accumulation. Taweel et al. (2013), examined the accumulation of Cu, Cd, Ni, Pb, and Zn in the muscle, liver, and gills of Tilapia fish (*Oreochromis niloticus*) living in the Langat River and Engineering Lake. As the conclusion of the study, it was determined that the accumulation ranking of the heavy metals was Cu > Zn > Ni > Pb > Cd in the liver samples, while it was Zn > Ni > Cu > Pb > Cd in the gill and muscle samples. The researchers reported that there was no risk in consumption of Tilapia fish.

The metal amounts determined in the muscle, liver, and gill tissues of the fish were compared to the values determined by the WHO, MFAL, and USEPA. As a result, it was determined that, in the muscle tissue of Caner fish, the Zn amount was higher than the acceptable level determined by the MFAL, the Fe amount in the liver tissue was higher than those of the MFAL and USEPA, the Mn amount was higher than that of the WHO, and the Zn amount was higher than that of the MFAL. Similarly, it was determined that, in the gill tissue of Caner fish, Mn amount was higher than the acceptable level determined by the WHO, and the Zn amount was higher than that of the MFAL. As per the muscle tissue of Tigris scraper, it was determined that the Mn amount was higher compared to the acceptable level determined by the WHO; in the liver tissue of Tigris scraper, it was determined that the Cu amount was higher compared to the acceptable level determined by the WHO, MFAL, and USEPA; as per the gill tissue of Tigris scraper, the Mn amount was higher compared to the level of WHO, and Ni amount was higher compared to the levels determined by the MFAL and WHO.

In the liver tissues of the grass carp, the Mn amount was higher than the acceptable level determined by the WHO, in its gill tissues, the Mn amount was higher than that of the WHO, and Zn amount was higher than those of WHO and MFAL. In the muscle tissues of the common carp, the Mn amount was higher than the acceptable level determined by the WHO for the fish tissues, and the amount of Ni was higher than that of MFAL; in its liver tissues, the Cn amount was higher than that of the WHO, MFAL, and USEPA, and the Mn amount was higher than that of WHO; as per the gill tissues,

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the Zn and Ni amounts were higher than those of WHO and MFAL, Mn amount was higher than that of WHO, and Ni amount than that of MFAL.

Conclusion

As the conclusion of the study, when the metal concentrations determined in the muscle, liver, and gill tissues of fish were compared to the values determined by the WHO, MFAL, and USEPA, it was determined that the metal concentrations determined in the fish tissues were higher than the acceptable levels. It is an important case for the human health, since the muscle, which is consumed by human beings, had a metal concentration over the acceptable levels. Accumulation of metals in tissues directly influences the blood parameters, enzyme activities, growth, and development of the living being. Although numerous factors influence the existence of metals in the waters, undoubtedly the most important factor is the human activities. The water resources are contaminated particularly due to domestic waste, industrial waste, and agricultural activities. At this point, particularly people living around the water resources should be informed by the authorities. Additionally, necessary precautions should be taken against the wastes being released to the water resources from the industrial facilities and these measurements should be supervised by the authorities. Also, a potential danger may exist in the future, depending on the agricultural development in this region. As the Tercan Dam Lake is also used for agricultural irrigation purposes, performance of pollution researches at certain periods is of significance for both environment and public health.

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REFERENCES

[1] Ahmad, K., Azizullah, A., Shama, S., Khattak, M. N. K. (2014): Determination of heavy metal contentes in water, sediments, and fish tissues of *Shizothorax plagiostomus* in river Panjkora at Lower Dir, Khyber Pakhtunkhwa, Pakistan. – Environment Monitoring Assessment 186: 7357-7366.

[2] Al-Saadi, H. A., Al-Lami, A. A., Hassan, F. A., Al-Dulymi, A. A. (2002): Heavy metals in water, suspended particles, sediments and aquatic plants of Habbaniya Lake, Iraq. – International Journal of Environmental Studies 59: 589-598.

[3] An, Y. J., Kampbell, D. H. (2003): Total, dissolved, and bioavailable metals at Lake Texoma Marinas. – Environmental Pollution 122: 253-259.

[4] Baharom, Z. S., Ishak, M. Y. (2015): Determination of heavy metal accumulation in fish species in Galas River, Kelantan and Beranang mining pool, Selangor. – Procedia Environmental Sciences 30: 320-325.

[5] Başyiğit, B., Tekin-Özan, S. (2013): Concentrations of some heavy metals in water, sediment and tissues of Pikeperch (*Sander lucioperca*) from Karataş Lake related to physico-chemical parameters, fish size and seasons. – Polish Journal of Fisheries and Aquatic Sciences 22: 11-22.

[6] Bosch, A. C., O'Neill, B., Sigge, G. O., Kerwath, S. E., Hoffman, L. C. (2016): Heavy metal accumulation and toxicity in Smoothhound (*Mustelus mustelus*) shark from Langebaan Lagoon, South Africa. – Food Chemistry 190: 871-878.

[7] Elbeshti, R. T. A., Elderwish, N. M., Abdelali, K. M. K., Taştan, Y. (2018): Effects of heavy metals on fish. – Menba Journal of Fisheries Faculty 4: 36-47.

[8] El-Moselhy, K. M., Othman, A. I., Abd El-Azem, H., El-Metwally. M. E. A. (2014): Bioaccumulation of heavy metals in some tissues of fish in the Red Sea, Egypt. – Egyptian Journal of Basic and Applied Sciences 1: 97-105.

[9] Erdoğrul, O., Ateş, D. A. (2006): Determination of cadmium and copper in fish samples from Sir and Menzelet Dam Lake, Kahramanmaraş, Turkey. – Environmental Monitoring and Assessment 117: 281-290.

[10] Fergusson, F. E. (1990): The Heavy Elements: Chemistry, Environmental Impact and Health Effects. – Pergamon Press, Oxford, UK.

[11] Kır, İ., Özan, S. T., Tuncay, T. (2007): The seasonal variations of some heavy metals in Kovada Lake's water and sediment. – Ege University Journal of Fisheries and Aquatic 24: 155-158 (in Turkish)

[12] Kirici, M., Taysı, M. R., Bengü, A. Ş., İspir, Ü. (2013a): Determination of some metal levels in *Capoeta capoeta umbla* (Heckel, 1843) caught from Murat River. – Iğdır University Journal of the Institute of Science and Technology 3: 85-90 (in Turkish).

[13] Kirici, M., Taysi, M. R., Bengü, A. Ş., İspir, Ü. (2013b): Determination of some metal concentrations in muscle tissues of *Capoeta trutta* (Heckel, 1843) caught from Murat River. – Erzincan University Journal of Science and Technology 6: 115-124 (in Turkish).

[14] Kirici, M., Kirici, M., Beydemir, Ş., Atamanalp, M. (2016a): Purification of carbonic anhydrase from *Capoeta umbla* (Heckel, 1843) gills and toxicological effects of some metals on enzyme activity. – Turkish Journal of Fisheries and Aquatic Sciences 16: 169-175.

[15] Kirici, M., Kirici, M., Demir, Y., Beydemir, S., Atamanalp, M. (2016b): The effects of Al^{3+} and Hg^{2+} on glucose 6-phosphate dehydrogenase from *Capoeta umbla* kidney. – Applied Ecology And Environmental Research 14: 253-264.

[16] Kirici, M., Atamanalp, M., Kirici, M., Beydemir, Ş. (2017a): *In vitro* effects of some metal ions on glutathione reductase in the gills and liver of *Capoeta trutta*. – Regulatory Mechanisms in Biosystems 8: 66-70.

[17] Kirici, M., Turk, C., Caglayan, C., Kirici, M. (2017b): Toxic effects of copper sulphate pentahydrate on antioxidant enzyme activities and lipid peroxidation of freshwater fish *Capoeta umbla* (Heckel, 1843) tissues. – Applied Ecology and Environmental Research 15: 1685-1696.

[18] Köse, E., Uysal, K. (2008): The comparison of heavy metal accumulation ratios in muscle, skin and gill of non-maturated common carp (*Cyprinus carpio* L., 1758). – Journal of Science and Technology of Dumlupınar University 17: 19-26.

[19] Kurtoğlu, S. (2006): The investigation of some chemical parameters and seasonal variations of sediment in Lake Uluabat. – Master Thesis, Uludağ University, Institute of Science and Technology, Bursa, Turkey (in Turkish).

[20] La Colla, N. S., Botté, S. E., Marcovecchio, J. E. (2018): Metals in coastal zones impacted with urban and industrial wastes: Insights on the metal accumulation pattern in fish species. – Journal of Marine Systems 181: 53-62.

[21] La Colla, N. S., Botté, S. E., Oliva, A. L., Marcovecchio, J. E. (2017): Tracing Cr, Pb, Fe and Mn occurrence in the Bahía Blanca estuary through commercial fish species. – Chemosphere 175: 286-293.

[22] Malik, N., Biswas, A. K., Qureshi, T. A., Borana, K., Virha, R. (2010): Bioaccumulation of heavy metals in fish tissues of a freshwater Lake of Bhopal. – Environmental Monitoring and Assessment 160: 267-76.

[23] Moiseenko, T. I., Kudryavtseva. L. P. (2001): Trace metal accumulation and fish pathologies in areas affected by mining and metallurgical enterprises in the Kola Region, Russia. – Environmental Pollution 114: 285-297.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/1706_1496114972

[24] Özmen, H., Külahçı, F., Çukurovalı, A., Doğru, M. (2004): Concentrations of heavy metal and radioactivity in surface water and sediment of Hazar Lake (Elazığ, Turkey). – Chemosphere 55: 401-408.
[25] Öztürk, M., Özözen, G., Minareci, O., Minareci, E. (2009): Determination of heavy metals in fish, water and sediments of Avsar Dam Lake in Turkey. – Iranian Journal of Environmental Health Science and Engineering 6: 73-80.
[26] Salomans, W., Rooij, N. M., Kerdijk, H., Bril, J. (1987): Sediments as a source for contaminants. – Hydrobiologia 149: 13-30.
[27] Sökmen, T. Ö., Güneş, M., Kirici, M. (2018): Determination of heavy metal levels in water, sediment and *Capoeta umbla* tissues of Karasu River (Erzincan). – Turkish Journal of Agricultural and Natural Sciences 5: 578-588 (in Turkish).
[28] Sönmez, A. Y., Kadak, A. E., Özdemir, R. C., Bilen, S. (2016): Establishing on heavy metal accumulation in some economically important fish species captured from Kastamonu Costal. – Alınteri 31: 84-90.
[29] Tao, Y., Yuan, Z., Wei, M., Xiaona, H. (2011): Characterization of heavy metals in water and sediments in Taihu Lake, China. – Environmental Monitoring and Assessment 184: 4367-4382.
[30] Taweel, A., Shuhaimi-Othman, M., Ahmad, A. K. (2013): Assessment of heavy metals in Tilapia fish (*Oreochromis niloticus*) from the Langat River and Engineering Lake in Bangi, Malaysia and evaluation of the health risk from Tilapia consumption. – Ecotoxicology and Environmental Safety 93: 45-51.
[31] Tekin-Özan, S., Aktan, N. (2012): Relationship of heavy metals in water, sediment and tissues with total lenght, weight and seasons of *Cyprinus carpio* L., 1752 from Işıklı Lake (Turkey). – Pakistan Journal of Zoology 44: 1405-1416.
[32] Tekin-Özan, S., Kır, İ. (2005): Comparative study on the accumulation of heavy metals in different organs of tench (*Tinca tinca* L., 1758) and plerocercoids of its endoparasite Ligula intestinalis. – Parasitology Research 97: 156-159.
[33] Tekin-Özan, S., Kır, İ., Barlas, M. (2004): Determination of some heavy metals in water of Kovada Lake (Isparta) and Pike Perch (*Stizostedion lucioperca* L., 1758). – 1st National Limnology Workshop, Istanbul University, 16-19 May 2004, Turkey (in Turkish).
[34] Tekin-Özan, S., Kır, İ., Tuncay, Y. (2007): The seasonal variations of some heavy metals in Kovada Lake's water and sediment. – Ege University Journal of Fisheries and Aquatic Sciences 24: 155-158 (in Turkish).
[35] Usero, J., Izquierdo, C., Morillo, J., Gracia, I. (2003): Heavy metals in fish (*Solea vulgaris*, *Anguilla anguilla* and *Liza aurata*) from salt marshes on the Southern Atlantic Coast of Spain. – Environmental International 1069: 1-8.
[36] Uysal, K., Emre, Y., Köse, E. (2008): The determination of heavy metal accumulation ratios in muscle, skin and gills of some migratory fish species by inductively coupled plasma-optical emission spectrometry (ICP-OES) in Beymelek Lagoon (Antalya/Turkey). – Microchemical Journal 90: 67-70.
[37] Venkatesha, R., Somashekar, R. K., Prakash, K. L. (2012): Heavy metal status of sediment in River Cauvery, Karnataka. – Environmental Monitoring and Assessment 184: 361-73.
[38] Yarsan, E., Bilgili, A., Türel, İ. (2000): Heavy metal levels in Mussels (*Unio stevenianus Krynicki*) obtained from Van Lake. – Turkish Journal of Veterinary and Animal Sciences 24: 93-96 (in Turkish).

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN 1785 0037 (Online)
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