FULL PAPER **TAM MAKALE**

DETERMINATION OF HEAVY METAL CONTENTS IN WATER, SEDIMENTS AND FISH TISSUES OF TINCA TINCA IN KOVADA LAKE, TURKEY

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Cite this article as:
Kayrak, S., Özan, S.T. (2018). Determination of Heavy Metal Contents in Water, Sediments and Fish Tissues of *Tinca tinca* in Kovada Lake, Turkey. Journal of Aquaculture Engineering and Fisheries Research, 4(2), 73-84.

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Submitted: 28.01.2018

Accepted: 20.05.2018

Published online: 01.06.2018

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ABSTRACT

The present study was carried out to detect the levels of heavy metals in water, sediment and tissues of tench (Tinca tinca) in Kovada Lake, Turkey. Water, sediment and fish samples were collected from September 2012 to February 2013 at different three sites. DORM 3, DOLT 4 and HISS 1 reference material showed good accuracy. As a result of analysis in water, all of the metals except Pb were determined in water. Fe was the highest and Cd was the lowest in water. Kovada Lake's water was classified as category I according to the standards Ministry of Forestry and Water Management. All of the metals were determined in sediment and fish tissues, and Fe was the highest and Cd was the lowest in sediment. The highest metal levels were found in liver compared with gill and muscle. No significant relationships were determined between metal levels in fish with fish weight and lenght. The metal levels which were detected in fish tissues was compared with acceptable levels for fish tissues given by World Health Organization, European Commission and Turkish Standart Institute. This study shows that a potential danger may occur in the future depending on the agricultural development.

Keywords: Heavy metal, Pollution, Tench, Water, Sediment, Turkey

Introduction

Pollution of the aquatic environments is one of the serious environmental problems in the World (Azizullah *et al.,* 2011). Among the several pollutants, heavy metals are known the most usual environmental pollutants. Owing to bioaccumulation in the food chain, long persistence and their toxicity, they are very harmful for the environment (Papagiannis *et al*., 2004). Heavy metals diffuse to aquatic environment from different natural and anthropogenic sources like industrial effluents, agricultural runoffs, burning of fossil fuels, geological structure, mining activities and atmospheric deposition (Papagiannis *et al*., 2004; Adnano, 1986; Kalay and Canlı, 2000). Low levels of some heavy metals essential for the development and growth, but some of them are nonessential and toxic for living organism. If an essential metal concentration exceed above permissible level, it will be toxic (Puttaiah *et al*., 2012).

Contamination of aquatic ecosystems by heavy metals can be confirmed in water, sediment and organisms (Förtster and Wittman, 1983). In natural waters, metals can be in dissolved and particulate forms (Petronis *et al*., 2012). The levels of heavy metal in water based on some chemical and physical parameters such as redox potential, temperature, pH, salinity, dissolved oxygen, ionic strength and conductivity (Göksu, 2003). Sediments can be a sensitive indicator to see the quality of aquatic systems. Moreover, sediments may act not only as sinks but also as sources of contamination in aquatic systems (Ergin *et al*., 1991; Adams *et al*., 1992; Irabien and Velasco, 1999). Heavy metals can be in different chemical forms in sediments as metal carbonates oxides, sulfides, ions in crystal lattices of minerals, which affect their mobilization capacity and bioavailability (Lopez *et al*., 1996; Weisz *et al*., 2000; Morilla *et al*., 2004).

Fish have been largely used to determinate the heavy metal pollution in aquatic systems and usually fish are at the top of the aquatic food chain and may accumulate large amount of metals from the water (Rajkowska and Protasoeicki, 2011). Nutritional advantages like the sufficient omega fatty acids, the presence of enough protein contents and low level of saturated fats make the fish an important source of diet in the World (Storelli, 2006; Keskin *et al*., 2007; Kumar *et al*., 2011). Fish are good inciator to determine heavy metals because of sampling easily, long living in water and making a continuous monitoring of the presence of pollutants (Farkas *et al*., 2003). Metals amounts can be increased in fish by water and through food chain (Heath, 1998). Heavy metals can enter fish in three different ways (via body surface, gills and digestive tract) (Dallinger *et al*., 1987; Pourang, 1985). Metal levels in fishes depend on various factors such as ecological needs, size, and age of individuals (Newman and Doubet, 1989), their life cycle and life history, feeding habits (Canpolat and Çalta, 2003), season of capture and physico-chemical parameters of water (Zhong and Wong, 2007).

In this study gill, liver and muscle were chosen as target organs for assessing metal accumulation. Muscles were selected because of its importance for human consumption and as a primary site of metal (Kotyze *et al*., 1999). Liver was analyzed because this organ tends to accumulate metals (Tepe et al., 2008) and is involved in detoxification (Kotyze *et al*., 1999).

In some previous studies, some researchers investigated heavy metal levels in water, sediment and Cyprinus carpio, Carassius carassius and Sander lucioperca from Kovada Lake (Kır et al., 2007; Tekin Ozan and Kır, 2007; Tekin Ozan *et al*., 2008). In the current study, we aimed to determine the heavy metal levels in water, sediment and some tissues of Tinca tinca inhabiting Kovada Lake and to show the differences in terms of heavy metal accumulation. And also we aimed to determine relationships between heavy metal levels in muscle, gill and liver of fish and fish size (total length and weight) and to compare with the acceptable metal levels in water and fish muscle given by different institutions.

Material and Methods

Kovada Lake (37º 38′ N, 30º 53′ E) is located in the southwest of Turkey, lies within the province of Isparta and south of the Eğirdir Lake (Kovada Channel which is at a distance of 15 km connect Kovada and Eğirdir Lakes) (Doğa Koruma Milli Parklar Genel Müdürlüğü,

2014) (Figure 1). Kovada Lake has an international importance because of the diversity of habitats, animal and plant species in. Owing to these features, the lake and surrounding area has been declared a natural protected area and national park in 1970 (Isparta İl Kültür ve Turizm Müdürlüğü, 2014). Its mean width and depth are about 15 km and 6 m. Its area and volume are about 1100 ha and 25.5 hm³, respectively. The lake's geological formation is a tectonic construction (Kazancı, 1999). The lake is polluted by industrial waste from agricultural areas though rain wash and fruit juice factories. Agricultural production in the region is dominated by apple and cherry production.

This study was carried out between September 2012-February 2013 as monthly. Water samples were taken 50 cm below the water surface in 500 ml bottles, filtered through a Whatman 0.45 µm glassfiber filter, transferred 500 ml polypropylene bottle, acidified with 5 ml of concentrated HNO_3 to pH less than 2.0. Then water samples stored at 4°C and were analyzed directly (APHA, 2005).

Sediment samples were taken from the same localities. Sediments were dried in an oven at 50°C for 48 h, passed through a 2 mm sieve and homogenized. A total of 60 fish samples were collected monthly at the three same sampling stations from the Kovada Lake. The total length (L ± 1 mm) and total weight (W ± 1 g) of each sample were recorded. Specimens ranged from 291 to 366 mm total lenght and from 395 to 651 g in weight. For analysis, 2-5 g of the epaxial muscle on the dorsal surface, the entire liver and four gill racers each sample were dissected, weighed and dried at 70°C for 24-48 h until they reached a constant weight. 0.5 g sediment and other all samples were placed in decomposition beakers and 5 ml HNO_3 added to each, were kept at room temperature for 24 h. Then they were heated at 120°C on hot plate for 2 h, until the solution evaporate slowly to near dryness. After cooling, added 1

Figure 1. Map of Kovada Lake (Turkey) (Taken from maps.google.com) and different localities from where the samples were taken.

ml H_2SO_4 and diluted to 25 ml with deionized water, then added 1-2 drop HNO_3 (UNEP, 1984).

All samples were analyzed for three times for Cd, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Se and Zn by using for ICP-AES Vista. Three standard material DORM-3, DOLT-4 and HISS-1 (National Research Council Canada) were analyzed for each ten elements. The absorption wavelength were 228.802 nm for Cd, 267.716 nm for Cr, 324.753 nm for Cu, 238.304 nm for Fe, 257.61 nm for Mn, 202.03 nm for Mo, 231.604 nm for Ni, 220.353 nm for Se, 196.026 nm for Pb and 213.856 nm for Zn, respectively. The analysis limits were 0.4 ug/L for Cd, 0.5 ug/L for Cr, 0.3 ug/L for Cu, 0.35 ug/L for Fe, 0.05 ug/L for Mn, 0.8 ug/L for Mo, 1.3 ug/L for Ni, 3 ug/L for Pb, 5 ug/L for Se and 0.3 ug/L for Zn.

All metal concentrations were determined as milligrams per liter for water and on dry weight basis as milligrams per gram for sediment and fish tissues. But we gave the results as milligrams as per kilogram. Statistical analysis of data was carried out using SPSS 16 statistical package programs. One-Way ANOVA and Duncan's Multiple Comparison Test were used to compare the data among tissues at the level of 0.05. Linear regression analyses were applied to the data to compare the relationships between fish size (total length and weight) and heavy metal concentrations (Duncan, 1955; Muller and Bethel, 2002; Gravetter and Wallnau, 2007).

Results and Discussion

The accuracy and precision were checked by analyzing standard reference materials (DORM-3, DOLT-4, HISS-1) under the same conditions (Table 1). Replicate analysis of these reference materials showed good accuracy, with recovery rates for metals between 91% and 106% for DORM 3, 91% and 104% for DOLT 4, 90% and 108%. for HISS 1.

The levels of heavy metals in water taken from Kovada Lake are given in Table 2. The Pb level in water samples was below the limits detected by ICP. The heavy metals predominantly found in the water of Kovada Lake were measured as Cd 0.01-0.41 ppb, Cr 0.09-1.66 ppb, Cu 0.25-0.82 ppb, Fe 29.42-669.95 ppb, Mn 4.66-37.19 ppb, Mo 0.81-4.20 ppb, Ni 0.11-2.88 ppb, Se 3.77-17.16 ppb and Zn 3.14-7.20 ppb. These results were arranged according to metal concentrations from the highest to lowest values as: Fe>Mn>Se>Zn>Mo>Ni>Cr>Cu>Cd. The findings of the present study about the accumulation of the heavy metal in the water of Kovada Lake are compared with the results of other researches. The Cr, Mn and Ni levels found in water Kovada Lake were lower than the values found in Yeniçağa Lake (Saygı ve Yiğit, 2012). The levels of Cd, Mn, Mo and Zn in water in Kovada Lake were found to be lower than the Eğirdir Lake (Kaptan and Tekin Özan, 2007), while Cr, Cu, Fe, Ni and Se were higher. In water of Kovada Lake, Cd, Cr, Cu, Fe, Mn, Ni and Pb concentrations were higher than, those of Hazar Lake (Karadede Akın, 2009). Cu, Cd, Cr, Ni, Zn and Mn levels in Kovada Lake water were lower than Taihu Lake (Tao *et al*., 2012). Kır et al. (2007), investigated Cd, Cr, Cu, Fe, Mn, Pb, Zn, Al and Ni levels as seasonally in Kovada Lake in 2005-2006. They measured that Cd, Cr, Cu, Pb, Al and Ni (in three seasons) were below detection limits. But we determined Cd, Cr, Cu and Ni as different values in the water. Fe, Ni and Zn levels were higher than those found in our study. This study was carried out ten years ago and during these 10 years the lake exposed to heavy metals a little from different sources such as agricultural, anthropogenic and atmospheric.

Metal concentrations were compared with water quality standarts for drinking water (Türkmen -266, 2005; EC, 1998; WHO, 2011; EPA, 2009; USEPA, 1999). The levels of all the metals were below to the maximum permitted concentration for drinking water quality guidelines (TSE-266, 2005; EC, 1998; WHO, 2011; EPA, 2009; USEPA, 1999). Ministry of Agricultural Rural Affairs, Water Control Administrative Regulations (Republic of Turkey Ministry of Food, Agriculture and Livestock. 2002) was classified the natural water from I to IV level according to heavy metal contents. Kovada Lake falls into the class of I quality waters according to heavy metal levels.

The levels of heavy metals in sediment taken from Kovada Lake are given in Table 3. The heavy metals predominantly found in the sediment of Kovada Lake

Table 1. Concentrations of metals found in certified reference material DORM-3, DOLT-4 and HISS-1 from the National Research Council, Canada.

Metals	DORM Certified	DORM-3 Observed	Recovery (%)	DOLT-4 Certified	DOLT-4 Observed	Recovery (%)	HISS-1 Certified	HISS-1 Observed	Recovery (%)
Cd	0.290 ± 0.020	0.31 ± 0.02	106	24.3 ± 0.8	25.23±0.05	103	0.024 ± 0.009	0.026 ± 0.02	108
Cr	1.89 ± 0.17	1.73 ± 0.14	91	-	-	-	30.0 ± 6.8	28.36 ± 2.56	94
Cu	15.5 ± 0.63	14.47 ± 0.55	93	31.2 ± 1.1	35.65 ± 1.23	104	2.29 ± 0.37	2.22 ± 1.45	96
Fe	347 ± 20	322.50 ± 15.54	92	1833 ± 75	1898.32 ± 7.25	103	-		-
Mn	-	-	-	-	-	-	66.1 ± 4.2	61.78 ± 2.36	93
Mo	-	-	-	-	-	-	-		-
Ni	1.28 ± 0.24	1.32 ± 0.33	103	0.97 ± 0.11	0.89 ± 0.001	91	2.16 ± 0.29	2.05 ± 1.48	94
Pb	0.395 ± 0.05	0.41 ± 0.08	103	8.3 ± 1.3	8.69 ± 0.32	104	3.13 ± 0.40	2.98 ± 0.03	95
Se	-	-	-	0.16 ± 0.04	0.15 ± 0.14	93	0.050 ± 0.007	0.045 ± 0.12	90
Zn	51.3 ± 3.1	47.5 ± 3.22	97	116 ± 6	108.23 ± 4.25	93	4.94 ± 0.79	5.12 ± 1.1	103

Table 2. The concentrations (ppb) of some heavy metals in Kovada Lake's water.

	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
Minimum	0.01	0.09	0.25	29.42	4.66	0.81	0.11	BDL*	3.77	3.14
Maximum	0.41	1.66	0.82	669.95	37.19	4.20	2.88	BDL	17.16	7.20
Average	0.19	0.92	0.54	214.45	14.56	2.48	1.26	BDL	8.43	5.18
Standart deviation	0.14	0.48	0.28	207.16	11.83	1.01	0.85	BDL	4.88	1.06

*Below Detection Limit

Table 3. The concentrations (mg kg $^{-1}$) of some heavy metals in Kovada Lake's sediment.

	Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
Minimum	0.01	0.51	1.39	401.28	15.94	0.06	0.53	0.05	0.05	1.81
Maximum	0.30	15.49	29.41	3932.76	593.45	0.82	35.16	4.45	0.60	26.38
Average	0.09	4.04	10.29	1853.10	130.35	0.29	8.82	1.21	0.26	9.46
Standart deviation	0.08	4.31	7.91	1239.13	169.57	0.24	9.76	1.22	0.20	7.30

Table 4. Heavy metal concentrations (mg kg $^{-1}$) in different organs of Tinca tinca from the Kovada Lake.

Tissue	**Muscle**				**Lıver**				**Gıll**			
Metal	**Min.**	**Max.**	**Ave.**	**St. Dev.**	**Min.**	**Max.**	**Ave.**	**St.dev.**	**Min.**	**Max.**	**Ave.**	**St. Dev.**
Cd	0.0042	0.08	0.02 ^{a*}	0.02	0.02	0.39	0.09 ^{b}	0.08	0.0018	0.05	0.02 ^{a}	0.01
Cr	0.04	1.55	0.81 ^{a}	0.57	0.27	6.44	2.59 ^{ab}	2.18	0.34	2.24	1.17 ^{b}	0.59
Cu	0.15	6.88	1.57 ^{a}	1.65	1.44	28.26	10.32 ^{a}	9.82	1.56	3.55	2.47 ^{a}	0.56
Fe	5.53	47.61	18.25 ^{b}	11.18	182.03	1040.43	516.54 ^{ab}	235.82	28.70	308.38	150.84 ^{a}	70.84

Mn	0.04	2.06	0.58^{ab}	0.49	0.31	4.72	1.67^{a}	0.98	3.63	25.40	10.83^{b}	5.80
Mo	0.04	0.20	0.11^{a}	0.05	0.10	1.13	0.70^{b}	0.31	0.10	0.27	0.17^{a}	0.05
Ni	0.26	1.48	0.73^{a}	0.34	0.34	3.75	2.35^{b}	1.12	0.57	2.05	1.08^{a}	0.46
Pb	0.0031	0.35	0.11^{a}	0.11	0.02	1.91	0.34^{a}	0.60	0.01	0.12	0.07^{a}	0.04
Se	0.60	4.63	1.68^{b}	1.48	0.21	6.06	2.65^{a}	1.59	0.18	2.26	1.07^{ab}	0.55
Zn	2.88	30.00	15.39^{a}	8.32	13.62	76.93	43.73^{ab}	17.13	18.95	53.53	34.67^{b}	8.92

*Means with the same superscript in the same row are not significant different according to Duncan's multiple range test ($p<0.05$).

were measured as Cd 0.01-0.30 mg/kg, Cr 0.51-15.49 mg/kg, Cu 1.39-29.41 mg/kg, Fe 401.28-3932.76 mg/kg, Mn 15.94-593.45 mg/kg, Mo 0.06-0.82 mg/kg, Ni 0.53-35.16 mg/kg, Pb 0.05-4.45 mg/kg, Se 0.05-0.60 mg/kg and Zn 1.81-26.38 mg/kg. These results were arranged according to metal concentrations from the highest to lowest values as: Fe>Mn>Cu>Zn>Ni>Cr>Pb>Mo>Se>Cd.

Iron is one of the most abundant metals in the world's crust and in all sources (Usero *et al*., 2003). Kerrison *et al.(*1988) reported that Cd accumulates slowly in the sediment. Cadmium is not found in the organic fraction for low adsorbtion constant and labile complexion with organic matter (Baron *et al*., 1990). The Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn levels are lower than the values in Beyler Reservoir (Fındık and Turan, 2012), the Pb, Se and Zn values are lower than the values Eğirdir Lake (Kaptan and Tekin Özan, 2014), the Fe, Cr, Cu, Ni, Pb and Cd concentrations were lower than Avşar Dam Lake (Öztürk *et al*., 2009), Fe, Mn, Zn, Cr, Ni and Pb levels were lower than the values Tokat Lakes (Mendil and Uluözlü, 2007). When compared with a previous study carried out in the same area (Kır *et al*., 2007), Cd, Cr, Fe, Pb, Zn and Ni levels were found lower. We think that the heavy metal levels in the lakes's sediment decreased in this period. Maybe, the plants accumulate the heavy metals.

While we can find a lot of material related to regulations and standarts about acceptable limits in water, to find sediment standarts is very difficult. A national sediment quality limits for Turkey is yet lacking and the evaluations have been made according to Dutch Target Limits (Tabinda *et al*., 2013). In the present study, Cd, Cu, Ni, Pb and Zn levels were below the these limits.

Heavy metal levels and their minimum and maximum concentrations of muscle, liver and gill of Tinca tinca were given in Table 4. According to the table, Cd levels vary significantly in muscle and liver (<0.05). Cr, Fe, Mn, Mo, Se and Zn concentrations varied significantly from tissues to tissues (<0.05). Ni concentrations in liver varied significantly (<0.05). Cu and Pb concentrations didn't vary significantly from tissues to tissues (>0.05). The distribution patterns of Cd in tissues of Tinca tinca in Kovada Lake follows the order: liver> muscle= gill, Cr, Cu, Fe, Mo, Ni and Zn levels follow the order: liver>muscle> gill, Mn level follow the order: gill> liver>gill and Pb and Se levels: liver> muscle> gill. In this study, the results showed that the highest of heavy metals were found in the liver while the lowest concentrations were found in muscle and gill. This finding is in aggrement with those of other studies regarding in fish tissues (Karadede Akın, 2009; Kır *et al*., 2006; Tekin Özan, 2008; Mohammadi *et al*., 2011; Ebrahimpour et al., 2011; Liu *et al*., 2012; Oymak *et al*., 2009; Karadede and Ünlü, 2007). Liver is a vital organ in vertebrata and has a major role in metabolism (Liu *et al*., 2012). The accumulation of metals in liver could be due to the greater tendency of the elements to react with the oxygen carboxylate, amino group, nitrogen and/or sulphur of the mercapto group in the metallothionein protein, whose level is highest in the liver (Al Yousuf *et al*., 2000). Metal levels in the gills could be due to the element complexing with the mucus, which is impossible to remove completely from between the lamellae before tissue is prepared for analysis (Heath, 1987). And muscle tended to accumulate low metal because at being inactive tissue in accumulating heavy metals (Karadede *et al*., 2004).

Fe was the highest metal in water, sediment and tissues. Iron is found in the structure of many proteins and enzymes. In humans, iron is a main constituent of proteins involved in oxygen transport (Institute of Medicine, 2001; Dalman, 1986). Also, iron in the body is found in hemoglobin (Miret *et al*., 2003). Second highest metal was zinc after iron. Similar results were found by some researches (Tekin Özan, 2008; Fındık and Çiçek, 2011; Türkmen *et al*., 2011). This can be due to that Zn is an essential metal (NAS-NRC, 1975). More than one hundred spesific enzymes require zinc for their catalytic function (Cousins, 1996). The lowest metal was Cd in tissues of fish. Cd was also lowest in water and sediment. The absorption of metals is to large extent a function of their chemical forms and properties (Adeosun *et al*., 2012).

Fish muscle is the main edible part of fish and directly influence human health (Coulibaly *et al*., 2012). Turkish Food Codex established maximum levels for four of the metal studied, above which human comsumption is not permitted: 0.2 mg/kg for Pb, 0.05 mg/kg for Cd, 20 mg/kg for Cu and 50 mg/kg for Fe (UNESCO/WHO/UNEP, 1992). The levels of Pb and Cd levels in muscle were higher than in some fishes these maximum levels. The acceptable levels given by World Health Organization reported as Pb: 0.10, Zn: 30, Cr: 1.0, Fe: 2.0 and Mn: 1.0 mg kg^{-1} (UNESCO/WHO/UNEP). Pb, Cr, Fe and Mn levels were higher than these limits in a few fishes given by World Health Organization. In spite of these, the level of only Pb in all studied metals were high the legal values for fish and fishery products proposed by European Commission (EC, 2006).

The relationships between fish size (weight and total lenght) and heavy metals was shown in Table 5. Negative relationships were found between fish size and weight and Cd, Cr, Fe, Mn, Mo, Ni and Se levels in the muscle, Cr, Fe, Mn, Mo, Ni, Pb, Se and Zn levels (Table 6) in the liver, Cd, Cu, Fe, Ni, Se and Zn levels in the gill. Other relationships were positive. But these relationships are not significant (>0.05).

Positive relationships were determined between fish total lenght and Cu, Pb levels in the muscle, Mo, Se and Zn in the liver, Fe and Mn in the gill. All the other relationships were negative. So that generally higher concentrations of heavy metals were observed in the small fish. And these relationships are not significant, too (>0.05).

Negative relationships were found between metal levels and fish sizes by several authors. In other research there was no significant relationships between the heavy metal levels and fish lenght (Farkas *et al*., 2003; Nisbet *et al*., 2010) showed that accumulation of metals (Cd, Cu, Zn, and Pb) in muscle, liver and gill decrease with an increase in the lenght of Abramis brama. Nussey *et al*. (2000) found that levels of metals increased with the decrease in the

Table 5. The relationships between total length and heavy metal concentrations of the Tinca tinca caught from the Kovada Lake.

Tissue		Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
Muscle	**Equation**	y=0.068-0.001X	y=0.126+0.022X	y=-15.346+0.531X	y=51.682-1.059X	y=2.603-0.064X	y=0.199-0.003X	y=2.153-0.045X	y=-0.773+0.028X	y=3.453-0.056X	y=21.769-0.201X
	R value	-0.062	-0.062	0.234	-0.043	-0.013	-0.057	-0.009	0.177	-0.085	-0.065
	P value	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
Liver	**Equation**	y=0.400-0.010X	y=1.438+0.037X	y=29.684-0.614X	y=-155.956+21.183X	y=4.015-0.074X	y=2.035-0.042X	y=7.382-0.159X	y=1.795-0.046X	y=11.204-0.271X	y=140.010-3.050X
	R value	-0.021	-0.066	-0.064	-0.047	-0.048	0.008	-0.001	-0.113	0.021	0.028
	P value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gill	**Equation**	y=0.084-0.002X	y=- 0.366+0.048X	y=2.212+0.008X	y=-392.523+17.127X	y=-24.817+1.124X	y=0.283-0.004X	y=1.131-0.002X	y=-0.170-0.003X	y=-0.029+0.035X	y=3.268+0.990X
	R value	-6.066	-0.045	-0.066	0.131	0.059	-0.052	-0.067	-0.082	-0.058	-0.029
	P value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a]Y is metal concentrations (mg/kg) X is total fish lenght (cm); [b]NS, Not significant at the $p<0.05$ level; [c]Significant at the level $p<0.01$ level; [d] Significant at the level $p<0.05$ level

Table 6. The relationships between weight and heavy metal concentrations of the Tinca tinca caught from the Kovada Lake.

Tissue		Cd	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Se	Zn
Muscle	Equation	y=0.031-2.005X	y=0.610+4.397X	y=-3.691+0.011X	y=1.304+0.018X	y=0.608-5.962X	y=0.147-7.073X	y=0.967-5.129X	y=-0.152+0.001X	y=3.682-0.004X	y=11.565+0.008X
	R value	-0.076	-0.064	0.171	-0.060	-0.067	-0.056	-0.055	0.068	-0.041	-0.062
	P value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Liver	Equation	y=0.185-2.418X	y=1.086+0.005X	y=37.869-0.072X	y=902.985-0.776X	y=1.837-1.478X	y=1.439-0.002X	y=4.498-0.004X	y=0.199+2.197X	y=2.401+0.001X	y=89.195-0.099X
	R value	0.040	-0.082	0.121	-0.090	-0.100	-0.029	-0.057	-0.500	-0.110	-0.045
	P value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Gill	Equation	y=0.054-5.754X	y=-0.628+0.004X	y=2.008+0.001X	y=17.681+0.279X	y=-11.438+0.046X	y=0.063+2.524X	y=1.129-3.672X	y=-0.062+3.386X	y=-0.275+0.003X	y=23.266+0.026X
	R value	-0.029	0.131	-0.093	-0.055	0.094	0.009	-0.098	0.181	-0.020	-0.083
	P value	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

[a]Y is metal concentrations (mg/kg) X is total fish weight (g); [b]NS, Not significant at the $p<0.05$ level; [c]Significant at the level $p<0.01$ level; [d] Significant at the level $p<0.05$ level.

length of Labeo umbratus. The metabolic activity is the most important factor that play a significant role in heavy metal accumulation (Douben, 1989; Elder and Collins, 1991). Canlı and Atli (2003) reported that the negative correlations between metal levels and size may be the difference in metabolic activity between younger and older fish. Heath (1987) found that the presence of heavy metals in water affect the fish development and juveniles are sensitive in the early life stages like larval development and juvenile growth. Canpolat and Çalta (2003) expressed that smaller fish are more active and need more oxygen to supply more energy.

In conclusion, Kovada Lake has an international importance because of the diversity of habitats, animal and plant species in. So that, the lake and surrounding area has been declared a natural protected area and national park in 1970 (Isparta İl Kültür ve Turizm Müdürlüğü. 2014). According to metal limits in water, the ecosystem of Kovada Lake is unpolluted. Comparison of metal levels with acceptable limits of WHO, UNESCO and EC in fish tissues, the lake is polluted with Pb, Cd, Fe and Mn. We hope that, the heavy metal contamination in the sampling area related to natural contributions and anthropic origin. Although levels of heavy metals are not high, this study shows that precautions need to be taken in order to prevent future heavy metal pollution. Otherwise, in the coming years heavy metal pollution in lake may be harmful for animal and people which eat the fish.

Acknowledgements

This work is supported by Suleyman Demirel University, SDUBAP 3300-YL1-12 project. I would like to thank Suleyman Demirel University – Scientific Research Project Management for their financial support. This study is part of Şule KAYRAK's Master's Thesis.

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