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Some Metal Levels in Gill, Liver, Kidney and Muscle Tissues of *Capoeta trutta* (Heckel, 1843) in Keban Dam Lake (Euphrates-Turkey)

Mesut Ural, Durali Danabas*
Tunceli University, Fisheries Faculty, TR62000, Tunceli, Turkey.
**Corresponding author: E-mail: ddanabas@tunceli.edu.tr, Phone: +904282131794, Fax:+904282131861*

Abstract

Concentrations of iron, manganese, lead, nickel, and mercury in different tissues of *Capoeta trutta* caught from various locations of Keban Dam Lake were determined by inductively-coupled plasma optical emission spectroscopy (ICP-OES). The concentrations of Fe were higher than that of all other metals in all tissues except for muscle of fish captured at Agin (S4). Concentrations of Fe, Mn, Pb and Ni varied significantly among sites in all fish tissues ($P<0.05$), except Ni in muscle ($P>0.05$). Fish caught from Pertek (S1), Kockale (S2) and Guluskur (S3) exhibited significantly higher levels of the metals in different tissues as compared to those caught at S4 site. The highest level of Fe (1064.67±487.06 mg kg^{-1}), Mn (143.42±14.14 mg kg^{-1}), Pb (18.27±1.25 mg kg^{-1}), Ni (11.32±1.40 mg kg^{-1}) and Hg (30.42±11.04 mg kg^{-1}) were obtained from liver (S3), gill (S2), liver (S2), gill (S2) and kidney (S3) tissues, respectively. Close monitoring of metal accumulation and aquatic pollution of the Keban Dam Lake for all seasons is recommended to avoid possible health hazards of consumers of fish from this lake.

Key Words: Metals, *Capoeta trutta*, accumulation, fish tissues, Keban Dam Lake

Keban Baraj Gölü (Fırat, Elazığ, Türkiye)'ndeki *Capoeta trutta*'nın Solungaç, Karaciğer, Böbrek ve Kas Dokularındaki Bazı Metal Seviyeleri

Özet

Keban Baraj Gölü'nün çeşitli bölgelerinden yakalan *Capoeta trutta*'nın farklı dokularındaki demir, mangan, kurşun, nikel ve civanın konsantrasyonları indüktif olarak eşleşmiş plazma optik emisyon spektrometresi (ICP-OES) ile belirlenmiştir. Demirin konsantrasyonu, Ağın (S4) istasyonunda yakalanan balıkların kası hariç tüm dokulardaki tüm diğer metal seviyelerinden daha yüksek bulunmuştur. Tüm balık dokularında Fe, Mn, Pb ve Ni konsantrasyonları, kastaki Ni hariç ($P>0.05$), istasyonlar arasında istatistiksel açıdan önemli ölçüde değişmiştir ($P<0.05$). Pertek (S1), Koçkale (S2) ve Gülüşkür (S3)'den yakalan balıklar, S4 istasyonundan yakalananlarla karşılaştırıldıklarında farklı dokularda önemli bir şekilde daha yüksek metal seviyeleri sergilemişlerdir. Demir (1064.67±487.06 mg kg^{-1}), Mn (143.42±14.14 mg kg^{-1}), Pb (18.27±1.25 mg kg^{-1}), Ni (11.32±1.40 mg kg^{-1}) ve Hg (30.42±11.04 mg kg^{-1})'nın en yüksek seviyeleri, sırasıyla karaciğer (S3), solungaç (S2), karaciğer (S2), solungaç (S2) ve böbrek (S3) dokularında elde edilmiştir. Sonuçta, Keban Baraj Gölü'nden elde edilen balıkları tüketen kişilerdeki olası sağlık sorunlarından sakınmak için, tüm dönemlerde bu baraj gölündeki metal birikimi ve su ortamı kirlenmesinin yakın bir şekilde izlenmesi önerilir.

Anahtar Kelimeler: Metaller, *Capoeta trutta*, birikim, balık dokuları, Keban Baraj Gölü

INTRODUCTION

The accumulation of toxic metals to hazardous levels in aquatic biota has become a problem of increasing concern. Excessive pollution of surface waters could lead to health hazards in man, either through drinking water and/or consumption of fish (Al-Kahtani, 2009). There are numerous sources of metal (M) pollution including mining, agricultural and silvicultural activities, waste disposal, industrial discharges and fuel combustion (Kennicutt et al., 1992; Olsson, 1998).

Some metals are known to be toxic even at low concentrations, including mercury (Hg) and lead (Pb) (Master, 1997; Le et al., 2009). Some others are known to be essential elements and play important roles in biological metabolism at very low concentrations (Le et al., 2009). Metals are elements and therefore virtually persistent in the environment (Masters, 1997). Thus, their content has steadily increased in soils and subsequently accumulated in plants, animals, and even in humans (Che et al., 2006). Pollutants enter fish through five main routes: Via food or non-food particles, gills, oral consumption of water and the skin (Heath, 1991; Nussev et al., 2000; Al-Kahtani, 2009; Danabas et al., 2011).

According to Heath (1991), fish can regulate metal concentration to a certain limit after which bioaccumulation occurs. The concentration of Ms in an organism's body vary from organ to organ and is the product of an equilibrium between the concentration of the metal in environment of organisms and its rate of ingestion and excretion (Adeyeye et al., 1996; Al-Kahtani, 2009).

Different forms of iron (Fe) may have a significant impact on the turnover of nutrients and biological activity in the water and the sediments (Jonsson, 1997). Some of Ms can, else, be toxic. For example, along with Hg and Pb, Cd is one of the "big three" M poisons (Manahan, 2003). Mercury in water ecosystems occurs in several forms. The type of Hg predominantly occurring in tissues (up to 100 %) of a majority of fish species is monomethylmercury ($MeHg^{+}$), whose neurotoxicity makes it the most toxic form of Hg. It is produced by microbial methylation in sediments, infiltrates the food chain and is consequently accumulated in fish. Fish are the main source of methylmercury contamination of people (Marsalek et al., 2007; Agah et al., 2010). Toxicologically, nickel is important because it has been established as a cause of respiratory tract cancer among workers involved with nickel (Ni) refining (Manahan, 2003).

Lead is not necessary for the biological functions of animals even at low concentrations (Ciftci et al., 2008). In addition, Pb residues could result in haematological, gastrointestinal and neurological dysfunctions in animals. Severe or prolonged exposure to Pb may also cause chronic nephropathy, hypertension and reproductive impairment. Lead inhibits enzymes, alters cellular calcium metabolism and slows nerve conduction (Lockitch, 1993; Ciftci et al., 2008; Al-Kahtani, 2009).

These make fish the main target in aqueous system contamination monitoring for both environmental and food safety purposes. So that, in this work, it was aimed to evaluate Fe, Manganese (Mn), Pb, Ni and Hg concentrations in gill, liver, kidney and muscle tissues of *C. trutta* that is one of economically important fish species; consumed as food by regional people and collected from four different sites of Keban Dam Lake (Turkey) where it is one of the most important dam lakes of country and has many important city and factory sewages without purification.

MATERIALS AND METHODS

Sampling Sites: Fish samples were caught in four different sites (Pertek (S1), Kockale (S2), Guluskur (S3) and Agin (S4) Sites) from Keban Dam Lake (Figure 1). These sites were chosen since S1 and S2 are in the vicinity of a city waste water discharge point and S3 has a discharge point of a chrome factory without purification. S4 was also chosen as a region with no important discharge.

Fish: *Capoeta trutta* (Heckel, 1843) were used for determining the levels of the metals. The fish (N=15 in each station) were caught from their natural areas at the sites by the gill-nets of various mesh sizes. Live weight (W) and total length (L) averages of fish caught from sites were respectively, in S1 376.20±28.39 g and 33.18±1.36 cm; in S2 230.44±10.72 g and 28.27±0.41 cm; in S3 273.23±18.97 g and 30.32±0.78 cm, and in S4 400.24±35.72 g and 32.91±0.89 cm. These fishes had been anaesthetized immediately 0.7 g L^{-1} benzocaine (Merck Millipore) dissolved in ethyl alcohol (Sardella et al., 2004) and observed anesthesia of fish being deep sedation, loss of swimming actions and partial loss of equilibrium (Altun and Danabas, 2006). Then, they were transferred to the laboratory, measured in lengths and weights, and dissected.

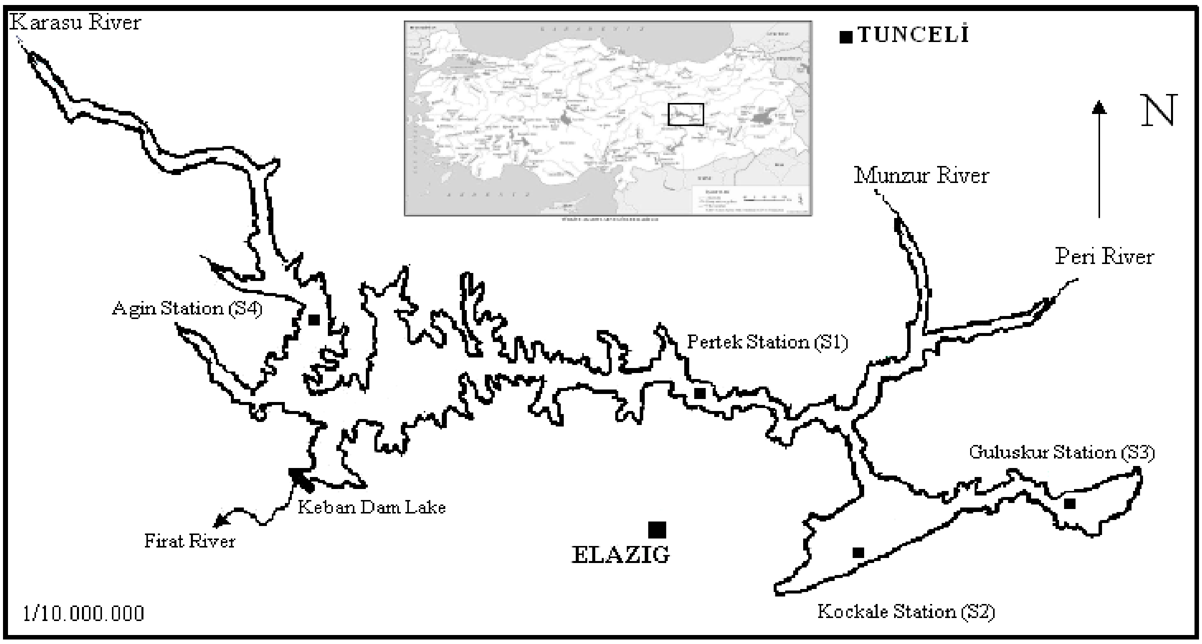

Figure 1. Map of sampling stations at Keban Dam Lake, Turkey.

Analyses

Water Parameters: Temperature, dissolved oxygen and pH were measured with a professional multiparameter instrument (YSI Inc., Yellow Springs, Ohio, USA) and the other parameters were measured by titrimetric methods (Table 1) (APHA, 1992).

Statistical Analysis: SPSS v15.0 statistical software was used for statistical analysis (SPSS Inc., Chicago, IL, USA). Data was statistically analyzed for means ± standard error and 0.05 significance value. The data collected was analyzed using ANOVA followed "Duncan Multiple Range Test". And, the results being in all stations were, only, analyzed at statistical analysis.

Table 1. Averages of water parameters at the four sampling sites.

Water Quality Parameters	Stations			
	Pertek	Kockale	Guluskur	Agin
Temperature (°C)	15,2±0.1*	15,5±0.1	15,3±0.2	15,1±0.2
pH	8,0±0.01	8,3±0.01	8,2±0.02	8,1±0.03
Dissolved O_2 (mg L^{-1})	8,7±0.02	7,7±0.09	8,4±0.03	9,2±0.01
Free CO_2 (mg L^{-1})	6,2±0.02	6,8±0.04	7,1±0.01	5,6±0.4
Nitrite (mg L^{-1})	0,052±0.001	0,049±0.002	0,045±0.004	0,013±0.005
Nitrate (mg L^{-1})	17.9±0.2	18.4±0.1	18.1±0.2	6.8±0.3
Ammonia (mg L^{-1})	1.30±0.02	2.0±0.1	0.60±0.03	0.01±0.001
Phosphate (mg L^{-1})	3.48±0.02	4.12±0.01	2.76±0.05	0.02±0.001
Total Hardness (mg L^{-1})	70.9±0.1	74.5±0.2	67.7±0.1	42.9±0.2

*Means (±Standard error of means)

Chemical Analyses: Fish were dissected by stainless-steel scalpel for taking the tissues purposed (gill, liver, kidney and muscle). Then, fish samples were dried for 24 h at 105 ˚C and 0.3 g of each sample was placed in Pyrex reactors of a microwave digestion unit (CEM Star 5). $HClO_4$: HNO_3 acids in 1:3 proportions for fish were inserted in the reactors, respectively. Samples were mineralized at 200 ˚C for thirty minutes. Afterwards, the samples were filtered in such a way as to make their volumes to 100 ml with ultra-pure distilled water. The levels of Fe, Mn, Pb, Ni and Hg in samples were determined by ICP-OES (Varian 720 ES). The analyses of metals in fish were recorded as means triplicate measurements (ASTM, 1985; APHA, 1992; EPA, 2001).

RESULT AND DISCUSSION

All of the results of heavy metal contents in fish tissues were given in Table 2.

The highest metal level in all tissues was found for Fe except that in muscle, while Ni was the lowest except that in muscle. The lowest metal levels were observed in S4 for all tissues ($P<0.05$). There were statistically differences among sites for Fe, Mn, Pb and Ni in all of the fish tissues ($P<0.05$), but there was no difference in Ni in muscle ($P>0.05$). Generally, fish caught at S1, S2 and S3 showed higher Ms levels than those caught at S4. The highest accumulation was observed Fe in all sites and tissues ($P<0.05$). The highest levels of Fe (1064.67±487.06 mg kg^{-1}) and Pb (18.27±1.25 mg kg^{-1})

were obtained in liver tissues of fish caught from S3 and S2 (P<0.05), respectively. The highest levels of Mn (143.42±14.14 mg kg^{-1}) and Ni (11.32±1.40 mg kg^{-1}) were obtained in gills of fish caught from S2 (P<0.05), while Hg (30.42±11.04 mg kg^{-1}) was in kidney of fish caught from S3.

weight, respectively (Turkish Food Codex, 2002).

Al-Kahtani (2009) studied the accumulation of HMs in tilapia fish (*Oreochromis niloticus*) from Al-Khadoud Spring, Al-Hassa, Saudi Arabia.

Table 2. Fe, Mn, Pb, Ni and Hg contents in fish samples (mg kg^{-1}- dry weight) of Pertek, Kockale, Guluskur and Agin Sites of Keban Dam Lake (Elazig, TURKEY).

Fish Tissues	Heavy Metals	Stations			
		Pertek	Kockale	Guluskur	Agin
Gills	**Fe**	388.20±67.15^{ab*}	962.19±233.50^{b}	782.36±242.18^{b}	0.82±0.09^{a}
	Mn	49.40±4.98^{b}	143.42±14.14^{c}	54.17±13.49^{b}	0.07±0.01^{a}
	Pb	4.60±1.18^{a}	17.47±1.32^{b}	4.24±0.77^{a}	0.04±0.01^{a}
	Ni	1.80±1.14^{a}	11.32±1.40^{b}	4.41±0.99^{a}	0.01±0.001^{a}
	Hg	ND	8.20±0.09	8.28±0.17	ND
Liver	**Fe**	489.20±68.46^{ab}	306.09±29.47^{a}	1064.67±487.06^{b}	1.24±0.19^{a}
	Mn	12.54±3.27^{ab}	24.57±2.09^{b}	22.62±9.36^{b}	0.02±0.005^{a}
	Pb	ND	18.27±1.25	3.93±0.18	0.03±0.007
	Ni	1.55±0.42^{ab}	5.05±0.71^{c}	3.92±1.56^{bc}	0.011±0.001^{a}
	Hg	0.87±0.15	8.21±0.10	8.77±0.12	ND
Kidney	**Fe**	386.20±61.73^{c}	336.68±38.12^{bc}	249.42±58.84^{b}	1.44±0.19^{a}
	Mn	10.52±3.51^{bc}	15.29±1.86^{c}	5.68±1.78^{ab}	0.02±0.004^{a}
	Pb	5.30±2.20^{ab}	17.11±1.84^{b}	2.20±0.0^{a}	1.21±1.15^{a}
	Ni	2.25±0.44^{b}	3.81±0.43^{b}	2.74±0.17^{b}	0.01±0.002^{a}
	Hg	3.43±0.68	8.10±0.07	30.42±11.04	ND
Muscle	**Fe**	77.06±17.18^{a}	201.89±23.81^{b}	206.26±67.49^{b}	0.42±0.10^{a}
	Mn	4.36±0.73^{ab}	11.24±1.17^{b}	9.37±3.87^{b}	0.70±0.68^{a}
	Pb	3.77±0.29^{ab}	9.62±0.94^{b}	4.30±0.72^{ab}	1.54±1.5^{a}
	Ni	1.85±0.65^{a}	3.29±1.33^{a}	4.56±1.54^{a}	0.52±0.5^{a}
	Hg	ND	8.20±0.09	8.53±0.15	ND

*Means (±Standard error of means) in the same line followed by different letters are significantly different according to Duncan's Multiple Range Test (p<0.05); ND: Not Determined.

It is known that As, Hg, Pb and Cd are the most commonly distributed environmental metal poisons (Reilly, 2002). They are accumulated in human tissues and may be the cause of some diseases (Rodriguez et al., 2003; Yilmaz et al., 2007). It is also known that fish consumption is the only significant source of methyl mercury for the public (Rice et al., 2000). The maximum levels of Hg and Pb for muscle of fish were proposed as 0.50 and 0.20 mg kg^{-1} dry

He stated that levels of HMs were higher in liver than muscle. The Pb levels in our study are lower in liver than his results, but, higher in muscle than his.

Mol et al. (2010) researched trace metal contents in *Silirus triostegus*, *Acanthobrama marmid*, *Aspius vorax*, *Capoeta trutta*, *Carasobarbus luteus*, *Chalcalburnus mossulens* and *Cyprinus carpio* from Ataturk Dam Lake (Euphrates, Turkey) to estimate the risk of human consumption and pollution of Euphrates River. They stated that trace metal amounts differed between the species even they were living in similar habitats and the variations of measured HMs were not determined (ND) - 0.649 mg kg^{-1} for Hg and ND – 0.236 for Pb. Karadede and Unlu (2000) studied the concentrations of some trace metals in various species from Ataturk Dam Lake. They did not determine Cd, Hg and Pb in the fish muscles. Mdegela et al. (2009) found that Pb and Hg concentrations were higher than our results.

Pereira et al. (2010) carried out the evaluation of exposure concentrations with metal accumulation (Mn, Ni and Pb) in gills of golden grey mullet (*Liza aurata*). When results of Pereira et al. (2010) were compared with ours, it could be stated that Mn and Pb concentrations were higher in S2 and lower in S4, while it is similar in S1 and S3; Ni concentrations were higher in S2 and S3, and lower in S1 and S4.

Staniskiene et al. (2006) studied distribution of heavy metals (Pb, Cd, Copper (Cu), Zinc (Zn), Fe, Ni, Chromium (Cr) and Mn) in tissues (muscle, fishbone, liver, gill and intestine) of freshwater fish in Lithuania. They obtained lower levels of Fe, Ni and Mn in muscle and gills than ours. However, they obtained lower levels of Fe and Mn in liver than ours in S1, S2 and S3, but higher in S4 and higher levels of Ni in liver than ours in S2 and S3, but lower in S1 and S4.

Le et al. (2009) studied heavy metals (Cr, Zn, Cd, Cu, Mn, Cobalt (Co), Strontium (Sr) and Pb) in a tropical eel (*Anguilla marmorata*) from the central part of Vietnam. Ural et al. (2011) determined trace element concentrations in water, sediment and fish samples (*Carassius auratus*, *Capoeta trutta* and *Cyprinus carpio*) collected from Ataturk Dam Lake which is the largest dam lake in Turkey. They found that the accumulation orders of elements in the tissues of the species were nearly similar to each other and mean concentrations for all trace element levels in species muscles were found at permissible levels set by FAO and Turkish legislation. However, it was determined concentrations of metals in the gills, liver, kidney, heart and muscle in *Capoeta umbla* caught from six stations from the Munzur River system. Metal concentrations in the tissues tended to vary significantly among sites ($p<0.05$). Liver (Cu, 10.10±0.23–23.03±9.37 ppm; Zn, 14.67±3.01–21.82±2.39 ppm; Cd, 18.04±4.56–52.69±10.65 ppb and Fe, 28.87±6.78–115.11±34.87 ppm) and kidney (Cu, 1.80±0.25–3.70±0.62 ppm; Zn, 20.81±0.37–29.36±0.70 ppm; Cd, 132.06±5.29–639.51±20.14 ppb and Fe, 24.40±1.98–59.39±1.97 ppm) tissues showed higher metal concentrations than other tissues (Ural et al., 2012). Le et al. (2009) obtained lower levels of Pb than our all sites and lower levels of Mn than our results in S1, S2 and S3; but higher in S4. However, it was determined that the Fe levels in study of Ural et al. (2012) were lower than our results except in S4.

CONCLUSION

Usually, many toxic compounds affect organisms in nature at the same time, each of them having a specific effect on physical and chemical processes that influence an organism's condition and reactions. Therefore, in order to maintain the quality of food it is important to regularly monitor and evaluate the pollution levels in fish as well as in water reservoirs.

The results of this study show that trace metal contents of the samples, caught from Keban Dam Lake (Euphrates, Turkey) were generally below the permissible limits. But, Hg and Pb levels in *C. trutta*, exceeded the permissible limits.

In conclusion, *C. trutta* caught from Keban Dam Lake, based on the higher levels of Pb and Hg might be unsafe for human consumption. It should be careful for consumption and consequently, very close monitoring of heavy metal accumulations and pollution of aquatic environment in Keban Dam Lake for all season is recommended to avoid the possible risks for health of consumers. As it was stated by Can et al. (2012), the further studies on these kind organisms will require for developing of legal protocols about their usage as bio-indicators of local water contaminations.

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