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Some Heavy Metals Accumulation in Tissues in *Capoeta umbla* (Heckel, 1843) from Uzuncayir Dam Lake (Tunceli, Turkey)

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Abstract Concentrations of metals were determined 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 stations ($p < 0.05$). 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. It seems that metal contamination in the river is too high for the health of fish and the people who eat them. The geographical locations of catch, season, nature of diet, and the size of fish used for analyses might lead to different metal concentration in the same fish species.

Keywords Metals · Accumulation · Fish · *Capoeta umbla* · Munzur River

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Water pollution is recognized globally as a potential threat to both human and other animal populations which interact with the aquatic environments (Gulec et al. 2011). Metals are non-biodegradable and are considered as major environmental pollutants causing cytotoxic, mutagenic and carcinogenic effects in animals. Metals subsequently accumulated in plants, animals, and even in humans (Che et al. 2006). Aquatic organisms have also the ability to accumulate metals from various sources including sediments, soil erosion and runoff, air depositions of dust and aerosol, and discharges of waste water (Labonne et al. 2001; Goodwin et al. 2003). Discharges of metal effluents into rivers may cause deleterious effects to the health (Gulec et al. 2011). Metal contamination may have devastating effects on the ecological balance of the recipient environment and on the diversity of aquatic organisms (Ashraj 2005).

Fish are often at the top of aquatic food chain and may accumulate large amounts of some metals from the water (Mansour and Sidky 2002). Therefore, bioaccumulation of metals in fish can be considered as an index of metal pollution in the aquatic bodies (Tawari-Fufeyin and Ekaye 2007) that could be a useful tool to study the biological role of metals present at higher concentrations in fish (Dural et al. 2007). Metal bioaccumulation is largely attributed to differences in uptake and depuration period for various metals in different fish species (Tawari-Fufeyin and Ekaye 2007). Multiple factors including season, physical and chemical properties of water can play a significant role in metal accumulation in different fish tissues. The gills are directly in contact with water. Therefore, the concentration of metals in gills reflects their concentration in water where the fish lives, whereas the concentrations in liver represent storage of metals in the water (Romeo et al. 1999).

Microelements such as zinc (Zn), iron (Fe), copper (Cu) which occur in the physiological concentration, play key roles in living processes and either an excess or deficit can disturb biochemical functions in both and animals (Atabeyoglu and Atamanalp 2010; Danabas et al. 2011). Discharge of Cu from different sources without any treatment increases its concentration in aquatic environments and hence shows its toxic action for aquatic organisms (Atabeyoglu and Atamanalp 2010). The toxic effects of metals on aquatic organisms range from complete loss of biota to subtle effects on rates of reproduction, growth and behavior of organisms (Bradh 2005). These metals, as they represent a group of highly toxic substances accumulating in the tissues of marine organisms and being conveyed through the food chain to human. Reports from literature suggest that these toxicants are responsible of hazardous effects on human health (Kaplan et al. 2011). Since the toxic effects of metals have been recognized, metal levels in the tissues of aquatic animals are occasionally monitored. Because the metal concentration in tissues reflects past exposure via water and/or food, it can demonstrate the current situation of the animals before toxicity affects the ecological balance of populations in the aquatic environment (Canli et al. 1998).

The Munzur River (Tunceli) is an important water supply in Turkey and also a fishing area for commercial and amateur fishing. Unfortunately, Munzur River has been contaminated by domestic effluents and agricultural products. Uzuncayir Dam is built on Munzur River and has a volume of 308 million hm^3 on an area of 13.43 m^2 (Yildirim et al. 2010). In this study, fish samples taken from discharge points where sewage is discharged into the dam lake, from various points around the lake and from the point where is located outside the dam lake area were analyzed. To obtain relevant results from the field studies, it is absolutely necessary to choose a common fish species. *Capoeta umbla* is of great commercial importance because it is the most common fresh water fish widely consumed in Tunceli. Thus, this study was undertaken to investigate current metal contamination at six different stations from Munzur River System to assure the suitability of the fish for human consumption.

Materials and Methods

The experiment was organized on Tunceli University, Fisheries Faculty, Aquaculture Department (Tunceli, Turkey).

Fish samples were caught in six Station from Munzur River System (Tunceli) (Fig. 1). The fish (n = 10) was caught from their natural areas in the sites by the gill-nets of various mesh sizes.

Fish were dissected by stainless-steel for taking the tissues purposed (gills, liver, kidney, heart and muscle). The samples were storage at 25°C until analysis. Before analysis, the samples were dried, after they undergone HNO_3 (10%) and then, ultra pure water. Sample (1 g) was weighed and put in microwave tubes. Then, pure HNO_3 (9 mL) was added into tubes. They thawed two-gradually in microwave oven (Cem Mars 5) at 180°C. The volume of sample was completed to 15 mL. Copper, Zn and Fe, were determined in flame atomic absorption system (Perkin Elmer AA-800) and, Pb and Cd were in graphite atomic absorption.

SPSS v18.0 statistical software was used for statistical analysis (SPSS Inc., Chicago, IL, USA). Data was statistically analyzed for means ± standard error of means and 0.05 significance values.

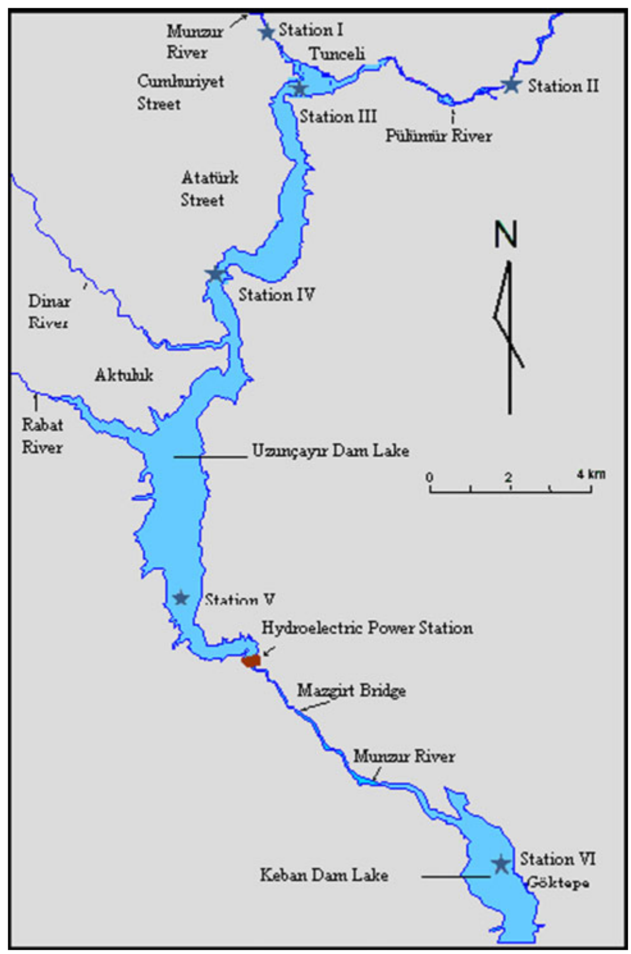

Fig. 1 Map of sampling sites on Munzur River System, Tunceli, Turkey

Results and Discussion

As with other foods eaten fish that contains heavy metals and human health is adversely affected. Therefore, the determination of metals in fish is necessary and important.

Mean concentrations and associated standard error of means of Cd, Pb, Cu, Zn and Fe in the gills, liver, kidney, heart and muscle of *C. umbla* caught from the Munzur River System are shown in Table 1. All metals concentrations varied from tissue to tissue and from station to station. Copper and Zn are trace elements that play essential roles in several cell functions. They are present at high levels in the brain, particularly in regions such as the olfactory bulb, hypothalamus, and hippocampus (Frederickson et al. 2000; Aedo et al. 2007).

The mean Cu concentrations were found high in kidney, heart and gill tissues at Station 6. But mean Cu concentrations in muscle at Station 1 and in liver at Station 3, were higher than other stations. The highest mean Cu concentration was found in liver as 23.03 mg kg^{-1}. If the comparison is made between tissues in each station, mean Cu concentrations were highest in liver. In another study, different five fish species were analyzed. Cu concentrations were found in the range of 0.20–0.45 mg kg^{-1} wet wt in muscle and 3.34–48.2 mg kg^{-1} wet wt in liver (Chen and Chen 2001). The toxic limit of Cu concentration is 30 mg/kg (FAO 1983). In this study, all mean Cu concentrations were below the toxic limit.

Yousafzai et al. (2009) studied accumulation of nickel (Ni), Pb, Cu and Zn in the liver of a freshwater fish, *Tor putitora* has been studied from polluted waters of River Kabul at two different sites and compared with those from pristine Warsak Dam Lake upstream of polluted part of the River Kabul. Liver showed highest concentration of Zn. The order of metal bioaccumulation in this organ was Zn > Cu > Pb > Ni > Chromium (Cr). Zinc, Cu and Pb concentrations were 2314.0, 283.4, 118.94 mg kg^{-1} wet wt, respectively, in Site 1. Zinc, Cu and Pb concentrations

Table 1 The mean concentrations of cadmium, lead, copper, zinc and iron in the gills, liver, kidney, heart and muscle in *Capoeta umbla* from the Munzur River System Tunceli, Turkey

Metals	Tissues	Stations					
		Station I	Station II	Station III	Station IV	Station V	Station VI
Cu (ppm)	Kidney	3.49 ± 0.92^{a} xy	1.80 ± 0.25^{a} y	3.26 ± 1.35^{a} xy	2.56 ± 0.17^{a} xy	2.38 ± 0.06^{a} xy	3.70 ± 0.62^{a} y
	Heart	2.11 ± 0.82^{b} xy	2.69 ± 0.29^{b} xy	2.71 ± 0.69^{b} xy	5.43 ± 1.23^{ab} xy	4.24 ± 0.82^{ab} xy	7.91 ± 2.19^{a} xy
	Liver	18.22 ± 1.16^{a} x	10.10 ± 0.23^{a} x	23.03 ± 9.37^{a} x	12.87 ± 3.95^{a} x	11.24 ± 5.51^{a} x	16.77 ± 3.55^{a} x
	Muscle	2.79 ± 1.16^{a} xy	1.14 ± 0.03^{ab} y	1.06 ± 0.45^{ab} y	0.87 ± 0.07^{b} y	1.10 ± 0.13^{ab} y	1.41 ± 0.41^{ab} y
	Gills	1.85 ± 0.09^{a} y	1.21 ± 0.04^{a} y	0.83 ± 0.28^{a} y	1.18 ± 0.05^{a} y	1.51 ± 0.11^{a} y	2.56 ± 1.27^{a} y
Zn (ppm)	Kidney	29.36 ± 0.70^{a} x	20.81 ± 0.37^{a} x	25.15 ± 0.90^{a} x	22.67 ± 4.33^{a} x	21.36 ± 1.34^{a} x	28.02 ± 6.17^{a} x
	Heart	12.74 ± 2.90^{a} y	14.42 ± 0.55^{a} xy	16.43 ± 0.71^{a} xy	14.57 ± 4.80^{a} xy	9.76 ± 1.42^{a} y	11.45 ± 0.61^{a} y
	Liver	18.81 ± 0.58^{a} xy	17.23 ± 0.63^{a} x	21.82 ± 2.39a x	16.96 ± 3.23^{a} xy	14.67 ± 3.01^{a} xy	16.61 ± 0.96^{a} xy
	Muscle	11.48 ± 2.38^{a} y	4.16 ± 0.54^{b} y	4.03 ± 0.29b y	4.39 ± 0.82^{b} y	4.75 ± 0.09^{b} y	11.31 ± 3.43^{a} y
	Gills	22.38 ± 1.39^{a} xy	19.85 ± 0.86^{a} x	19.23 ± 1.67a x	18.48 ± 2.34^{a} xy	23.11 ± 2.16^{a} x	24.19 ± 3.05^{a} x
Pb (ppb)	Kidney	UDL	UDL	6.77 ± 2.10	UDL	UDL	UDL
	Heart	148.00 ± 5.69	UDL	UDL	UDL	79.31 ± 2.15	UDL
	Liver	UDL	UDL	22.51 ± 5.55	UDL	UDL	UDL
	Muscle	UDL	UDL	UDL	UDL	UDL	UDL
	Gills	UDL	UDL	19.58 ± 1.68	UDL	UDL	UDL
Cd (ppb)	Kidney	639.51 ± 20.14^{a} x	132.06 ± 5.29^{d} x	307.93 ± 45.91^{b} x	263.06 ± 41.74^{bc} x	198.00 ± 21.30 ^{cd} x	229.76 ± 32.66^{bc} x
	Heart	10.13 ± 4.68^{b} y	3.49 ± 0.41^{b} y	37.16 ± 18.89^{a} y	9.40 ± 3.34^{b} y	6.40 ± 0.25^{b} y	10.55 ± 2.90^{b} y
	Liver	52.20 ± 3.87^{a} y	24.64 ± 0.90^{b} y	52.69 ± 10.65^{a} xy	24.90 ± 3.66^{b} y	18.04 ± 4.56^{b} y	23.61 ± 5.64^{b} y
	Muscle	4.99 ± 1.53^{a} y	0.53 ± 0.06^{b} y	2.23 ± 1.25^{b} y	0.49 ± 0.10^{b} y	0.72 ± 0.02^{b} y	1.25 ± 0.50^{b} y
	Gills	6.40 ± 0.77^{a} y	2.35 ± 0.47^{b} y	4.53 ± 0.82^{a} y	2.26 ± 0.14^{b} y	2.20 ± 0.92^{b} y	1.10 ± 0.29^{b} y
Fe (ppm)	Kidney	59.39 ± 1.97^{a} x	56.88 ± 3.52^{a} x	38.22 ± 3.83^{b} xy	24.40 ± 1.98^{b} x	32.70 ± 10.54^{b} xy	31.28 ± 4.60^{b} xy
	Heart	24.17 ± 7.43^{a} y	43.06 ± 5.75^{a} x	49.18 ± 9.87^{a} xy	36.96 ± 16.83^{a} x	26.26 ± 6.22^{a} xy	37.65 ± 2.81^{a} xy
	Liver	69.20 ± 10.32^{ab} x	63.82 ± 3.62^{ab} x	115.11 ± 34.87^{a} x	28.87 ± 6.78^{b} x	29.51 ± 15.72^{b} xy	61.67 ± 17.68^{a} bx
	Muscle	30.47 ± 12.43^{a} y	6.95 ± 0.90^{b} y	18.87 ± 6.64^{ab} y	4.88 ± 0.85^{b} y	6.84 ± 1.25^{b} y	5.66 ± 0.39^{b} y
	Gills	79.17 ± 9.33^{a} x	2.35 ± 0.60^{b} y	91.85 ± 21.38^{a} x	35.67 ± 11.24^{ab} x	88.76 ± 43.27^{a} x	29.43 ± 5.55^{ab} xy

UDL under detectable limits. The letters (according to tissues, xy in same column and to stations, abc in same line) show results of statistical analyses were 1935.5, 146.9, 136.8 mg kg^{-1} wet wt, respectively, in Site 2. The metal concentrations obtained from this study, is much higher than our study.

Zinc is an essential trace element. According to National Academy of Sciences-National Research Council (NAS-NRC) the recommended daily allowance is 15 mg/day for adults and 10 mg/day in growing children (NAS-NRC 1974). If the Zn concentration in water up to 40 mg/kg, it may cause toxicity, such as symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea (NAS-NRC 1975). Mean Zn concentrations were found high in kidney and muscle at Station 1, in heart and liver at Station 3 and in Station 6 in gills. The highest mean Zn concentration was determined in kidney at Station 1 (29.36 mg kg^{-1}). In a similar study, 19 fish species were collected in Yangtze River. They analyzed some metal concentrations. In this study, they found Cd, 0.0097 mg kg^{-1}; Cu, 0.437 mg kg^{-1}; Pb, 0.14 mg kg^{-1} and Zn, 5.907 mg kg^{-1} in muscle. According to these results, mean Cd concentration was higher and mean Cu concentration was lower than our results. In our study, in Station 1 and 6 mean Zn concentrations were about twice that of theirs (Zhang et al. 2007).

Mean Pb concentration was 148.00 μg kg^{-1} in heart in Station 1 and in Station 3, 6.77, 22.51 and 19.58 μg kg^{-1}, in kidney, liver and gills, respectively. In Station 5, mean Pb concentration was found as 79.31 μg kg^{-1} in heart. The other mean Pb concentrations were under the detectable limits. Boscher et al. (2010), was detected lead concentrations at low levels (0–181.4 ng g^{-1} wet wt) and cadmium levels varied between 4.0 and 103.9 ng g^{-1} (wet wt) in four fish species from seven rivers during August and September.

In a study, some metals were analyzed in some tissues of *C. umbla* caught in Keban Dam Lake (Elazig, Turkey). They determined that in general, the lowest levels of Cu, Fe, Manganese (Mn) and Zn were found in muscle and skin compared to other elements (Canpolat and Calta 2003).

Excessive Cd exposure may give rise to renal, pulmonary, hepatic, skeletal, reproductive diseases and cancer. The major effects of this metal poisoning are experienced in the lungs, kidneys and bones (Nordberg 2004). Mean Cd concentrations were higher in kidney, muscle and liver tissues at Station 1. In Station 3, the concentrations in heart and liver were higher than other stations. If the stations evaluated within, mean Cd concentration in kidney was 12–130 times higher than other tissues. The highest mean Cd concentration was found in Station 1 as 639.51 μg kg^{-1}. Mendil et al. (2005) collected seven fish species from some lakes. In these samples metals were determined using flame and graphite furnace atomic absorption spectrometry after microwave digestion method. The average metal concentrations in the seven fish species varied in the following ranges: Fe, 64.3–197; Mn, 11.7–72.9; Zn, 11.9–38.6; Cu, 1.0–4.1; Pb, 0.7–2.4; Cr, 0.6–1.6; Ni, 1.2–3.4; Cd, 0.1–1.2 μg g^{-1}.

In Station 1, the mean Fe concentrations were high in kidney and muscle and in Station 3, were high in heart, liver and gills. The highest Fe concentration was determined in liver, 115.11 mg kg^{-1} in Station 3. According to these data, Fe had the highest concentration.

Al-Kahtani (2009) studied the accumulation of metals in tilapia fish (*Oreochromis niloticus*) from Al-Khadoud Spring, Al-Hassa, Saudi Arabia. He stated that metals levels were higher in liver than muscle and the levels in liver and muscle tissues were ranked Zn > Cu > Pb > Cd. In our study, the metal levels in liver were ranked generally Cu < Zn < Cd and Zn > Cd > Cu in muscle. These differences could be because of having different waste waters.

Kurun et al. (2010) studied the total metal levels (Fe, Aliminum (Al), Cr, Mn, Cu, Zn, Ni, Pb, Hg and Cd) in crayfish, *Astacus leptodactylus* (Eschscholtz, 1823) in Terkos Lake (Turkey). In our study, levels of Cu and Fe were lower in gill, muscle and liver tissues, whereas Fe level in liver of fish caught from Station 3 was high. However, Cd levels in our study were higher than their results.

Danabas et al. (2011) studied the levels of Cu in liver, muscle and gill tissues in *Capoeta trutta* (Heckel, 1843) from Munzur River (Turkey). They obtained relatively, higher Cu levels in liver and lower Cu levels in muscle and gills than our results.

In conclusion, Munzur River System is one of the most important water sources of the region, because of having a great potential aquaculture and fisheries activities. Determination of heavy metals concentrations in fish is another important subject both to nature management and human consumption of fish (Amundsen et al., 1997). The muscle of fish were used for human consumption and Turkish Food Codex (2002) sets the maximum limits of Zn, Cu and Cd as respectively, 50, 20 and 0.05 mg kg^{-1} dry weight in the muscle of fish. There is not anyone exceeding of limits in all tissues for all of the metals in our study. So that, *C. umbla* caught from Munzur River System was safe for human consumption. None the less, the continuously monitoring of metal accumulations in river system is recommended in view of the possible risks to health of consumers.

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