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Original Research

Some heavy metals in the muscle of *Capoeta trutta*: risk assessment for the consumers

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Abstract: This study was carried out to detect the concentrations of some heavy metals (copper, iron, zinc, cadmium and chromium) in the muscle of *Capoeta trutta* (Heckel, 1843) and in their surrounding water in order to study the potential human risk of consumption. The relationship between the heavy metal load of fish and some of their biological aspects (weight, length and sex) was also examined. In addition, the accumulation factors of heavy metals in this species were determined. The concentrations of Cu, Fe, Zn, Cd and Cr in water and muscle samples were analysed using ICP. Cu, Zn and Fe were detected in all samples, but Cd and Cr were not found in detectable levels. The results showed that heavy metals accumulation in muscle of fish was higher than that in the water. It was found that the level of heavy metals in the muscle of fish showed differences according to weight, length and sex of fish.

Key words: Heavy metal accumulation, accumulation factor, muscle, *Capoeta trutta*.

Introduction

Heavy metal pollution is a serious and widespread environmental problem due to the toxic, persistent, non-biodegradable and bio-accumulation properties of these contaminants (1). In recent years, industrial and mechanical activities have raised natural concentrations causing serious environmental problems. Aquatic environment is one of the receiving ends for pollutants, particularly heavy metals which are ploughed back into the food chains through bioaccumulation in plankton and invertebrates to fishes and finally biomagnified in human (2). Pollution of heavy metals in aquatic ecosystem is growing at an alarming rate and has become an important worldwide problem (3). The aim of the present study is to determine the concentrations of copper, iron, zinc, cadmium and chromium in muscle of *Capoeta trutta* from Karakaya Dam Lake in order to find out whether this species has any risk for human consumption.

Materials and Methods

Site description

Karakaya Dam Lake (Figure 1), is the third largest dam lake on the River Euphrates and is situated 166 km downstream of Keban Dam (4).

Reagents and apparatus

All reagents were of analytical grade unless otherwise stated. Distilled water was used for the preparation of solutions. All the plastic and glassware were cleaned by soaking, with contact, overnight 0.1 N nitric acid solution and then rinsed with distilled water prior to use. HNO_3 used for digestion are supplied by Merck. The concentrations of heavy metals were determined by ICP (Perkin Elmer Optima 5300 DV).

Blank preparation

At each step of the digestion processes of the samples acid blanks were done using an identical procedure to ensure that the samples and chemicals used were not contaminated. They contain the same digestion reagents as the real samples with the same acid ratios but without fish sample. After digestion, acid blanks were treated as samples and diluted with the same factor. They were analysed by ICP before real samples and their values were subtracted to check the equipment to read only the exact values of heavy metals in real samples. Each set of digested samples had its own acid blank and was corrected by using its blank sample.

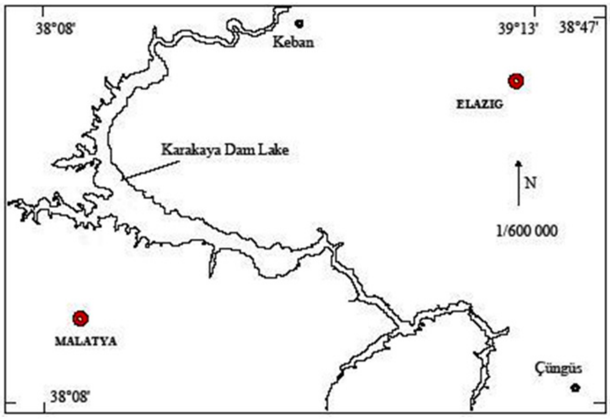

Figure 1. Karakaya Dam Lake, Malatya-Turkey (5).

Fish collection and analysis

Fish samples were collected from Karakaya Dam Lake by gill net (from July 2008 to March 2009). Captured fish were immediately transported to the laboratory in a freezer bag with ice. Total length and weight were measured to the nearest millimetre and gram before dissection, and then 10 g homogenized muscle (cleaned from skin) samples were taken from 30 fish. They were individually transferred to 4 ml glass vials previously washed (with 0.1 N nitric acid), dried,

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Table 1. Heavy metal concentration in the water and acceptable values suggested by USEPA (9).

	Cu	Fe	Zn
Heavy metal concentrations (mg L^{-1})	0.01	0.04	0.07
Permissible limits (mg L^{-1})			
MC	0.013	-	0.12
CC	0.009	1	0.12

MC: Maximum concentrations CC: Continuously concentrations

and weighed and then they were dried in an oven for 24 hours at 105ºC and kept in a desiccator for a few days until constant weight was obtained. Vials were again weighed to obtain dry weight of tissues, and then samples were digested on a hot plate by adding 2 ml suprapure nitric acid (65%, Merck, Whitehouse Station, New Jersey). Digested samples were kept at room temperature for 24 hours and then diluted to 50 ml with deionised distilled water. Standard solutions for calibration graphs were prepared. Blanks were also prepared using the procedure as above, but without the samples. Diluted samples and blank solutions were analysed by ICP for determination of copper, iron, zinc, cadmium and chromium levels (6).

Accumulation Factor (AF)

The Accumulation Factor is the ratio between the accumulated concentration of a given pollutant in any organ and its dissolved concentration in water. It gives an indication about the accumulation efficiency for any particular pollutant in any fish organ (7). Accumulation Factor was calculated according to Aboul Ezz and Abdel-Razek (8) using the following equation:

$AF = M_{tissue} / M_{water}$

If the accumulation factor is greater than 1.0, then bioaccumulation for metals occurs by fish species.

Statistical analysis

GraphPad Prisim 5.0 package programs were used to get the statistical analysis (t-test and One Way ANOVA, Duncan) and graph of the data obtained during the research.

Results and Discussion

Heavy metals in water

In the water samples, the concentration of Cu, Fe and Zn were 0.01, 0.04 and 0.07 mg L^{-1} respectively. By comparing measured concentrations of metals with water quality standards, it was found that all metal concentrations were lowest than the permissible limits (Table 1).

Heavy metals in fish

Only Cu, Fe and Zn were detected in the muscle samples analysed (Figure 2). All others were found to be undetectable levels. In this study, the order in relation to the concentration of heavy metal in the muscle was found as Zn>Fe>Cu. The order of some heavy metals in the muscle of some fish species was found as Zn>Fe>Cu>Mn for *Capoeta capoeta umbla* from Lake Hazar (10), Zn>Cu>Pb>Cd for *Liza aurata* from Lake Manzala (11), Fe>Pb>Cd>Cu>Ni for fish from Upper Lake and Fe>Ni>Cu>Cd>Pb for fish from Shahpura Lake (12), Zn>Hg>As>Cu for *Silurus triostegus*, Zn>Hg>As>Cu for *Aspius vorax*, Zn>Cu>As>Pb for *Cyprinus carpio*, Zn>Cu>As>Hg for *Carasobarbus luteus*, Zn>Cu>As for *Capoeta trutta*, Zn>Cu>Hg>As for *Chalcalburnus mossulensis*, Zn>Cu>As>Pb>Hg for *Acanthobrama marmid* (13). In general, our findings showed similarity with the findings of these researches.

Heavy metal accumulation in muscle increased with fish size (Figure 3 and 4). These increase were found significant ($P<0.05$). Similar results were found for *Capoeta capoeta umbla* (10) and for *Tilapia zilli* (14).

Some studies stated that accumulation of heavy metals in fish change not only according to the size and sex of fish. But also it was controlled by specific uptake, detoxification and elimination mechanisms, depends on

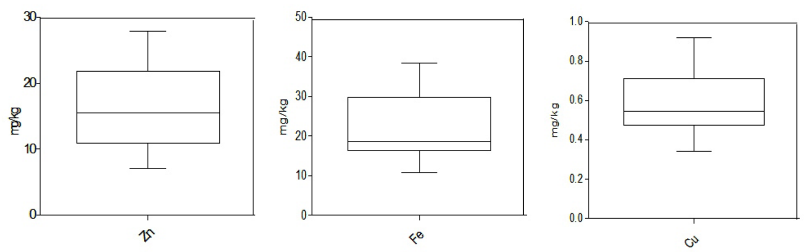

Figure 2. Box-Whisker diagram dissemination of some heavy metals concentration in muscle of *C. trutta*.

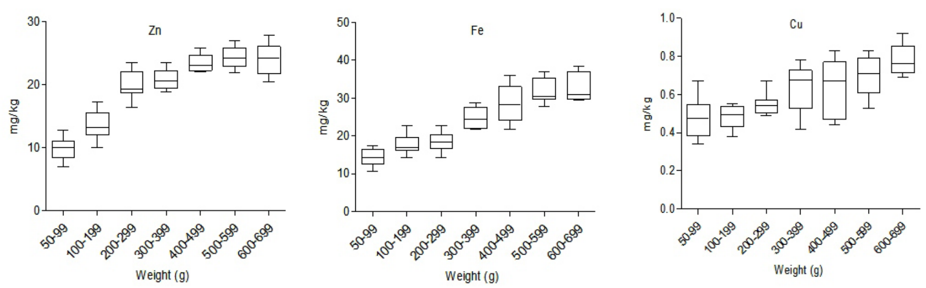

Figure 3. Some trace metals in muscle tissue of *C. trutta* fish species in relation to fish weight.

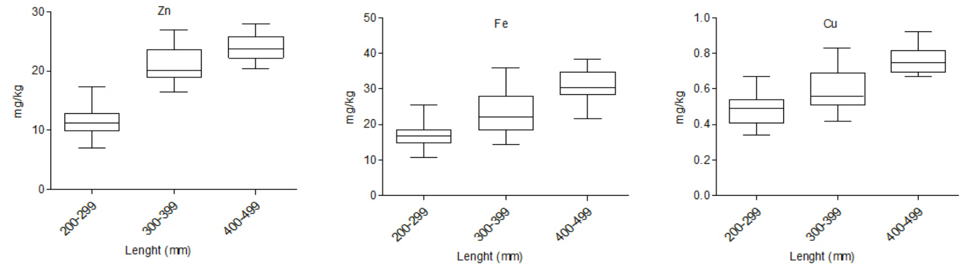

Figure 4. Some trace metals in muscle tissue of *C. trutta* fish species in relation to fish length.

the size-specific metabolic rate of organisms (10).

The effect of sex on the level of the tested metals was also examined (Figure 5). Although the concentration of all metals analysed in muscle tissue of female fish were found to be higher than those of male fish, the differences were not statistically significant (P>0.05). Al-Yousuf *et al.* (15) found that Cu, Zn and Cd concentration is more in female fish compared to the male fish.

The concentrations of heavy metals in some fish species examined by some researches were compared with the present study in Table 2.

These results clearly show that accumulation levels of heavy metals in the tissues change according to the habitat and fish species. The heavy metal accumulation in tissues are much higher than the level of changes in the environment and concentrations are changeable according to the type and the concentration of the metal, water quality, species of the organism, season, age and nutrition type (22). The concentration rates of all elements determined in *C. trutta* muscle tissues differs according to the weight and this shows that heavy metal accumulation level changes according to the weight groups. The lowest level of concentration of all elements in the muscles of *C. trutta* was found in 100-399 g in weight groups. When length is taken into account the lowest concentration of all elements for *C. trutta* was found in 200-299 mm in length group. As a result it is found that all elements accumulation in the muscle of *C. trutta* changes according to the weight and length groups. When the accumulation levels of all elements between female and male *C. trutta* caught in Karakaya Dam Lake was compared. All elements (except for Fe) are found in higher levels in muscle tissues of male *C. trutta*.

The variability in heavy metal levels in different species depends on feeding habits (23), ecological needs (24), metabolism (25) and biological aspects of fish (26). Yılmaz and Solak (27) found that *C. trutta* have

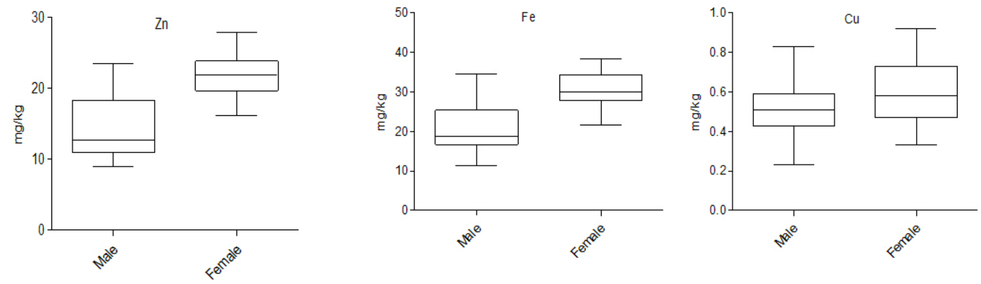

Figure 5. Some trace metals in muscle tissue of *C. trutta* fish species in relation to fish sex.

Table 2. Some heavy metal concentrations (mg/kg) determined in the muscle tissue of *C. trutta* and some fish species.

Fish species	Zn	Fe	Cu	References
Capoeta trutta	7.00-27.88	10.67-38.36	0.34-0.92	present study
Capoeta capoeta umbla	3.51	18.13	46.59	Canpolat and Calta (16)
Acanthobrama marmid	3.18	9.31	13.28	
Cyprinus carpio	2.83	19.02	27.87	Calta and Canpolat (17)
Chondrostoma regium	3.13	22.51	38.66	
Oreochromis niloticus		0.80	1.41	
Tilapia zilli		1.97	1.04	Kanayochukwu *et al.* (18)
Serathrodon niloticus		2.84	3.80	
Clarias gariepinus		18.01	10.80	
Ethmaliosa timbriata		6.20	1.85	
Capoeta umbla	13.28	19.96	1.35	Canpolat (19)
Aspius vorax	10.536	18.367	0.009	Canpolat *et al.* (20)
Luciobarbus xanthopterus	10.49-49.12	12.04-69.16	0.30-1.88	Dusukcan *et al.* (21)

Table 3. The accumulation factor (AF) from water in *C. trutta* from Karakaya Dam Lake.

	Heavy metals		
	Cu	**Fe**	**Zn**
Heavy metal concentrations in water (mg L^{-1})	0.01	0.04	0.07
Heavy metal concentrations in muscle (mg kg^{-1})	0.59	22.87	10.79
Accumulation Factor (AF)	59.0	571.75	154.14

more bottom material in the digestive system due to not making a major food preferences and owning a ventral mouth. Thus, heavy metals that are present larger amounts in sediment passes in fish through the digestive. This can be one of the reason to be more heavy metal in the muscle of *C. trutta* than that in water. Kır *et al.* (28) stated that it can be explained to be the higher amount of heavy metal accumulation in sediments due to the high metal binding capacity of sediments and high molecular weight of heavy metals.

Accumulation factor

The average concentrations of the metals detected in fish muscles and the values of accumulation factor (AF) are summarized in Table 3. It was found that the concentrations of metals in muscle are much higher than in the water. The accumulation factor from water to fish in case of *C. trutta* was in the order of Fe (571.75)>Zn (154.14)>Cu (59.0). Iron was the greatest metal accumulated by *C. trutta* from water, while the accumulation factor of Cu was the lowest.

The presence of metals in high levels in fish environment does not indicate a direct toxic risk to fish, if there is no significant accumulation of metals by fish tissues (29). On the other hand, all accumulation factors (AF) from water were higher than 1.00 which means that the *C. trutta* accumulated metals from water. This result agrees with some previous studies on Tilapia species (3, 30).

Conclusion

In conclusion there was a clear difference between the concentrations of heavy metals within muscle tissue of fish. However, there was no rather clear difference for some metal levels between the comparable parameters such as fish size, sex and seasons. Sometimes, smaller fish showed higher concentrations of a metal or bigger fish of another metal. Heavy metals pollution affects not only aquatic organisms, but also public health as a result of bioaccumulation in food chain. Our results show that heavy metal levels in the muscle samples taken from *C. trutta* caught from Karakaya Dam Lake were under the dangerous limits given by EPA (31) and FAO (32) and there is no any risk for public health by eating of *C. trutta* (Table 4).

Table 4. Heavy metal concentration in the muscle tissue of *C. trutta* and acceptable values suggested by EPA (1989) and FAO (1983).

	Cu	Fe	Zn
EPA (1989) (mg/g)	54	410	410
FAO (1993) (mg/kg)	10.0	-	150
C. trutta (mg/kg)	0.34-0.92	10.67-38.36	7.00-27.88

References

1. Abdel-Satar AM, Geneid YA. Evaluation of heavy metal status in ecosystem of Lake Manzalah, Egypt. Glo J Environ Res 2009; 3:194-204.
2. Edward JB, Idowu EO, Oso JA, Ibidapo OR. Determination of heavy metal concentration in fish samples, sediment and water from Odo-Ayo River in Ado-Ekiti, Ekiti-State, Nigeria. Int J Environ Mon Anal 2013; 1:27-33
3. Abdel-Baki AS, Dkhil MA, Al-Quraishy S. Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of WadiHanifah, Saudi Arabia. Afr J Biotechno 2011; 10:2541-2547.
4. Anul N. Karakaya Dam Lake Limnological Report. Turkish Republic The Ministry of Public Works and Settlement, General Directorate of State Hydraulic Works, The 9. Regional Directorate, Elazig, Turkey, 1995, (in Turkish).
5. Pala G, Tellioğlu A, Eroğlu M, Şen D. The digestive system content of *Mastacembelus mastacembelus* (Banks &Solander, 1794) inhabiting in Karakaya Dam Lake (Malatya-Turkey). Turk J Fish Aquat Sci 2010; 10:229-233.
6. APHA. Standart Methods for Examination of Water and Wastewater. 16th ed. American Public Health Assosiciation, Washington, 1985.
7. Authman MMN, Abbas HHH. Accumulation and distribution of copper and zinc in both water and some vital tissues of two fish species (*Tilapia zilii* and *Mugil cephalus*) of Lake Qarun, Fayoum province, Egypt. Pak J Biol Sci 2007; 10:2106-2122.
8. Aboul Ezz AS. Abdel-Razek SE. Heavy metal accumulation in the *Tilapia nilotica* L. and in the waters of Lake Manzalah. Egypt. J App Sci 1991; 6:37-52.
9. USEPA. National Recommended Water Quality Criteria, Office of Water. 822-R-02-047, 2002.
10. 10 Canpolat O, Çalta M. Heavy metals in some tissue and organs of *Capoeta capoeta umbla* (Heckel, 1843) fish species in relation to body size, age, sex and seasons. Fresenius Environ Bull 2003; 12: 961-966.
11. Bahnasawy M, Khidr AA, Dheina N. Assessment of heavy metal concentrations in water, plankton, and fish of Lake Manzala, Egypt. Turk J Zool 2011; 35:271-280.
12. Tirkey A, Shrivastava P, Saxena A. Bioaccumulation of heavy metals in different components of two Lakes Ecosystem. Current World Environ 2012; 7:293-297.
13. Mol S, Ozden O, Oymak SA. Trace metal contents in fish species from Atatürk Dam Lake (Euphrates, Turkey). Turk J Fish Aquat Sci 2010; 10:209-213.
14. Zyadah MA. Accumulation of some heavy metals in *Tilapia zillii* organs from Lake Manzalah, Egypt. Turk J Zool 1999; 23:365-372.
15. 15 Al-Yousuf MH, El-Shahawi MS, Al-Ghais SM. Trace metals in liver, skin, and muscle of *Lethrinas lentjan* fish species in relation to body length and sex. Sci Total Environ 2000; 256:87-94.
16. Canpolat O, Calta M. Comparison of some heavy metal levels in muscles taken from three different parts of *Capoeta capoeta umbla* caught in Lake Hazar (Elazığ, Turkey). Pak J Biol Sci 2001; 4:891-892.
17. Calta M, Canpolat O. The comparison of three cyprinid species in terms of heavy metal accumulation in some tissues. Water Environ Res 2006; 78:548-551.

18. 18 Kanayochukwu NJ, Ebere OO, Obi OI. Heavy metal levels in muscles of some fish species from Aladja River; Warri, Nigeria: A public health concern. Adv Environ Biol 2010; 4: 125-130.
19. Canpolat O. Accumulation factor of heavy metals in *Capoeta umbla* fish species. Fresenius Environ Bull 2013; 22:745-751.
20. Canpolat O, Eroğlu M, Çoban MZ, Düşükcan M. Transfer factors and bioaccumulation of some heavy metals in muscle of a freshwater fish species:A human health concern. Fresenius Environ Bull 2014; 23:418-425.
21. Dusukcan M, Eroğlu M, Canpolat O, Çoban MZ, Çalta M, Şen D. Distribution of some heavy metals in muscle tissues of *Luciobarbus xanthopterus*. Turk j Sci Techno 2014; 9:37-46.
22. Ozkan F, Gocer M, Karayakar F, Koyuncu E, Dönmez E, Saglamtimur B. The accumulation of Cu, Zn and Cd in red bream (*Chrysophrys aurata* L., 1758), red mullet (*Mullus barbatus* L.,1758) and grey mullet (*Mugil cephalus* L.,1758) species from Mediterranean coasts, Mersin, Turkey (in Turkish). 9th National Fisheries Symposium, Isparta, Turkey, 1997, pp. 419-425.
23. Romeo M, Siau Y, Sidoumou Z, Gnassia-Barelli M. Heavy metal distribution in different fish species from the Mauritania coast. Sci Total Environ 1999; 232:169-175.
24. Canli M, Furness RW. Toxicity of heavy metals dissolved in sea water and influences of sex and size on metal accumulation and tissue distribution in the Norway lobster Nephropsnorvegicus. Mar Environ Res 1993; 36:217-236.
25. Linde AR, Sánchez-Galán S, Izquierdo JI, Arribas P, Marañón E, García-Vázquez E. Brown trout as biomonitor of heavy metal pollution: effect of age on the reliability of the assessment. Eco Environ Saf 1998; 40:120-125.
26. Canli M, Atli G. The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species. Environ Poll 2003; 121:129-136.
27. Yılmaz F, Solak K. Feeding organisms living in *Capoeta trutta* (Heckel;1843) in the Tigris River and changes in these organisms according to month and age. Tr J of Zoology 1999; 23:973-978.
28. Kır İ, Tekin Özan S, Tuncay Y. The seasonal variations of some heavy metals in Kovada Lake's water and sediment. Ege Uni J of Fish Aqu Sci 2007; 24:155-158.
29. Kamaruzzaman YB, Ong CM, Rina ZS. Concentration of Zn, Cu and Pb in some selected marine fishes of the Pahang Coastal waters, Malaysiay. Amer J App Sci 2010; **7**:309-314.
30. Rashed MN. Monitoring of environmental heavy metal in fish from Nasser Lake. Environ Int 2001; 27:27-33.
31. EPA. Assessing Human Health Risks from Chemically Contaminated Fish and Shellfish: A Guidance Manual, EPA-503/8-89-002, US Environmental Protection Agency, Office of Research and Development, Washington DC, 1989.
32. FAO. Compilation of Legal Limits for Hazardous Substances in Fish and Fishery Products, FAO Fishery Circulars No:764, Fish and Agriculture Organization, Roma, Italy, 1983.