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Original Research

Some heavy metals in *Luciobarbus esocinus* for public consumption and consumer protection

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Abstract: In this study, the concentrations of some heavy metals were determined in the muscle of *Luciobarbus esocinus* Heckel, 1843 and in water where they live. The results were evaluated in term of potential human risk of consumption of this fish and the relationship between the heavy metal load of fish and some of their biological aspects (weight, length and sex). In addition, the accumulation factor of heavy metals in the muscle of *L. esocinus* were also determined. The Cr, Pb and Ni were not found in detectable levels according to results obtained by ICP. Only Cu, Zn and Fe were detected. It was found that heavy metals concentrations in the muscle of *L. esocinus* were higher than that in the water. The concentration of heavy metals showed differences according to weight, length and sex of fish. The results were discussed and compared with tolerable values for heavy metals provided from the EPA, FAO and WHO in order to determine whether this fish species has any risk for human consumption.

Key words: Accumulation factor; *Luciobarbus esocinus*; Heavy metals; Public consumption; Consumer protection.

Introduction

The accumulation of toxic metals to hazardous levels in aquatic biota has become a problem of increasing concern (1). The rate of bioaccumulation of heavy metals in aquatic organisms depends on the ability of the organisms to digest the metals and the concentration of such metal in the aquatic ecosystem. In addition, it has to do with the concentration of the heavy metal in the surrounding soil sediments as well as the feeding habits of the organism. Aquatic animals (including fish) accumulate trace metals in their body at considerable amounts and these metals stay in their body over a long period. Fishes have been recognized as a good accumulator of organic and inorganic pollutants (2,3). Heavy metals like copper, iron and zinc are essential for fish metabolism, while some others such as mercury, cadmium and lead have no known role in biological systems. For normal metabolism, the essential metals must be taken up from water or food, but excessive intake of the essential metals can produce toxic effects (4). Fish constitute an important source of protein for many people throughout the world and fish consumption has increased in importance among health-conscious people because it provides a healthy and low cholesterol sources of protein and other nutrients (5,6,7).

The aim of this study is to determine some heavy metal concentrations in the muscle of *L. esocinus* from Karakaya Dam Lake (Turkey) and to determine the possible potential human risk of consumption of *L. esocinus* and to investigate the relationships between some biological aspects of fish and metal concentrations in the muscle and accumulation factor.

Materials and Methods

Karakaya Dam Lake (Figure 1) is the third largest dam lake on the River Euphrates (in respect to the surface area of lake) right after Keban Dam Lake.

All reagents were of analytical reagent 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 zinc, iron, copper, chrome, lead and nickel were determined by ICP (Perkin Elmer Optima 5300 DV).

The concentrations of metals were measured in the muscles of fish collected by gill net in the open water of Karakaya Dam Lake. Captured fish were placed in a freezer bag with ice and immediately transported to

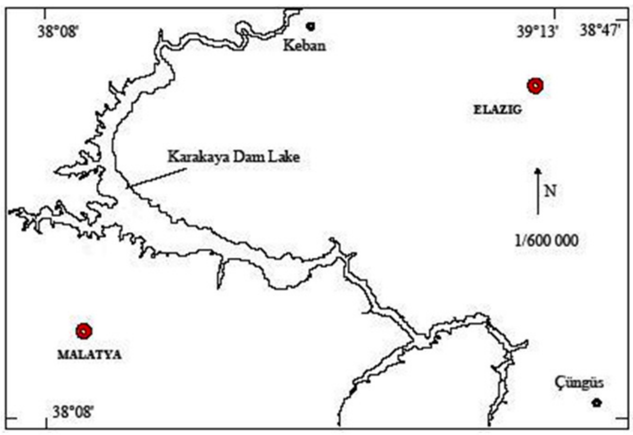

Figure 1. Karakaya Dam Lake, Malatya-Turkey (8).

the laboratory. Total length and weight of each fish was measured to the nearest millimetre and gram before dissection, and then approximately 5g muscle (cleaned from skin) samples were dissected from a total of 21 *L. esocinus*. Muscle samples were individually transferred to 4 mL glass vials previously washed (with 0.1 N nitric acid), dried, and weighed and then they were dried in an oven for 24 h 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 (duplicate digestion, in each case) 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 24h 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 (Perkin Elmer Optima 5300 DV) for determination of zinc (Zn), iron (Fe), copper (Cu), chromium (Cr), lead (Pb) and nickel (Ni) levels (9).

The Accumulation Factor (AF) 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 (10). Accumulation Factor (AF) was calculated according to Aboul Ezz and Abdel-Razek (11) 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.

All statistical analyses were performed by using SPSS ver.22.0 computer program (IBM Corporation).

Results

The concentration of heavy metals detected in the muscle of *L. esocinus* and in the water where they live are given in Table 1. The order of heavy metal accumulation was Zn>Fe>Cu in water and Fe >Zn >Cu in the muscle of fish. Only Cu, Fe and Zn were detected in the muscle tissues samples analysed. Cr, Pb and Ni were found to be undetectable levels in the muscle samples. The accumulation factor (AF) from water to fish in case of *L. esocinus* was in the order of Fe>Zn>Cu (Table 1). According to AF result, Fe was the greatest metal accumulated by *L. esocinus* from water.

The levels of Cu, Fe and Zn in the muscle of *L. esocinus* increased with the increasing of fish weight (Figure 2). According to determinant coefficient (R^2 values), there was a very strong relationship between heavy metal concentrations and fish weight (Figure 2).

The levels of Cu, Fe and Zn in the muscle of *L. esocinus* increased with the increasing of fish length (Figure 3). According to determinant coefficient (R^2 values),

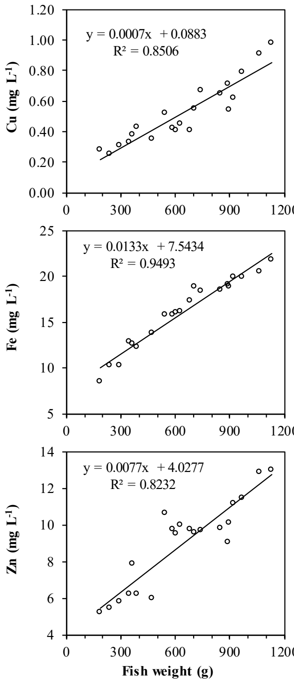

Figure 2. The relationship between fish weight and heavy metal accumulation in *L. esocinus* from Karakaya Dam Lake.

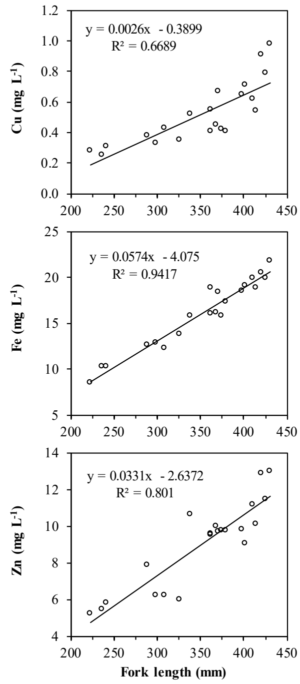

Figure 3. The relationship between fish length and heavy metal accumulation in *L. esocinus* from Karakaya Dam Lake.

these relationships was very strong for Fe and Zn and strong for Cu (Figure 3).

The levels of Cu, Fe and Zn in the muscle tissue of *L. esocinus* in relation to sex are given in Figure 4. The levels of Cu, Fe and Zn between sexes were found insignificant (*t-test; P>0.05*).

Table 1. Mean values with ± standard error (SH) of Cu, Fe and Zn in the surrounding water and in the muscle of *L. esocinus* from Karakaya Dam Lake together with the accumulation factor (AF) from water.

	Cu	Fe	Zn
Heavy metal levels in the surrounding water (mg L^{-1})	0.01	0.04	0.06
Heavy metal levels in the muscle of *L. esocinus* (mg kg^{-1})	0.52±0.04	16.08±0.83	9.01±0.52
Accumulation factor (AF)	52.0	402.00	150.17

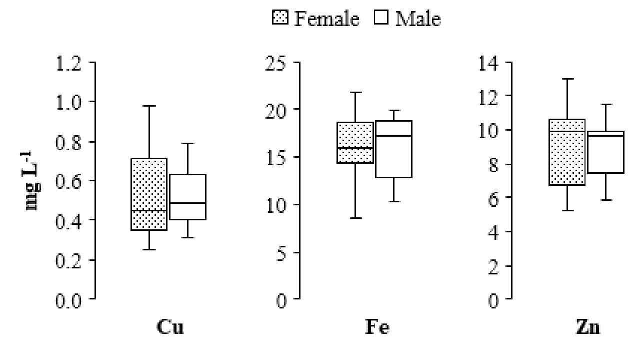

Figure 4. The level of Cu, Fe and Zn in the muscle tissue of *L. esocinus* in relation to sex.

Discussion

In this study the concentration of heavy metals, Cu, Fe and Zn, were 0.01, 0.04 and 0.06 mg L^{-1} respectively in the water samples. Zn content was the highest and that of Cu was the lowest in water. Contamination of aquatic ecosystems with heavy metals has seriously increased worldwide attention (12). By comparing measured concentrations of metals with water quality standards, it was found that all metal concentrations were lowest than the permissible limits (Table 2).

The accumulation factor from water to fish in case of *L. esocinus* was in the order of Fe (402.00)>Zn (150.17)>Cu (52.0). Iron was the greatest metal accumulated by *L. esocinus* 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 (14). On the other hand, all AF from water were higher than 1.00, which means that the *L. esocinus* accumulated metals from water. This result agrees with many previous studies. Rashed (15) determined transfer factors for Co, Cr, Cu, Fe, Mn, Ni, Sr and Zn from water, sediment and plant in *Tilapia nilotica* fish in Nasser Lake, results indicated that only transfer factors from water for all metals were >1.00, which means that fish accumulated metals from water. Also Abdel-Baki et al**.** (16) calculated transfer factors of five heavy metals from water and sediment in Tilapia fish, results indicated that fish accumulated all metals in its tissues from water. Transfer factors of metals from water in fish muscles were 41.789, 8.621, 11.923 24.714, 35.938 for Pb, Cd, Hg, Cu and Cr respectively.

Table 2. Heavy metal concentration in the water and acceptable values suggested by USEPA (13).

	Cu	Fe	Zn
Heavy metals in water (mg L^{-1})	0.01	0.04	0.06
Permissible limits (mg L^{-1})			
MC (mg L^{-1})	0.013	-	0.12
CC (mg L^{-1})	0.009	1	0.12

MC: Maximum concentrations, CC: Continuously concentrations.

In this study, the order in relation to the concentration of heavy in the muscle is found as Fe>Zn>Cu. In a research about the Fe, Mn, Cu, Zn, Cd, Cr and Pb accumulation in the organs and tissues of *Capoeta capoeta umbla* which lives in Lake Hazar, the order of these heavy metals in relation to their concentration in muscle is found as Zn>Fe>Cu>Mn (17). In a research about the accumulation of Fe, Zn, Ni, Cu, Co and Mn, in the muscles of *Channa punctatus* the order of accumulation is Fe>Zn>Ni>Cu>Co>Mn, whereas in *Clarias gariepinus* it was Fe>Zn>Ni>Cu=Mn>Co>Cr and in *Labeo rohit*a the pattern of accumulation was Zn>Fe>Ni>Cu>Co>Mn (18).

In a research about the accumulation of Cd, Cu, Mo, Fe, Mn, Ni, Pb and Zn in the gill, liver and muscle of *Cyprinion macrostomus* in Atatürk Dam Lake, the order in relation to the concentration of these heavy metals in the muscle is found as Zn>Fe>Cu>Mn. In the search about the accumulation of heavy metals Fe, Zn, Cd and Pb in tissues *Capoeta umbla* from Uzuncayir Dam Lake the order of the heavy metal concentration is found as Fe>Zn>Cd>Cu (19). Findings in these researches support the findings in this study.

The levels of Cu, Fe and Zn determined in *L. esocinus* muscle tissues differs according to the weight and length of fish. Their concentrations increased with in-

Table 3. Some heavy metal concentrations (mg/kg) determined in the muscle tissue of *L. esocinus* and some fish species.

Fish species	Zn	Fe	Cu	References
L. esocinus	5.19-13.02	8.50-21.81	0.25-0.98	This study
C. trutta	7.00-27.88	10.67-38.36	0.34-0.92	Eroğlu *et al.* (22)
A. marmid	3.18	9.31	13.28	Calta and Canpolat (23)
C. carpio	2.83	19.02	27.87	
C. regium	3.13	22.51	38.66	
S. triostegus	12.38	-	0.101	Mol *et al.* (24)
A. vorax	10.46	-	0.215	
C.carpio (common)	17.45	-	0.385	
C. carpio (mirror)	10.85	-	0.414	
C. luteus	19.74	-	0.258	
C. trutta	10.27	-	0.241	
C. mossulensis	13.72	-	0.465	
A. marmid	16.94	-	2.785	
A. vorax	10.536	18.367	0.009	Canpolat *et al*. (25)
L. xanthopterus	10.49-49.12	12.04-69.16	0.30-1.88	Dusukcan *et al.* (26)
C. carpio	6.8-14.65	4.67-10.83	0.23-0.74	Canpolat *et al.* (27)
M. mastacembelus	5.18-14.59	10.10-45.89	0.011-0.055	Eroğlu *et al.* (28)

Table 4. Heavy metal concentration in the muscle tissue of *L. esocinus* and acceptable values suggested by FAO (32), EPA (33), and WHO (34).

	Heavy metals		
	Cu	Fe	Zn
FAO (32) (mg kg^{-1})	10.0	-	150
EPA (33) (mg kg^{-1})	54	410	410
WHO (34) (mg kg^{-1})	3	146	10-75
L. esocinus (mg kg^{-1})	0.25-0.98	8.50-21.81	5.19-13.02

creasing of the weight and length of fish. Similarly, it was reported that the organs tend to accumulate high concentrations of heavy metals with the increase of fish size. (17, 20, 21, 22).

Table 3 shows the concentration levels of heavy metals in some fish species examined by some researches and heavy metal concentration determined in the muscle of *L. esocinus* in this study. As it can be seen in Table 3, accumulation levels of heavy metals in the muscle change according to the habitat and fish species.

As a result, mobility degrees, activities and the accumulation of heavy metals in the living organisms are related to so many factors such as pH, temperature, organic matter, processes of ionic changes and microbial activity (29). It is found out that the heavy metal accumulation level may change according to the size, age, life period, nutrition type of the fish and the season they caught (30).

It is found that heavy metals are hazardous for the aquatic ecosystems especially for the Cyprinidae species, which are nourished in deep water. As a result, it is determined that these species are more contaminated when compared to the predator fish (31).

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 because of bioaccumulation in food chain. Our results show that heavy metal levels in the muscle samples taken from *L. esocinus* caught from Karakaya Dam Lake were under the dangerous limits given by FAO (32) and EPA (33) and there is no any risk for public health by eating *L. esocinus* (Table 4).

Interest conflict

There are not any financial and personal relationships among the authors.

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