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Original Research

Some heavy metals in the flesh of chub, *Squalius cephalus*, from Karakaya Dam Lake (Malatya, Turkey)

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Abstract: This research aimed to find out the levels of Iron (Fe), Zinc (Zn), and Cupper (Cu) in the flesh of Chub (*Squalius cephalus*) and in the Karakaya Dam Lake water in which they live. The findings were evaluated in terms of the risk of consuming of this fish as human food. In addition, the changes of the heavy metal level of fish with weight, length and sex of them. The accumulation factor for each metal was also found. The level of heavy metals in the flesh of fish were found higher than that in the water. The level of heavy metals changed with the weight, length and sex of fish. The results were compared with acceptable values for heavy metals given by FAO/WHO to detect whether the flesh of chub has any risk for consumption as human food.

Key words: Karakaya Dam Lake; Chub; *Squalius cephalus*; Iron; Zinc; Cupper.

Introduction

During the last decade, most researches are focused on the risk issues, assessment, and maintaining of environment quality. The estimation and monitoring of environmental pollution are becoming increasingly important to develop different monitoring methods and strategies (1). The natural water reservoirs are extensively polluted with heavy metals released from agricultural fields, sewage disposal, atmospheric deposition and wastes of domestic and industrial areas (2, 3). Aquatic environments, particularly lakes and reservoirs located near the industrial or urban areas, are potential targets for the flow of environmentally harmful elements such as organic and inorganic contaminants. One such group of contaminants or aquatic pollutants is the heavy metals (4, 5). The heavy metals are deposited, assimilated or incorporated in water, sediment and the body of aquatic animals due to be not degraded for a long time (6, 7) and thus, causing heavy metal pollution in water resources (7, 8). The being of heavy metals in the aquatic environment is a serious problem because of their toxic effects and threat to plants and animals life by disturbing the natural ecological balance. The main problem associated with the heavy metals in the water reservoir is the accumulation of them in the food chain and permanent in nature during many years (9).

The present study was aimed to find the levels of some heavy metals in the flesh of *S. cephalus* obtained from Karakaya Dam Lake (Malatya, Turkey) and to determine the possible potential risk of *S. cephalus* consumed as human food. In addition, accumulation factor and the changes of heavy metal concentrations with the weight, length and sex of fish were investigated as well.

Materials and Methods

In respect to the surface area, Karakaya Dam Lake is one of the largest dam lake established on the Euphrates (Figure 1).

All reagents were of analytical reagent grade unless otherwise stated. Distilled water was used for the preparation of solutions. All materials used for experiment were soaked in 0.1 N nitric acid solution during overnight and then rinsed with distilled water before using. Nitric acid was used for digestion of fish flesh.

Fish samples were collected by gill net in the open water of Karakaya Dam Lake, then they were placed in a freezer bag with ice and immediately transported to the laboratory. Total length and weight of fish was measured before dissection, and then nearly 5g flesh samples were removed. These samples were put into 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

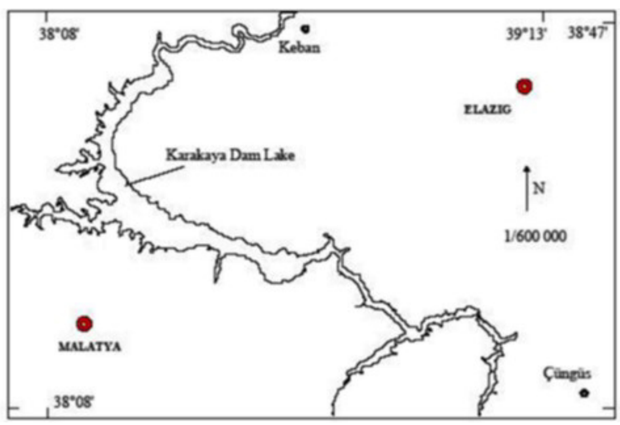

Figure 1. Karakaya Dam Lake, Malatya-Turkey (10).

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 the determination of the amounts of heavy metals (9).

The ratio of the concentration of a pollutant accumulated in any organ of aquatic organism to the concentration of this pollutant in the water is called as Accumulation Factor (AF). It is an indication of transition and accumulation efficiency for any particular pollutant from water to fish body. Accumulation Factor (AF) was calculated using the equation: $AF = M_{tissue} / M_{water}$ given by Aboul Ezz and Abdel-Razek (11).

If the accumulation factor is greater than 1.0 then bioaccumulation for metals occurs by fish species. All statistical analysis was performed with SPSS ver. 22.0-statistic software package. Data were expressed as mean ± standard error (SH) or min-max. Comparisons between sexes were performed with analysis of non-parametric Mann-Whitney U test. A value of $P < 0.05$ was considered statistically significant.

Results

The amounts of heavy metals detected in the flesh of *S. cephalus* and in the water where they live are given in Table 1. The sequence of heavy metal was Fe>Zn>Cu in water and Zn>Fe>Cu in the flesh of fish. The accumulation factor (AF) was in the order of Zn>Cu>Fe (Table 1).

The amounts of Zn, Fe and Cu in the flesh of *S. cephalus* increased with the increasing of fish weight (Figure 2). According to determinant coefficient R^2 values (12), the relationships with fish weight was strong for Fe (R^2=0.868) and Zn (R^2=0.801) and moderate for Cu (R^2=0.664) (Figure 2). The amounts of Cu, Fe and Zn in the flesh of *S. cephalus* increased with the increasing of total length of fish (Figure 3). The relationships of heavy metal levels with total length was very strong for Fe and strong for Zn and for Cu (Figure 3). According to sexes, the differences of the heavy metal levels were not significantly for Zn and for Cu (P>0.05), but significant for Fe (P<0.05) (Figure 4).

Discussion

In this study, the amounts of Cu, Fe and Zn in the water samples from Karakaya Dam Lake were 0.002,

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

	Zn	Fe	Cu
Mean value of heavy metals:			
in the surrounding water (mg L^{-1})	0.02	0.04	0.002
in the flesh of *Squalius cephalus* (mg kg^{-1})	6.74	5.05	0.28
Accumulation factor (AF)	337.0	126.25	140.0

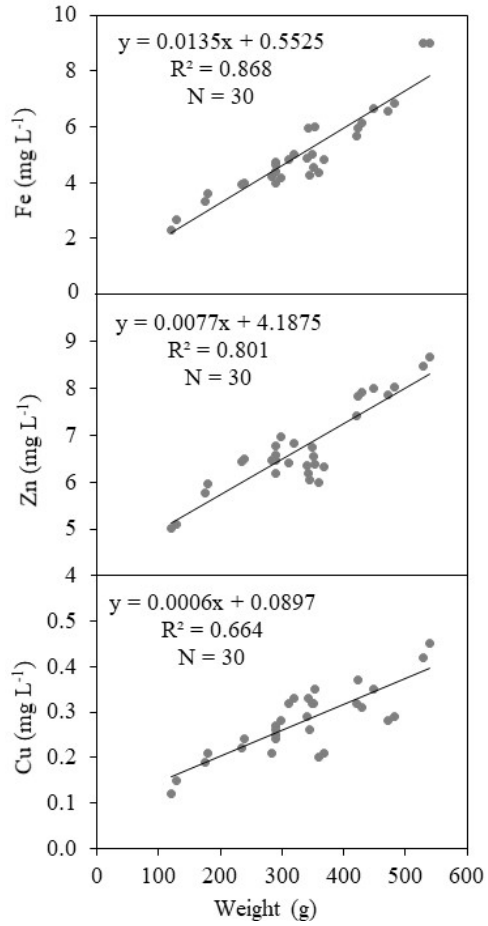

Figure 2. The changes of heavy metal levels in the flesh of *S. cephalus* in relation to fish weight.

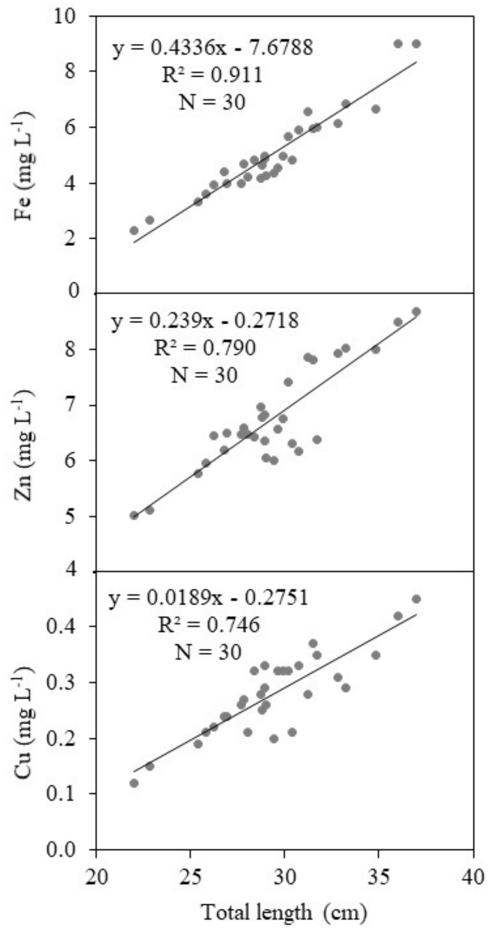

Figure 3. The changes of heavy metal levels in the flesh of *S. cephalus* in relation to total length of fish.

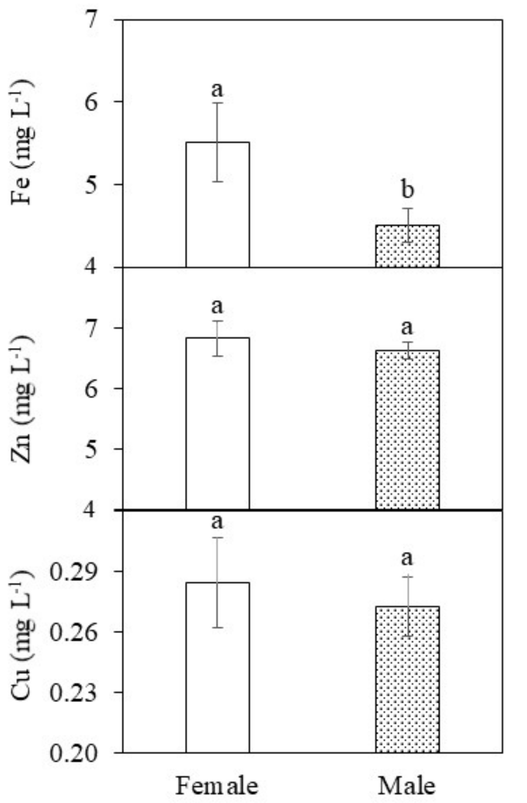

Figure 4. The changes of heavy metal levels in the flesh of *S. cephalus* in relation to sexes of fish. Mean values with standard error bars (N = 30). The heavy metal level between the sexes showed by different letters is statistically significant (P<0.05; Mann-Whitney U test).

0.04 and 0.02 mg L^{-1} respectively. Fe content was the highest and it was followed by Zn and Cu. By comparing measured concentrations of metals with water quality standards, it was found that all metal concentrations of the present study were lower than the permissible limits (Table 2).

The accumulation factor (AF) from water to fish in case of *S. cephalus* was in the order of Zn (337.0) > Cu (140.0) > Fe (126.25). Zinc was the greatest metal accumulated by *S. cephalus* from water, while the accumulation factor of Fe 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 *S. cephalus* accumulated metals from water. The results agree with the result of a previous study (15) determined transfer factors for some heavy metals from water, sediment and plant in *Tilapia nilotica* fish in Nasser Lake. This results indicated that only transfer factors from water for all metals were >1.00, which means that fish mostly accumulated metals from water. Also Abdel-Baki et al**.** (7) 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.

Table 2. Heavy metal concentration in the water and acceptable values suggested by WHO and USA.

Heavy metals (mg L^{-1})	*WHO (guidelines)	*USA (standards)	Present study
Cu	2	1.3	0.002
Fe	-	0.3	0.04
Zn	3	5.0	0.02

* Values were taken from Javed and Usmani (13).

Heavy metal concentrations in fish are important for both human consumption of fish and nature management (16). In this study, the order in relation to the concentration of heavy in the flesh is found as Zn>Fe>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 flesh is found as Zn>Fe>Cu>Mn (17). In a research about the accumulation of Fe, Zn, Pb, Cu, Cd and Ni in the musles of lungfish (*Polypterus annectens*), African carp (*Heterotis niloticus*) and catfish (*Clarotes laticeps*) in the order of accumulation is the concentration of heavy metals increases in the following order: Fe>Zn>Pb>Cu>Cd>Ni (18).

The amounts of Cu, Fe and Zn determined in the flesh of *S. cephalus* differs according to the weight and length of fish. Their concentrations increased with increasing 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 (17-24).

The levels of Zn, Fe and Cu in the muscle of some fish species together with in the flesh of *S. cephalus* are given in Table 3. As it can be seen in Table 3, accumulation levels of heavy metals in the body of fish change

Table 3. The amounts of some heavy metal (mg/kg) determined in the muscle of some fish species.

Fish species	Zn	Fe	Cu	References
S. cephalus	5.01-8.68	2.28-9-8.99	0.12-0.45	Present study
C. trutta	7.00-27.88	10.67-38.36	0.34-0.92	(24)
A. marmid	3.18	9.31	13.28	
C. carpio	2.83	19.02	27.87	(21)
C. regium	3.13	22.51	38.66	
L. cephalus	8.94±0.62	4.71±0.92	ND	(16)
S. lucioperca	6.85±1.18	6.12±2.9	ND	
A. vorax	10.536	18.367	0.009	(20)
L. xanthopterus	10.49-49.12	12.04-69.16	0.30-1.88	(23)
C. carpio	6.8-14.65	4.67-10.83	0.23-0.74	(22)
M. mastacembelus	5.18-14.59	10.10-45.89	0.011-0.055	(19)
	16.326	32.608	0.028	(25)
L. esocinus	5.19-13.02	8.50-21.81	0.25-0.98	(26)

ND: not determined.

Table 4. Comparative account of heavy metal concentrations in the flesh of *S. cephalus* with standard guidelines.

Heavy metals	Present study (mg kg^{-1})	Recommended levels (mg kg^{-1})	References
Cu	0.12-0.45	30	(30)
Fe	2.28-8.99	100	(31)
Zn	5.01-8.68	100	(31)

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 (27). 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 (28).

It is stated that heavy metals are hazardous for the aquatic ecosystems especially for the Cyprinids that are mostly nourished in deep water. Therefore, cyprinids are more contaminated when compared with the predator fish (29).

In conclusion, there was a clear difference between the concentrations of heavy metals in the flesh of fish and water. 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. The results show that heavy metal levels in the flesh samples taken from *S. cephalus* caught from Karakaya Dam Lake were under the dangerous limits given by FAO/WHO and there is no any risk for public health by eating *S. cephalus* (Table 4).

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