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Bioaccumulation of Zn, Cu and Mn in the Caviar and Muscle of Persian Sturgeon (*Acipenser persicus*) from the Caspian Sea, Iran

Abdulreza Mashroofeh · Alireza Riyahi Bakhtiari · Mohammad Pourkazemi

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Abstract Concentrations of Zn, Cu and Mn were examined in caviar and muscle of the Persian sturgeon (*Acipenser persicus*) collected from coastal waters of south Caspian Sea during March and April, 2011. Mean Zn, Cu and Mn concentrations in caviar samples were 21.48, 2.05 and 1.66 μg g^{-1} wet weight basis, respectively. The mean Zn, Cu and Mn concentrations in muscle tissues were 7.49, 1.00 and 0.34 μg g^{-1} wet weight basis, respectively. The mean concentrations of Zn and Cu in caviar and muscle samples were under the permissible limits proposed by the United Kingdom's Ministry of Agriculture, Fisheries and Food (2000).

Keywords *Acipenser persicus* · Caviar · Muscle · Caspian Sea · Metals

Worldwide, sturgeons are an important source of food and income. Until recently, 80 %–90 % of the world's sturgeon catch was taken from the Caspian Sea (Kajiwara et al. 2003). The Persian sturgeon (*Acipenser persicus*), is a bottom dweller occurring primarily on sand bottoms in South Caspian Sea, especially along the Iranian coast (Moghim et al. 2006). The Persian sturgeon occupies an intermediate trophic level for Acipenseriformes, feeding mainly on mollusks, crabs and fish (Agusa et al. 2004; Hosseini et al. 2008). More than 80 % of total sturgeon stocking in Iran is for this species (Kottelat et al. 2010). However Caspian sturgeon populations are imperiled due to a poorly regulated fishery, illegal catch, poaching, over-harvesting, spawning habitat loss, water quality, and serious chemical pollution (Billard and Lecointre 2001; Moghim et al. 2006). Among these, chemical contamination seems to be one of the most significant factors influencing the sturgeon population (Agusa et al. 2004; Pourkazemi 2006). Sturgeons are at a high potential risk for accumulating metals in their tissues due to the high lipid content in their bodies, long lives, long juvenile stage and benthivorous diet (Billard and Lecointre 2001; Jaric et al. 2011). Benthivorous fish are generally considered to be prone to higher concentrations of metal accumulation (Jaric et al. 2011).

The Caspian Sea is the largest enclosed basin of the world (Dumont 1998), surrounded by Russia, Kazakhstan, Turkmenistan, Iran and Azerbaijan. Hundreds of pollutants are discharged into the Caspian Sea every day. Of these, metals are regarded as serious pollutants of the aquatic ecosystems because of their toxicity, long persistence, bioaccumulation, and biomagnification in the food chain (Papagiannis et al. 2004; Oymak et al. 2009). Although zinc (Zn), copper (Cu) and manganese (Mn) are essential elements in organism nutrition and fulfill many biochemical functions in organism metabolism, they can also produce toxic effects when their intake is excessive (Uluozlu et al. 2007). The main sources of the Caspian Sea pollution are atmospheric fallout, run-off from major rivers, mining, industrial and agricultural activities, as well as local pollutant emissions (Karpinsky 1992; Dumont 1998). Since

A. Mashroofeh · A. R. Bakhtiari (✉)
Environmental Forensic Laboratory, Department of Environmental Sciences, Faculty of Natural Resource, Tarbiat Modares University, P.O. Box 46414-356, Noor, Mazandaran, Iran
e-mail: ariyahi@gmail.com; riahi@modares.ac.ir

A. Mashroofeh
e-mail: a.r.mashrofe@gmail.com

M. Pourkazemi
International Sturgeon Research Institute, P.O. Box 41635-3464, Rasht, Iran
e-mail: pkazemi_m@yahoo.com; pourkazemi@sturgeon.ir

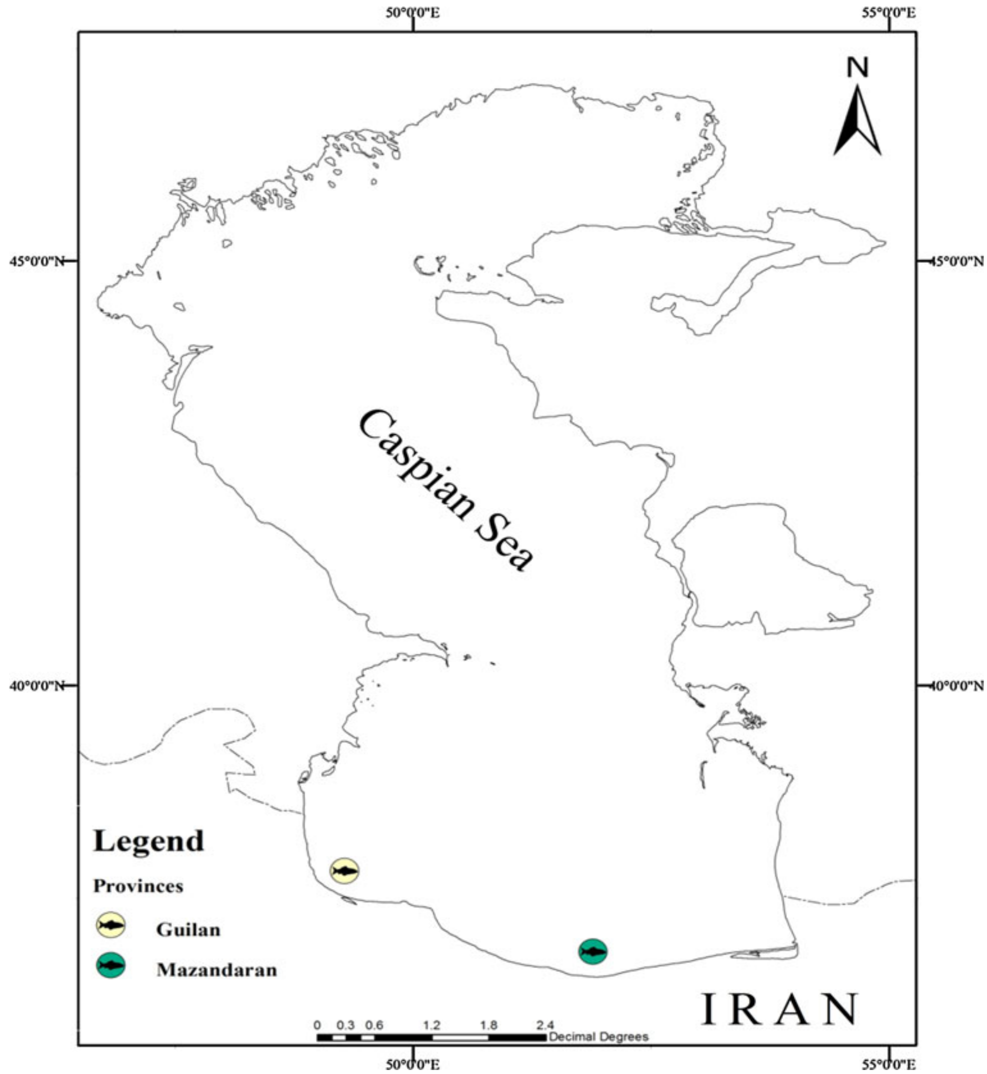

Fig. 1 Map of sampling locations of Persian sturgeon in the Caspian Sea

the Caspian Sea is a closed basin without any outlet, various environmental pollutants released from coastal catchment areas have accumulated (Anan et al. 2002). During the last few decades, the levels of heavy metals in sediments of the Caspian Sea have increased greatly (Karpinsky 1992).

The objectives of present study were to determine concentrations of Zn, Cu and Mn in caviar and muscle samples of Persian sturgeon in the South Caspian Sea, and to compare the obtained results with those from other studies.

Materials and Methods

A total of 24 fish were collected from two of the important sturgeon fishery zones in Guilan and Mazandaran Provinces during March and April, 2011 (Fig. 1). The biological data of the specimens were recorded. Fish samples were transported to the laboratory in a thermos flask with ice on the same day. They were dissected with laboratory set, and caviar and muscle samples were quickly removed, washed with distilled water and frozen at −20°C until chemical analysis.

The analytical procedure is given elsewhere (Yap et al. 2004; Amin et al. 2009; Yap et al. 2009, 2010), but a brief summary follows. About 1 g of sample was added to 10 ml of concentrated (65 %) supra-pure HNO_3 (Merck, Darmstadt, Germany) in a Teflon PTFE tube and incubated for 1 h at 40°C in a hot block digester, followed by heating at 140°C for 3 h. The digested samples were diluted to a measured volume with double deionized water. Samples were filtered through Whatman No. 1 filter paper, and the filtrate stored until metal determination. Concentrations of Zn, Cu and Mn were measured using an atomic absorption spectrometer (Shimadzu, AA-670, Kyoto, Japan) with an air/acetylene flame. Quality assurance was assessed for each batch of 20 digested samples by inclusion of two blanks and reference materials SRM1577b (Bovine liver;

Table 1 Results for essential element analysis of reference materials for quality assurance/quality control

	Cu	Mn	Zn
DORM2			
Certified value	2.34 ± 0.16	3.66 ± 0.34	25.6 ± 2.3
Measured mean	2.19 ± 0.13	3.23 ± 0.25	26.5 ± 1.7
Recovery (%)	93.6	88.2	103.5
SRM1577b			
Certified value	160 ± 8.0	10.5 ± 1.2	127 ± 16.0
Measured mean	164 ± 2.1	10.4 ± 0.99	133.4 ± 8.4
Recovery (%)	102.5	99	105

All values are μg g^{-1} wet weight. n = 4

National Institute of Standards and Technology, Gaithersburg, MD, USA) and DORM2 (Dogfish muscle; National Research Council Canada). Recoveries of the metals ranged from 88 % to 105 % (Table 1). In this study, concentrations of metals are expressed as μg g^{-1} wet weight of tissue. Excel and SPSS version 17 (SPSS Inc., Chicago, IL, USA) were used for data manipulations and statistical analysis.

Results and Discussion

The biological characteristics of the specimens and concentrations of Zn, Cu and Mn in caviar and muscle samples of Persian sturgeon are shown in Table 2. These metals were detected in all samples analyzed, with caviar having significantly higher ($p < 0.05$) concentrations than muscle tissue (Fig. 2). Mean concentrations of the metals followed in the order of Zn > Cu > Mn in both caviar and muscle.

Caviar (roe of sturgeon) as a food source is of high nutritional content. Mean Zn, Cu and Mn concentrations in the caviar samples were found to be 21.48, 2.05 and 1.66 μg g^{-1} wet weight basis, respectively. In comparison to our metals measurements, Wang et al. (2008) found concentrations of Zn (16.8–24.0 μg g^{-1} wet weight) and Mn (0.8–1.4 μg g^{-1} wet weight) that were comparable, and Cu concentrations (0.7–1.6 μg g^{-1} wet weight) that were lower by about half. Wirth et al. (2000) found Zn concentrations (10–12 μg g^{-1} wet weight) that were lower by about half, and Cu concentrations (1.2–1.7 μg g^{-1} wet weight) that were comparable.

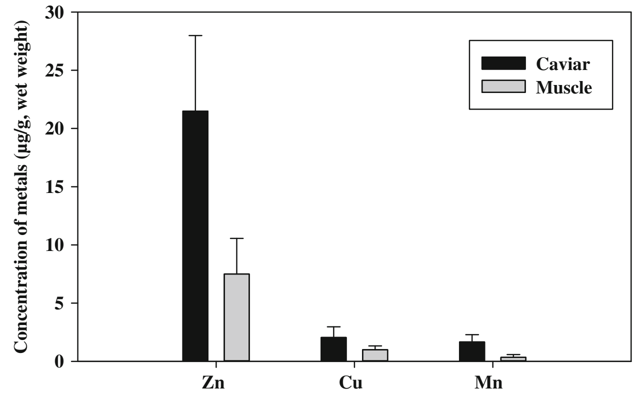

Fig. 2 Comparison of metal concentrations in caviar and muscle samples of Persian sturgeon. Each *bar* indicates the mean and standard deviation (SD) respectively

Mean concentrations of Zn, Cu and Mn in muscle were 7.49, 1.00 and 0.34 μg g^{-1} wet weight basis, respectively. Pourang et al. (2005) found Zn levels (17.95–24.47 μg g^{-1} wet weight) that were nearly 3 times higher, Cu levels (1.21–1.91 μg g^{-1} wet weight) that were higher by about half, and Mn levels (0.32–0.57 μg g^{-1} wet weight) that were comparable.

It has been demonstrated that bioavailability and toxicity of Zn, Cu and Mn in aquatic organisms depend on the total concentration of each metal in the water (Papagiannis et al. 2004). Concentrations of persistent toxic substances in caviar and muscle reflect discharges of these substances into receiving aquatic ecosystems, bioaccumulation through the food web, and chemical partitioning and kinetics in the female sturgeon (Wang et al. 2008). Many researchers indicated that different fish species from the same area contained different metals levels in their tissues (Canli and Atli 2003; Jaric et al. 2011). Metal bioaccumulation of fish is species-dependent (Uysal et al. 2008). Further, concentrations of metals in tissues of fish depend upon environmental factors such as water temperature, body size, fish age and the processes of biotransformation and excretion (Al-Yousuf et al. 2000; Agusa et al. 2004; Hosseini et al. 2008). The feeding habits and life styles of the different species also influence accumulation levels (Karadede et al. 2004).

Table 2 Biometry data and concentration (mean ± SD, range and median on μg g^{-1} wet weight) of metals in caviar and muscle samples of Persian sturgeon from southern Caspian Sea

Weight (kg)	Length (cm)	Sample	Zn	Cu	Mn
20.71 ± 3.69	182.14 ± 14.48	Caviar	21.48 ± 6.50	2.05 ± 0.98	1.66 ± 0.61
15–27	149–206		10.94–41.47	0.54–4.19	0.94–3.48
20	185		20.22	1.89	1.58
		Muscle	7.49 ± 3.07	1.00 ± 0.32	0.34 ± 0.24
			3.98–13.71	0.48–1.62	0.024–0.80
			0.82	0.98	0.25

In the present study, concentrations of Zn and Cu in muscle and caviar samples of the Persian sturgeon were lower than the guidelines for food, as summarized by MAFF (2000). The guidelines for Zn and Cu are 50 and 20 μg g^{-1} wet weight, respectively. Therefore, the measured concentrations for these particular metals are below the published guidelines, and the levels would appear not to constitute any threat to the human population that may consume sturgeon or caviar obtained from these study locations.

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