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Metal Concentrations in Tissues of Two Fish Species From Qeshm Island, Iran

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Abstract The purpose of this study was to determine the concentrations of metals, cadmium, chromium, lead and nickel in *Liza vaigiensis* and *Johnius carutta*, in order to: compare metal concentrations between two species with different gender, and to determine the significance between metal concentrations in the gill, liver and muscle. The highest mean concentrations of cadmium, chromium, lead and nickel in different tissues of these two fish species were found in the liver of *L. vaigiensis* at 0.68, 0.83, 0.37 and 1.42 μg g^{-1}, respectively; while the lowest mean concentrations of cadmium, chromium, lead and nickel were observed in the muscle of *J. carutta* at 0.16, 0.16, 0.03 and 0.29 μg g^{-1}, respectively. The results showed that the metal concentrations in both species were higher in the females than in the males (except chromium in gill and cadmium in muscle of *J. carutta*). Also, the results indicated that the metal concentrations were different among fish tissues (one-way ANOVA, $p < 0.001$), but there was no difference (except lead in gills of *J. carutta*) between sex (male vs. female).

Keywords Contamination · Liver · Muscle · *Liza vaigiensis* · *Johnius carutta*

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Qeshm Island is located a few kilometers off the southern coast of Iran (the Persian Gulf), opposite the port cities of Bandar Abbas and Bandar Khamir. It is located at 26 °31′ to 26 °57′ N and 55 °15′ to 56 °18′ E (Fig. 1). The island, which hosts a 300 square kilometer free zone jurisdiction, is 135 km long, and lies strategically in the Strait of Hormuz, just 60 km from the Omani port of Khasab, and about 180 km from the UAE Port Rashid. The island comprises 59 towns and villages and the population is approximately 100,000. The average temperature on the island is approximately 27°C. The warmest months are June through August, and the coldest from October to January.

The pollution of freshwaters with a wide range of metals has become a matter of great concern over the last few decades, because of the damage caused to the aquatic life. Metals like copper, zinc and nickel are essential metals since they play an important role in biological systems, while some others such as cadmium and lead are non-essential metals; as they have no known role in biological systems. When metals enter into the aquatic ecosystems, their capacity to accumulate may cause stress on fish and marine animals. One of the most important properties of toxic pollutants such as metals is that they can be accumulated in organs of the organisms (Palaniappan and Karthikeyan 2009). Studies from the field and laboratory experiments showed that accumulation of metals in a tissue is mainly dependent upon water-metal concentrations, exposure period and tissue (Bochenek et al. 2008;

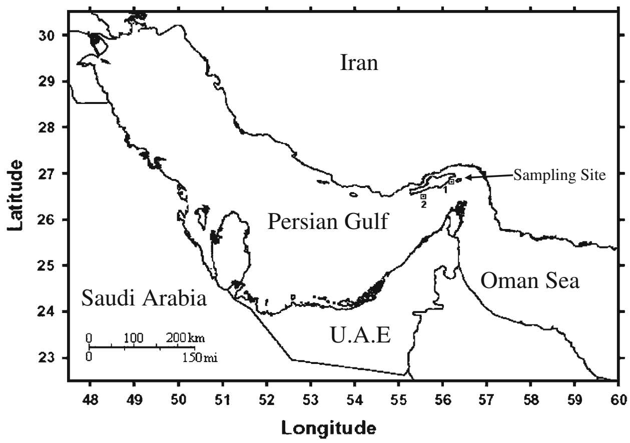

Fig. 1 Map of the study area (the Qeshm Island)

Mansouri et al. 2011); although some other environmental factors such as salinity, pH, hardness and temperature play significant roles in metal accumulation (Yim et al. 2006; Karthikeyan et al. 2007). Ecological needs, sex, and size of fish and marine animals were also found to affect metal accumulation in their tissues (Al-Yousuf et al. 2000; Canli and Atli 2003).

Fish samples are considered as one of the most indicative organisms, in freshwater systems, for the estimation of metal pollution (Erdoĝrul and Ates 2006). Fish accumulates substantial amounts of metals in their tissues especially in muscles and thus, represent a major dietary source of these metals for humans (Dural et al. 2006). Fish contamination with metals was reported as a result of pollution of water with fertilizers containing metals (Dural et al. 2006). Contaminants in fish pose risks to human consumers and to piscivorous wildlife. Knowledge of metal concentrations in fish is important both with respect to nature management and human consumption of fish (Ebrahimpour and Mushrifah 2010). Therefore, monitoring metals is of great importance to know the bioaccumulation potential of these pollutants and it is an important step in the management of aquatic ecosystems.

Our study aimed to measure the concentrations of cadmium, chromium, lead and nickel in *Liza vaigiensis* and *Johnius carutta*, which are consumed in Qeshm city and Hormozgan province, Iran. This was in order to: (1) compare metal concentrations between two species with different gender, and (2) to determine the significant between metal concentrations in the gill, liver and muscle.

Materials and Methods

Fish were caught in two stations by fishermen's nets in February 2012, and then transported to the laboratory. Fish tissues that were analyzed in this study were gill, liver and muscle. In the laboratory, they were immediately dissected using a stainless steel dissection instrument while wearing clean plastic gloves. Total size and weight of the animals were measured. Total size and weight of fish were 40.5 (±2.4) cm and 718.0 (±67.3) g for *Liza vaigiensis;* and 20.7 (±1.5) cm and 138.2 (±38.9) g for *Johnius carutta,* respectively. Approximately 1 g wet weight of each sample (gill, liver, and muscle) was dissected and accurately weighed into 150-mL Erlenmeyer flasks, 10 mL nitric acid (65 %) was added to each sample, and the samples were left overnight to be slowly digested; thereafter, 5 mL perchloric acid (70 %) was added to each sample (Mansouri et al. 2011). All reagents used were of analytical reagent grade (Merck, Germany). Digestion was performed on a hot plate (sand bath) at 200°C, for about 6 h or until solutions were clear. After cooling, the solution was quantitatively transferred to 50 mL polyethylene bottles and made up to 25 mL with deionized water. Then the solution was filtered using 0.45 µm nitrocellulose membrane filter. The concentrations of metals were measured using a Shimadzu AA 680 flame atomic absorption spectrophotometer. The detection limits for each metal were: cadmium (0.09), chromium (0.03), lead (0.04), and nickel (0.03) µg g^{-1}. Results for cadmium, chromium, lead, and nickel gave a mean recovery of 98 %, 99 %, 99 % and 102 %, respectively.

Data analyses were performed using the statistical package SPSS (version 16; SPSS, Chicago, IL). Concentrations of metals were compared in different tissues of two species using one-way analysis of variance (ANOVA). Also, metal concentrations in tissues were compared between males and females of each species using Student's t test. Data were log transformed to obtain normal distributions that satisfied the homogeneity of variance required by ANOVA. The concentrations of metals in tissues were expressed as microgram per gram wet weight (ww). Values are given in means ± standard errors (SE).

Results and Discussion

The accumulation of metals in aquatic systems suggests that fish may serve as a useful indicator of contaminating metals in aquatic systems, because they respond with great sensitivity to changes in the aquatic environment (Vinodhini and Narayanan 2008; Mansouri et al. 2011). The metal (cadmium, lead, chromium and nickel) concentrations in two fish species are given in Tables 1,2 and 3. These metals are all regarded as potential hazards to humans. The highest mean concentrations of cadmium, chromium, lead and nickel in different tissues of these two fish species were observed in the liver of *Liza vaigiensis* at 0.68, 0.83, 0.37 and 1.42 µg g^{-1}, respectively; while the lowest mean concentrations of cadmium, chromium, lead and nickel were found in the muscle of *Johnius carutta* at 0.16, 0.16, 0.03 and 0.29 μg g^{-1}, respectively (Table 4).

Results showed that the metal concentrations in both fish species were in descending order of nickel > chromium > cadmium > lead. Also, the pattern of metal accumulation in tissues of two fish species were in descending order of liver > gill > muscle. The metal concentrations (cadmium, chromium, lead and nickel) were from 2.5 to 10 times higher in the liver than in the muscle tissues of both species. The concentration of cadmium was more than 4 and 3 times higher in the liver than in the muscle of *Liza vaigiensis* and *Johnius carutta*, respectively. Also, the concentration of lead was about 3 and 10 times higher in the liver than in the muscle of both species, respectively. Other studies have also reported that in fish species the muscle is not an active tissue in accumulating metals (Karadede et al. 2004; Tekin-Özan and Kir 2008). Liver was found to accumulate high concentrations of metals. Liver tissues are expressed to be the main site of trace metal detoxification within fish. This can possibly be attributed to the tendency of the liver to accumulate pollutants of various kinds at higher concentrations from the environment (Licata et al. 2005). The literature shows that in many cases the liver also has an important role in contaminant storage, redistribution, detoxification or transformation and acts as an active site of pathological effects induced by contaminants (Licata et al. 2005). The liver tissue is highly active in uptake and storage of metals. Fish respond to metal exposure by producing metallothionein, particularly in liver (Kargin 1998). Thus, the liver tissues in fish are more than any other fish organs recommended as an environmental indicator of water pollution. The gill is placed where active and passive exchanges occur between the animal and aquatic environment. Therefore, high concentrations of metals accumulate in the gill tissues by absorption and adsorption (Kargin 1998). The metal concentration in muscle as the edible part of the fish is important (Erdoĝrul and Ates 2006).

The results showed that the metal concentrations in both species were higher in the females than in the males (except chromium in gill and cadmium in muscle of *Johnius carutta*). Also, the results indicated that the metal concentrations were different among fish tissues (one-way ANOVA, $p < 0.001$), but there was no difference (except lead in gills of *Johnius carutta*) between sexes (male vs. female). Studying metals in tissues of *Lethrinus lentjan*, Al-Yousuf et al. (2000) showed that the metal concentrations were higher in females than in males. In contrast, Keenan and Alikhan (1991) did not observe any differences in cadmium concentrations between males and females of *Cambarus bartoni* specimens. The differences in the available number of active sites in the protein and cytochrome P-450 and the nature of hormones in female and male fish might cause this behavior (Jargensen and Pedersen 1994). Also, Paez-Osuna and Tron-Mayen (1995) have reported that sex-based differences in trace metal concentrations of *Penaeus californiensis* specimens may be due to differences in preferred diets of males and females.

The studied fish species in the Qeshm Island are consumed by humans. In the present study, metal concentrations in muscle tissues of both fish species were analyzed because these concentrations provide information on the potential risk to the fish themselves or their predators and consumers (especially humans). The concentrations of metals have been expressed on a dry weight basis. A wet weight-dry weight conversion factor of 0.2 can be assumed (Pourang et al. 2005). According to the FAO (1983) maximum permissible concentrations are 0.5 μg g^{-1} for cadmium (in this study 0.16 μg/g for both fish species) and

Table 1 Mean (±SE) metal concentration (micrograms per gram wet weight) in the gill of *Liza vaigiensis* and *Johnius carutta* from Qeshm Island of southern Iran

Species	Sex	No.	Metals			
			Cd	Cr	Pb	Ni
Liza vaigiensis		22				
	Male	11	0.22 ± 0.02	0.40 ± 0.04	0.16 ± 0.01	0.66 ± 0.05
	Female	11	0.39 ± 0.03	0.58 ± 0.05	0.24 ± 0.01	0.91 ± 0.04
	Overall mean		0.30 ± 0.02	0.49 ± 0.03	0.20 ± 0.01	0.79 ± 0.04
	p value sex[a]		NS	NS	NS	NS
Johnius carutta		20				
	Male	10	0.28 ± 0.05	0.50 ± 0.04	0.11 ± 0.01	0.58 ± 0.06
	Female	10	0.31 ± 0.02	0.46 ± 0.03	0.25 ± 0.03	0.71 ± 0.09
	Overall mean		0.30 ± 0.02	0.48 ± 0.02	0.18 ± 0.02	0.65 ± 0.05
	p value sex		NS	NS	0.04	NS

[a] *p* value for Student's *t* test; *NS* not significant

Table 2 Mean (±SE) metal concentration (micrograms per gram wet weight) in the liver of *Liza vaigiensis* and *Johnius carutta* from Qeshm Island of southern Iran

Species	Sex	No.	Metals			
			Cd	Cr	Pb	Ni
Liza vaigiensis		22				
	Male	11	0.56 ± 0.04	0.62 ± 0.05	0.31 ± 0.03	1.17 ± 0.10
	Female	11	0.81 ± 0.04	1.04 ± 0.04	0.42 ± 0.01	1.68 ± 0.11
	Overall mean		0.68 ± 0.04	0.83 ± 0.05	0.37 ± 0.02	1.42 ± 0.09
	p value sex[a]		NS	NS	NS	NS
Johnius carutta		20				
	Male	10	0.49 ± 0.08	0.64 ± 0.03	0.24 ± 0.01	1.07 ± 0.06
	Female	10	0.68 ± 0.04	0.78 ± 0.04	0.36 ± 0.02	1.17 ± 0.08
	Overall mean		0.59 ± 0.04	0.71 ± 0.03	0.30 ± 0.01	1.12 ± 0.05
	p value sex		NS	NS	NS	NS

[a] *p* value for Student's *t* test; *NS* not significant

Table 3 Mean (±SE) metal concentration (micrograms per gram wet weight) in the muscle of *Liza vaigiensis* and *Johnius carutta* from Qeshm Island of southern Iran

Species	Sex	No.	Metals			
			Cd	Cr	Pb	Ni
Liza vaigiensis		22				
	Male	11	0.13 ± 0.03	0.33 ± 0.02	0.10 ± 0.01	0.48 ± 0.11
	Female	11	0.19 ± 0.01	0.33 ± 0.02	0.12 ± 0.01	0.57 ± 0.04
	Overall mean		0.16 ± 0.01	0.33 ± 0.02	0.11 ± 0.01	0.52 ± 0.06
	p value sex[a]		NS	NS	NS	NS
Johnius carutta		20				
	Male	10	0.19 ± 0.03	0.12 ± 0.02	0.02 ± 0.01	0.24 ± 0.03
	Female	10	0.13 ± 0.01	0.21 ± 0.03	0.05 ± 0.01	0.34 ± 0.06
	Overall mean		0.16 ± 0.01	0.16 ± 0.02	0.03 ± 0.00	0.29 ± 0.03
	p value sex		NS	NS	NS	NS

[a] *p* value for Student's *t* test; *NS* not significant

Table 4 Statistical analysis of Cd, Cr, Pb and Ni concentrations in the gill, liver and muscle of *Liza vaigiensis* and *Johnius carutta*

Fish species	Cd		Cr		Pb		Ni	
	One-way *F* value	ANOVA *p* value	One-way *F* value	ANOVA *p* value	One-way *F* value	ANOVA *p* value	One-way *F* value	ANOVA *p* value
Liza vaigiensis	78.1	<0.001	28.4	<0.001	68.1	<0.001	42.9	<0.001
Johnius carutta	30.6	<0.001	95.9	<0.001	50.6	<0.001	67.8	<0.001

p significance level

0.5 μg g^{-1} for lead (in this study 0.11 μg g^{-1} for *Liza vaigiensis* and 0.03 μg g^{-1} for *Johnius carutta*). The cadmium and lead concentrations in the muscle of both fish from Qeshm Island are below the levels of concern for human consumption as defined by the FAO (1983). In routine monitoring of pollutants in fish, chromium is not usually an analytical target; and there is absence of contemporary information available for comparison purposes (Ebrahimpour and Mushrifah 2010).

The concentrations of metals in two fish species were generally comparable to values reported in other studies. Kalay et al. (1999) found that muscle tissues in *Mugil cephalus* and *Mullus barbatus* collected from Northeast Mediterranean Sea contained cadmium, chromium, lead and nickel at 1.17–0.96, 1.53–1.30, 6.79–6.24 and 3.95–3.18 μg g^{-1} in both species, respectively. In this study, we found lower concentrations of metals than Kalay et al. (1999). These were lower than the concentrations we found for cadmium and lead in our study. Ebrahimpour et al. (2011) reported cadmium, chromium and lead in the muscle tissues of *Carassius gibelio* collected from the Anzali wetland, Iran at concentrations of 0.25 μg g^{-1}, 0.7 μg g^{-1} and 1.2 μg g^{-1}, respectively. The FDA-recommended daily allowance is 120 μg for chromium (FDA 1994). Lendinez et al. (2001) determined the chromium concentrations of *Merluccius merluccius*, *Mugil* sp., and *Mullus surmuletus* from the Southern Spain as 0.010, 0.014 and 0.079 μg g^{-1}. In our study, chromium was observed at higher concentrations than the Lendinez et al. (2001) study.

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