Iran. J. Ichthyol. (2023) 10(2): 102-113
P-ISSN: 2383-1561; E-ISSN: 2383-0964

ORIGINAL ARTICLE

Determination of heavy metals (Cd, Zn, Pb and Hg) content in *Capoeta fusca* from Lar wetland, Zahedan, Iran

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Article history:
Accepted 29 May 2023

Abstract
This study examined the concentrations of heavy metals (cadmium, zinc, lead, and mercury) and their potential health risks for consumers in the muscle and gill tissues of *Capoeta fusca*, collected from Lar wetland in Sistan and Baluchestan province. Thirty samples were collected and heavy metal levels in samples were analyzed by ICP-OES atomic absorption spectrophotometer (Perkin Elmer, Model; Optima DV 2000). Mercury content was measured by Atomic Adsorption method (nova 400P, analytic jena) hydride production technique. The concentration of cadmium was lower than the detection limit (0/05 mg/kg) of the atomic absorption spectrophotometer, so its concentration was not reported in the study. The results showed that the amount of Lead in gill tissue is significantly higher than that of muscle tissue, and the concentration of zinc in muscle tissue is higher than that of gill. The mercury concentrations of muscle and gill tissues are not significantly different from each other. The accumulation of heavy metals in the samples follows this pattern: zinc>lead>mercury. The concentration of lead in the muscle of *C. fusca* is higher than the international standards. Therefore, among the investigated metals, the main risk for human health can be related to the amount of lead in fish samples, which can be transmitted to humans directly after consuming fish. The relatively high concentration of heavy metals in the studied fish is probably due to the entry of the wastewater of Zahedan city into the Lar lagoon.

Keywords: Pollution, Toxic metals, Risk assessment, Fish, Aquatic ecosystems.

INTRODUCTION

Rapid population growth, industrialization and rapid economic development have led to the movement of pollutants in the environment and changes in its biogeochemical cycles (Ali & Khan 2018). One of the most dangerous pollutants affecting the environment are heavy metals (Mahmuda et al. 2020). Heavy metals are defined as metallic elements that have a relatively high density compared to water. Among them, arsenic (As), mercury (Hg), cadmium (Cd) and chromium (Cr) have no known essential function in living organisms and are toxic even in small amounts when ingested for a long time. These elements are considered the most toxic substances for humans, animals and the environment. Some rare elements are also known as heavy metals, such as copper (Cu), selenium (Se), iron (Fe) and zinc (Zn), which are essential for the body's metabolism, but are toxic in higher concentrations (Pandey & Madhuri 2014). Heavy metals are distinguished from other pollutants due to their toxicity, bioaccumulation, non-degradability in the environment, high solubility in water, long shelf life, increased accumulation in the food chain, and are a serious threat to freshwater ecosystems and, as a result, freshwater fish (Taslima et al. 2022). Fish can be exposed to heavy metals contamination through various ways (e.g. food and water consumption, or through skin) (Squadrone et al. 2013), and when the pollutant is absorbed, it can be transferred to different tissues such as bone, muscle and liver (Nussey et al. 2000). Bioaccumulation of heavy metals in fish depends on various environmental factors such as pH, temperature, salinity, water hardness, sampling location, season, concentration and type of pollutant, ecological and physiological characteristics of species such as age, sex, size and length of fish, habitat preference, feeding habits, nutritional level, reproductive status, fish

Journal homepage: ijichthyol.org/ DOI: https://doi.org/10.22034/iji.v10i2.973/ DOR: https://dorl.net/dor/20.1001.1.23831561.2023.10.2.9.3

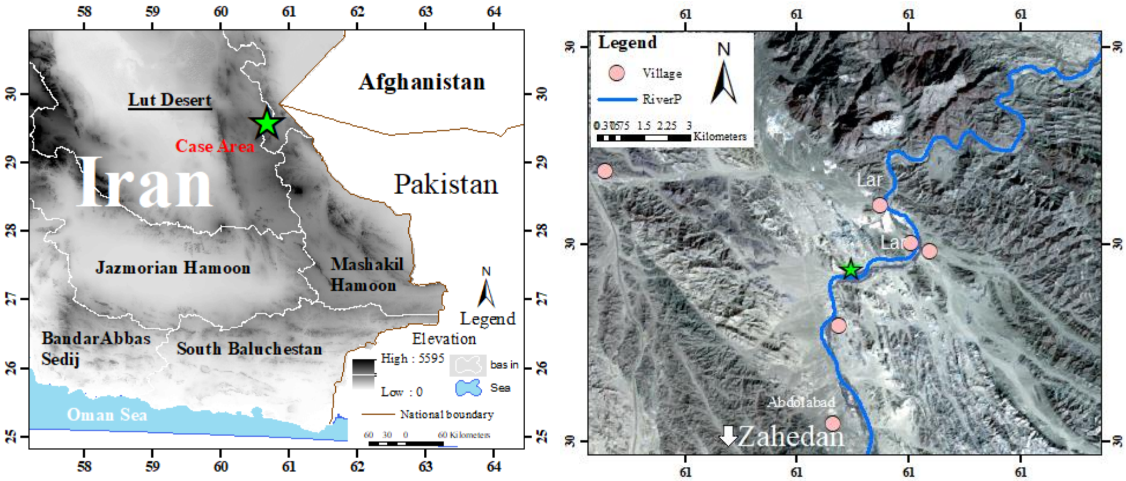

Fig.1. Map of sampling site located in the Lar Wetland in Zahedan, Iran.

health, duration of exposure to heavy metals, and etc. (Mohammadi et al. 2011; AL-Taee et al. 2020; Sheikhzadeh & Hamidian 2021). Factors such as high levels of omega-3 fatty acids, low cholesterol and high protein, fat-soluble vitamins, elements such as phosphorus and sodium, minerals, calcium, zinc and iron have made fish one of the most important components in the human diet (Malakootian et al. 2016; Isangedigh & David 2019). Consuming fish reduces various diseases, including mental disorders, cardiovascular diseases, rheumatoid arthritis, and some types of cancer, and can helps the normal growth of neurons (Rahmani et al. 2014). Among animal species, the fishes are the creatures that can be severely affected by toxic pollutants (Pandey & Madhuri 2014). The Fishes are usually at the top of the aquatic food chain and their natural metabolism can accumulate metals from food, water and sediments (Hossain et al. 2022). Therefore, fishes are often used as an important biological indicator to investigate the level of metals in their living environment and to assess environmental risks (Zhao et al. 2012). The Lar Wetland is very important from a health point of view due to the its role in feeding and supplying water to the wildlife of the region and also because the wastewater discharge of Zahedan city takes place in this ecosystem. *Capoeta fusca*, *Carassius auratus*, and *Gambusia holbrooki* are three species that have been recorded from Lar wetland (Ghanbarifardi 2021, unpublished report). Therefore, the main purpose of this study was (i) to investigate the content of heavy metals (cadmium, zinc, lead and mercury) in muscle and gills tissues of the *Capoeta fusca* caught in the Lar wetland of Zahedan city and (ii) to calculate the health risks to consumers.

MATERIALS AND METHODS

Study area: Zahedan is located in the southeast part of Iran (29.50215967° N, 60.85580867° E) and Lar wetland is located in the 15 kilometers northeast of Zahedan, which is shared between Iran and Pakistan (Fig. 1).

Sampling collection: A total of 30 samples of *Capoeta fusca* were collected from Zahedan to study the concentrations of four heavy metals cadmium (Cd), lead (Pb), mercury (Hg) and zinc (Zn) in muscle and gills tissues. The weight and length of the samples were measured to find the relationship between these parameters and the concentration of heavy metals. Then, all collected samples were coded and stored in cool boxes and immediately transferred to the freezer and kept at -20°C until analysis (Hosseini et al. 2018; Korkmaz et al. 2019)

Heavy metals analysis: In the laboratory, the samples were taken out of the freezer, and when they reached room temperature, their muscle and gills tissue were dissected and dried in the oven at 100°C. Next, the dried samples were completely ground with a Chinese mortar and 0.5 g of muscle and 0.5 g of gills from each sample were weighed with an analytical balance. Then

7 ml of HNO3 65% and 1ml of H_2O_2 added and the samples were placed in the microwave (Mileston, Model: ETHOS 1000 W) for digestion. After acid digestion, the samples were transferred to a balloon and made up to 50ml with distilled water. Finally, the levels of heavy metals in the samples were measured using an ICP-OES atomic absorption spectrophotometer (Perkin Elmer, Model; Optima DV 2000), and mercury was measured by the Atomic Adsorption method (nova 400P, analytic jena). These steps were carried out in the central laboratory of the Sistan and Baluchestan University.

Human risk assessment

Estimated Daily and weekly Intake of metal (EDI and EWI): The daily intake of metals depends on factors such as metal concentrations in food and daily food intake, which are used to assess human health concerns (Keshavarzi et al. 2018). To do this, the EDI should be determined, which is based on the concentration of the metal in the food as well as the daily intake of certain food items (Tahity et al. 2022). The amount of EDI and EWI were measured as the following equations:

$$\mathbf{EDI\ (\mu g/day/60\ kg\ body\ weight) = C \times FIR} \quad (1)$$

$$\mathbf{EWI\ (\mu g/week/60\ kg\ body\ weight) = EDI \times 7\ day} \quad (2)$$

Permissible tolerable amount of weekly intake (PTWI) was calculated as;

$$\mathbf{PTWI\ (\mu g/week/60\ kg\ body\ weight) = RfD \times BW \times 7\ (days)} \quad (3)$$

In above equations, C is the mean heavy metal level in fish muscle tissue (mg/kg), $\boldsymbol{FIR}$ (Fish consumption ratio); is daily fish consumption per capita for Iranian population (7g/person/day) which used by the ISIRI (Institute of Standards and Industrial Research of Iran) (Keshavarzi et al. 2018). RfD (Oral reference dose) is the reference dose of the metal (3.0×10^{-4}mg/kg/day for Hg, 1.0×10^{-3}mg/kg/day for Cd, 4.0×10^{-3}mg/kg/day for Pb, 3.0×10^{-1}mg/kg/day for Zn) and BW (Body weight); is the average body weight of Iranian people which was considered as 60 kg (USEPA 2011; Keshavarzi et al. 2018; Korkmaz et al. 2019).

Target hazard quotient (THQ): The non-carcinogenic health risk was calculated using the Target Hazard Quotient equation introduced by the USEPA (United States Environmental Protection Agency) (USEPA 2011). The THQ is defined as the ratio of the lifetime median daily dose to the reference dose (RfD). The target hazard quotient (THQ) does not predict the actual adverse health effect on the exposed population, but provides a signal of the level of risk from pollutant exposure (Nyarko et al. 2023).

Values less than unity indicate no significant toxic hazards. THQ is calculated by following equation:

$$THQ = \frac{EF\times ED\times EDI}{BW\times AT\times RfD}\times 10^{-3} \quad (4)$$

Where THQ is the target hazard quotient, EF is the exposure frequency (365 days/year), ED is the exposure duration (70 years for non-cancer risk as used by the USEPA, EDI; Estimated Daily Intake, BW; average body weight (60 kg), AT is the average exposure time for non-carcinogens (EF × ED) as used in description non-cancer risk, and RfD (Oral reference dose) for each metal. If THQ≥1, it presents adverse health effects and THQ<1 presents that potential non-carcinogenic effects are very unlikely (Lei et al. 2015).

Statistical analyses: The SPSS software (Version 22.0 for Windows) was used for statistical analysis of data. Standard deviation and mean concentration of heavy metals in fish samples were estimated. The normality of the data was checked using the Kolmogorov-Smirnov test. In examining the correlation between two quantitative variables, Pearson's parametric test was used for data with normal distribution, and Spearman's test was used for non-normal data. Statistical differences between the concentration of heavy metals in muscle and gill tissues were determined using the paired t-test if the data were normal. If the data were not normally distributed, the Wilcoxon test was used (Mo et al. 2019). P values less than 0.05 indicated a significant difference (confidence level of 95 percent).

Table 1. Mean±SE of heavy metals in muscle and gill tissue of *Capoeta fusca* collected from Lar wetland (mg kg^{-1}).

Station	Tissues		Lead (Pb)	Zinc (Zn)	Mercury (Hg)
Zahedan	Muscle	Mean±S.E	28.143±5.369	70.183±4.244	0.120±0.010
		Maximum	171	140.9	0.284
		Minimum	11.6	19.5	0.045
	gill	Mean± S.E	81.050±20.738	44.610±2.538	0.250±0.0479
		Maximum	584.7	91.3	0.990
		Minimum	0	21.2	0
FAO* (Staniskiene et al. 2006; Tuzen et al. 2009)			0.5	40	0.5
WHO* (Pourang et al. 2005; Türkmen et al. 2009)			0.5	50	0.5
NHMRC* (Pourang et al. 2005; Türkmen et al. 2009)			1.5	150	1
MAFF* (Tuzen et al. 2009)			2	50	1

*These international standard concentrations are defined only for muscle tissue.

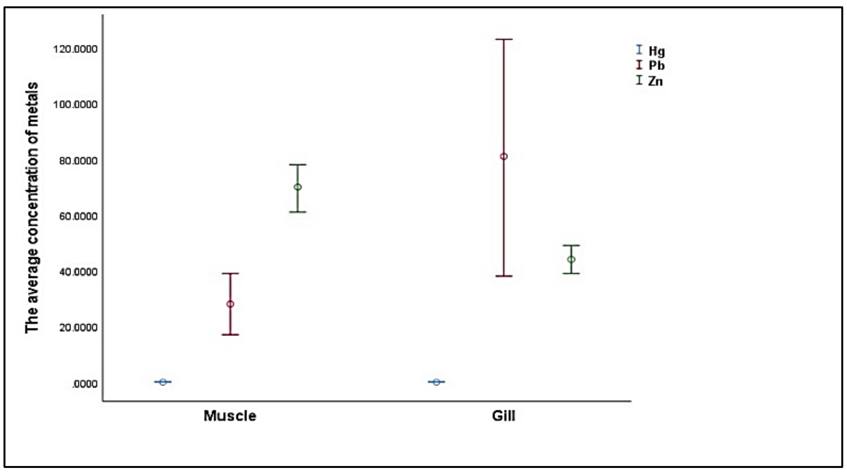

Fig.1. Comparison of Pb, Zn and Hg concentrations (mg kg^{-1}) in muscle and gill tissues of *Capoeta fusca*.

RESULTS

Data have shown that the average concentration of Pb in the gill tissue of the *Capoeta fusca* samples is significantly higher than that of the muscle tissue (81.050 mg/kg *vs* 28.143mg/kg respectively), whereas the average concentration of Hg between the gill tissue (0.250mg/kg) and the muscle tissue (0.120mg/kg) is not significantly different from each other. Also, the median concentration of Zn in the gills was lower than its concentration in the muscle (44.610mg/kg vs 70.183mg/kg respectively). The accumulation of heavy metals in muscle follows this pattern: Zn>Pb>Hg. The comparison of metal concentrations obtained in this study with the concentrations determined by WHO (World Health Organization), FAO (Food and Agricultural Organization), NHMRC (National Health and Medical Research Council) and MAFF (Ministry of Agricultural, Forestry and Fisheries) shows that the concentration of Pb in the muscle of fish samples is higher than international standards, while the concentration of Hg is lower than the international standards and the concentration of Zn is only within the permissible limits recommended by NHMRC standards (Table 1, Fig. 2). The estimated daily/weekly Intake of metals (EDI and EWI), the permissible tolerable amount of daily/weekly intake (PTDI and PTWI), and the risk index are announced in Table 2. The risk index for each heavy metal is estimated separately. The obtained THQ shows a number greater than 1 only for the heavy metal Pb, and for Zn and Hg, this parameter is estimated to be less than 1. Therefore, considering the THQ obtained for Pb and also because the average concentration of lead is higher than the international standards, the

Table 2. Estimated Daily Intake (EDI) and Estimated Weekly Intake (EWI) from fish consumption by local residents.

Heavy metals	EDI	EWI	PTDI[a]	PTWI[b]	THQ[c]
Lead	2.814	19.698	240	1680	4.279
Zinc	7.018	49.126	18000	126000	0.142
Mercury	0.012	0.084	18	126	0.243

[a]PTDI: Provisional Tolerable Daily Intake
[b]PTWI: Provisional Tolerable Weekly Intake
[c]THQ: Target Hazard Quotient

Table 3. Correlation of heavy metals with *Capoeta fusca* weight.

Heavy metal	Muscle		Gill	
	Correlation Coefficient	*P* value	Correlation Coefficient	*P* value
Lead	-0.060	0.751	-0.067	0.725
Mercury	0.190	0.314	-0.042	0.827
Zinc	-0.391	0.033	-0.031	0.871

Table 4. Correlation of heavy metals with *Capoeta fusca* length.

Heavy metal	Muscle		Gill	
	Correlation Coefficient	*P* value	Correlation Coefficient	*P* value
Lead	0.261	0.164	0.188	0.319
Mercury	-0.058	0.760	0.268	0.152
Zinc	-0.340	0.066	0.308	0.098

consumption of this type of fish should be done with caution.

Investigation of correlation of metals with length and weight of *Capoeta fusca*: To evaluate the correlation of the data, first the normality of the data was checked using the Kolmogorov-Smirnov test. If the data were normal, Pearson test was used and if the data were not normal, Spearman test was used. Examination of Kolmogorov-Smirnov test revealed that the weight of *Capoeta fusca* and zinc metal samples measured in the muscle and gills have a normal distribution and the rest of the data do not have a normal distribution.

Correlation of heavy metals with *Capoeta fusca* weight: The results of the correlation between the studied heavy metals and fish weight showed that there is a significant inverse correlation only between zinc in muscle and the weight of *Capoeta fusca* and there is no significant correlation between the weight of the fish and other heavy metals (Table 3).

Correlation of heavy metals with *Capoeta fusca* length: The results of the correlation between the studied heavy metals and fish length showed that there is no significant correlation between fish length and heavy metals (Table 4).

DISCUSSION

Lead: In this study, the average concentration of Pb in the muscle and gill tissue of the *Capoeta fusca* was measured as 28.143 and 81.050mg/kg, respectively. The maximum concentration of Pb in fish samples allowed by MAFF, FAO, WHO and NHMRC is 2, 0.5, 0.5 1.5mg/kg, respectively (Pourang et al. 2005; Staniskiene et al. 2006; Türkmen et al. 2009; Tuzen et al. 2009). The results of the statistical analysis in this study showed that the amount of Pb in the muscle tissue is higher than the international standards. Also, the concentration of Pb in gill tissue is significantly higher than that of muscle (*P*-value=0/022<0/05), which is consistent with the results of previous study (Huang et al. 2022). In fact, the absorption of divalent Pb through the gills into the bloodstream is the main absorption method in freshwater fish (Sharma & Agrawal 2005). Previously the average concentration of Pb in the muscle tissue of *Hypophthalmichthys* *molitrix* (silver carp) was measured as 0.23 mg/kg from Sistan region (Miri et al. 2017) which is significantly less than the result obtained in the present study. The amount of lead in mentioned study was within the range recommended by WHO and FAO, but exceeded the amount recommended by EC. Also, the average concentration of Pb in the muscle of *Cyprinus carpio*, *Ctenopharyngodon idella*, *Hypophthalmichthys nobilis*, *Hypophthalmichthys molitrix*, *Schizocypris altidorsalis*, *Schizothorax zardunyi* species belonging to the Hamon wetland of Sistan and Baluchestan province was reported as 0.51 mg/kg (Zolfaghari 2018), which is significantly less than the result obtained in the present study. The average concentration of Pb in the muscle tissue of *Otolithes ruber* in Abadan and Bandar Abbas ports was determined to be 0.638 and 0.668 mg/kg, respectively (Askary Sary et al. 2012). Also, lead concentration in the muscle tissue of three types of marine carp fish (*Cyprinus carpio*), golden mullet (*Liza auratus*) and white fish (*Rutilus frisii kuttom*), were measured 0.41, 0.58 and 0.46mg/kg respectively (Askary Sary & Velayatzadeh 2013), and were determined in the muscles of Persian Gulf fishes, 0.58-0.73 and 0.69-0.76mg/kg, respectively (Mohammadnabizadeh & Pour Khabaz 2013). The results of studies on fish species caught from Shadegan wetland showed that the average concentration of Pb in the edible parts of all species with concentrations between 2.09 and 12.87mg/kg is higher than the FDA limit (Sheikhzadeh & Hamidian 2021). Also, the average concentration of Pb in the muscle tissue of *Esox Lucius* from Anzali wetland in its western, central and eastern parts was measured as 0.52, 0.45 and 0.49mg/kg respectively, which is lower than the FDA standard (Ahmadi & Khanipour 2020). The mean concentration of lead in previous studies is significantly lower than the result obtained in this study, because the level of pollution in the study area is very high due to the direct discharge of sewage into it. This difference in the amounts of heavy metals of different fish species depends on factors such as the size of the fish, age, food behavior and habitat (Al-Yousuf et al. 2000). In the study conducted on the species *Liza auratus*, the amount of Pb in the gills was higher than in the muscle, which is consistent with the result of the present study (Sharif Fazli et al. 2005). Also, the concentration of Pb in the gill, muscle and liver tissues of the studied species of *Pampus aragenteus*, *Scomberomorus commerson*, *Otolithes ruber* and *Parastromateus niger* was reported to be significantly lower than the FAO/WHO limit, which is contrary to the result obtained from the present study that the concentration of Pb in the muscle tissue is higher than the international standards (Sobhanardakani et al. 2011). The average concentration of Pb in the muscle and gills of *Cyprinus carpio* was reported as 0.13 and 0.50mg/kg, respectively, which is much lower than the results obtained from the present study. But this result is consistent with this study in that the amount of lead in gills is higher compared to muscles. (Erdoğrul & Erbilir 2007). Lead toxicity depends on the life stage of the fish, pH and hardness of the water, as well as the presence of organic matter (Baatrup 1991; Jezierska et al. 2009; Ahmadi & Khanipour 2020). Depending on the level of Pb, this metal has the potential to cause a variety of biological effects, including decreased hemoglobin synthesis, neurobehavioral and mental disorders, peripheral neuropathy, indirect effects on the heart, kidney damage, and reproductive problems (Mansouri et al. 2010). Lead also reduces the activity of three important metabolic enzymes, including glucose-6-phosphate dehydrogenase, lactate dehydrogenase and pyruvate kinase (Marcotrigiano & Storelli 2003). Long-term exposure to lead causes neurochemical changes in the brain of *Clarias batrachus* catfish. Lead increases the level of histamine and serotonin, but decreases the content of Gamma-aminobutyric acid (GABA), monoamine oxidase (MAO), acetylcholinesterase (AChE). In addition, it reduces the content of fat, cholesterol and protein in the brain (Menezes & Qasim 1984). The sources of lead release into the environment by waste streams include battery manufacturing, electroplating and finishing of acid metals, ammunition, tetraethyl lead production, ceramic and glass industries, printing, painting, dyeing and other industries (Zolfaghari 2018).

Zinc: The mean concentration of Zn in the muscle and gill tissue of the studied species was determined to be 70.183 and 44.610mg/kg, respectively. The maximum concentration of Zn in fish samples allowed by MAFF, FAO, WHO and NHMRC is 50, 40, 50 and 150mg/kg, respectively (Pourang et al. 2005; Staniskiene et al. 2006; Türkmen et al. 2009; Tuzen et al. 2009). The results showed that the amount of Zn is only within the permissible limit recommended by NHMRC standards and is higher than the permissible limit recommended by MAFF, WHO and FAO. Also, the results of statistical investigations showed that the measured values of Zn concentration between muscle and gill tissue have significant differences with each other (*P*-value=0/000<0/05). So that zinc concentration in muscle tissue is about 1.5 times higher than its concentration in gill tissue. Previously, the average concentration of Zn in the muscle tissue of *Epinephelus coioides* in Khor Musa, was reported as 26.01 mg/kg (Askary Sary et al. 2009), which is less than the result obtained from the present study. Also, in a study on *Oncorhynchus mykiss* and *Cyprinus carpio*, the average concentration of Zn in muscle tissue was determined to be 0.37 and 0.15mg/kg, respectively (Askary Sary & Velayatzadeh 2014). This amount is also significantly less than the result obtained from the present study. Contrary to the results of the present study, in the study conducted by Sheikhzadeh & Hamidian 2021, the highest average concentration of zinc was observed in the gill tissue of *Cyprinus carpio*. In the muscle tissue of white fish and common carp, the average concentration of Zn has been reported as 29.97 and 30.20mg/kg, respectively (Elsagh 2012). The concentration of Zn in the previous studies is lower than the result obtained in the present study, which in fact, due to the direct discharge of industrial effluents and domestic sewage in to the studied area, the high level of heavy metals including zinc, in this area is not far from expected. Also, the results of previous studies on *Capoeta fusca* showed that quantitatively the amount of Zn was more than other metals (Ni, Co, Cd and Cr). In fact, the rate of zinc excretion is very slow compared to its bioaccumulation rate (Mansouri et al. 2010). The mean concentration of Zn in the gills and muscle of *Dicentrarchus labrax, Sparus aurata, Mugil cephalus* from Camlik wetland in Iskenderun Bay, was reported to be 115.58 and 78.5 mg/kg, respectively (Dural et al. 2006), which although unlike this study, the average concentration of zinc in gill tissue is reported to be higher than that of muscle tissue, but the average concentration of zinc in muscle tissue is almost within the concentration range reported in the present study. Zn is an essential element involves in many metabolic processes, such as the immune system, neurotransmission, and cell signaling and also plays a role in some enzymatic reactions as a cofactor (Pastorino et al. 2020). It helps to control the biochemical and physiological mechanisms of living tissues and is necessary to maintain health, but increasing its concentration may cause skin irritation, vomiting, nausea and stomach cramps (Carolin et al. 2017; Hossain et al. 2022). However higher concentrations of Zinc may have severe toxic effects and cause liver damage, respiratory disorders and disruption of protein metabolism (Beesley & Marmiroli 2011; O'Mara et al. 2019). A chronically elevated zinc dose increases the risk of developing anemia and damage to the pancreas, decreases the level of HDL cholesterol and increases the level of LDL cholesterol and possibly increases the symptoms of Alzheimer`s disease (Sharma & Agrawal 2005).

Mercury: In this research, the average concentration of Hg in muscle and gill tissue of the studied species was reported as 0.120 and 0.250mg/kg respectively. The maximum concentration of Hg in fish samples allowed by MAFF, FAO, WHO and NHMRC is 1, 0.5, 0.5 and 1 mg/kg (Pourang et al. 2005; Staniskiene et al. 2006; Türkmen et al. 2009; Tuzen et al. 2009). The results of statistical investigations showed that Hg concentration is lower than the limit of international standards. Also, the results showed that the measured values of Hg concentration between muscle and gill tissue do not differ significantly from each other (*P*-value=0/09>0/05). Based on the studies, the average concentration of Hg in *Liza abu* muscle tissue was 0.75µg/g, which is lower than the standard set by FAO, EPA, WHO and USFDA (Cheraghi et al. 2013), but it is more than the average obtained in this study. Also, the average concentration of Hg in *Parastromateus niger* was determined to be 0.331µg/g, which was within the permitted range recommended by FAO, WHO and USFDA (Ahmadi Kordestani et al. 2013) and it is almost close to the average obtained in this study. Previously, the highest accumulation of Hg=0.065µg/g, was observed in the gill tissue of *Barbus sharpeyi* species (Sheikhzadeh & Hamidian 2021) which is lower than the average obtained in this study. In the muscle tissue of Mahshahr port *Otolithes ruber*, the average concentration of Hg was 0.354µg/g. This amount was more than the limit recommended by MAFF and USEPA (Mardoukhi et al. 2013) and also is more than the result obtained from the present study. In another study, Velayatzadeh (2014) were reported that the average concentration of Hg in *Arius thalassinus* muscle to be 0.41µg/g, which was lower than international standards (FAO, FDA, WHO). Although in the present study, the average concentration of Hg was to be lower than the international standards, but the mean Hg concentration obtained from this study is more than the present study. In this study, no significant correlation was observed between length and weight of black fish with Hg level, but this correlation has been investigated by other researchers. In the study conducted on two species of common and silver carp, a positive and significant correlation was obtained between Hg concentration and weight and length (Malvandi et al. 2015). Also, in America, a significant correlation was observed between size and amount of Hg in *Sciaenops ocellatus* species (Adams & Onorato 2005). On the other hand, in a study conducted in Florida, no significant relationship was observed between the amount of Hg and the length and weight of fish (Malvandi et al. 2015). According to the studies, Hg is produces dramatic consequences both for vertebrates and invertebrates (Zupo et al. 2019). Mercury is very toxic for fish because it caused structural, physiological and biochemical damage to the nervous system in concentrations below the lethal limit (Baatrup 1991). Also, mercury toxicity resulted defects of important organs of fish such as abnormal and irregular fins, head, tails and several spinal difficulties (Taslima et al. 2022). Human exposure to mercury occurs primarily through fish consumption, particularly muscle tissue. Mercury, even in low concentrations, is very toxic to human health and causes impaired fetal brain development, movement problems, reduced vision, thinking, general weakness, loss of consciousness and ultimately death (Costa et al. 2020).

CONCLUSION

In this study, the concentrations of four heavy metals (Pb, Hg, Zn and Cd) in muscle and gill tissue of *Capoeta fusca* and health risks were investigated. The results showed that there is little concern about the amount of Zn and Hg in fish because the amount of Zn is within the permissible limit recommended by NHMRC and the amount of Hg is lower than the limit of international standards of WHO, FAO, NHMRC and MAFF. Among the investigated metals, the main risk for human health can be related to the amount of Pb in fish samples, because the amount of Pb exceeded the permissible limit recommended by the mentioned international standards. Considering that the studied species lives in sewage water, these results were not far from expected, and native people who use fish as a source of food, should keep in mind what kind of water the fish they catch lives in, so that there is no serious risk to their health. Eventually, due to the accumulation of Pb at toxic levels and the risk index greater than one for this metal, it is recommended to continue investigating the concentration of the other heavy metals in the target fish as well as the wetland water sample.

ACKNOWLEDGMENTS
The authors gratefully acknowledge the financial and Lab support for this work that was provided by University of Sistan and Baluchestan. We would also like to thank the General Department of Environmental Protection of Sistan and Baluchistan Province for the laboratory facilities and field trip transportation. Dr. Mohsen Hamidianpour kindly helped us with map preparation.

FUNDING
University of Sistan and Baluchestan provided financial support for the current study.

REFERENCES
Adams, D.H. & Onorato, G. V. 2005. Mercury concentrations in red drum, *Sciaenops ocellatus*, from estuarine and offshore waters of Florida. Marine Pollution Bulletin 50(3): 291-300.

Ahmadi, M. & khanipour, A.A. 2020. Determination and measurement of lead and chromium heavy metals in the edible muscle tissue of duck fish (*Esox Lucius*) of Bandar Anzali International Wetland. Advanced Aquaculture Science 3(3): 55-61.

Ahmadi Kordestani, Z.; Hamidian, A.; Hosseini, S.V. & Ashrafi, S. 2013. Risk assessment of mercury due to consumption of edible aquatic species. Journal of Marine Biology 5(1): 63-70.

Ali, H. & Khan, E. 2018. Assessment of potentially toxic heavy metals and health risk in water, sediments, and different fish species of River Kabul, Pakistan. Human and Ecological Risk Assessment: An International Journal 24(8): 2101-2118.

AL Taee, S.K.; Al-Mallah, K.H. & Kh.Ismail H. 2020. Review on some heavy metals toxicity on freshwater fishes. Journal of Applied Veterinary Sciences 5(3): 78-86.

Al-Yousuf, M.H.; El-Shahawi, M.S. & Al-Ghais, S.M. 2000. Trace metals in liver, skin and muscle of *Lethrinus lentjan* fish species in relation to body length and sex. Science of the total environment 256(2-3): 87-94.

Askary Sary, A.; Farhangnia, M. & Baztorabi, M. 2009.The measurement and comparison of heavy metals (Lead, Zinc and Copper) in the tissues muscle and liver in orange spotted grouper (*Epinephelus coiodes*). Journal of Wetland Eco biology 1(2): 101-106.

Askary Sary, A.; Javahery Baboli, M.; Mahjob, S. & Velayatzadeh, M. 2012. The comparison of heavy metals (Hg, Cd, Pb) in the muscle of *Otolithes ruber* in Abadan and Bandar Abbas Ports, the Persian Gulf. Iranian Scientific Fisheries Journal 21(3): 99-106.

Askary Sary, A. & Velayatzadeh, M. 2013. Bioaccumulation Lead and Zinc metals in the liver and muscle of *Cyprinus carpio*, *Rutilus frisii kuttom* and *Liza auratus*. Journal of Food Hygiene 3(1): 89-99.

Askary Sary, A. & Velayatzadeh, M. 2014. Determination of lead and zinc in *Cyprinus carpio* and *Oncorhynchus mykiss* from Iran in 2001 and 2011. International Journal of Biosciences 4(11): 1-9.

Baatrup, E. 1991. Structural and functional effects of heavy metals on the nervous system, including sense organs, of fish. Comparative Biochemistry and Physiology Part C: Comparative Pharmacology 100(1-2):253-257.

Beesley, L. & Marmiroli, M. 2011. The immobilisation and retention of soluble arsenic, cadmium and zinc by biochar. Environmental pollution 159(2): 474-480.

Carolin, C.F.; Kumar, P.S.; Saravanan, A.; Joshiba, G.J. & Naushad, M. 2017. Efficient techniques for the removal of toxic heavy metals from aquatic environment: A review. Journal of Environmental Chemical Engineering 5(3): 2782-2799.

Cheraghi, M.; Pourkhabbaz, H. & Javanmardi, S. 2013. Determination of mercury concentration in *Liza abu* from Karoon River. Journal of Mazandaran University of Medical Sciences 23(103): 105-112.

Costa, F.; Coelho, J. P.; Baptista, J.; Martinho, F.; Pereira, M .E. and Pardal, M.A. 2020. Mercury accumulation in fish species along the Portuguese coast: are there potential risks to human health?. Marine Pollution Bulletin 150: 110740.

Dural, M.; Lugal Göksu, M.Z.; Özak, A.A. & Derici, B. 2006. Bioaccumulation of some heavy metals in different tissues of *Dicentrarchus labrax L*, 1758, *Sparus aurata L*, 1758 and *Mugil cephalus* L, 1758 from the Camlik lagoon of the eastern cost of mediterranean (turkey). Environmental Monitoring and Assessment 118(1-3): 65-74.

Elsagh, A. 2012. Determination of Zinc, Copper, Cobalt and manganese intensity in *Rutilus frisii kutum* and *Cyprinus carpio* fishes of Caspian Sea. Journal of Gorgan University of Medical Sciences 13(4): 107-113.

Erdoğrul, Ö. & Erbilir, F. 2007. Heavy metal and trace elements in various fish samples from Sır Dam Lake, Kahramanmaraş, Turkey. Environmental Monitoring and Assessment 130(1-3): 373-379.

Ghanbarifardi, M. 2021. Monitoring of managed wildlife areas and habitats of Sistan and Baluchestan Province. General Department of Environmental Protection, Sistan and Baluchestan, Zahedan, Iran, Unpublished Report.

Hossain, M.B.; Bhuiyan, N.Z.; Kasem, A.; Hossain, M.K.; Sultana, S.; Nur, A.U.; Yu, J.; Albeshr, M.F. & Arai, T. 2022. Heavy Metals in Four Marine Fish and Shrimp Species from a Subtropical Coastal Area: Accumulation and Consumer Health Risk Assessment. Biology (Basel) 11(12): 1780.

Hosseini, M.; Naderi, M.; Gholami, S. & Hadipour, M. 2018. Toxic metals in the muscle and liver of five main commercially-important fishes from the Persian Gulf, Southern Iran. Caspian Journal of Environmental Science 16(2): 191-198.

Huang, H.; Li, Y.; Zheng, X.; Wang, Z.; Wang, Z. & Cheng, X. 2022. Nutritional value and bioaccumulation of heavy metals in nine commercial fish species from Dachen Fishing Ground, East China Sea. Scientific Reports 12: 6927.

Isangedighi, I. A. & David, G.S. 2019. Heavy metals contamination in fish: effects on human health. Journal of Aquatic Science and Marine Biology 2(4): 7-12.

Jezierska, B.; Ługowska, K. & Witeska, M. 2009. The effects of heavy metals on embryonic development of fish (a review). Fish physiology and biochemistry 35(4):625-640.

Keshavarzi, B.; Hassanaghaei, M.; Moore, F.; Mehr, M. R.; Soltanian, S.; Lahijanzadeh, A. R. & Sorooshian, A. 2018. Heavy metal contamination and health risk assessment in three commercial fish species in the Persian Gulf. Marine Pollution Bulletin 129(1):245-252.

Korkmaz, C.; Ay, Ö.; Ersoysal, Y.; Köroğlu, M.A. & Erdem, C. 2019. Heavy metal levels in muscle tissues of some fish species caught from north-east Mediterranean: Evaluation of their effects on human health. Journal of Food Composition and Analysis 81: 1-9.

Lei, M.; Tie, B. Q.; Song, Z. G.; Liao, B. H.; Lepo, J. E. & Huang, Y.Z. 2015. Heavy metal pollution and potential health risk assessment of white rice around mine areas in Hunan Province, China. Food security 7: 45-54.

Mahmuda, M.; Rahman, M.H.; Bashar, A.; Rohani, M.F. & Hossain, M.S. 2020. Heavy metal contamination in tilapia, Oreochromis niloticus collected from different fish markets of Mymensingh District. Journal of Agriculture, Food and Environment 1(4): 1-5.

Malakootian, M.; Mortazavi, M.S. & Ahmadi, A. 2016. Heavy metals bioaccumulation in fish of southern Iran and risk assessment of fish consumption. Environmental Health Engineering and Management Journal 3(2): 61-68.

Malvandi, H.; Esmaili Sari, A. &. Aliabadani, M. 2015. The Determination of Khramulia *Capoeta capoeta* Mercury Concentration in Zarrin Gol River, Golestan Province. Veterinary Research and Biological Products 28(1):50-57.

Mansouri, B.; Ebrahimpour, M. & Babaei,H. 2010. Determine of heavy metals in different tissues of Black Fish (*Capoeta fusca*) in central part Qanats of Birjand. Veterinary Research and Biological Products 23(4): 45-52.

Marcotrigiano G.O. & Storelli M.M. 2003. Heavy metal, polychlorinated biphenyl and organochlorine pesticide residues in marine organisms: Risk evaluation for consumers. Veterinary Research Communications 27(Suppl): 183-195

Mardoukhi, S.; Hosseini, S.V. & Hosseini, S. M. 2013. Risk to consumers from mercury in croaker (*Otolithes ruber*), from the Mahshahr port. Journal of Fisheries Science and Technology 2(3): 43-55.

Menezes, M.R. & Qasim, S.Z. 1984. Effects of mercury accumulation on the electrophoretic patterns of the serum, haemoglobin and eye lens proteins of *Tilapia mossambica* (Peters). Water Research 18(2): 153-161.

Miri, M.; Akbari, E.; Amrane, A.; Jafari, S.J.; Eslami, H.; Hoseinzadeh, E.; Zarrabi, M.; Salimi, J.; Sayyad-Arbabi, M. & Taghavi, M. 2017. Health risk assessment of heavy metal intake due to fish consumption in the Sistan region, Iran. Environmental Monitoring and Assessment 189:1-10.

Mohammadi, M.; Askary Sary, A. & Khodadadi, M. 2011. Determination of heavy metals in two barbs, *Barbus grypus* and *Barbus xanthopterus* in Karoon and Dez Rivers, Khoozestan, Iran. Bulletin of environmental contamination and toxicology 87(2): 158-162.

Mo, W.Y.; Man, Y.B.; Zhang, F. & Wong, M.H. 2019. Fermented food waste for culturing jade perch and Nile tilapia: Growth performance and health risk assessment based on metal/loids. Journal of Environmental Management 236: 236-244.

Mohammad Nabizadeh, S. & Pour Khabaz, A. 2013. Biomonitoring of heavy metals of fish tissues in Khamir and Laft ports of Hormozgan Province. Iranian Veterinary Journal 9(1): 64-75.

Nussey, G.; van Vuren, J.H.J. & du Preez, H.H. 2000. Bioaccumulation of chromium, manganese, nickel and lead in the tissues of the *moggel*, *Labeo umbratus* (*Cyprinidae*), from Witbank Dam, Mpumalanga. Water SA 26(2): 269-284.

Nyarko, E.; Boateng, C.M.; Asamoah, O.; Edusei, M.O. & Mahu, E. 2023. Potential human health risks associated with ingestion of heavy metals through fish consumption in the Gulf of Guinea. Toxicology Reports 10: 117-123.

O'Mara, K.; Adams, M.; Burford, M.A.; Fry, B. & Cresswell, T. 2019. Uptake and accumulation of cadmium, manganese and zinc by fisheries species: Trophic differences in sensitivity to environmental metal accumulation. Science of the Total Environment 690: 867-877.

Pandey, G. & Madhuri, S. 2014. Heavy metals causing toxicity in animals and fishes. Research Journal of Animal, Veterinary and Fishery Sciences 2(2): 17-23.

Pastorino, P.; Prearo, M.; Bertoli, M.; Abete, M.C.; Dondo, A.; Salvi, G.; Zaccaroni, A.; Elia, A.C. & Pizzul, E. 2020. Accumulation of As, Cd, Pb, and Zn in sediment, chironomids and fish from a high-mountain lake: First insights from the Carnic Alps. Science of the Total Environment 729: 139007.

Pourang, N.; Nikouyan, A. & Dennis, J.H. 2005. Trace element concentrations in fish, surficial sediments and water from northern part of the Persian Gulf. Environmental monitoring and assessment 109: 293-316.

Rahmani, J.; Fakhri, Y.; Shahsavani, A.; Bahmani, Z.; Urbina, M.A.; Chirumbolo, S.; Keramati, H.; Moradi,B.; Bay, A. & Bjørklund, G. 2018. A systematic review and meta-analysis of metal concentrations in canned tuna fish in Iran and human health risk assessment. Food and Chemical Toxicology 118: 753-765.

Sharif Fazli, M.; Abtahi, B. & Sabbagh Kashani, A. 2005. Assessing Pb, Ni and Zn Accumulation in the tissues of *Liza Aurata* in the South Caspian Sea. Iranian Scientific Fisheries Journal 14(1): 65-78.

Sharma, R.K. & Agrawal, M. 2005. Biological effects of heavy metals: an overview. Journal of environmental Biology 26(2): 301-313.

Sheikhzadeh, H. & Hamidian, A.H. 2021. Bioaccumulation of heavy metals in fish species of Iran: a review. Environmental Geochemistry and Health 43(10): 3749-3869.

Sobhanardakani, S.; Tayebi, L. & Farmany, A. 2011. Toxic metal (Pb, Hg and As) contamination of muscle, gill and liver tissues of *Otolithes rubber*, *Pampus argenteus*, *Parastromateus niger*, *Scomberomorus commerson* and *Onchorynchus mykiss*. World Applied Sciences Journal 14(10): 1453-1456

Squadrone, S.; Prearo, M.; Brizio, P.; Gavinelli, S.; Pellegrino, M.; Scanzio, T.; Guarise, S.; Benedetto, A. & Abete, M. C. 2013. Heavy metals distribution in muscle, liver, kidney and gill of European catfish (*Silurus glanis*) from Italian Rivers. Chemosphere 90(2): 358-365.

Staniskiene, B.; Matusevicius, P.; Budreckiene, R. & Skibniewska, K.A. 2006. Distribution of Heavy Metals in Tissues of Freshwater Fish in Lithuania. Polish Journal of Environmental Studies 15(4): 585-591.

Tahity, T.; Islam, M.R.U.; Bhuiyan, N.Z.; Choudhury, T.R.; Yu, J.; Noman, M.A.; Hosen, M.M.; Quraishi, S. B.; Paray, B.A.; Arai, T. & Hossain, M. B. 2022. Toxics 10(8):410.

Taslima, K.; Al-Emran, M.; Rahman, M. S.; Hasan, J.; Ferdous, Z.; Rohani, M.F. & Shahjahan, M. 2022. Impacts of heavy metals on early development, growth and reproduction of fish - A review. Toxicology Reports 9: 858-868.

Türkmen, M.; Türkmen, A.; Tepe, Y.; Töre, Y. & Ateş, A. 2009. Determination of metals in fish species from Aegean and Mediterranean seas. Food Chemistry 113(1):N233-237.

Tuzen, M.; Karaman, I.; Citak, D. & Soylak, M. 2009. Mercury (II) and methyl mercury determinations in water and fish samples by using solid phase extraction and cold vapour atomic absorption spectrometry combination. Food and Chemical Toxicology 47(7):B1648-1652.

USEPA. 2011. USEPA Regional Screening Level (RSL) Summary Table: November 2011.

Velayatzadeh, M.; Askari Sari, A. & Hoseinzadeh Sahafi, H. 2014. Determination of mercury, cadmium, arsenic and lead in muscle and liver of *Liza dussumieri* from the Persian Gulf, Iran. Journal of Biodiversity and Environmental Sciences 5(3):227-234.

Zhao, S.; Feng, C.; Quan, W.; Chen, X.; Niu, J. & Shen, Z. 2012. Role of living environments in the accumulation characteristics of heavy metals in fishes and crabs in the Yangtze River Estuary, China. Marine pollution bulletin 64(6):1163-1171.

Zolfaghari, G. 2018. Risk assessment of mercury and lead in fish species from Iranian international wetlands. MethodsX 5: 438-447.

Zupo, V.; Graber, G.; Kamel, S.; Plichta, V.; Granitzer, S.; Gundacker, C. & Wittmann, K.J. 2019. Mercury accumulation in freshwater and marine fish from the wild and from aquaculture ponds. Environmental Pollution 255: 112975.

Iran. J. Ichthyol. (2023) 10(2): 102-113
P-ISSN: 2383-1561; E-ISSN: 2383-0964
http://www.ijichthyol.org

doi: 10.22034/iji.v10i2.973
dor: 20.1001.1.23831561.2023.10.2.9.3

مقاله کامل

تعیین میزان فلزات سنگین (کادمیوم، روی، سرب و جیوه) در ماهی *Capoeta fusca* تالاب لار، شهر زاهدان، استان سیستان و بلوچستان

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چکیده: این مطالعه به‌منظور بررسی غلظت فلزات سنگین (کادمیوم، روی، سرب و جیوه) در بافت ماهیچه و آبشش ماهی *Capoeta fusca* تالاب لار در استان سیستان و بلوچستان و خطرات سلامتی بالقوه برای مصرف‌کنندگان صورت گرفته است. ۳۰ نمونه ماهی جمع‌آوری شد و غلظت فلزات سنگین در نمونه‌ها با دستگاه اسپکتروفوتومتر جذب اتمی ICP-OES (Perkin Elmer, Model; Optima DV 2000) اندازه‌گیری شد. غلظت جیوه با روش جذب اتمی (nova 400P, analytic jena) تکنیک تولید هیدرید اندازه‌گیری شد. غلظت کادمیوم کمتر از حد تشخیص اسپکتروفوتومتر جذب اتمی بود (۰/۰۵ mg/kg)، بنابراین غلظت آن در این مطالعه گزارش نشده است. نتایج نشان دادند که غلظت سرب در بافت آبشش به‌طور معنی‌داری بیشتر از بافت ماهیچه بود و غلظت روی در بافت ماهیچه بیشتر از بافت آبشش بود. غلظت جیوه در بافت ماهیچه و آبشش تفاوت معنی‌داری با یکدیگر نداشت. تجمع فلزات سنگین در نمونه‌ها از این الگو پیروی می‌کند: جیوه<سرب<روی. غلظت سرب در بافت ماهیچه *Capoeta fusca* بالاتر از حد استانداردهای بین‌المللی بود. بنابراین در بین فلزات بررسی‌شده، ریسک اصلی برای سلامت انسان می‌تواند مربوط به فلز سرب در نمونه‌های ماهی باشد که می‌تواند مستقیماً بعد از مصرف ماهی به انسان منتقل شود. غلظت نسبتاً بالای فلزات سنگین در ماهی مورد مطالعه احتمالاً می‌تواند به‌دلیل ورود فاضلاب شهر زاهدان به تالاب لار باشد.

کلمات‌کلیدی: آلودگی، فلزات سمی، ارزیابی خطر، ماهی، اکوسیستم‌های آبی.