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Determination of heavy metals including Hg, Pb, Cd, and Cr in edible fishes *Liza abu, Brachirus orientalis* and attributed cancer and non-cancer risk assessment

Afsaneh Azadeh[1], **Afshin Takdastan**[2,3*], **Nematollah Jaafarzadeh Haghighi Fard**[2,3], **Ali Akbar Babaei**[2,3], **Soleyman Alivand**[4]

[1]Student Research Committee, Department of Environmental Health Engineering, School of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[2]Environmental Technologies Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[3]Department of Environmental Health Engineering, School of Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[4]Department of Biostatistics and Epidemiology, School of Health, Isfahan University of Medical Sciences, Isfahan, Iran

Abstract

Background: Heavy metals are considered as pollutants polluting aquatic ecosystems because of their toxic effects and bioaccumulation in organisms. They can cause chronic poisoning when ingested by human. The present study was conducted to determine the concentration of heavy metals, mercury (Hg), lead (Pb), cadmium (Cd), and chromium (Cr) in the muscle tissue of *Liza abu* and *Brachirus orientalis* fish in Mahshahr, and also, to estimate the risk of muscle consumption of these fish.

Methods: Forty samples of both fish species were randomly selected and after preparation and extraction and digestion processes, the metals were measured using ICP-OES Agilent Model 5100.

Results: The mean concentrations of Hg, Pb, Cd, and Cr in the muscle tissue of the *Liza abu* fish were 0.616 ± 0.383, 1.227 ± 1.77, 0.076 ± 0.030, and 0.567 ± 0.267 mg/kg dry weight, and in the muscle tissue of the *Brachirus orientalis* fish were 0.846 ± 0.659, 0.515 ± 1.245, 0.061 ± 0.047, and 0.586 ± 0.548 mg/kg dry weight, respectively. HI for *Liza abu* and *Brachirus orientalis* was 0.025 and 0.336, respectively.

Conclusion: According to the results of this study, the concentrations of Hg and Cr in the muscle tissue of *Liza abu* and *Brachirus orientalis* were slightly higher than some global standards such as the World Health Organization (WHO) and Food and Agriculture Organization (FAO). HQ index was below 1 for two fish species, meaning that there was no non-carcinogenic risk. In all samples analyzed, carcinogenic risk Cr was slightly above the permissible limit of 1×10^{-4} to 1×10^{-6} ،other metals were in this range.

Keywords: Fishes, Hg, Cr, HI, CR

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***Correspondence to:**
Afshin Takdastan,
Email: afshin_ir@yahoo.com

Introduction

The aquatic ecosystems pollutants are very important as they put human health and other environmental organisms in danger (1). Heavy metals are one of the pollutants in aquatic ecosystems (2). Heavy metals enter the environment through natural resources (mostly rock erosion and weathering) and human resources such as mines, industrial drainage, sewage and surface runoff, and dam construction (3). Heavy metals are considered as serious environmental pollutants due to their stability in the environment and their tendency to accumulate in aquatic organisms (4). Essential metals are absorbed by fish from water for normal metabolism, and also, non-essential metals are absorbed by fish and accumulate in their tissues (5). These metals can enter the human body through the consumption of contaminated fish. The degree of absorption and accumulation of heavy metals in fish depends on factors such as environmental conditions, physical, chemical and biological factors of water, the type of elements and their physiological status (6). Some metals in fish are essential because they play a vital role in the biological system of fish as well as in humans. However, some of them, such as mercury (Hg), lead (Pb), cadmium (Cd), and chromium (Cr), are poisonous for human, and chronic exposure to these pollutants can cause liver, kidney, bone and potentially cancer problems (7-9). Studies have shown that Hg accumulates in kidney and causes kidney diseases, including proteinuria and immunological glomeruli. Hg accumulation also increases lymphocyte coagulation, insomnia, hypertrophy, deafness, ataxia, central nervous system problems, kidney damage, and carcinogenesis. Pb is one of the most important environmental pollutants and the most toxic heavy metals for the environment (10). Exposure to high levels of Pb can cause brain damage, paralysis, anemia, and digestive problems. Prolonged exposure to Pb can damage the kidneys, reproductive systems, nervous system, immune system and lead to Pb poisoning. The most important damage is the appearance of blue lines on the gums (11, 12). Cd and Cr are among the heavy metals entering the environment through waste streams and readily absorbed by living organisms (13). The Cd is generally not present in its pure state in the environment and is found in nature in mineral form in combination with other components such as oxygen and chlorine or sulfur. Exposure to Cd may affect the lungs, kidneys, heart, bones and carcinogenicity (14). Excessive exposure to Cr is associated with lung cancer in humans and kidney injury in animals (15). The port of Mahshahr has special economic and social importance due to different species of aquatic animals in this area. The increasing demand for aquatic products as a valuable food source has led to the full growth and development of the fisheries and aquaculture industry in the southern regions of the country. Existence of urban and industrial activities in different areas of this sea has caused a large amount of various pollutants, including heavy elements, to enter it, which has led to aquatic pollution (16). The human daily diet is one of the largest and most important sources of exposure to metals (17). Fish has been considered as a human food as it is a strong source of protein, minerals, and unsaturated fatty acids (18). Heavy metals enter the body of the fish through the food and non-food particles and can have toxic effects (19). The permitted levels declared by the World Health Organization (WHO) for the metals Hg, Cd, Pb, and Cr are 0.1, 0.2, 0.5, and 10 µg/g, respectively (20, 21). Risk assessment is the science by which environmental pollutants affect human health, so the main aim of the present study was to determine the concentration of heavy metals including Pb, Cd, Cr, and Hg in two species of *Liza abu* and *Brachirus orientalis*, and also, to determine whether they are carcinogenic or not.

Materials and Methods

Study area

The study area was Bandar Mahshahr, which is located in the south of Khuzestan province of Iran with a longitude of 49° and 13' and latitude of 30° and 33', with an altitude of 3 m above the sea level. Bandar Mahshahr has 372 hectares of dilapidated texture, which is a large area and is about 15% of the total area of the city. The study was done between October 2019 and March 2020.

Sample collection

In this study, 40 fish samples of both species (20 samples of *Liza abu* fish and 20 samples of *Brachirus orientalis* fish) were used to investigate the concentration of heavy metals. Sampling was done randomly using local fishermen during 6 months in both hot and cold seasons of 2019 and 2020. Thus, in each season, the desired contaminant was extracted and measured in 5 to 10 samples (randomly) from both fish tissues on average. After recording the specifications, the fish were placed in a plastic bag, and then, placed in an ice container containing ice and transferred to a laboratory for preparation and analysis.

Sample treatment and analysis

Prior to separation and preparation, fish samples were washed with distilled water. After the passage of time and excess water, bioassay operations (measurement of length and weight) were performed. Then, the muscle tissues were separated and some of them were transferred to the containers (washed with nitric acid) and placed in an oven at 140°C for 4 hours to dry completely. The samples were pulverized with a porcelain mortar and placed in a desiccator to prevent the absorption of air moisture. The muscle tissue prepared from the studied samples, after weighing to dry, was placed in an oven at 105°C for 48 hours.

Measurement of Hg, Pb, Cd, and Cr

Then, in order to perform chemical digestion, 1 g of each dried sample was poured into separate digestion tubes and 6 ml of nitric acid solution (65% Merck Germany) was added to the contents of the tubes at a ratio of 1:6. After this step for acidic digestion, contents of storage tubes were placed in a fume hood with a heating system at 90°C to dry, and a clear solution was obtained. The resulting clear solution was passed through a 45 mm Whatman filter paper and transferred to a volumetric flask with a volume of 15 ml (22). Finally, the samples were transferred to Falcon tubes with caps for injection. ICP-OES Agilent model 5100 device, was used to measure the concentration of metals in all samples. The daily intake of fish and the maximum allowable consumption for the samples were calculated using the following procedure.

Statistical analysis

Data were analyzed using SPSS version 2018. Descriptive statistics (mean and deviation) were employed for analysis of heavy metals concentrations. Analytical statistics (Spearman's statistical test and one sample *t* test) were used to investigate the relationship between quantity variables.

Health risk assessment

The risk assessment for adults was performed to estimate the possible hazard associated with the consumption of heavy metals contained in the Mahshahr city fish.

Estimated daily intake

The estimated amount of metal absorbed by the consumer per day, is calculated by Eq. (1) (23).

$$EDI = \frac{Mc \times CR}{ABw} \quad (1)$$

Where *EDI* is the amount of daily metal absorption through fish consumption (mg of metal per kg per day), *Mc* indicates the concentration of metal in dried fish (mg of metal per kg of fish), *ABw* is average weight of consumers (70 kg), and *CR* is daily consumption rate of fish (50 g/day).

Determination of the daily limit of fish consumption (CRlim)

CRlim is a criterion for assessing the health of the consumer and is obtained from Eq. (2) (24).

$$CRlim = \frac{RFD \times ABw}{Mc} \quad (2)$$

RFD is reference dose (mg/kg/day), *ABw* is average body weight (70 kg adults), *Mc* is concentration of metal in fish tissue (mg/kg).

Target hazard quotient

The health risks of fish consumption by the public are assessed on the basis of THQ. Details of the THQ estimation method were published by the US Environmental Protection Agency (US EPA, 2000), and calculations were performed according to the average 70 kg adult human body weight (25).

$$THQ = \frac{EF \times ED \times IFR \times C}{RFD \times ABw \times ATn} \times 10^{-3} \quad (3)$$

Where *THQ* is target hazard quotient, *EF* is the exposure frequency (365 days/year), *ED* is total duration of exposure (70 years for adults), *IFR* is the fish ingestion rate (g/day), *Mc* is metal concentration in fish tissue (mg/kg), *RFD* is the reference oral dose of the metals (mg/kg/day), *ABw* is average body weight (70 kg for adults), and *ATn* is the average time for non-carcinogens.

Hazard index of equation

To assess the health risk of fish users, hazard index (HI), according to Eq. (4), was used. This index is calculated by sum of THQ values obtained for each metal. Risk index values equal or above 1 indicates a high risk of non-cancerous diseases and lower values indicate that the fish studied will not be harmful to consumer health and the risk of non-cancerous disease does not exist (26).

$$\text{Hazard index (HI)} = \Sigma THQ = THQPb + THQCd + THQHg + THQCr \quad (4)$$

Carcinogenic risk

The estimated amount of cancer growth probability over the life of the general population (CR) in the face of any carcinogenic chemical (27), calculated using Eq. (5), is defined as the probability that a person will develop cancer due to exposure to a particular contaminant or a set of contaminants in the environment (28).

$$CR = EDI \times SFi \quad (5)$$

Where *CR* is carcinogenic risk, *EDI* is the estimated daily intake of each heavy metal (mg/kg/day); and *SFi* is the ingestion cancer slope factor (mg/kg/day). The standards used for these calculations are as shown in Table 1. Cancer risk (CR) is an indicator of carcinogenic risk. CSF indicates carcinogenic slope factor calculated for only Cd, Pb, and Cr because Hg CSFs are not published by the USEPA, and the CSF values are 0.38, 0.0085, and 0.5 mg/kg/day for Cd, Pb, and Cr, respectively, according to the Integrated Risk Information System (IRIS) database (29, 30). CR values greater than 10^{-4} indicate that there is a risk of carcinogenesis. CR values between 10^{-4} and 10^{-6} indicate that the carcinogenic risk is acceptable. And CR values lower than 10^{-6} indicate that the risk of carcinogenesis is very low (30).

Results

The concentrations of heavy metals analyzed in the samples of this study are shown in Table 2. Analysis of the measured data showed that in *Liza abu* fish, Pb had the highest concentration (1.227 mg/kg) and Cd had the lowest concentration (0/076 mg/kg) in the muscle tissue of the fish. In *Brachirus orientalis*, Hg had the highest concentration (0.864 mg/kg) and Cd had the lowest concentration (0.061 mg/kg) in the fish muscle tissue. Higher metal concentrations are due to various human activities such as petrochemical plants and effluents from port activities (31). The results of the Spearman's correlation coefficient test shows that there is not statistically significant relationship between the weight of

Table 1. RfDing (US EPA) and CSFing (mg/kg/day) (32, 33)

Metals	RfDing (mg/kg/person/day)	CSFing (mg/kg/day)
Hg	0.0005	-
Pb	0.004	0.0085
Cd	0.001	0.380
Cr	0.003	0. 5

Table 2. Concentrations (mg/kg/dry weight) of heavy metals in *Cynoglossus arel* in Mahshahr city

Fish	Weight (kg)	Length (cm)	Hg	Pb	Cr	Cd
Liza abu	88±14.44	19.05±1.80	0.616± 0.383	1.227±1.77	0.567±0.278	0.076±0.030
Brachirus orientalis	270.05±153.406	26.33±3.860	0.846±0.659	0.515±1.245	0.586±0.548	0.061±0.047

Values are presented as mean ± SD.

two species of *Liza abu* and *Brachirus orientalis* and the concentration of heavy metals studied ($P \geq 0.05$). There is a statistically significant and direct relationship between the concentration of Cr and Hg and the length of unripe fish, so that by increasing the length of fish, the concentration of Cr and Hg increases and vice versa ($P \leq 0.05$). However, for other studied metals, no relationship was observed between metal concentration and length of fish ($P \geq 0.05$). Also, the results of this test show that there is no statistically significant relationship between the weight of *Brachirus orientalis* fish and the concentration of heavy metals studied ($P \geq 0.05$), but there was a statistically significant and direct relationship between Cr concentration and fish length, so that by increasing the length of the fish, the concentration of Cr metal increases but for other studied metal, no relationship was found between metal concentration and length of fish ($P \geq 0.05$). The average concentration of Pb and Cd in *Liza abu* fish is higher than that in *Brachirus orientalis* fish and the concentration of Hg and Cr in *Brachirus orientalis* fish is higher than that in *Liza abu* fish (Figure 1). The concentrations of metals measured in the muscle of the studied fish with international standards were compared using one-sample *t* test (Table 3). Hg concentrations in *Brachirus orientalis* and *Liza abu* were lower than the Nation Health and Medical Research Council (NHMRC) standard but higher than the WHO, Food and Agriculture Organization (FAO), Food and Drug Administration (FDA), and UK Ministry of Agriculture, Fisheries and Food (UKMAFF) standards. The concentration of Pb in *Liza abu* fish was higher than the WHO and FAO standards and lower than the FDA, UKMAFF, and NHMRC standards. The concentration of Pb in *Brachirus orientalis* fish was lower than the permissible level set by the WHO, FAO, FDA UKMAFF, and NHMRC standards. The concentration of Cd in *Brachirus orientalis* was lower than the limited set by the WHO, FAO, FDA standards, and slightly higher than the UKMAFF standard. The concentration of Cr in *Liza abu* and *Brachirus orientalis* fish was lower than the limited set by the UKMAFF, NHMRC, and FDA standards, and was higher than the FAO and WHO standards. Tables 4, 5, 6, and 7 provide the estimated daily intake, permissible daily intake of fish, toxic risk factor, and cancer risk analysis. Heavy metals are of particular importance to the world because they are environmentally sustainable, recycled biochemical, and pose ecological hazards. Heavy metals such as Hg, Pb, Cd and Cr can be considered as potentially toxic metals. Since fish muscle play an essential role in human nutrition and ensuring fish health is of particular importance to the consumer, fish health should be considered in all ecological areas. According to the per capita consumption of fish in Iran, the amount of Hg that enters the human body through the consumption of *Liza abu* and *Brachirus orientalis* fish, is about 0.00008 and 0.0001206 mg/kg/day for an adult weighing 70 kg. Also, the risk index of *Liza abu* and *Brachirus orientalis* fish consumption in adults was 0.176 and 0.266, respectively. According to the maximum daily consumption of fish and considering the average weight of 70 kg for the consumer, the permissible amount of consumption of *Liza abu* and *Brachirus orientalis* fish with an average concentration of 0.616 and 0.846 mg/kg are 0.157 and 0.100 mg/kg, respectively. In the case of

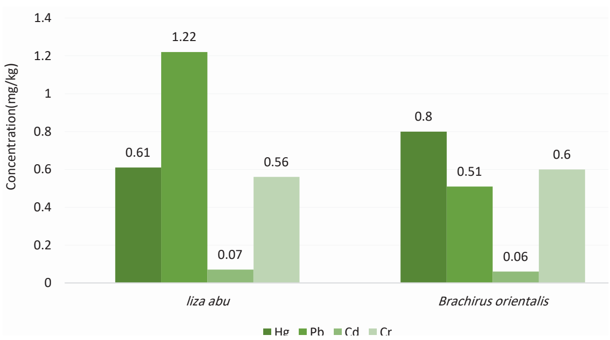

Figure 1. Mean concentrations of heavy metals in the studied fish.

Table 3. International standards related to the heavy metal concentrations in the fishes

International standards (mg/kg)	Hg	Pb	Cd	Cr
WHO	0.5 (34)	0.5 (36)	0.2 (35)	0.2 (34)
FDA	0.5 (37)	5 (37)	1 (37)	0.9 (37)
NHMRC	1 (37)	1.5 (35)	0.05 (35)	10 (35)
UKMAFF	0.5 (39)	2 (38)	0.02 (38)	20 (35)
FAO	0.5 (37)	0.5 (41)	0.5 (41)	0.1 (40)

Abbreviations: WHO, World Health Organization; FDA, Food and Drug Administration; NHMRC, Nation Health and Medical Research Council; UKMAFF, UK Ministry of Agriculture, Fisheries and Food; FAO, Food and Agriculture Organization (FAO).

Table 4. Estimated daily intake of heavy metals

Fish	Hg	Pb	Cd	Cr
Liza abu	0.00008	0.00017	0.00001	0.00008
Brachirus orientalis	0.0001206	0.000074	0.000009	0.000084

Table 5. Daily consumption rate of the studied fish

Fish	Hg	Pb	Cd	Cr
Liza abu	0.157	5.193	5.314	2.329
Brachirus orientalis	0.100	8.895	7.578	2.592

Table 6. THQ and HI values of heavy metals in the studied fishes

Fish	THQ				HI
	Hg	Pb	Cd	Cr	
Liza abu	0.176	0.044	0.016	0.027	0.025
Brachirus orientalis	0.266	0.018	0.009	0.043	0.336

Table 7. Carcinogenic risk values of heavy metals in the studied fishes in Mahshahr

Fish	Pb	Cd	Cr
Liza abu	0.14×10^{-6}	0.38×10^{-6}	0.4×10^{-5}
Brachirus orientalis	0.62×10^{-7}	0.34×10^{-6}	0.42×10^{-5}

Pb, the amount of concentration that enters the human body through the consumption of *Liza abu* and *Brachirus orientalis* fish, is about 0.00017 and 0.000074 mg/kg/day for an adult weighing 70 kg. Also, the rate of risk index of *Liza abu* and *Brachirus orientalis* fish consumption in adults was 0.044 and 0.18, respectively. According to the maximum daily consumption of fish and considering the average weight of 70 kg for the consumer, the permissible consumption of *Liza abu* and *Brachirus orientalis* fish with an average concentration of 1.227 and 0.516 mg/kg, respectively, is 5.193 and 8.895 mg/kg/day, respectively. The amount of cadmium that enters the human body through the consumption of *Liza abu* and *Brachirus orientalis* is about 0.00001 and 0.000009 mg/kg/day for an adult weighing 70 kg. Also, the risk index of *Liza abu* and *Brachirus orientalis* fish consumption in adults was 0.016 and 0.009. According to the maximum daily consumption of fish and considering the average weight of 70 kg for the consumer, the permissible limit for consumption of *Liza abu* and *Brachirus orientalis* fish with an average concentration of 0.076 and 0.061 mg/kg are 5.314 and 7.578 mg/kg/day, respectively. Also, in the case of Cr, which enters the human body through the consumption of *Liza abu* and *Brachirus orientalis*, it is about 0.00008 and 0.000084 mg/kg/day for an adult weighing 70 kg. Also, the risk index of *Liza abu* and *Brachirus orientalis* fish consumption in adults was 0.027 and 0.043, respectively. According to the maximum daily consumption of fish and considering the average weight of 70 kg for the consumer, the permissible consumption of *Liza abu* and *Brachirus orientalis* fish with an average concentration of 0.567 and 0.586 mg/kg are 2.329 and 2.592 mg/kg/day, respectively.

The calculated THQ for the metals Pb, Cd, and Cr in the two species of *Liza abu and Brachirus orientalis* was lower than 1, meaning that the risk of non-cancerous diseases in people consuming this type of fish is low (Table 6).

CR due to consumption of *Liza abu* and *Brachirus orientalis* followed the sequence: Cr > Pb > Cd.

Pb, Cd, and Cr are carcinogenic metals, hence, carcinogenic risk was calculated for these metals. In all samples analyzed, Cr was slightly above the permissible limit of 10^{-6} to 10^{-4}, other metals were in this range (Table 7).

Discussion

The average concentrations of Hg, Pb, Cd, and Cr in *Brachirus orientalis* were 0.846, 0.516, 0.061, and 0.586 mg/kg, respectively, and in whitefish *Liza abu*, were 0.616, 1.227, 0.076, 0.567, respectively. The obtained values related to the concentration of heavy metals in *Brachirus orientalis* are Hg > Cr > Pb > Cd and in *Liza abu* fish are Pb > Hg > Cr > Cd. The amount of Hg in the muscle of fish *Brachirus orientalis* was higher than other heavy metals, its higher concentration compared to the other metals is due to the entry of industrial effluents into the waters of Khormousi and the Persian Gulf. The amount of Pb in whitefish *Liza abu* was higher than other heavy metals. In both fish studied, Cd had the lowest concentration. The low Cd contamination in the studied samples is probably due to their ability to regulate the amount of Cd. Lead and cadmium are toxic elements that have no metabolic function and are harmful to human health at low levels. Exposure to these contaminants through water and food can cause chronic and sometimes acute poisoning (42). According to the results of the study, the average concentration of Hg in both fish is lower than the NHMRC standard, but is slightly higher than the WHO, FAO, FDA, and UKMAFF standards. Cheraghi et al, in their study conducted in Karun River found that the average concentration of Hg in the muscle of *Liza abu* was below the standard limit set by reputable international organizations such as the FAO, WHO, and FDA, which is not consistent with the results of the present study (43). The reason for the discrepancy between the results of mercury in *Liza abu* in different studies is the physical and chemical conditions of the water, the ecological and biological characteristics of this fish, and the method of measuring heavy metals concentration (44). The results of the study of Ahmadi Kordestani et al, on the muscle of white shrimp (*Litopenaeus vannamei*), white shrimp (*Fenneropenaeus indicus*), black halva (*Parastromateus niger*), and the long crab astacus (*Leptodactylus*) are consistent with the results of the present research (45). The average concentration of Cd in *Liza abu* was 0.07 mg/kg and in *Brachirus orientalis* fish was 0.06 mg/kg dry weight, which was below the WHO, FAO, FDA standards, and slightly higher than the UKMAFF standards, which is consistent with the results of a study by Isa Solgi et al, on the common carp (*Cyprinus carpio*) in Zarivar Wetland (46). Also, Salemi et al, in a study in Mahshahr port observed that the concentration of Cd was 2.848 mg/dry weight, which is higher than the FAO, WHO, and FDA standards and is not consistent with the results of the present study, but like the present study, the concentration of Cd was higher than the UKMAFF standard (47). In a study by Pourang et al, in the northern Persian Gulf on *Psettodes erumei*, Cd levels were lower than the NHMRC standard and higher than the UKMAFF, which is consistent with the present study (48). Cr and Hg are toxic pollutants that are transmitted to human body through the food chain, so they deserve special attention. The average concentration of Cr in *Liza abu* was 0.56 mg/kg and in *Brachirus orientalis* was 0.58 mg/kg dry weight, which are higher than the WHO and FAO standards and lower than the UKMAFF and NHMRC standards. The FDA standard is in the lower range. The average concentration of Cr in common carp (*Cyprinus carpio*) in the study of Salemi et al in the coast of Dezful, was reported to be 0.02 mg/kg dry weight, which is lower than the international standards (the UKMAFF and NHMRC standards) compared to the present study. It complies with the FDA standards but does not comply with the FAO and WHO standards (49). In another study conducted by Salemi et al, in Mahshahr city on *Barbus grypus*, the average Cr concentration was higher than the WHO, FAO, and FDA standards (47). The average concentration of Pb in *Liza abu* was 1.2 mg/kg dry ozone and in *Brachirus orientalis* was 0.51 mg/kg/dry weight, which in both fish was lower than the UKMAFF, NHMRC, and FDA standards and higher than the WHO and FAO standards. In the study of Salgi et al, the concentration of Pb metal was lower than the international standards, which is consistent with the results of the present study, with the exception of the WHO and FAO (46). In a study conducted by Salemi et al, on common *Cyprinus carpio* fish on the shores of Dez on Dezful, the average concentration of Pb was 34.5 mg/kg, which was higher than the WHO, FAO, and FDA standards (49). In a study by Chakeri et al, on *Rastrelliger kanagurta*, the Pb content was 0.01 mg/kg, which were lower than the standards of WHO, MAFF, and NHMRC (50). One of the most important requirements in risk assessment guidelines is to pay attention to the risk assessment of contaminants in the final recipient, i.e., human. Differences in the concentration of heavy metals in different tissues of fish can be due to the variability of the ability of heavy metals to overcome metal bonds such as metallothionein. In adults, the health risk from food intake is often found in THQ-contaminated sea food. If the THQ is greater than 1, the at-risk population is likely to be affected by the harmful effects.

The results of the *Liza abu* fish showed the highest amount of THQ for Hg and the lowest one for Cd. In this study, none of the metals had a hazard threshold greater than 1, so it can be concluded that exposure to these metals will not lead to non-carcinogenic effects in humans.

HI for all four metals (Hg, Cd, Pb, and Cr) was lower than 1, so the consumption of *Liza abu* and *Brachirus orientalis* fish will not pose a serious risk to the consumer in terms of heavy metals studied. The results of THQ and HI in the present study are consistent with the results of studies of Salemi et al in Mahshahr (47), Salemi et al on common carp in Dezful (49), and Ahmadi Kordestani et al (2013) (45).

Conclusion

Based on the results of the present study, the level of potential hazards and dangers caused by the studied metals in the muscle tissue of *Liza abu* and *Brachirus orientalis* fish was lower than 1.

Accordingly, the muscle consumption of the studied fish does not pose a threat to the consumer in terms of health and the possibility of developing non-cancerous diseases. It is suggested that laws and measures such as public education, equipping ports and coastal cities with sewage collection system, and treating municipal sewage and effluents can be implemented to prevent pollutants from entering water systems. Due to the importance of *Liza abu* and *Brachirus orientalis* fish in nutrition and their high consumption in the south of the country, it is suggested to study the health risk and contamination of other metals that were not studied in these fish and do more careful management to control pollutants.

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Ethical issues

The study protocols were approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences Ahvaz, Iran (Ethical code: IR.AJUMS.REC.1398.554).

Competing interests

The authors declare that they have no conflict of interests.

Authors' contributions

All authors contributed and were involved in the problem suggestion, experiments design, data collection, and manuscript approval.

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