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Original Article

Food Risk of some heavy metals for adults and children via consumption of fish species: *Euryglossa orientalis*, *Argyrops spinifer* and *Sillago sihama*

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Abstract: This study aimed to investigate the concentration of some heavy metals in three fish species with high consumption in Shif Island, Bushehr Province, and calculation of the estimated daily intake (EDI), estimated weekly intake (EWI), Target Hazard Quotients (THQ) and hazarded index (HI). Three species *viz. Euryglossaorientalis, Argyrops spinifer,* and *Sillago sihama* were collected from the Bushehr coastal water using fishing boat. After the transfer of samples to the laboratory, the heavy metals were extracted and analyzed using Atomic Absorption Spectrophotometer (AAS). Based on the results, the average concentrations of Fe, Zn, Cu, Mn and Ni in *E. orientalis* were 10.02, 8.33, 1.18, 0.80, and 0.86 mg/kg, in *A. spinifer* 7.25, 5.75, 0.74, 0.43, and 0.37 mg/kg, and in *S. sihama* 6.20 , 8.27, 0.60, 0.47, and 1.28 mg/kg, respectively. Daily and weekly intake values in all three studied species in the group of children were higher than the adult group. The highest and lowest daily and weekly intake rates were observed for Fe in the *E. orientalis* and Cu in *A. spinifer*. The Target hazard quotient (THQ) and Hazard index (HI) for both adults and children showed less than 1. Also, the comparison of metal concentrations showed that the concentration of Mn in all three species and Ni in *E. orientalis* and *S. sihama* were higher than the WHO standard.

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Introduction

Heavy metals are dangerous pollutants in our natural environment due to their toxicity. When organisms are exposed to high metal levels in an aquatic environment, they can absorb the available metals directly from the environment, contaminated water and food, and thus, accumulate them in their tissues. Further they can enter the food chain and extend the problem to humans (Jovanović et al., 2017). Fish is an important part of the human diet and therefore in many studies, the contamination of various tissues of fish by metals has been investigated (Baramaki et al., 2012).

In different regions of the Persian Gulf, oil pollution, along with other urban, agricultural and industrial pollution has degraded this valuable ecosystem and their resources such aquatic species are at risk of contamination (Pourrang et al., 2005). Bushehr area has particular economic importance due to having about 800 oil platforms and traffic about 25000 oil tankers each year (Hosseini et al., 2014).

Humans are exposed to heavy metals through various pathways, primarily via the food chain. Metals such as iron, zinc, and copper are essential to the human body. These elements are cofactor of many enzymes and the human body needs a specific concentration of these elements (Iron 8-18 mg/day, copper 0.9 mg/day, zinc 8-11 mg/day and nickel 0.5 mg/day). However, outside of this range, the effects of deficiency and toxicity may be observed (Singh et al., 2006; FAO, 1963).

Risk assessment is a process that probability and magnitude of damage, loss, or damage from a hazard and potential health hazard are estimated (Yeganeh, 2012). The general objective of risk assessment is to pay attention to the status of soil, air, water or sediment contamination, investigation of all possible exposure ways of the studied organisms to contamination, estimating the amount of pollutants in body organisms and determination the adverse effects (Mansouri et al., 2012). The risks of heavy metals are mainly divided into carcinogenic and non-carcinogenic effects. In an assessment of the non-

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carcinogenic effects of heavy metals, a function called risk ratio (THQ, Target Hazard Quotient) is used. THQ is a ratio of a concentration of heavy metal content in the tissue to its RfD. The oral reference dose (RFD) is the daily exposure of persons to pollutants or toxins that can pose no appreciable risk during their lifetime. The unit of RfD is usually mg/kg body weight/day. The THQ values below 1 show that there is no non-carcinogenic health risk to the consumer. Albeit, if the frequency and extent of exposure to contamination are increased, the probability of adverse effects will be increased (Yeganeh, 2012).

With increasing population and subsequently increase in per capita fish consumption, human exposure to heavy metals has increased due to fish consumption. Therefore, determination of the concentration of these metals and providing a suitable strategy for consuming food containing these pollutants, is important (Zazouli et al., 2013; Guang et al., 2015). Many studies have been carried out on the risk assessment of heavy metals (Zheng et al., 2007; Kalani and Riazi, 2014; WHO, 1985). Sewage and oil spill from tankers are the sources of pollution in the coastal area and fish caught from these waters polluted with heavy metals. Therefore, this research was conducted to determine the risks of heavy metals for humans associated with fish consumption in three fish species, including *Euryglossaorientalis, Argyrops spinifer,* and *Sillago sihama*

Materials and Methods

Study area: Shif Island is one of the small islands in the Bushehr Province. It locates 12 km northwest of the Bushehr city and 6 Km north of the Bushehr Port (29°4′12"N, 50°53′25"E).

Sampling: A total of 30 fishes (10 specimens of each species) of *E. orientalis, A. spinifer* and *S. sihama* were collected. Fishes after collection were stored in ice and transported to the laboratory. Then, they were washed with deionized water to remove external contamination. After the biometric characteristics (weight, length, and sex) were recorded, the muscle samples of fish species were separated. Each sample was dried at 105°C until to reach a constant weight.

Chemical analysis: Two grams of each muscle sample was digested with nitric acid and perchloric acid (4:1) at 40°C for 1 hour and 140°C for 3 hours (Yap et al., 2006). The digested samples were filtered with Whatman filter paper No. 42 and then diluted to 25 ml with deionized distilled water and analyzed for heavy metals using the Atomic Absorption Spectrophotometer (AAS). For the heavy metals standard solutions, the calibration curves fit was R^2 = 0.9925-0.9976, that showed the extreme linearity.

Estimated daily intake and estimated weekly intake of heavy metals: Estimated Daily Intake (EDI) of studied heavy metals from the consumption of the three species was calculated according to following formula:

$$EDI = (Cm \times IR) / BW$$

Where estimated daily intake (EDI) (mg/kg-day) is the EDI of heavy metal, C (mg/kg) is the mean concentration of heavy metal, IR (g/day) is the amount of fish consumption which is taken as 20 g/day based on Banagar et al. (2015), and BW (kg) is the body weight of the consumer (70 kg for Adult). The estimated weekly intake was calculated by multiplying the daily intake of the heavy metal in the number of days of the week according to the following formula:

$$EWI = EDI \times \text{Number of days of the week}$$

PTDI= Provisional Tolerable Daily Intake

PTWI= Provisional Tolerable Weekly Intake

Target Hazard Quotient: THQ (Target Hazard Quotient) is the ratio between exposure and reference oral dose (RfDing) and it is usually applied to show the risk of non-carcinogenic effects, which are calculated based on the following formula:

$$THQ = EF \times ED \times IR \times C / RFD \times BW \times AT$$

Where THQ is target hazard quotient, EF = Frequency of exposure (365 days per year), ED = total exposure time (60 years), RFD = Reference dose (mg/kg/day) and AT = Average Days (EF × ED).

Hazard index (HI): Hazard index (HI) was calculated by summing all the calculated THQ values of heavy metals in fish for each species.

Table 1. Concentration of Fe, Zn, Cu, Mn and Ni (µg/g/ww) in muscle tissue of *Euryglossa orientalis*, *Argyrops spinifer* and *Sillago sihama* in the Shif Island.

Muscle	Mn	Zn	Fe	Mn	Ni
Euryglossa orientalis	1.18	8.33	10.02	0.80	0.86
Argyrops spinifer	0.74	5.75	7.25	0.43	0.37
Sillago sihama	0.60	8.27	6.20	0.47	1.28

Table 2. Estimated daily intake (mg/ kg /day) of heavy metals (Fe, Zn, Cu, Mn and Ni) for muscle tissue of *Euryglossa orientalis*, *Argyrops spinifer* and *Sillago sihama* consumed by adults and children and the Provisional Tolerable Daily Intake (EPA, 2005).

		EDI				
	Fish species	Cu	Fe	Zn	Mn	Ni
adults	*Euryglossa orientalis*	0.28	3.57	2.97	0.42	0.30
	Argyrops spinifer	0.15	2.58	0.26	2.05	0.16
	Sillago sihama	0.16	2.21	2.95	0.21	0.45
children	*Euryglossa orientalis*	1.10	13.82	11.48	1.62	1.18
	Argyrops spinifer	0.20	3.55	0.35	2.82	0.22
	Sillago sihama	0.64	8.55	11.40	0.82	1.76
	PTDI	40	500	300	140	-

Table 3. Estimated weekly intake of heavy metals (Fe, Zn, Cu, Mn and Ni) in muscle tissue of *Euryglossa orientalis*, *Argyrops spinifer* and *Sillago sihama* (adults and children) (mg/kg/week) and the Provisional Tolerable Weekly Intake (EPA, 2005).

		EWI				
	Fish species	Cu	Fe	Zn	Mn	**Ni**
adults	*Euryglossa orientalis*	1.96	24.99	20.79	2.94	2.10
	Argyrops spinifer	1.05	18.06	1.82	14.35	1.12
	Sillago sihama	1.12	15.47	20.65	1.47	3.15
children	*Euryglossa orientalis*	7.7	96.74	80.36	11.34	8.26
	Argyrops spinifer	1.4	24.85	2.45	19.74	1.54
	Sillago sihama	4.48	59.58	79.80	5.74	12.32
	PTDI	280	3500	2100	980	-

$$HI= \sum THQ = THQcu + THQfe + THQzn + THQmn + THQni$$

Statistical analyses: The data were statistically analysed with SPSS version 22 statistical package programs. The Shapiro-Wilk test was used to analyze the normality of data distribution.

Results

The heavy metals concentration in fishes is shown in Table 1. The highest and lowest concentrations of metals in *E. orientalis*, *A. spinifer* and *S. sihama* were Fe-Mn, Fe-Ni and Zn- Mn, respectively.

The estimated daily intake values for both adults and children are presented in Table 2. According to the results of daily intake values, in the adult group for Cu and Zn, the ascending line was *A. spinifer* < *S. sihama* < *E. orientalis*, for Fe *S. sihama* < *A. spinifer* < *E. orientalis*, for Mn *S. sihama* < *E. orientalis* < *A. spinifer* and for Ni *A. spinifer* < *E. orientalis* < *S. sihama*, and for children group, the corresponding values for Fe, Cu, Zn and Ni were as follows *A. spinifer* < *S. sihama* < *E. orientalis* and for Mn *S. sihama* < *E. orientalis* < *A. spinifer*.

Estimated weekly intake for both adults and children are shown in Table 3. The highest amount of weekly intake in adults (24.99) and children (96.74) was found for Fe in the *E. orientalis*. Also, the lowest weekly intake values of Cu in both adults and children were 1.05 and 1.4 in *A. spinifer*, respectively.

The values of THQ and HI (Fe, Zn, Cu, Mn and Ni) for three studied fish species are given in Table 4. According to the results, the highest and lowest risk indices are for *S. sihama* and *A. spinifer*. The Target Hazard Quotient and Hazard Index for all metals were lower than 1. Therefore there was no a potential health risk for adults and children via the consumption of

Table 4. Target hazard quotient (THQ) and hazard index (HI) values of heavy metals through fish consumption in the Shif Island.

		THQ					HI
	Fish species	Cu	Fe	Zn	Mn	**Ni**	
adults	*Euryglossa orientalis*	0.039	0.005	0.009	0.003	0.015	0.039
	Argyrops spinifer	0.026	0.003	0.0008	0.014	0.006	0.026
	Sillago sihama	0.039	0.003	0.009	0.001	0.022	0.039
children	*Euryglossa orientalis*	0.151	0.019	0.036	0.011	0.058	0.151
	Argyrops spinifer	0.099	0.014	0.026	0.007	0.025	0.099
	Sillago sihama	0.159	0.012	0.038	0.005	0.088	0.159

Table 5. Comparison of Fe, Cu, Zn, Mn and Ni concentrations in the muscle tissue of *Euryglossa orientalis*, *Argyrops spinifer* and *Sillago sihama* with global standards (µg/g/ww).

	Ni	**Mn**	**Zn**	**Fe**	**Cu**	Reference
WHO	0.6	0.5	75	100	3	(WHO, 1985)
MAFF	-	-	50	-	30	(MAFF, 1995)
FAO	-	-	40	100	30	(FAO, 1963)
NHMRC	-	-	150	-	10	(Maher, 1986)
Euryglossa orientalis	0.86	1.18	8.33	10.02	0.80	Present Study
Argyrops spinifer	0.37	0.74	5.75	7.25	0.43	Present Study
Sillago sihama	1.28	0.60	8.27	6.20	0.47	Present Study

these species.

Discussion

As fish is an important part of the human diet, it is often deemed as the most suitable object among the bioindicators of an aquatic ecosystem. In recent years, fish consumption has increased significantly. Similarly, the concentration of heavy metals has increased in fishes (Ullah et al., 2017).

In this study, the highest concentrations of Zn, Cu, Fe and Mn in fish were observed in *E. orientalis*. Concerning the *E. orientalis* is benthic fish species that feed on sediments and benthic invertebrates tend to accumulate the highest concentrations of heavy metals in comparison to other species. In the case of Ni, the highest concentrations were found in *S. sihama* and the lowest in *A. spinifer*. Henry et al. (2004) investigated heavy metals in four fish species from the French coast, and concluded that the *E. orientalis* had the highest levels of cadmium, copper and lead in agreement with our findings. Differences in the heavy metal concentrations are observed among the fish species depend on feeding habits, age, size, and length of fish, and habitat.

Considering the per capita fish consumption in the south of the country (20 gr/day) and the mean weight of adults and children (70 and 14.5 kg, respectively), the highest daily and weekly intake in adult group for Fe, Zn and Cu were observed in the *E. orientalis*, while for Mn in *A. spinifer* and Ni in *S. sihama*. For the children group, the highest daily and weekly intake for Fe, Zn and Cu were found in *E. orientalis*, for Mn in *A. spinifer* fish and Ni in *S. sihama*. Generally, the daily and weekly intake rates of the studied metals in children were higher than adults, except for Mn in *A. spinifer* and Ni in all species, which adults were a higher than children. The results are in agreement with Shahri et al. (2017) findings that studied Ni, Pb, Cd and Zn in the muscle of four fish species of in the Chabahar region with highest daily intake of metals in children than adults.

The risk of heavy metals due to the consumption of marine products is often calculated by THQ. THQ is based on the ratio of the metals in the food stuff to the reference amount (RFD) of those metals. If the amount is less than 1, it indicates a lack of food risk and vice versa, if more than 1, represents a risk of food intake (Bajgiran et al., 2015). The THQ of Fe, Cu, Zn, and Mn for the adults and children were less than 1 value. Also, the THQ for all of the metals, except Mn in *A. spinifer* and Ni in three other species, was higher for children compared with adults. In the study of

Wang (2005) that health risk of heavy metals through the consumption of vegetables and fish in Tianjin, China was assessed, the THQ in children was 1.5 to 3.5 times higher than the adults. Also, the hazard index (HI) of these metals was less than 1, indicating no health risk from the intake of these species for the consumer. Karimi et al. (2014) examined the concentrations of chromium, nickel, zinc, and copper in the muscle and skin tissues of two edible fish species of *Alosa Caspica* and *Clupeonella cultiventris caspia* in the southern Caspian Sea and indicating consumption of these fish species with a current rate of contamination is not a risk for consumers. Ullah et al. (2017) studied heavy metals in 8 species of fish and the implications for human consumption in Bangladesh. According to the results, the consumption of 140 gr/ week for the adult is not prohibited. In this study, to assess the risk of heavy metal accumulation, these values were compared with the standards in this field. The results showed that the concentrations of heavy metals of Cu, Fe and Zn were lower than global values, but the concentration of Mn in each of the 3 species, as well as the concentration of Ni metal in *E. orientalis* and *S. sihama*, was higher than the WHO standard.

Considering that the fish species studied are in high-consumption in Shif and Bushehr, the concentration of metals such as Mn and Ni in these species is higher than WHO standard, it is necessary to manage the exposure of this metals around Shif Island and manage its input sewage.

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چکیده فارسی

ریسک غذایی برخی فلزات سنگین در گروه کودکان و بزرگسالان مصرف کننده ماهی کفشک، شانک و شورت

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چکیده:
این تحقیق با هدف بررسی غلظت برخی عناصر سنگین در ۳ گونه از ماهیان پرمصرف در جزیره شیف (استان بوشهر) و تخمین جذب روزانه (EDI)، جذب هفتگی (EWI) و برآورد پتانسیل خطر (THQ) و شاخص خطر (HI) انجام شد. در این پژوهش سه گونه کفشک، شانک، شورت از آب‌های ساحلی استان بوشهر با استفاده از قایق صیادی نمونه‌برداری شد. پس از انتقال نمونه‌ها به آزمایشگاه عناصر سنگین مربوطه استخراج شده و با استفاده از دستگاه جذب اتمی (شعله) Analytik Jena مدل Contraa700 اندازه‌گیری شد. با توجه به نتایج میانگین غلظت فلزات آهن، روی، مس، منگنز و نیکل به‌ترتیب در گونه‌ی کفشک (۱۰/۰۲، ۸/۳۳، ۱/۱۸، ۰/۸۰ و ۰/۸۶)، شانک (۷/۲۵، ۵/۷۵، ۰/۷۴، ۰/۴۳ و ۰/۳۷) و شورت (۶/۲۰، ۸/۲۷، ۰/۶۰، ۰/۴۷ و ۱/۲۸) به‌دست آمد. مقادیر جذب روزانه و هفتگی در هر ۳ گونه ماهی در گروه کودکان بالاتر از گروه بزرگسالان بود. بیشترین و کمترین مقادیر جذب روزانه و هفتگی به‌ترتیب مربوط به فلز آهن در گونه‌ی کفشک و فلز مس در گونه ی شانک مشاهده شد. تخمین پتانسیل خطر و شاخص خطر برای دو گروه بزرگسالان و کودکان نشان داد که در هر ۳ گونه مقادیر پتانسیل خطر و شاخص خطر کمتر از ۱ بود. همچنین مقایسه غلظت فلزات با استانداردهای جهانی نشان داد که غلظت فلز منگنز در هر ۳ گونه و غلظت فلز نیکل در گونه‌های کفشک و شورت بالاتر از استاندارد WHO است اما در سایر عناصر مقادیر پایین تر از استانداردهای جهانی به‌دست آمد.

کلمات کلیدی: خلیج فارس، جزیره شیف، فلزات سنگین، ارزیابی خطر.