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RESEARCH PAPER

Human Health Risk Assessment via the Consumption of *platycephalus indicus* in the Persian Gulf, Iran

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Abstract
The present paper assesses human health risk associated with accumulation of lead, copper, zinc, nickel, and Arsenic in the muscle of bartail flathead (*Platycephalus indicus*) collected from Jofreh Pier and Bushehr Port, northwest of the Persian Gulf of Iran. It collects eighty *P. indicus* in total, analyzing them via ICP-OES of two seasons (summer and winter) of 2019. Thus, it manages to estimate daily intake (EDI), estimated weekly intake (EWI), target hazard quotient (THQ), hazard index (HI), and Carcinogenic risk (CR). The mean concentration (µg/g) range are observed as follows: zinc (16.37-50.17)> As (5.65-8.83)> Cu (2.19-3.63)> Pb (0.62-6.37)> Ni (0.17-1.08). Hazard index (HI) for adult and children during consumption of *P.indicus* has been below 1, with the highest HI values calculated for adults (0.06) in Bushehr and children (0.14) in Jofreh. The CR levels for Ni and Pb have been within acceptable limits (10^{-6} to 10^{-4}), while arsenic has stood at unacceptable levels (> 10^{-4}) in the sampling sites.

Keywords: *platycephalus indicus*, Heavy metals, Hazard index, Persian Gulf

INTRODUCTION

In recent decades, seawater pollution with a wide range of environmental pollutants has become one of the most fundamental problems in the world. Aquatic ecosystems are widely exposed to heavy metal contamination from industrial and human activities (Kamaruzzaman et al., 2011, Tokatli and Ustaoğlu, 2020). The Persian Gulf is one of the largest bays in the world, which has special importance as the habitat of many aquatic organisms. Total capture fisheries was estimated at 773.198 tons in 2018, in which 731.161 tons belong to the southern waters of Iran. About 60.600 tons of southern waters catch was related to Bushehr province in the Persian Gulf (IFOSY, 2018).

In the last decades, fish global consumption has grown simultaneously with the increasing concern of their nutritional value and health benefits (El- Moselhy et al., 2014). Fishes are generally located at top of the aquatic food chain, and heavy metals in water, sediments and food can accumulate in fish tissues (Zhao et al., 2012). Therefore, the accumulation of heavy metals in fish tissues can counteract their valuable effects; several harmful effects of heavy metals on human have been recognized for many years (Castro-Gonzalez and Mendez-Armenta, 2008). Thus, many researches and monitoring programs have been implemented to evaluate of the fish quality for human consumption and control of the aquatic ecosystem health (Meche et al., 2010, Tepe, 2009,). According to available statistics, aquatic consumption in Iran has increased from 1 kg in 1978 to 12.2 kg in 2018 (IFOSY, 2018). Therefore, the possibility of human exposure to harmful chemicals such as heavy metals through the consumption of seafood is inevitable.

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Over the past few decades, the growing trend of various activities in the coasts of Bushehr region, northeast of the Persian Gulf, has caused these coasts to be exposed to various pollutions. One of the most important sources of coastal pollution is petrochemical plants which are directly and indirectly exposed to organic and inorganic pollutants. Also, these coasts are considered as heavy metal contaminated areas in the Persian Gulf due to various human activities such as maritime transport, aquaculture farms and municipal sewage. Many previous studies have pointed to the contamination of heavy metals in aquatic organisms in the Persian Gulf, including various species of fish and shrimp (Adel et al., 2016, keshavarzi et al., 2018).

Currently, different species of fish are used as biological indicators to assess the level of heavy metal pollution in aquatic ecosystems. Fish is one of the most important aquatic species used to assess the quality of the environment in aquatic ecosystems due to its unique characteristics such as its abundance and suitable extent, and its large location in the food chain. Among the indicator species for measuring the level of contamination, *Platycephalus indicus* can be investigated as one of the most valuable families and species in the Persian Gulf and the coasts of Bushehr, as well. *P.indicus* is an expensive fish in the northern provinces of the Persian Gulf due to its taste, marketability and its important role in the fishing economy, therefore this fish is a target species for fishing (Hashemi and Taghavi, 2013).

Heavy metals are stable pollutants and one of their lasting consequences is bio-magnification in the food chain. As a result of this process, their amount in the food chain can increase several times as much as water or air (Ali and Khan, 2019, Ustaoğlua and Islam, 2020). Studies have shown that these heavy metals accumulate in various organs of the body and eventually cause insufficiency and danger to the human body (Mehmood et al., 2019; Jaishankar et al., 2014; Mutlu et al., 2012). Among heavy metals, cadmium, lead, arsenic, zinc, and nickel are of special importance due to their long half-lives in humans and other animals and their high toxicity (Jaishankar et al., 2014, Yüksel et al., 2021, Ustaoğlua et al., 2020). Because of the carcinogenic and neurotoxic effects of heavy metals, even in very small quantities, special attention has been paid to this issue worldwide (Sankhla et al., 2017). In recent years, new analytical methods for measuring and analyzing metal content (even at ppb levels) have been able to search for disorders related to the consumption of heavy metals and then examine the carcinogenic effects on various organs (El- Moselhy et al., 2014). Furthermore, the Carcinogenic risk (CR) is used today to assess the effects of carcinogenesis (Gholizadeh et al., 2021). Several methods are used such as Estimated Daily Intake (EDI), Estimated Weekly Intake (EWI), and Target Hazard Quotient (THQ) to study the non-carcinogenic effects of these metals. This study aimed to investigate the contamination of *P.indicus* in the coastal area of Bushehr province with heavy metals (lead, nickel, zinc, copper, and arsenic) and to evaluate their potential carcinogenic and non-carcinogenic risk to consumers.

MATERIALS AND METHODS

The study areas were Jofreh pier (50 ° 49′ 20″ E, 28° 58′ 23″ N) and Bushehr port (50° 48′ 22″ E, 28° 55′ 8″ N) in Bushehr province located in the northwest of the Persian Gulf. Sampling sites were extremely important in the oil, gas, and petrochemical sector in the Iran, the region, and the world (Fig.1). Bushehr port is important due to factors such as environmental pollution and industrial activities. Jafreh pier is one of the best recreational and sightseeing options on the beaches of Bushehr. It is also known as one of the important fishing and hunting areas.

The sampling of *P. indicus* was performed in two sites and two seasons (summer and winter) of 2019 to measure the accumulation of heavy metals (lead, nickel, zinc, copper, and arsenic) in muscle. Fish samples were caught mainly by trawls and fishing weirs (20 samples were randomly collected from each site in each season). Immediately after sampling, samples were washed with clean water, wrapped in plastic bags, and transported to the laboratory in an icebox and kept

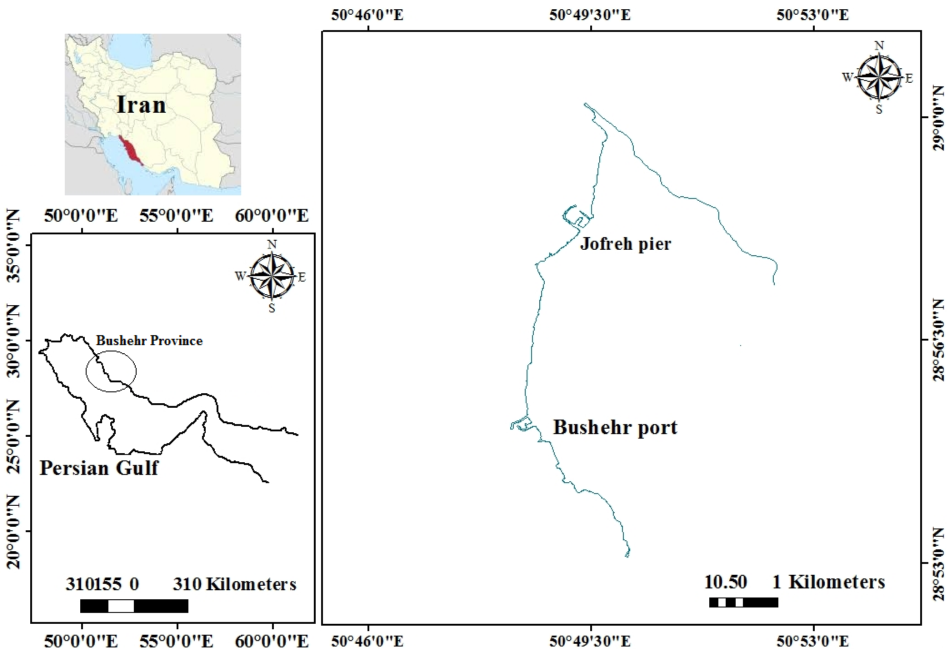

Fig 1. Map showing study area and sampling sites.

in the laboratory at -20 °C and were frozen until laboratory operations (Ruangsomboom and Wongrat, 2006).

The samples were washed with urban and distilled water. The total length was measured to the nearest 0.1cm. The weight was taken by digital scale with accuracy of 0.01 g. After biometry, the muscle was isolated and washed with distilled water and dried in an oven at 60 °C for 48 hours. 3 grams of the weighed muscle powdered and placed in a 50 ml Erlenmeyer flask. 4 mg of Nitric acid (65% Merck) was added to the sample and the samples were placed under the hood at room temperature for at least 1 hour for initial digestion. Then 1.5 ml of perchloric acid (70% Merck) was added to the samples. The samples were then placed on a hot plate at 140 ° C for 6 h to complete digestion (Gholizadeh and Patimar, 2018). After digestion, the samples were placed in ambient air to cool. Finally, the samples were made to 25 ml using deionized water, and then solutions were filtered through Whatman No.42 filter paper (Yap et al., 2002). The samples were then stored in a polyethylene container with a lid in a cold refrigerator at 4 °C until analysis. The metal concentrations were determined using an ICP-OES (Optima 2100 DV, Perkin Elmer Inc., Shelton, CT, USA).

To avoid pollution by environment, nitrile gloves and a cotton laboratory coat were worn during all the steps of the analytical procedures. All work surfaces were cleaned with ethanol 70% (Alcohol Pars Co, Iran) before and during the steps to prevent airborne plastics and cross contamination. All experimental equipment were washed with tap water and rinsed with pure distilled water prior to working. The samples were immediately covered with clean white sheets of paper in all the steps. Also, during all the phases, clean devices were used to gather and store the samples. For more assurance, in each batch, a control glass petri dish with deionized filtered water was left in the clean cabinet of the laboratory in which all steps were done to capture any possible airborne pollution they were then checked for possible plastic pollution.

The consumption of foodstuffs along with heavy metals can be estimated human health hazards (Traina et al., 2019). Therefore, EDI is evaluated, it depends on daily consumption of food and heavy metal concentration in foods (Batista et al., 2012). EWI was calculated by multiplying the EDI by 7. EDI and EWI were measured by the following equation (Yabanli et al., 2016):

EDI= $\left(C \times FIR_D\right) / BW$

EWI= $\left(C \times FIR_W\right) / BW$

EDI is the daily intake of metals by the body through the consumption of fish (μg/kg body weight/day), EWI is the weekly absorption of metals by the body through the consumption of fish (μg/kg body weight/week), C is concentration of metals in muscle tissue of consumed fish (μg/g in terms of wet weight) and FIR_D is the amount of fish consumed in the studied areas in terms of grams per day and BW shows the bodyweight of the consumer (70 kg for adults and 15 kg for children) (ISIRI (Institute of Standards and Industrial Research of Iran), 2015).

Hazard Index (THQ) is the ratio between the exposure of metals and their reference dose, which is used to express non-toxic effects. According to USEPA (2019), the recommended level for THQ is 1. If the THQ is lower than 1, it indicates that it has no negative impact on human health during life. A THQ greater than 1 can indicate health side effects for consumers. In this relationship, EFr frequency of exposure (365 days /year), ED is the exposure duration (70 years), IR is the eating rate (31.92 g/person/day), C is the heavy metal concentration in the studied fish (mg/kg), RfD is the oral reference dose (mg/kg/day), Bw is the mean bodyweight of the consumer and AT is the exposure time for non-carcinogenic (365 days/year × number of exposure years is about 72 years. The RfD are 0.004, 0.02, 0.3, 0.04 and 0.0003 mg/kg/day for Pb, Ni, Zn, Cu, and As, respectively (USEPA, 2019)

THQ= $\dfrac{EFr \times EDtot \times IR \times C}{\left(RfD \times BWa \times ATN\right)} \times 10^{-3}$

In this study, the full potential for non-carcinogenic risk to humans was measured by summing the amounts of THQ in the metals. The total THQ was referred as the hazard index (HI). Total THQ was calculated based on the following equation:

HI= $\sum THQ = THQ(Pb) + THQ(Ni) + THQ(Zn) + THQ(Cu) + THQ(As)$

The daily consumption limit of fish, based on the carcinogenic effects of contaminants was calculated according to the following equation.

$CR_{lim} = \dfrac{\left(ARL \times W_{AB}\right)}{CSF \times C_m}$

Based on the non-carcinogenic effects of the contaminants, the maximum daily intake of fish was determined using the following equation:

$CR_{lim} = \dfrac{\left(RfD \times W_{AB}\right)}{C_m}$

Where CR_{lim} is the maximum daily intake of infected fish (kg/day), ARL indicates the maximum acceptable lifetime risk (used in the present study, 5-10 (Yu et al. 2014)), W_{AB} mean body weight Consumer (kg), CSF indicates cancer inclination factor. RfD is the reference dose (mg/kg/day), and C_m is the concentration of metal in the edible part of fish (mg/kg) (Alipour et al. 2015).

The Carcinogenic risk (CR) was obtained from the following equation. In this regard, EDI is the rate of daily intake of metals by the body and CSF is an oral cancer slope factor (mg/kg/day).

CR= $EDI \times CSF$

Moreover, a cancer risk index between 10^{-6} (risk of cancer during human life 1 in 1000000) and 10^{-4} (risk of cancer during human life 1 in 10000) indicates a distance from the potential risks predicted for the agents. It causes cancer. Therefore, chemicals with a risk factor of lower than 10^{-6} are not considered to be hazardous chemicals (Tepanosyan et al., 2017)

Statistical analysis of data obtained from measuring the concentrations of heavy metals lead, nickel, zinc, copper, and arsenic in the muscle of *P.indicus* was performed using SPSS software version 24. Excel version 2013 was used to draw graphs and tables. The Shapiro-Wilk test was used for data normalization. Differences of significant between the sampling sites and seasons were determined using independent-samples t-test with a significance level of $P< 0.05$. Linear regression and Pearson correlation tests were used to determine the existence of a linear relationship between the accumulation of heavy metals lead, nickel, zinc, copper, and arsenic in the muscle of *P. indicus* and biometric characteristics (total length and weight). The results were compared with international standards to assess the risk of accumulation of studied heavy metals in the muscle of *P. indicus*.

RESULTS AND DISCUSSION

The exploration, extraction, and transportation of petroleum products in the Persian Gulf caused an increase in the amounts of heavy metals such as lead and cadmium, which led to chemical pollution of the marine environment of the Persian Gulf and aquatic organisms (Filazi et al., 2003). In the present study, muscle was selected as the target organ due to its important role in human nutrition and the need to ensure its health for human consumption (Reyahi-khoram et al., 2016). The average concentrations of lead, nickel, zinc, copper, and arsenic in the muscle of *P. indicus* at different places and times were shown in Table 1. All results were presented based on wet weight. Mean concentration range of lead, nickel, zinc, copper, and arsenic in muscle were 0.62-6.37, 0.17-1.08, 16.37-50.17, 2.19-3.63 and 5.65-8.83 µg/g, respectively.

The highest concentration of heavy metals was observed in the muscle in Bushehr port. Among the sampling seasons, the highest concentration of metals was observed in the summer. There was a significant difference between the concentration of heavy metals in the sites and sampling seasons ($P<0.05$). Similar results were observed in the other conducted studies (Bahnasawy et al., 2011; Ibrahim and Omar, 2013). These seasonal changes may be due to fluctuations in

Table 1. Statistics Summary of mean metal concentrations (µg kg^{-1} ww) and biometrics of *P. indicus* (n=80)

Site	Bushehr		Jofreh		Recommended limits (ppm)
Metal	**Summer**	**Winter**	**Summer**	**Winter**	
Ni	0.7±0.11	0.54±0.2	0.52±0.2	0.44±0.13	0.38 (WHO 1985) 0.5 (FDA 1987)
Cu	3.02±0.71	2.88±0.8	2.92±0.41	2.78±0.73	30 (FAO/WHO 1983) 20 (MAFF 2000)
Zn	27.38±8.2	25.75±10.4	29.28±9.01	25.65±7.75	150 (FAO/WHO 1989) 50 (MAFF 2000)
As	7.49±2.35	7.16±2.16	7.39±1.91	7.02±2.72	1 (FAO/WHO 2019)
Pb	1.82±0.31	1.8±0.17	1.73±0.11	1.71±0.15	0.3 (FAO/WHO 2019) 2 (MAFF 2000)
Length (cm)	20.5±4.25	19.4±5.55	20.1±4.18	19.6±5.12	
Weight (g)	216.1±6.31	209.5±17.72	215.4±23.35	196.3±23. 5	

Table 2. Correlations among metals for length and weight of *P.indicus*

	Pb	Ni	Cu	Zn	As	length	weight
Pb	1						
Ni	0.73**	1					
Cu	0.19	0.23	1				
Zn	0.28	0.13	0.56**	1			
As	-0.35*	-0.47**	0.15	0.21	1		
length	0.66**	0.42*	0.24	0.16	0.14	1	
weight	0.7**	0.45*	0.25	0.43*	0.3	0.26	1

Table 3. Comparison of heavy metal levels (mg/kg ww) in the muscles of *P.indicus* from sampling sites with concentrations taken from the literature.

Study Site	Pb	Ni	Cu	Zn	As	Reference
Musa estuary Mahshahr harbor, Iran (Persian Gulf)	0.07-0.77		1.37-3.14		1.44-43.6	Keshavarzia et al. (2018)
Bushehr port, Iran (Persian Gulf)	0.56	2.7	13.12			Saadatmand et al. (2016)
Oman Sea, Iran	0.0041	0.081			0.001	Sadeghi et al. (2019)
Tanzania (Indian Ocean)	1.426	0.052	< D.L.			Mwakalapa et al. (2019)
Hangzhou Bay, China			0.21-0.69	4.26-7.36	0.04-0.5	Zhu et al. (2020)
Xiangshan Bay, China	ND-0.02	0.001-0.02	0.14-0.47	2.52-5.26	0.16-8.04	Liu et al. (2019)
Bangladesh Coast	0.07-0.63	0.1-0.6	1.3-14	31-138	0.8-13	Raknuzzaman et al. (2016)
Black Sea, Turkey	0.28-0.87	1.14-3.60	0.65-2.78	38.8-93.4	0.11-0.32	Tuzen (2009)
Jofreh and Bushehr ports, Iran (Persian Gulf)	2.29±0.61	0.51±0.36	9.74±3.6	24.96±9.24	7.66±1.19	This study

agricultural drainage, urban and industrial wastewater discharges to the coastal environment. The concentration of most heavy metals in the body of aquatic organisms was higher in summer both in unpolluted sites and in areas with human industrial activities (Mendil et al., 2010). The increased metal concentration in the fish tissues was observed in the summer due to the temperature increase which is related to the increase in metabolism (Aderinola et al., 2009).

The highest concentration was observed of Zn (29.28±9.01 μg/g) in summer in Jofreh pier, while the lowest concentration was related to Ni (0.44±0.13 μg/g) and Pb (1.71±0.15 μg/g) in winter. The trend of heavy metal concentrations in muscle samples was: Zn> As> Cu> Pb> Ni. The biometric results of *P.indicus* during sampling times were presented in Table 1. The length range of the sampled fish was measured between 17.9-21.5 cm in summer and 17.1-20.3 cm in winter. Weight range was observed between 161.1-228.4 g in summer and 156.7-225.6 g in winter. The non-significant difference was found in the length and weight of fish between the sites (t-test, $P < 0.05$). Accumulation of nickel, copper, arsenic, and lead was higher than the

Table 4. Estimated EDI, EWI, THQ, and HI of metals due to consumption of *P.indicus* from sampling sites.

Site	Metal	TDI*	EDI (µg/kg/day)		EWI(µg/kg/day)		THQ		HI	
			Adult	Children	Adult	Children	Adult	Children	Adult	Children
Jofreh	Pb	1.5[a]	0.3	1.4	2.1	9.78	0.0004	0.002	0.03	0.14
	Ni	12[b]	0.1	0.44	0.64	3.1	0.008	0.04		
	Zn	300[c]	9.38	43.78	65.76	306.48	0.013	0.06		
	Cu	500[c]	2.1	16.73	10.1	45.44	0.002	0.01		
	As	2.14[d]	3.3	15. 4	23.1	107.8	0.004	0.022		
Bushehr	Pb	1.5[a]	1.45	7.2	10.8	50.78	0.0022	0.01	0.06	0.3
	Ni	12[b]	0.33	1.54	2.31	10.77	0.03	0.14		
	Zn	300[c]	12.72	59.34	89.01	414.4	0.018	0.08		
	Cu	500[c]	6.47	30.21	45.32	211.5	0.009	0.04		
	As	2.14[d]	3.78	17.63	26.44	123.4	0.005	0.025		

*TDI: tolerable daily intake. [a] (EFSA, 2010), [b] (WHO, 2011), [c] (JECFA, 1982), [d] (JECFA, 1988)

Table 5. Compare average heavy metal concentrations in *P. indicus* (n=80) and maximum Permitted levels of metals in fish (mg/kg ww)

Site	Metal	RfD (mg/kg/day)	CR_{lim}		CSF	CR_{lim}		CR (mg/kg)	
			Adult	Children		Adult	Children	Adult	Children
Jofreh	Pb	0.004	0.12	0.02	0.0085	2×10^{-4}	1×10^{-4}	2.67×10^{-5}	12×10^{-5}
	Ni	0.02	2.15	0.46	1.7	2×10^{-5}	1.3×10^{-5}	1×10^{-4}	21×10^{-4}
	Zn	0.3	0.97	0.21					
	Cu	0.04	0.85	0.18					
	As	0.0003	0.002	0.0005	1.5	6.24×10^{-6}	1.34×10^{-6}	15×10^{-3}	67×10^{-3}
Bushehr	Pb	0.004	0.42	0.09	0.0085	15×10^{-4}	7×10^{-4}	7.64×10^{-5}	35×10^{-5}
	Ni	0.02	7.07	1.51	1.7	6×10^{-5}	4.4×10^{-5}	4×10^{-4}	71×10^{-4}
	Zn	0.3	0.99	0.22					
	Cu	0.04	0.88	0.19					
	As	0.0003	0.003	0.0006	1.5	5.66×10^{-6}	1.21×10^{-6}	17×10^{-3}	79×10^{-3}

international standards (WHO, 2011, MAFF, 2000; FAO/WHO, 2019). Therefore, human health risk assessment was performed to estimate the risk of these metals. Higher levels of heavy metals in compared to the studied international standards can be considered as a warning.

The Pearson correlation test was used to evaluate the adsorption of metals with weight and length and their relationship with each other (Table 2). There was a significant relationship between lead and nickel uptake in muscle and total weight and length of fish ($P<0.05$). In other words, the absorption of lead and nickel metals in muscle increased with increasing of weight and length. No significant relationship was observed between absorption of Cu and As in muscle and weight and length ($P>0.05$). Positive correlations were observed between Pb and Ni (0.73), and Zn and Cu ($P<0.05$). Arsenic showed a significant negative correlation with Pb and Ni ($P>0.05$).

The concentration of heavy elements revealed a significant positive correlation with total length and weight in the study sites ($P<0.05$). In other words, the total length and weight of the fish increased, the concentration of heavy elements in the muscle was higher. Comparing the results of the heavy metals concentrations of leads, nickel, zinc, copper, and arsenic in *P.indicus* at the present study with other reported values were observed in Table 3.

The reason for this difference were observed in various factors such as fish nutritional behavior, the distance of fish to the source of pollution, adjacent coastal industries and effluent disposal regulations, aquaculture activities and type of fish species (I-Hsun et al., 2005). Moreover, the entry of different amounts of urban, industrial and especially agricultural wastewater (due to production of wastewater contaminated with toxins and chemical fertilizers) were observed from the coast to the sea. On the other hand, heavy shipping traffic, refineries, industrial facilities and coastal urban cities were found in sampling sites of the Persian Gulf.

EDI, EWI, THQ, and HI of metals through *P.indicus* consumption for adults (70 kg) and children (15 kg) were shown in Table 4. The comparison of the EDI between the two sampling sites showed that the EDI in Bushehr port was higher than Jofreh pier. The highest EDI was related to Zn (adult: 12.72 and children: 59.34 μg/kg/day in Bushehr port) and the lowest was related to Ni (adult: 0.1 and children: 0.44 μg/kg/day in Jofreh pier). The results showed that the EDI level for Ni, Cu, Zn, and Pb in *P.indicus* was lower than the tolerable daily intake (TDI), which indicated the consumption of *P.indicus* had fewer health risks for people. The highest estimated EDI was observed for As at sampling sites. Due to the consumption of *P.indicus* for adults and children, the mean values of THQ were calculated for each element followed the downward trend of Zn> Ni> As> Cu> Pb. According to the THQ results, the values of the studied heavy metals in the sampling sites were lower than 1. THQ of lead, cadmium, copper, zinc, nickel was recorded as safe for most fish species in the Persian Gulf for human consumption (except arsenic and mercury) (Keshavarzi et al., 2018; Sadeghi et al., 2019). According to Table 4, HI values for lead, nickel, zinc, copper, and arsenic were lower than 1 at the sampling sites. The highest HI values were calculated for adults (0.06) in Bushehr and children (0.14) in Jofreh pier. Therefore, consumers do not experience health side effects with regular consumption of fish.

In the present study, the highest CR_{lim} in the Bushehr port was observed for adults based on nickel (7.07 kg.day) and the lowest amount in Jofreh pier was found for children based on arsenic (0.0005 kg.day) (Table 5). Among these heavy metals, Pb and Ni were classified as carcinogen. Therefore, CR values were calculated to understand the carcinogenic risk. The values of CR based on USEPA (2019) were as follows: negligible (less than 10^{-6}), acceptable (between 10^{-6}–10^{-4}) and unacceptable (above 10^{-4}) showed that CR levels for Ni and Pb were within ceptable limits (10^{-6} to 10^{-4}) at the study sites.

CONCLUSIONS

This research is the information on the study of human healthiness hazard due to heavy metals in *P. indicus* as commercial fish of two fishing ports of Bushehr province, Persian Gulf. The results showed a positive correlation between heavy metals in *P. indicus* and total weight and length. The highest HI values were calculated for adults (0.06) in Bushehr and children (0.14) in Jofreh pier. Therefore, consumers do not experience health side effects with regular consumption of fish. CR levels for arsenic were unceptable (above 10^{-4}) at both sites. Therefore, the risk of cancer due to long-term consumption of this fish is worrying.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

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