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Estimation of target hazard quotients for metals by consumption of fish in the North Coast of the Persian Gulf, Iran

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Original Article

Abstract

In the residential area of the North Coast of the Persian Gulf, consumption of fish is a possible source of exposure to heavy metals and other pollutants, all of which may act as potential risk factors for serious syndromes and fatal diseases. Health risks associated with Pb, Cd, and Hg were assessed based on the target hazard quotients (THQ), which can be derived from concentrations of heavy metals in fish consumed in Bandar Abbas and Bandar Lengeh, Iran. In the present study, 4 fish species (Euryglossa orientalis, Psettodes erumei, Epinephelus coioides and Lethrinus nebulosus) were randomly collected in commercial catches at local fishing ports from September 2011 to April 2012. Dorsal muscle was dissected as target sample after digestion. All samples were analyzed for their Cd and Pb contents using an inductively coupled plasma-atomic emission spectrometry (ICP-AES) and for their Hg content using an advanced mercury analyzer. The United States Environmental Protection Agency (US EPA) region III risk-based concentration table was used to estimate THQ values for both adults and children. THQ values over 1 were not observed through the consumption of fish. Total THQ values of Pb, Cd, and Hg for adults were 0.19 and 0.16 in Bandar Abbas and Bandar Lengeh, respectively. For children, they were 0.26 and 0.20 in Bandar Abbas and Bandar Lengeh, respectively, showing that the health risk associated with exposure to these 3 heavy metals was insignificant. However, according to the data concerning levels of environmental pollutants in the most consumed fish and seafood species, more specific recommendations are needed regarding human consumption (kind of species, and frequency and size of meals.

KEYWORDS: Environmental Pollutants, Fish, Heavy Metals, Iran, Risk Factors, Sea Foods

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Introduction

In recent years, heavy metals pollution, especially in the food chain, has attracted much attention.[1,2] Fish and other aquatic organisms can absorb and accumulate heavy metals in their body.[3] This process depends on various parameters such as characteristics of the species under consideration, the exposure period, temperature, salinity, water pH, and seasonal changes in water characteristics. Heavy metals are released into the water by anthropogenic activities. Thus, they enter the food chain and accumulate in animal bodies such as fish. Consumption of such animals as food may have

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some adverse effects on human health.[4]

In spite of the health benefits of fish, the high levels of heavy metals accumulated in some of them contribute to the possible adverse effects, particularly in fetuses and young children. Studies on the health benefits and risks of fish consumption have focused on recreational, subsistence, and commercial fish.[5]

The Beijing Declaration, held by the World Health Organization (WHO) in 2007, expresses the rights of all individuals to a safe and adequate diet.[6] The declaration emphasizes the importance of a safe diet and provides guidelines for food control.[7]

Fish is an important source of proteins, minerals, vitamins, and polyunsaturated fatty acids (PUFAs), especially omega-3 PUFAs. Fish consumption has been reported to reduce the risk of coronary heart disease, decrease mild hypertension, and prevent certain cardiac arrhythmias.[7] On the other hand, seafood consumption might be an important way of human exposure to chemical contaminants.[5]

Several methods have been proposed for estimation of the potential risks to human health caused by toxic metals. Among them, the target hazard quotients (THQ), proposed by the US Environmental Protection Agency (USEPA), has been recognized as a reasonable index for the evaluation of heavy metals intake by consumption of contaminated food.[8] The THQ is a ratio of the consumed dose of a toxic metal via an oral reference dose (RfD) proposed by the USEPA. A THQ value above 1 means that contaminated foods intake has likely some noticeable harmful effects on the exposed population. The higher the THQ value is, the higher the probability of the hazard risk on the human body will be. Based on THQ values, studies have been performed on the potential risk assessment of dietary intake of heavy metals via the consumption of seafood.[8,9]

Urban and suburban areas of Bandar Abbas and Bandar Lengeh, Iran, have been polluted by some sources of heavy metals. Nevertheless, information on the health risks of these elements is quite limited. The main objective of this study was to use the THQ concept to estimate the health risks of Pb, Cd, and Hg via consumption of fish on the general public in these two cities.

Materials and Methods

Hormozgan Province is located in Southern Iran (Figure 1). It is the first largest commercial port and harbor in Iran. Rapid development of agriculture and industries, and lack of legislation and regulations has led to the discharge of heavy metals, such as Cu, Zn, Pb, Cd, Hg, and Cr into the environment in large quantities through atmospheric deposition, solid waste disposal, sludge application, and wastewater irrigation.

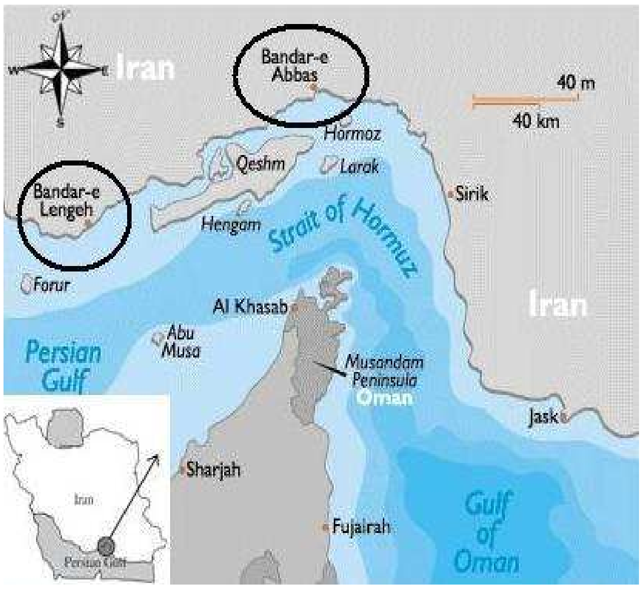

Figure 1. Sampling location map

Two large residential areas, which are known as the two largest fishing ports in this province were selected as the study areas. Wastewater irrigation and sludge application are the prevailing processes that have resulted in heavy metal contamination in these areas. In the present study, 4 economically important fish species with a high consumption rate in the local population were selected. They included 2 species of flat fish, Oriental sole (Euryglossa orientalis) and Deep flounder (Psettodes erumei), 1 specie from the Serranidae family (Hamoor), Orange spotted grouper (Epinephelus coioides), and one specie from the Lethrinidae family (Shehri), Spangled emperor (Lethrinus nebulosus) (Table 1). The selected fish species belong to different families and have different trophic/ecological characteristics, i.e., they include demersal top carnivores (e.g. Hamoor) and benthic feeders (e.g. Flat fishes).

Fish species were randomly collected from commercial catches landed at local fishing ports from September 2011 to April 2012, and the biometrics of sampled fish were determined.

After the collection, fish samples were immediately stored on ice in an isolated box[10], and transferred to reference laboratory belonging to the Hormozgan Environmental Deputy. The samples were thoroughly washed under tap water to eliminate dust and dirt. After that, a part of the dorsal muscle (edible tissue) from each of the samples was dissected as the target sample and prepared for processing. All samples were dried at 60°C for 48 hours in the laboratory oven.[7,11]

Glassware was soaked in HNO_3 (10% v/v) and cleaned with ultrapure water. Subsequently, 0.2-0.4 g of prepared sample was digested in Teflon beaker using ultrapure nitric acid (65% v/v, 5 ml). The digesting process was completed using a microwave, operated for about 30 minutes at 200 °C. Prepared samples were transferred to the test tube and brought up to volume (50 ml).[12]

All samples were analyzed 3 times for Cd and Pb using an inductively coupled plasma-atomic emission spectrometry (ICP-AES) (Varian Model-liberty series II, Palo Alto, USA) and for Hg using an advanced mercury analyzer (LECO AMA 254, LECO Corp., St. Joseph, MI, USA).

In order to assess the analytical capability of the proposed methodology, accuracy of heavy metals analysis was tested with fish protein for trace metals (DORM 2), and dogfish liver for trace metals (DOLT 2). Results confirmed that observed and reference values were not statistically different ($P < 0.05$) (Table 2).

Average body weight of people and mean dietary fish consumption rate were derived from national and local organizations such as the Institute of Standard and Industrial Research of Iran (ISIRI), Iranian Department of Environment, and Iranian Fishery Organization reports.

Table 1. Overview of sampled species

Scientific name	Common Name	Station	Length (cm)	Weight (g)	No. of samples
E. orientalis	Oriental sole	BA	38.3 ± 4.01	605.0 ± 140.09	10
		BL	28.1 ± 6.49	513.0 ± 252.51	10
P. erumei	Deep flounder	BA	48.1 ± 5.36	1672.0 ± 289.52	10
		BL	31.0 ± 6.37	1309.0 ± 320.25	10
E. coioides	Orange spotted grouper	BA	48.0 ± 9.50	2278.9 ± 360.95	10
		BL	54.3 ± 6.58	2437.9 ± 350.26	10
L. nebulosus	Spangled emperor	BA	26.17 ± 4.3	312.5 ± 70.25	10
		BL	23.18 ± 4.89	533.9 ± 39.25	10

BA: Bandar Abbas; BL: Bandar Lengeh

Table 2. Comparison of the obtained and reference concentrations (μg/g dry weight)

CRM		Pb	Cd	Hg
DORM-2	Certified	0.065 ± 0.007	0.043 ± 0.008	0.789 ± 0.074
	Obtained	0.063 ± 0.008	0.045 ± 0.009	0.079 ± 0.270
DOLT-2	Certified	0.220 ± 0.020	20.800 ± 0.500	4.640 ± 0.260
	Obtained	0.230 ± 0.030	20.700 ± 0.400	4.60 0± 0.220

CRM: Canadian Reference Materials; DORMM-2: Fish protein for trace metals; DOLT-2: Dogfish liver for trace metals

The methodology for estimation of THQ was provided in the USEPA region III risk-based concentration table.[13] For carcinogenic effects, risk is expressed as excess probability of contracting cancer over a lifetime. For non-carcinogenic effects, risk is expressed as a THQ, the ratio between the exposure and the reference dose.

A THQ of less than 1 shows that the exposed population, probably, has not experienced any evident adverse effects. The dose calculations were carried out using the standard assumption from an integrated USEPA risk analysis considering an average adult body weight of 55.9 kg, and child body weight of 32.7 kg. Evidently, children are more sensitive to pollutants. There will be a certain amount of discrepancy in health risks between age groups and the locality of the inhabitants. In this respect, the THQ was determined based on the USEPA methods described by the following equation:

$$THQ = \frac{E_F \times E_D \times E_{IR} \times \times C}{R_{FD} \times W_{AB} \times T_A} \times 10^{-3} \qquad \text{(Eq. 1)}$$

where E_F is the exposure frequency (365 days/year), E_D is the exposure duration (72 years) equivalent to the average lifetime in Iran, F_{IR} is the food ingestion rate (g/person/day), C is the metal concentration in food (Ag/g), R_{FD} is the oral reference dose (mg/kg/day), W_{AB} is the average body weight (55.9 kg for adults and 32.7 kg for children), and T_A is the average exposure time for non-carcinogens (365 days/years of exposure, assuming 70 years in this study). It was further assumed that cooking has no effect on the toxicity of heavy metals in seafood.[14] For the inhabitants of the two studied areas, the daily fish consumption was 22.14 g/person/day for adults and 15.16 g/person/day for children.

Results and Discussion

Concentrations of Pb, Cd, and Hg in fish in the two studied areas are shown in table 3. E. coioides, L. nebulosus, and P. erumei had the highest concentrations of Pb, Cd, and Hg, respectively, in Bandar Abbas. E. coioides had the highest concentration of both Pb and Cd, and P. erumei accumulated the highest concentration of Hg in Bandar Lengeh (Table 3).

The average concentrations of the 3 metals were higher in Bandar Abbas than Bandar Lengeh. This result is mainly due to unmanaged shipping activities, river runoff, untreated sewage discharge by coastal settlements, and toxic and industrial wastes discharge into the sea adjacent to Bandar Abbas.

The concentrations of metals in fish from this region during this study were compared with those reported previously (Table 4).

Table 3. Average concentrations of heavy metals in fish species (μg/g dry weight)

Station\metals	Species	Pb		Cd		Hg	
		Range	Mean	Range	Mean	Range	Mean
Bandar Abbas	E. orientalis	0.18-0.25	0.20	0.09-0.51	0.17	0.14-0.27	0.21
	P. erumei	0.16-0.34	0.31	0.22-0.61	0.23	0.10- 0.55	0.28
	E. coioides	0.07-0.76	0.54	0.17-0.21	0.20	0.12-0.23	0.19
	L. nebulosus	0.14-0.37	0.32	0.12-0.30	0.27	0.07-0.26	0.17
Bandar Lengeh	E. orientalis	0.16-0.23	0.21	0.14-0.20	0.16	0.15-0.24	0.21
	P. erumei	0.01-0.09	0.04	0.01-0.14	0.09	0.14-0.31	0.26
	E. coioides	0.11-0.36	0.29	0.14-0.35	0.31	0.09-0.17	0.11
	L. nebulosus	0.16-0.27	0.21	0.23-0.33	0.27	0.11-0.21	0.14

Table 4. Heavy metal concentrations (μg.g-1 dry weight) in fish in other water areas

Species or population	Location	Hg	Pb	Cd	Reference
E. encrasicolus	Sicily, Mediterranean Sea	0.03 ± 0.03	< 0.001	0.18 ± 0.17	
S. pilchardus	Sicily, Mediterranean Sea	0.08 ± 0.03	< 0.001	0.08 ± 0.09	4
M. barbatus	Sicily, Mediterranean Sea	0.08 ± 0.26	0.84 ± 0.069	< 0.06	
Ostrea plicatula	Xiamen, China	0.008	0.211	0.334	
R. philippinarum	Xiamen, China	0.008	0.151	0.133	8
S. constricta	Xiamen, China	0.007	0.215	0.054	
Tegillarca granosa	Xiamen, China	0.008	0.210	0.369	
T. mutbilis	Bandar Abbas, Iran	-	-	8.69 ± 6.23	15
Psettodes erumei	Hormozgan Province, Iran	-	-	0.25 ± 0.12	16
Euryglossa orientalis	Hormozgan Province, Iran	-	-	0.12 ± 0.05	
Corpus corpino	Caspian Sea, Iran	-	138.75 ± 26.2	72.87 ± 22.2	
Mugila auratus	Caspian Sea, Iran	-	75.11 ± 37.4	27.96 ± 12.1	17
Rutilus frisikutum	Caspian Sea, Iran	-	121.36 ± 53.2	38.84 ± 18.9	
Anchovy fish	Jingsu River, Taihu Lake	-	$1.5 \times 10^{-2} \pm 1.3 \times 10^{-1}$	$7.0 \times 10^{-4} \pm 3.6 \times 10^{-3}$	18
Istiophorus platypterus	Gulf of California	1.48 × 0.93 (0.23–3.62)	$3.6 \times 10^{-1} \pm 2.9 \times 10^{-1}$ (1.6×10^{-1}–1.5)	$5.5 \times 10^{-1} \pm 3.7 \times 10^{-1}$ (2.6×10^{-1}–1.55)	19
Tetrapturus audax	Gulf of California	1.72 ± 0.61 (0.81–3.12)	$3.5 \times 10^{-1} \pm 8.0 \times 10^{-2}$ (1.8×10^{-1}–4.9×10^{-1})	$3.7 \times 10^{-1} \pm 4.0 \times 10^{-1}$ (1.2×10^{-1}–1.38)	
European Anchovy	Adratic Sea	$7.0 \times 10^{-2} \pm 9.0 \times 10^{-2}$ 2.0×10^{-2}–2.1×10^{-1}	$1.0 \times 10^{-1} \pm 1.0 \times 10^{-2}$ (9.0×10^{-2}–1.0×10^{-1})	$1.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$ (1.0×10^{-2} – 2.0×10^{-2})	
Four spotted megrim	Adratic Sea	$3.5 \times 10^{-1} \pm 1.9 \times 10^{-1}$ (1.4×10^{-1}–6.9×10^{-1})	$2.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$ (ND–2.0×10^{-2})	$4.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$ 3.0×10^{-2}-7.0×10^{-2}	9
Starry ray	Adratic Sea	$3.9 \times 10^{-1} \pm 3.6 \times 10^{-1}$ (7.0×10^{-2}–8.9×10^{-1})	$2.0 \times 10^{-2} \pm 2.0 \times 10^{-2}$ (ND–6.0×10^{-2})	$1.0 \times 10^{-2} \pm 3.0 \times 10^{-2}$ (2.0×10^{-2}- 1.0×10^{-2})	
Rosefish	Adratic Sea	1.25 ± 0.85 (2.4×10^{-1}–2.98)	$1.3 \times 10^{-1} \pm 9.0 \times 10^{-2}$ (3.0×10^{-2} - 3.3×10^{-1})	$3.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$ (1.0×10^{-2}–8.0×10^{-2})	
Cyprinus carpio	Meiliang Bay, Taihu Lake	-	$1.8 \times 10^{-1} \pm 3.0 \times 10^{-2}$	$2.1 \times 10^{-2} \pm 8.0 \times 10^{-3}$	
Carassius auratus	Meiliang Bay, Taihu Lake	-	$2.9 \times 10^{-1} \pm 1.0 \times 10^{-2}$	$1.3 \times 10^{-2} \pm 8.0 \times 10^{-3}$	20
Hypophthalmichthys molitrix	Meiliang Bay, Taihu Lake	-	$1.8 \times 10^{-1} \pm 4.6 \times 10^{-2}$	$3.0 \times 10^{-3} \pm 1.0 \times 10^{-3}$	
Aristichthys nobilis	Meiliang Bay, Taihu Lake	-	$1.8 \times 10^{-1} \pm 3.1 \times 10^{-2}$	$4.0 \times 10^{-3} \pm 1.0 \times 10^{-3}$	
Gymoncypris namensis	Nam Co Lake, Tibet Plateau	-	4.7×10^{-2}	2.5×10^{-2}	21

Table 4. Heavy metal concentrations (µg.g-1 dry weight) in fish in other water areas (Continue)

Species or population	Location	Hg	Pb	Cd	Reference
Gymoncypris waddellii	Yamdro Lake, Tibet Plateau	-	7.9×10^{-2}	2.4×10^{-2}	
Ptychobarbus dipogon	Lhasa River, Tibet Plateau	-	2.4×10^{-2}	2.4×10^{-2}	
Lagocephalus lagocephalus	Ghana, Atlantic coast	$6.6 \times 10^{-2} \pm 2.3 \times 10^{-2}$	-	-	22
Pseudotolithus senegalensis	Ghana, Atlantic coast	$3.1 \times 10^{-2} \pm 2.5 \times 10^{-2}$	-	-	
Braehydentera aurita	Ghana, Atlantic coast	$12.2 \times 10^{-2} \pm 3.0 \times 10^{-2}$	-	-	
Fish	Dong Li District, Tianjin	2.0×10^{-2} (1.0×10^{-3}-4.3×10^{-2})	1.0×10^{-2} (2.0×10^{-3}–2.0×10^{-2})	2.0×10^{-3} (4.0×10^{-4}–5.0×10^{-3})	23
Fish	Xi Qing District, Tianjin	2.0×10^{-2} (4.0×10^{-3}–4.0×10^{-2})	6.0×10^{-2} (1.0×10^{-3}–2.8×10^{-1})	6.0×10^{-3} (2.0×10^{-4}–3.0×10^{-2})	
Fish	Jin Nan District, Tianjin	4.0×10^{-2} (5.0×10^{-3}–1.0×10^{-1})	7.0×10^{-2} (3.0×10^{-3}–2.8×10^{-1})	8.0×10^{-3} (4.0×10^{-4}–3.0×10^{-2})	
Fish	Bei Chen District, Tianjin	7.0×10^{-1} (6.6×10^{-2}–7.0×10^{-1})	5.0×10^{-3} (3.0×10^{-3}–6.0×10^{-3})	2.0×10^{-3} (1.0×10^{-3}–3.0×10^{-3})	
Bluefish	New Jersey, USA	$2.6 \times 10^{-1} \pm 2.0 \times 10^{-2}$	$6.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$	$6.0 \times 10^{-3} \pm 2.0 \times 10^{-3}$	24
Chilean sea bass	New Jersey, USA	$3.8 \times 10^{-1} \pm 6.0 \times 10^{-2}$	$1.1 \times 10^{-1} \pm 1.0 \times 10^{-2}$	$4.0 \times 10^{-3} \pm 1.0 \times 10^{-3}$	
Croaker	New Jersey, USA	$1.4 \times 10^{-1} \pm 2.0 \times 10^{-2}$	$9.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$	$1.0 \times 10^{-3} \pm 4.0 \times 10^{-4}$	
Flounder	New Jersey, USA	$5.0 \times 10^{-2} \pm 1.0 \times 10^{-3}$	$6.0 \times 10^{-2} \pm 1.0 \times 10^{-2}$	$1.0 \times 10^{-2} \pm 2.0 \times 10^{-3}$	
Enedrias nebulosus	Masan Bay, Korea	-	5.0×10^{-2}	1.0×10^{-2}	
Pleuronichthys cornutus	Masan Bay, Korea	-	1.1×10^{-1}	ND	25
Conger myriaster	Masan Bay, Korea	-	4.0×10^{-2}	ND	
Acanthogobius flavimanus	Masan Bay, Korea	-	7.0×10^{-2}	3.0×10^{-2}	
Hexagrammos otakii	Masan Bay, Korea	-	4.0×10^{-2}	1.0×10^{-1}	
Sebastiscus marmoratus	Masan Bay, Korea	-	1.5×10^{-1}	1.0×10^{-1}	
Lethrinus lentjan	United Arab Emirates	-	–	$1.1 \times 10^{-1} \pm 2.0 \times 10^{-2}$	26
Makaria mazara	Taipei, Taiwan	10.3 (1.71–22.9)	1.43 (1.11×10^{-1}–6.8×10^{-1})	1.2×10^{-1} (1.5×10^{-2}–3.1×10^{-2})	27
Thunnus albacores	Taipei, Taiwan	9.75 (8.8–10.4)	2.1×10^{-1} (1.7×10^{-1}-3.1×10^{-1})	7.0×10^{-2} (1.5×10^{-2}-3.1×10^{-2})	
Trichiurus lepturus	Taipei, Taiwan	1.28 (0.14–6.85)	1.3×10^{-1} (5.0×10^{-3}–4.2×10^{-1})	1.3×10^{-1} (3.0×10^{-2}–3.2×10^{-1})	
Chanos chanos	Taipei, Taiwan	2.54 (0.24–4.60)	1.2×10^{-1} (5.0×10^{-3}–1.9)	3.5×10^{-2} (5.0×10^{-3}–2.7×10^{-1})	

Table 4. Heavy metal concentrations (µg.g-1 dry weight) in fish in other water areas (Continue)

Species or population	Location	Hg	Pb	Cd	Reference
Cyprinus carpio	Taipei, Taiwan	2.19 (0.69–5.40)	9.5×10^{-2} (1.0×10^{-1}–2.5×10^{-1})	1.0×10^{-1} (ND–1.0×10^{-1})	
Euryglossa orientalis	Persian Gulf, Iran	2.1×10^{-1}	2×10^{-1}	1.6×10^{-1}	This study
Psettodes erumei	Persian Gulf, Iran	2.7×10^{-1}	1.7×10^{-1}	1.6×10^{-1}	This study
Epinephelus coioides	Persian Gulf, Iran	1.5×10^{-1}	4.1×10^{-1}	2.5×10^{-1}	This study
Letherinus nebulosus	Persian Gulf, Iran	1.5×10^{-1}	2.6×10^{-1}	2.7×10^{-1}	This study

Table 5. Concentrations of Pb, Cd, and Hg in 4 types of fish samples (µg/g dry weight)

Areas	Metals					
	Pb		Cd		Hg	
	Mean	Range	Mean	Range	Mean	Range
Bandar Abbas	0.34	(0.07-0.76)	0.21	(0.09-0.61)	0.21	(0.07-0.42)
Bandar Lengeh	0.18	(0.01-0.36)	0.20	(0.01-0.35)	0.18	(0.09-0.31)

Mean values of Cd, in our investigation, except for L. nebulosus, were lower than those reported for Lethrinus lentjan in the United Arab Emirates.[26]

Our results for Cd were lower than those reported in Xiamen in China,[8] in Sicily in the Mediterranean Sea,[4] and the Gulf of California.[19]

On the other hand, our results were higher than those reported from Adriatic sea,[9] Jingsu River,[18] Meiliang Bay,[20] Nam Co Lake,[18] Dong Li District, and Xi Qing District, Jin Nan District, and Bei Chen District,[20] New Jersey,[24] and Taipei.[27] The concentration of Cd observed in our studied fish was similar to that in Hexagrammos otakii and Sebastiscus marmoratus fish from Masan Bay.[25]

The concentrations of Pb in the current study were lower than those reported in fish muscle in Sicily in the Mediterranean Sea,[4] 240 shellfish (including oyster, short-necked clam, razor clam, and mud clam) collected from 6 administrative regions in Xiamen of China,[8] and in Istiphorus platypterus and Terrapturus audax in the Gulf of California.[19]

The comparison of our results with other results in table 5 showed that the concentration of Pb in the Persian Gulf was higher than that in the Jinsu River,[18] Adriatic Sea,[9] Lake Nam Co,[21] and Dong Li District. Xi Qing District, Jin Nan District, and Bei Chen District,[23] New Jersey,[24] and Masan Bay.[25] The concentration of Pb was similar to that in fish from Taipei city in Taiwan.[27]

Lower concentrations of mercury were found in our study in comparison t that in Taipei,[27] New Jersy,[28] Bei Chen District,[23] and the Adriatic Sea.[9] Hg concentration in fish tissues in our study were higher compared with that in fish muscle in Sicily,[4] shellfish in Xiamen,[8] Flounder fish in New Jersy,[24] fish species in Dong Li, Xi Qing, and Jin Nan Districts,[23] and Lagocephalus lagocephalus and Pseudotolithus senegalensis in Ghana,[22] Atlantic Coast, and in European Anchovy in the Adriatic Sea.[9] Similar concentrations of Hg were observed in Rose Fish in the Adriatic Sea[9]and Braehydentera aurita in Ghana.[23]

Health risks posed by exposure to Pb, Cd, and Hg to the local inhabitants in the two coastal regions of the Persian Gulf, Iran, through the consumption of contaminated fish were investigated based on estimated THQs. The results showed that THQ values were lower than 1 for both adults and children by consuming fish alone (Table 5).

Table 6. THQs and EWI for individual metals caused by the consumption of fish

Areas		Pb		Cd		Hg	
		THQ	EWI	THQ	EWI	THQ	EWI
Adults	Bandar Abbas	0.01	0.55	0.04	0.17	0.14	0.90
	Bandar Lengeh	0.01	0.55	0.03	0.13	0.12	0.38
Children	Bandar Abbas	0.02	0.18	0.06	0.25	0.18	0.74
	Bandar Lengeh	0.01	0.55	0.04	0.17	0.15	0.52

THQs: target hazard quotients

RfDs are based on 1×10^{-3} µg/g/day for Cd, 4×10^{-3} µg/g/day for Pb, and 5×10^{-4} µg/g/day for Hg.[15] The THQ of the studied metals through the consumption of fish for residents (adults and children) from the two districts were derived and listed in table 6. The results show that there are no THQ values higher than 1 through the consumption of fish, suggesting that the health risks associated with heavy metals exposure are insignificant.

An important aspect in assessing the risk to human health from potentially harmful chemicals in food is the knowledge that the dietary intake of such substances must remain within determined safety margins. For Hg, Cd, and Pb, the WHO has established a safe intake level, known as provisional tolerable weekly intake (PTWI). The PTWI for Cd, Pb, and Hg is 5, 7, and 25 µg/kg body weight, respectively.[29]

In our case, the estimated weekly intakes (EWI) of Cd, Pb, and Hg through the consumption of fish (Pb: 0.18-0.55 µg/kg body weight, Cd: 0.13-0.25 µg/kg body weight, Hg: 0.38-0.90 µg/kg body weight) were lower than the established weekly intake limits (Table 6).

To further elucidate the specific risk contribution in each district, detailed information on food consumption structure and the metals concentrations in these areas will hopefully be obtained by future efforts with the associated institutions.

Conclusion

In the present study, the concentrations of heavy metals (Hg, Pb, and Cd) were determined in fish from the Persian Gulf. The considerable variation in levels of these contaminants among different species highlights the important role of ecological and physiological factors in concentrating pollutants. The THQ values below 1 of Cd, Hg, and Pb showed no risk for the consumers' health. Nevertheless, analysis of mercury data suggests that dietary consumption of certain fish species can vary this neurotoxin intake substantially, thus, determining great differences in health risks. Consequently, intake might be of concern, especially in the cases where the exposure is closer to the tolerable weekly intake. As a final conclusion, we suggest providing more specific recommendations regarding human consumption (species, frequency, and size of meals) according to the data concerning levels of environmental pollutants in the most consumed fish and seafood species.

Conflict of Interests

Authors have no conflict of interests.

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