Int. J. Environ. Res., 5(3):757-762, Summer 2011
ISSN: 1735-6865

Mercury Bioaccumulation in Some Commercially Valuable Marine Organisms from Mosa Bay, Persian Gulf

Mortazavi, M. S.* and Sharifian, S.

Persian Gulf and Oman Sea Ecological Research Institute, P. O. Box 79145-1597
Bandar Abbas, Hormozgan, Iran

Received 23 Sep. 2010; Revised 11 March 2011; Accepted 17 March 2011

ABSTRACT: This study was undertaken to determine the concentration of mercury in edible muscle of five commercially valuable marine organisms from Mosa Bay, Persian Gulf, Iran. The total mercury concentrations were determined by cold vapour atomic absorption spectrophotometry and expressed in µg/g dry weight. Certified reference materials were used for each batch of analysis. Mercury concentration was 0.373 µg/g for *Liza abu*, 1.172 µg/g *Sparidentex hasta*, 0.445µg/g for *Acanthopagrus latus*, 0.390 µg/g for *Thunnus tonggol*, and 0.360 µg/g for *Fenneropenaeus indicus*. Carnivorous fish had higher level of mercury than non-carnivorous. Statistical analysis revealed weak correlation between fish mercury concentration and length for all studied organisms. The observed concentrations were comparable to those found in other areas of the Persian Gulf and were lower than the WHO guideline of 0.5 mg/kg wet weight. Our result demonstrated that estimated daily and weekly intakes of mercury via consumption of fish flesh were far below the PTDI and PTWI values recommended by FAO/WHO.

Key words: Mercury,Marine Organisms, Food Safety, Persian Gulf, Mosa Bay

INTRODUCTION

Fish is widely consumed in many parts of the world by humans because it has high protein content, low saturated fat and also contains omega fatty acids known to support good health (Ikem and Egiebor, 2005). However, fish can also contain toxic levels of some metals (Carvalho *et al*., 2005). In particular, some organisms of fish have been found to contain elevated mercury concentrations, which may be toxic both for the fish and for humans who consume the fish (Wiener *et al*., 2003). Mercury is a natural element that is found in minute quantities in air, water and all living things. This toxic element can find its way into food sources through a number of ways including natural uptake and pollution. Mercury exists in nature in two forms, inorganic mercury and organic methyl mercury. In the sea, pollutants are potentially accumulated in marine organisms and sediments, and subsequently transferred to man through the food chain. For this reason, determination of chemical quality of aquatic organisms, particularly the contents of heavy metals in fish is extremely important for human health (Dural *et al*., 2007). Mercury poisoning can have devastating effects, one of the first major examples of this was the Minamata Bay disaster in Japan, which has resulted in the deaths of over 1,000 people and left over 2,000 seriously ill from contaminated seafood (Harada 1995). Many factors, include physiological (species, size, age, sex, sexual maturity, diet) and broader environmental conditions (water chemistry, salinity, temperature, and levels of contamination) may influence mercury loading in fish (Verdouw *et al*., 2010; Carvalho *et al*., 2005).

Fish have long been a favourite meal for people that living around the Persian Gulf and Oman Sea. The Persian Gulf is shallow basin with an average depth of 30-45 m and a total area of round 240 sq. Km (Saeidi *et al*., 2008). Mosa Bay (Khowr-e-Mosa) is located in the North western Persian Gulf Coast of Iran. Along the coast of this bay, there are agriculture lands and industrial plants (petrochemical plants, LPG plants, oil transfer docks and cargo ship's ballasts water). This bay has a great importance for the local fisheries activities in Khuzestan Province and fish from this aqua resource serve as the main source of animal protein for the population surrounding the bay. This research, on determination of mercury level in some marine species, was carried out for the first time for

*Corresponding author E-mail: mseddiq1@yahoo.com

Mosa Bay. Abu mullet (*Liza abu*), Sobaity Sea bream (*Sparidentex hasta*), yellowfin seabream (*Acanthopagrus latus*), long tail tuna (*Thunnus tonggol*) and Indian white shrimp (*Fenneropenaeus indicus*), are some commercially valuable fish and shrimp species that exist in the human diet of the region. Therefore, the objective of the study was to determine the level of mercury in commonly consumed fishes in the Persian Gulf region and risk of mercury on daily consumption.

MATERIALS & METHODS

All glassware used in the present study was soaked in detergent solution before being rinsed and soaked in 10% (v/v) HNO_3 overnight. All reagents were of analytical reagent grade: nitric acid (Merck, Germany); stannous chloride 99% (Merck, Germany). Deionised water was used for the preparation of all solutions (Milli-Q System, Millipore). Mercury stock standard solution (1000 mg/ l) was prepared by dissolving 1.354 g of $HgCl_2$ in HNO_3 in a 1000 ml glass volumetric flask and kept in the refrigerator (+4 °C). The working solutions were freshly prepared by diluting an appropriate aliquot of the stock solution through intermediate solutions using 10% HNO_3. Stannous chloride solution (1.1% v/v) was prepared by dissolving the salt in 1000 ml of 3% HCl. Fish and shrimp samples were caught in March 2009 from five different areas in Mosa Bay (Fig. 1). A total number of 85 fish and shrimp representing five species (*Liza abu*, *Sparidentex hasta*, *Acanthopagrus latus*, *Thunnus tonggol*, and *Fenneropenaeus indicus*) were caught and placed in clean plastic bags and stored on ice in an ice chest, then transported to the laboratory, identified by species; and washed with distilled water. The edible muscle tissue were analysed (MOOPAM, 1999). The selected fish species are of great commercial values in the region of Persian Gulf and represent different habitat as shown in Table 1.

The moisture content of the tissue samples was determined according to AOAC method (1995) in triplicate. Muscle tissues of fish and shrimp samples were dried at 80 °C. The samples were then ground on an agate mortar to obtain a fine homogeneous powder. The homogenized samples (0.5 g wet and 0.2 g dry sample) were weighted in digestion tubes and 5 ml HNO3 was added before the mixture was digested using Ethos 1 millestone Microwave Instrument. Digested samples were then cooled and subsequently diluted to 25ml volume with Milli-Q water. Blanks were prepared in parallel. Mercury was determined in all the digests

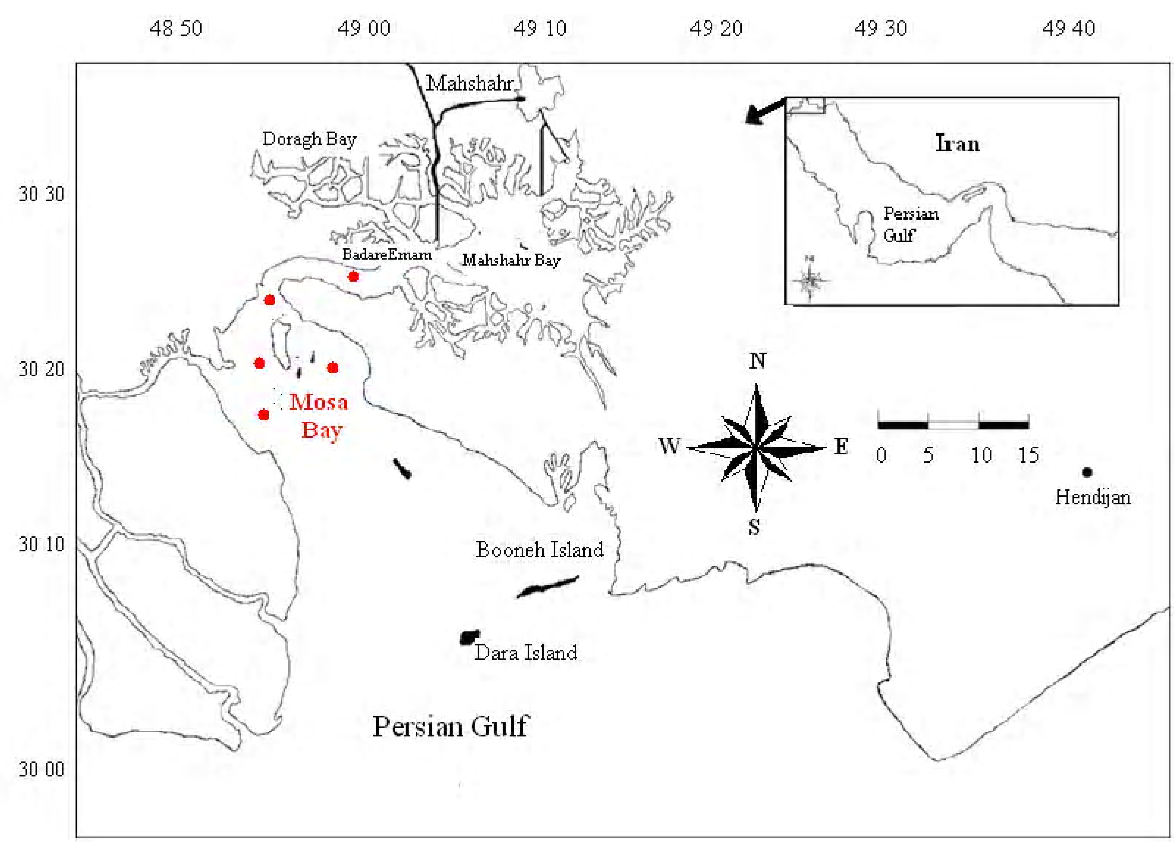

Fig. 1. Map of the Mosa Bay showing the location of the sampling sites

Table 1. Characteristics of fish and shrimp samples, collected from the Persian Gulf (mean ± S.E.)

Fish species					
Common name	**Scientific name**	**n**	**Total length (cm)**	**Total weight (g)**	**Feeding habit**
Abu mullet	*Liza abu*	20	188.9 ± 3.3	83.9 ± 5.3	Detritus
Sobaity Sea bream	*Sparidentex hasta*	10	328.2 ± 4.1	490.6 ± 22.1	Carnivorous
Yellowfin Sea bream	*Acanthopagrus latus*	10	254.5 ± 6.0	304.6 ± 21.7	Carnivorous
long tail tuna	*Thunnus tonggol*	20	68.1 ± 0.8	3268.0 ± 80.4	Omnivorous
Indian white shrimp	*Fenneropenaeus indicus*	25	113.2 ± 2.2	10.3 ± 0.6	Benthophagous

using cold vapour atomic absorption spectrophotometry Thermo M5, Vapour system VP100. The reliability and consistency of Hg level in fish analysis was confirmed by using certified reference materials DORM2. The recovery values of CRMs were in the range 95.5-98.0%.

The estimated daily/weekly intake (EDI/EWI) values of mercury by an adult (µg/kg body weight) were calculated using the averages value by each fish species, i.e. EDI (or EWI) in µg/kg body weight = mean concentration of element (µg/g wet wt.) multiplied by the amount of fish consumed/day (or week) (g) and divided by the average weight of an individual (70 kg) (Saei-Dehkordi *et al.*, 2010; Hajeb *et al.*, 2009).

A logarithmic transform was done to improve normality of data. The descriptive statistics (mean, standard errors, range) and one-way analysis of variance (ANOVA) were conducted using SPSS (Version 13.0, SPSS Inc., Chicago, IL, USA). A one-way ANOVA statistical procedure was employed in the assessment of variation in mercury concentrations among marine species. Homogeneity of variances was evaluated with the Levene-test. The Games-Howell test was applied since variances were not homogeneous. Significance was tested at $P < 0.05$ level. The linear regression analyses were applied to data to compare the relationships between size and mercury concentrations.

RESULTS & DISCUSION

The results of mercury concentrations for the five analyzed marine species (four fish and one shrimp species) are shown in Table 2 and expressed as means and standard error on dry and wet basis (µg/g). As presented in Table 2 the highest mercury concentration belonged to *S. hasta* by 1.172 ± 0.210 µg/g dry weights. Thereafter, sorting from highest to the lowest mercury levels, the species were ranked as follows: *A. latus* (0.445 ± 0.164 µg/g) > *T. tonggol* (0.390 ± 0.065 µg/g) > *L. abu* (0.373 ± 0.100 µg/g) and *F. indicus* (0.360 ± 0.027 µg/g). These results are similar and comparable to Agah *et al.* (2007). According to their study, the mean ± SD of muscle Hg concentrations (µg/g wet weight) of four Persian Gulf fish species sampled in January 2004, were between 0.05 and 0.11 µg/g (*Pomadasys* sp., Haemulidae), 0.14–0.68 µg/g (*Platycephalus* sp., Platycephalidae), 0.1–0.26 µg/g (*Epinephelus tauvina*, Serranidae) and 0.02–0.11 µg/g (*Pampus argenteus*). According to Saei-Dehkordi *et al.* (2010), the range of total mercury levels in *Acanthopagrus latus* and *Thunus tonggol* (Persian Gulf) caught in July to September 2009 and January to March 2010, found to be 0.394 ± 0.128 and 0.527 ± 0.190 µg/g of wet weight, respectively. The Hg amounts of these species in our study were considerably lower, despite of sample weight. Hajeb et al. (2009) also determined the level of mercury in commonly consumed fishes in Malaysia (the South China Sea) and found that mercury levels of *T. tonggol* was 0.12 ± 0.38 µg/g of wet weight (0.50 ± 0.71 µg/g of dry weight). A comparison between mercury concentrations in different species of Persian Gulf fish found in this study and other researches are shown in Table 3.

The one-way analysis of variance (ANOVA) showed significant differences ($P < 0.05$) in mercury concentration among different fish species. The differences in Hg levels have been linked to the diet and hence the trophic level of the fish species (Saei-Dehkordi *et al.*, 2010; Hajeb et al., 2009; Agah et al., 2007). Lima *et al.* (2005) assessed the level of mercury and selenium in fish samples from Cachoeira (ParãState, Brazil) and found a highest level of Hg concentration in carnivorous species than non-carnivorous. Similarly in our study, Sobaity Sea bream and Yellow-fin Sea bream had highest averaged Hg concentration.

The relationship between the size of the fish and the concentrations of Hg species is shown in Table 4. The results showed weak correlation between fish Hg concentration and length for all studied species. Maybe it is because our fish samples had little variation in size and weight and all samples were almost at commercially sizes. Similarly, Castilhos and Bidone did not find any significant correlation between Hg concentration and fish size of the Tapajós River Region in Brazil (Castilhos and Bidone, 2000). For total mercury versus fish weight there was also no correlation noted for all fish species (results not shown).

Table 2. Total mercury in muscle of marine species from Persian Gulf (mean ± SE)

Fish species	n	moisture	Total mercury (µg/g dry wt.)		Total mercury (µg/g wet wt.)	
			Mean ± SE	**range**	**Mean ± SE**	**range**
Abu mullet	20	75.2	0.373 ± 0.100	0.013–1.565	0.093 ± 0.025	0.003–0.388
Sobaity seabream	10	72.4	1.172 ± 0.210	0.149–2.362	0.475 ± 0.058	0.041–0.651
Yellowfin seabream	10	71.8	0.445 ± 0.164	0.049–1.581	0.092 ± 0.033	0.010–0.319
long tail tuna	21	75.9	0.390 ± 0.065	0.117–1.527	0.094 ± 0.016	0.028–0.368
Indian white shrimp	25	74.7	0.360 ± 0.027	0.171–0.771	0.091 ± 0.007	0.043–0.195

Table 3. Mercury level in fish muscle from Persian Gulf reported by other studies in comparison to data reported in current study

Region	Species sampled	Mercury level (µg/g)		Reference
		Dry wt.	**Wet wt.**	
Persian Gulf (Iran)	Abu mullet	0.013-1.565	0.003–0.388	This study
	Sobaity seabream	0.149-2.362	0.041–0.651	
	Yellowfin Seabream	0.049-1.581	0.010–0.319	
	long tail tuna	0.117-1.527	0.028 –0.368	
	Indian white shrimp	0.171-0.771	0.043–0.195	
Persian Gulf (Iran)	Various fish (15)	-	0.127–0.527	Saei-Dehkordi *et al.*, 2010
Persian Gulf (Iran)	Largetooth Flounder	-	0.022–0.034	Agah *et al.*, 2007
	Spotfin Flathead	-	0.014–0.073	
	Threadfin bream	-	0.030–0.078	
	Greater Lizardfih	-	0.012–0.086	
	Giant seacatfish	-	0.030–0.048	
Persian Gulf (Iran)	Canned tuna	-	0.043-0.253	Khansari *et al.*, 2005
Persian Gulf (Kuwait)	Various fish (7)	-	0.014–0.780	Al Majed and Preston, 2000
Persian Gulf (Kuwait)	Various fish (5)	-	0.011–0.28	ROPME, 1999
Persian Gulf (Saudi)	Various fish (4)	-	0.007–0.25	
Persian Gulf (Qatar)	Various fish (4)	-	0.06–0.208	
Persian Gulf	Greasy grouper	-	0.107	Ahmad and Al-Ghais, 1996
(United Arab Emirates)	Dory snapper	-	0.107	
Persian Gulf (Bahrain)	Various species	-	0.084	Madany *et al.*, 1996
Persian Gulf (Qatar)	Flounder	-	0.13–0.16	Kureishy, 1993
	Threadfin bream	-	0.02	

Table 4. The relationships between mercury concentrations and total lengths of marine species [a]

	Marine species				
	L. abu	***S. hasta***	***A. latus***	***T. tonggol***	***F. indicus***
Equation	y= -0.0031x + 0.9586	y= 0.025x - 7.0287	y= 0.0079x - 1.5671	y= 0.0042x + 0.1063	y= 0.0025x +0.0725
R value	0.1058	0.4933	0.2898	0.0520	0.2017
P value	NS [b]	NS	NS	NS	NS

[a] In the equations, y is mercury concentration (mg/g d.w.) and x is total length of marine species (cm).
[b] NS, not significant, $P > 0.05$.

Several studies have shown that fish consumption may constitute an important source of inorganic mercury exposure for human (Fakour *et al*., 2010; Dakeishi *et al*., 2005; Ohno *et al*., 2007; Díez *et al*., 2008). The daily intake of an element from food consumption is dependent on the element concentration in food and amount of food consumed (Hajeb *et al*., 2009). In Iran, the amounts of daily and weekly fresh fish muscle consumption are 21 and 147 g, respectively (Annual Fishery Statistics of Iran, 2010). The estimated daily/weekly intakes (EDI/EWI) for an adult by 70 kg body weight are shown in fig. 2. According to the Joint FAO/WHO Expert Committee on Food Additives the provisional tolerable weekly/daily intakes (PTWI/PTDI) of mercury is equivalent to 5 µg/kg body weight (equivalent to 0.71 µg/kg/bw/day) (Torres-Escribano *et al*., 2010). Hence, the EDI and EWI values revealed that the dietary exposure to mercury could be considered safe. The values were much lower than PTDI and PTWI as recommended safety standard limits (Fig. 2).

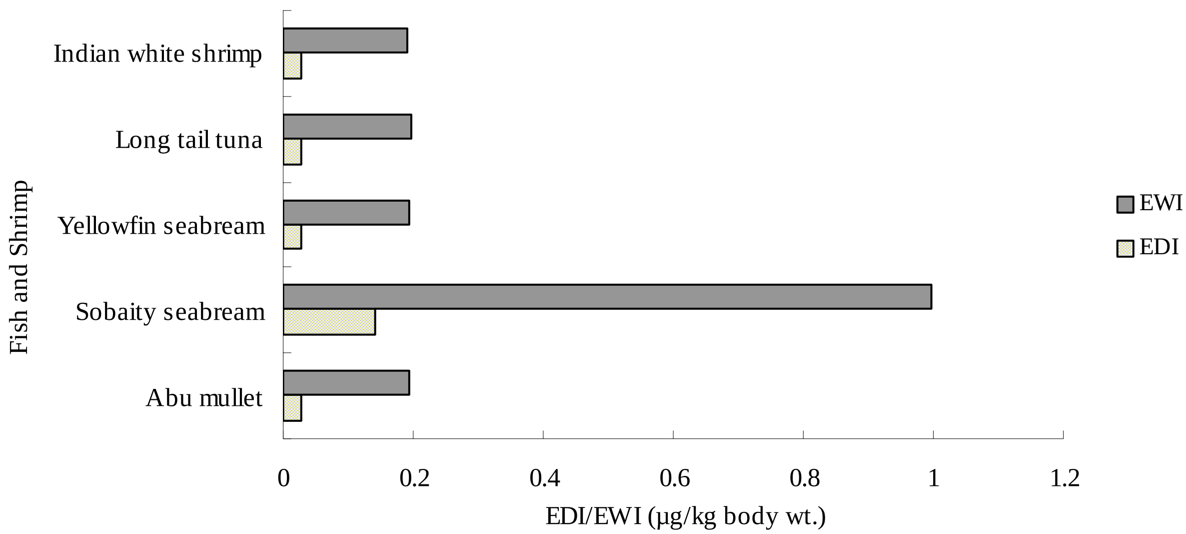

Fig. 2. The estimated daily and weekly intakes of Mercury of the studied samples from the Mosa Bay, Persian Gulf

CONCLUSION

Fish is a favourite meal for people that living around the Persian Gulf and Oman Sea. The Mosa Bay is one of important bays in the Persian Gulf region and has received an increased attention due to its noticeable economically role and fishing activities. This study evaluated mercury concentrations in five species of commercially fish species caught from the Bay. The results showed that fish with carnivorous feeding habit had higher metal quantities than those measured in omnivorous and benthophagous. The levels of mercury in all analyzed fish were below the WHO guideline of 0.5 mg/kg wet weight. Considering the EDIs and EWIs, the safety of dietary intake of metals via fish consumption should be considered acceptable in the Bay region. However both low-risk groups (adolescents and adults) and high-risk groups (pregnant mothers and children) should consume fish in moderation since large consumption pattern especially for Sobaity seabream may result in increased health risks.

ACKNOWLEDGEMENTS

The authors are grateful to the Persian Gulf and Oman Sea Ecological Research Institute for supporting this research.

REFERENCES

Agah, H., Leermakers, M., Elskens, M., Fatemi, M. R. and Baeyens, W. (2007). Total Mercury and Methyl Mercury Concentrations in Fish from the Persian Gulf and the Caspian Sea. Water Air Soil Pollution, **181**, 95–105.

Ahmad, S. and Al-Ghais, S. M. (1996). Metal contents in the tissues of *Lutjanus fulviflamma* (Smith 1949) and *Epinephelus tauvina* (Forskal 1775) collected from the Arabian Gulf. Bulletin of Environmental Contamination and Toxicology, **57**, 957–963.

Al-Majed, N., and Preston, M. (2004). The distribution and inventory of total and methylmercury in Kuwait Bay. Marine Pollution Bulletin, **49**, 930–937.

Annual Fishery Statistics of Iran. (2010). Consumption of Fish in Iran. Ministry of Agriculture, pp. 36–40.

AOAC (1995). Official methods of analysis, 16th ed. Arlington, VA, USA: Association of Official Analytical Chemists.

Hajeb, P., Jinap, S., Ismail, A., Fatimah, A. B., Jamilah, B. and Rahim, M. A. (2009). Assessment of mercury level in commonly consumed marine fishes in Malaysia. Food Control, **20**, 79–84.

Carvalho, M. L., Santiago, S., and Nunes, M. L. (2005). Assessment of the essential element and heavy metal content of edible fish muscle. Analytical and Bioanalytical Chemistry, **382**, 426–432.

Castilhos, Z. C. and Bidone, E. D. (2000) Hg Biomagnification in the lchthyofauna of the Tapajós River Region, Amazonia, Brazil. Bulletin of Environmental Contamination and Toxicology. **64**, 693-700. DOI: 10.1007/ s001280000059.

Dakeishi, M., Nakai, K., Sakamoto, M., Iwata, T., Suzuki K., Liu, X.J., Ohno, T., Kurosawa, T., Satoh, H. and Murata, K. (2005). Effects of hair treatment on hair mercury—the best biomarker of methylmercury exposure? Environ Health Prev. Med. **10**, 208–12.

Díez, S., Montuori, P., Pagano, A., Sarnacchiaro, P., Bayona, J. M. and Triassi, M. (2008). Hair mercury levels in an urban population from southern Italy: fish consumption as a determinant of exposure. Environ Int. **34**, 162–7.

Dural, M., Göksu, M. Z. L. and Ozak, A. A. (2007). Investigation of heavy metal levels in economically important fish species captured from the Tuzla lagoon. Food Chemistry, **102**, 415–421.

Fakour, H., Esmaili-Sari, A. and Zayeri, F. (2010). Mercury exposure assessment in Iranian women's hair of a port town with respect to fish consumption and amalgam fillings. Science of the Total Environment, **408**, 1538–1543.

Khansari, E., Ghazi-Kansari, M. and Abdollahi, M. (2005). Heavy metal content of canned tuna fish. Food Chemistry, **93**, 293–296.

Kureishy, W. T. (1993). Concentration of heavy metals in marine organisms around Qatar before and after the Gulf War oil spill. Marine Pollution Bulletin, **27**, 183–186.

Harada, M. (1995). Minamata disease: methylmercury poisoning in Japan caused by environmental pollution. Critical Reviews in Toxicology, **25**, 1–24.

Ikem, A. and Egiebor, N. O. (2005). Assessment of trace elements in canned fishes (mackerel, tuna, salmon, sardines and herrings) marketed in Georgia and Alabama (United States of America). Journal of Food Composition and Analysis, **18**, 771–787.

Madany, I. M., Wahab, A. A. A. and Alalawi, Z. (1996). Trace metal concentrations in marine organisms from the coastal areas of Bahrain, Arabian Gulf. Water, Air and Soil Pollution, **91**, 233–248.

MOOPAM. (1999). Manual of oceanographic observations and pollutants analysis methods (Third Edition). The Regional Organisation for the Protection of the Marine Environment (ROPME), Kuwait.

Ohno, T., Sakamoto, M., Kurosawa, T., Dakeishi, M., Iwata, T. and Murata K. (2007). Total mercury levels in hair, toenail, and urine among women free from occupational exposure and their relations to renal tubular function. Environmental Research, **103**, 191–7.

ROPME. (1999). State of the marine environment report 1999. The land base of the Persian Gulf. Iran: ROPME, Marine Department of Environmental Organization of Iran. Saeidi, M., Abtahi, B., Mortazavi, M. S., Aghajery, N. and Ghodrati Shojaeii., M. (2008). Zinc concentration in Spangied Emperor (*Lethrinus nebulosus*) tissues caught in Northern part of the Persian Gulf. Environmental Science, **6**, 75-82.

Saei-Dehkordi, S. S., Fallah, A. A. and Nematollahi, A. (2010). Arsenic and mercury in commercially valuable fish species from the Persian Gulf: Influence of season and habitat. Food and Chemical Toxicology, **48**, 2945–2950.

Torres-Escribano, S., Vélez, D. and Montoro, R., (2010). Mercury and methylmercury bioaccessibility in swordfish. Food Additive Contamination, **27**, 327–337.

Wiener, J. G., Krabbenhoft, D. P., Heinz, G. H. and Scheuhammer, A. M. (2003). Ecotoxicology of mercury. In D. J. Hoffman, B. A. Rattner, G. A. Burton, and J. Cairns (Eds.), Handbook of ecotoxicology (2nd ed., pp. 409–443). New York: Lewis Publishers.