Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

p-ISSN: 0972-6268
e-ISSN: 2395-3454

Vol. 16 | No. 2 | pp. 647-651 | 2017

Original Research Paper | Open Access

Concentration of Heavy Metals in Tissues of *Mugil cephalus* and *Lethrinus miniatus* from Jazan Coast, Saudi Arabia

Ali H. Bahhari*, Ibrahim N. Al-Switi* and Abdul Jabbar Al-Rajab†**
*Department of Zoology, College of Sciences, King Saud University, Riyadh, Saudi Arabia
**Center for Environmental Research and Studies, Jazan University, Jazan, Saudi Arabia
†Corresponding author: AJ Al-Rajab

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 27-05-2016
Accepted: 16-07-2016

Key Words:
Heavy metal
Seawater concentration
Mugil cephalus
Lethrinus miniatus
Red sea

ABSTRACT

Presence of heavy metals at high concentrations in edible fish might lead to some health issues for consumers. The current work determined the concentrations of four heavy metals Cd, Pb, Zn and Cu in seawater, gills and muscles of two common fishes, *Mugil cephalus* and *Lethrinus miniatus*, collected in summer 2014 from two different areas of Red Sea, Jazan, Saudi Arabia, using ICP-AES after microwave digestion procedure. The concentrations of investigated metals were higher in the gills than in muscles for the two fish species. However, the concentration of zinc was higher than other metals in all samples, in the following order Zn>Cu>Pb>Cd. The average of maximum metal concentration was measured for Zn (11.087 ± 1.672 mg kg^{-1}w.w) in the gills of *Lethrinus miniatus,* Cu (0.548 ± 0.249 mg kg^{-1}w.w) in the gills of *Mugilcephalu,* Pb (0.131 ± 0.092 mg kg^{-1}w.w) in the gills of *Mugilcephalu,* and Cd (0.064 ± 0.017 mg kg^{-1}w.w) in the gills of *Lethrinus miniatus.* Concentration of investigated metals in water was following the same order in the fish tissues Zn>Cu>Pb>Cd, with a maximum detected concentrations of 0.0233, 0.0085, 0.0059, and 0.0023 mg L^{-1}, respectively. Despite the detection of heavy metals in the edible tissues of investigated fish, the concentrations were within the recommended maximum residual level of FAO/WHO and EU. Therefore, the investigated fish might be considered safe for human consumption. More extended investigations are highly recommended.

INTRODUCTION

Fish is considered as an important part of the human diet providing protein, unsaturated fatty acids, minerals, and vitamins. Fish are used as indicators for monitoring the accumulation of heavy metals in aqua environment (Makedonski et al. 2015, Elnabris et al. 2013).

Heavy metals are considered as the main pollutants of marine ecosystem due to their high potential toxicity, non-biodegradable properties, wide sources, and accumulative behaviours in different organisms (Zhu et al. 2012). The concentrations of heavy metals in marine environment depend on the climate conditions, biogeochemical processes, human activities and current directions in the sea (Santos et al. 2003, Bruces et al. 1996). However, a proper management of the coastal area of the Red Sea is of the public and scientific concern regarding the high activities of humans in this area and the relatively low density of population along its coasts. The major resources of marine contamination with heavy metals are the industrial activities (shipping, sewages, etc.) and urbanization (Li et al. 2007). Ships traversing the Red Sea and carrying cargoes, which could contain hazardous materials, are a potential source of coastal contamination in case of any accident or spills (Saad & Fahmy 1994). Moreover, the poor efficiency of wastewater treatment plants in heavy metals removal might lead to contamination of seawater and sediments. Such pollution could have serious effects on coastal fisheries, mangroves, tourism and public health. The Saudi Red Sea coast extends for nearly 1932 km, about 350 km is in the Jazan area on the southeastern shore of Red Sea (Youssef 2015).

Jazan province is located in southwest of Saudi Arabia (16.4-18.33°N, 41.4-43.4°E, Fig. 1) covering an area of 13500 km^2 with a population of about 1.5 million. However, the coastal area of Jazan challenges some important environmental issues because of the urbanization and the growing industrial activities (Al-Hatim et al. 2015). Saad & Fahmy (1994) investigated the concentrations of heavy metals in coastal Red Sea waters in Jeddah. Their results showed high concentrations of heavy metals in eleven stations as follow: 6.68, 6.52, 1.69 and 1.05 $\mu g\ L^{-1}$ for Mn, Zn, Cu and Cd respectively. Badr et al. (2008) showed that sediment contamination with lead was high in the coastal area of Jeddah (KSA), the calculated contamination factors for investigated metals were: Cd, Pb, Ni, Cu, Zn, Cr, and Mn from the highest to lowest concentration. In the same study, lead and zinc reported to have the highest concentrations among other metals in sediments, fish and water samples, the concentrations of these two metals were below the maximum recommended limits of 53-2360 and 50-2497 for Pb and Zn, respectively.

The bioavailability of heavy metals in water has been reported in different studies. These metals could be accumulated in water for a certain period before getting released under specific physico-chemical conditions and enter in the food chain (Daka et al. 2003, Shokrzadeh et al. 2008, Shokrzadeh et al. 2009). Moreover, determination of the concentration of heavy metals in the aquatic environment and their potential hazardous levels for animals and humans is of public and scientific concern (Tabari et al. 2010). In this study, we investigated the concentrations of heavy metal (Zn, Cu, Pb, Cd) in the sea water and tissues of *Mugil cephalus* and *Lethrinus miniatus* from two different sites in Jazan, Saudi Arabia. To the best of our knowledge, this is the first study about the concentrations of heavy metal in sea water and these two investigated fish from the Jazan area.

MATERIALS AND METHODS

Sampling: Fish samples were collected at two stations of Jazan province (Jazan fishing port and Baish fishing port) during summer 2014 by professional fishermen (Fig. 1). The local fish market of Jazan is located nearby the Jazan fishing port which is the main fish supplier for the province.

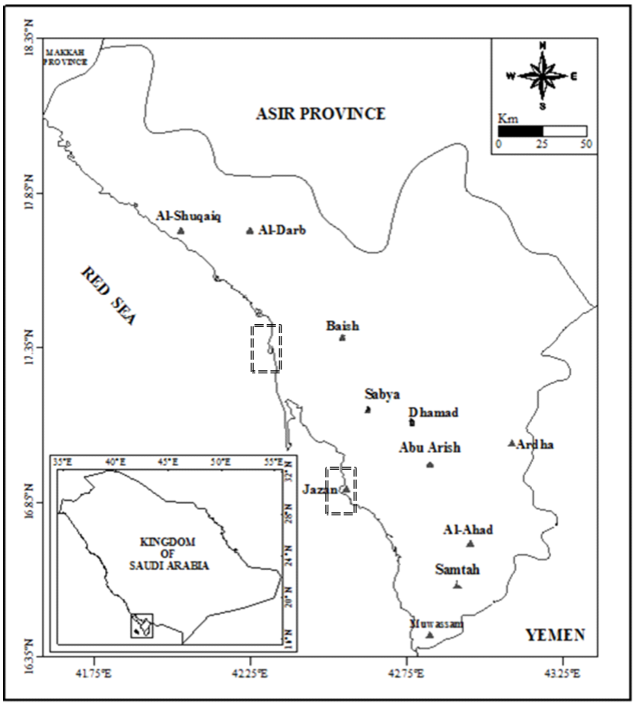

Fig. 1: Map of study area, Jazan city and Baish, southwestern Saudi Arabia.

Baish fishing port is located at less than 5 km south of the economic city of Baish which contains different heavy industries (steel, refinery, etc.).

Samples were transferred directly to the lab in a field cooler at 4°C, and kept in the refrigerator at 4°C till analysis within 48 h. In total 120 fish were collected from the two sites, 30 fish of *Mugil cephalus* and 30 fish of *Lethrinus miniatus* from each site. The length and weight of all samples were measured in the lab. The average length and weight of the fish were 39.2 ± 3.7 cm and 400 ± 51 g for *Mugil cephalus*, and 34.3 ± 4.1 cm and 450 ± 45.5 g for *Lethrinus miniatus*; there was no significant difference in the length and weight of each kind of fish from both sites. From each site, five water samples (1 L each) were collected in a clean polyethylene container washed twice with distilled water and a solution of 2% nitric acid before use. Samples were collected at an approximate depth of 50 cm below the surface. Water samples were transferred refrigerated in an ice cooler to laboratory for physico-chemical properties and heavy metals analyses.

Analytical methods: Samples preparation and analyses were done as follows: From each fish sample, the whole gills and 10 g of the epaxial muscle on the dorsal surface were taken out and weighed before digestion. Samples were homogenized separately, and 0.5 g of each organ were digested using concentrated nitric acid and hydrogen peroxide (4:1 v/v) according to FAO methods (FAO 2010). Samples were digested in Ethos Up microwave (Ethos, Milestone, Italy), then analysed using an inductively coupled plasma atomic emission spectrometry (ICP-AES; Agilent 7700, Agilent Technology, Santa Clara, CA, USA) for the concentrations of cadmium, lead, zinc and copper. Concentrations of heavy metals were calculated as milligram per kilogram (ppm) wet weight. For water samples, they were filtered using filter papers (Whatman, Sigma Aldrich, Germany), then 5 mL of each sample was placed in a microwave cell, then 5 mL of nitric acid and 1 mL of hydrogen peroxide was added. Samples were placed in Ethos Up microwave (Ethos, Milestone, Italy) for 27 min at 185°C. After digestion, samples were cooled and the volume completed to 50 mL with MilliQ water. Concentrations of Cd, Pb, Zn and Cu in water samples were determined using ICAP-AES as described above. Statistical analysis of data was carried out with Statistical Package for the Social Sciences SPSS software version 22, 2013 (IBM, USA). Independent samples *t*-test was used to compare data among fish and collection sites.

RESULTS

The mean values of investigated heavy metals (cadmium,

Table 1: Mean heavy metal concentrations (±S.D.) mg kg^{-1} in gills and muscles tissues of *Mugil cephalus* and *Lethrinus miniatus* collected from Jazan city and Baish, Saudi Arabia.

	Mugil cephalus				*Lethrinus miniatus*			
	Gill		Muscle		Gill		Muscle	
	Jazan	Baish	Jazan	Baish	Jazan	Baish	Jazan	Baish
Cd	0.019 ± 0.006	0.006 ± 0.005	0.005 ± 0.003	0.0003 ± 0.0001	0.064 ± 0.017	0.044 ± 0.024	0.007 ± 0.008	0.0001 ± 0.0002
Minimum-maximum	0.011 – 0.026	0.001 – 0.013	0.000 – 0.007	0.0002 – 0.0005	0.043 – 0.080	0.013 – 0.080	0.000 – 0.020	0.0000 – 0.0004
Pb	0.131 ± 0.092	0.063 ± 0.018	0.003 ± 0.001	0.003 ± 0.002	0.029 ± 0.022	0.014 ± 0.011	0.005 ± 0.005	0.004 ± 0.007
Minimum-maximum	0.050 – 0.260	0.039 – 0.080	0.001 – 0.005	0.000 – 0.004	0.003 – 0.049	0.002 – 0.031	0.002 – 0.014	0.000 – 0.017
Zn	6.783 ± 0.566	6.098 ± 0.079	2.891 ± 0.682	2.468 ± 0.741	11.087 ± 1.672	9.843 ± 2.180	1.495 ± 0.699	1.127 ± 0.387
Minimum-maximum	5.905 – 7.364	5.019 – 7.244	1.892 – 3.763	1.615 – 3.420	9.121 – 13.390	7.920 – 13.560	0.928 – 2.467	0.522 – 1.548
Cu	0.548 ± 0.249	0.348 ± 0.059	0.442 ± 0.250	0.2730 ± 0.089	0.377 ± 0.098	0.327 ± 0.067	0.340 ± 0.067	0.240 ± 0.153
Minimum-maximum	0.297 – 0.877	0.270 – 0.411	0.221 – 0.784	0.179 – 0.386	0.273 – 0.496	0.254 – 0.433	0.290 – 0.420	0.089 – 0.480

lead, zinc, and copper) are presented in Table 1 for *Mugil cephalus* and *Lethrinus miniatus* gills and muscles in two different sites of Jazan area (Jazan city and Baish). Cadmium concentration was higher in gills than in muscles for the two investigated fish in both the sites. Muscles and gills of fish collected from Jazan city contained significantly higher concentration of cadmium than those collected from Baish for *Mugil cephalus* and *Lethrinus miniatus*. But, the tissues of *Lethrinus miniatus* had higher concentration of cadmium than *Mugil cephalus* in both sites. Lead concentrations were significantly higher in gills than in muscle in *Mugil cephalus* and *Lethrinus miniatus.* Also, concentrations of lead in all samples collected from Jazan city were significantly higher than those collected from Baish. However, no significant difference found in the concentration of lead in the muscle of *Mugil cephalus* and *Lethrinus miniatus* (Table 1).

Zinc concentrations were significantly higher than other heavy metals in all samples and sites. Its concentrations in gills were higher than in muscle for *Mugil cephalus* and *Lethrinus miniatus.* The concentrations of zinc were higher in gills of *Lethrinus miniatus* than in *Mugil cephalus*; these findings were opposite in case of muscle, whereas the *Mugil cephalus* muscle contained higher concentration of zinc than *Lethrinus miniatus* (Table 1). On the other hand, the copper concentrations followed the same scenario as other investigated heavy metals. The copper concentration was higher in gills than in muscles for the two investigated fish and in both sites. Concentrations of copper in samples collected from Jazan city were higher than those determined in Baish samples (Table 1).

Results obtained from water samples of both sites were correlated to our findings in investigated fish. Table 2 shows the concentrations of cadmium, lead, zinc and copper in sea water samples collected from the two investigated sites. The concentrations of all determined heavy metals were higher in Jazan city site than in Baish. Zinc concentrations were significantly higher than other heavy metals, followed by copper and then lead; the lowest detected concentrations were for cadmium (Table 2).

DISCUSSION

Four selected heavy metals (Cd, Pb, Zn, Cu) were detected in gills and muscles of all fish collected from two sites of Jazan area. The concentrations of investigated metals were higher in the gills than in muscles for the two fish species. However, the concentration of zinc was higher than other metals in all samples, in the following order Zn>Cu>Pb>Cd. The maximum metal concentration was measured for Zn (11.087 ± 1.672 mg kg^{-1}w.w) in the gills of *Lethrinus*

Table 2: Mean heavy metal concentrations (±S.D.) mg L^{-1} in seawater collected from Jazan city and Baish, Saudi Arabia.

	Jazan	Baish
Cd	0.0023 ± 0.0041	0.0002 ± 0.0001
Minimum-maximum	0.0002 – 0.0097	0.0002 – 0.0003
Pb	0.0059 ± 0.0005	0.0034 ± 0.0013
Minimum-maximum	0.0051 – 0.0065	0.0019 – 0.0053
Zn	0.0233 ± 0.0009	0.0212 ± 0.0013
Minimum-maximum	0.0220 – 0.0241	0.0200 – 0.0230
Cu	0.0085 ± 0.0061	0.0078 ± 0.0009
Minimum-maximum	0.0006 – 0.0170	0.0067 – 0.0088

miniatus, Cu (0.548 ± 0.249 mg kg^{-1}w.w) in the gills of *Mugilcephalu,* Pb (0.131 ± 0.092 mg kg^{-1}w.w) in the gills of *Mugilcephalu,* and Cd (0.064 ± 0.017 mg kg^{-1}w.w) in the gills of *Lethrinus miniatus*. Similar results were reported by Elnabris et al. (2013) in six fish species collected from Gaza market (Palestine), whereas the concentrations of metals found in muscles ranged as, Zn: 3.71-20.54, Cu: 0.25-0.91, Pb: 0-0.55, and Cd: 0-0.09 mg kg^{-1} wet weight. However, fish muscles present the most edible portion of commercial fish, but they are not considered as active accumulation tissues for heavy metals (Bahnasawy et al. 2009, Al-Switi & Hasayen 2013). But, in highly polluted environments, the heavy metals might be accumulated in different fish tissues including muscles at levels exceeding the maximum acceptable limit (Kalay et al. 1999).

Concentration of investigated metals in water was following the same order in the fish tissues Zn>Cu>Pb> Cd, with a maximum detected concentrations of 0.0233, 0.0085, 0.0059, and 0.0023 mg L^{-1}, respectively. Our results were in accordance with the results reported by Saad & Fahmy (1994), who found the concentrations of heavy metals in coastal Red Sea waters in Jeddah. Their results showed high concentrations of heavy metals in eleven stations as follow: 6.68, 6.52, 1.69 and 1.05 µg L^{-1} for Mn, Zn, Cu and Cd respectively. Despite the detection of heavy metals in the edible tissues of investigated fish, the concentrations were within the recommended maximum residual level of FAO (FAO 2010) and EU (EU 2001). Therefore, the investigated fishes might be considered safe for human consumption.

CONCLUSIONS

This study monitored the presence of heavy metal concentration (Cd, Pb, Zn, and Cu) in seawater, gills and muscle tissues of two common fishes *Mugil cephalus* and *Lethrinus miniatus.* The concentrations of investigated metals were higher in the gills than in muscles for the two fish species. However, the concentration of zinc was higher than other metals in all the samples, in the following order Zn>Cu>Pb>Cd. Concentration of investigated metals in water was in the same order as in the fish tissues. Despite the detection of heavy metals in the edible tissues of investigated fish, the concentrations were within the recommended maximum residual level of FAO/WHO and EU. Therefore, the investigated fish might be considered safe for human consumption. More extended investigations are highly recommended. However, a proper wastewater treatment and effective environmental friendly planning of industrial activities in the coastal area are highly recommended to reduce the contamination risk of marine environment with heavy metals.

ACKNOWLEDGEMENT

The authors thank King Saud University for the financial support to this project.

REFERENCES

Al-Hatim, H.Y., Alrajhi, D. and Al-Rajab, A.J. 2015. Detection of pesticide residue in dams and well water in Jazan area, Saudi Arabia. American Journal of Environmental Sciences, 11(5): 358-365.

Al-Switi, I.N. and Hasayen, K.A. 2013. The comparison of heavy metal concentration in commercial marine fish collected from Red sea and Arabian Gulf in between 2009-2013, with reference to national and international standards. Ultra Scientist, 25(1)B: 75-84.

Badr, N.B.E., El-Fiky, A., Mostafa, A.R. and Al-Mur, B.A. 2008. Metal pollution records in core sediments of some Red sea coastal areas, Kingdom of Saudi Arabia. Environ. Monit. Assess., DOI 10.1007/s10661-008-0452-x.

Bahnasawy, M., Khidr, A. and Dheina, N. 2009. Seasonal variations of heavy metals concentrations in Mullet, *Mugil cephalus* and *Liza ramada* (Mugilidae) from Lake Manzala, Egypt. J. Appl. Sci. Res., 5: 845-852.

Bruces, W.R., Vandam, L.F., Bell, R.G., Green, M.O. and Kim, J.P. 1996. Heavy metal and suspended sediment fluxes from a contaminated, intertidal inlet (Manukau Harbour, New Zealand). Marine Pollution Bulletin, 32: 812-822.

Daka, E.R., Allen, J.R. and Hawkins, S.J. 2003. Heavy metal contamination in sediment and biomonitors from sites in the Isle of Man. Marine Pollution Bulletin, 46(6): 784-794.

Elnabris, K.J., Muzyed, S.M. and El-Ashgar, N.M. 2013. Heavy metal concentrations in some commercially important fishes and their contribution to heavy metals exposure in Palestinian people of Gaza Strip (Palestine). Journal of the Association of Arab Univer-

sities for Basic and Applied Sciences, 13: 44-51.
EU 2001. Commission Regulation as regards heavy metals, Directive, 2001/22/EC, No: 466.
FAO 2010. The State of World Fisheries and Aquaculture, <http://www.fao.org/docrep/013/i1820e/i1820e.pdf>.
Kalay, M., Aly, O. and Canil, M. 1999. Heavy metal concentrations in fish tissues from the Northeast Mediterranean sea. Bull. Environ. Contam. Toxicol., 63: 673-681.
Li, R.Y., Yang, H., Zhou, Z.G, Lu, J.J., Shao, X.H. and Jin, F. 2007. Fractionation of heavy metals in sediments from Dianchi lake, China. Pedosphere, 17(2): 265-272.
Makedonski, L., Peycheva, K. and Stancheva M. 2015. Determination of some heavy metal of selected black sea fish species, Food Control. 72: 313-318.
Saad. M.A.H. and Fahmy, M.A. 1994. Heavy metal pollution in coastal Red Sea waters, Jeddah. JKAU: Mar. Sci., 7: 67-74.
Santos, B.J.C., Belter, N.R. and Gomez, A.J.L. 2003. Spatial variations of heavy metals contamination in sediments from Odiel River (Southwest Spain). Environment International, 29: 69-77.
Shokrzadeh, M., Saberyan, M. and Saravi, S.S.S. 2008. Assessment of lead (Pb) and cadmium (Cd) in 10 samples of Iranian and foreign consumed tea leaves and dissolved beverages. Toxicological and Environmental Chemistry, 90(5): 879-883.
Shokrzadeh, M., Saravi, S.S.S. and Yazdi Y.Z. 2009. Lindane residues in cultivated cucumber and in the most consumed fish in Caspian Sea (Iran). Toxicology and Industrial Health, 25(8): 517-523.
Tabari, S., Saravi, S.S.S., Bandany, G.A., Dehghan, A. and Shokrzadeh, M. 2010. Heavy metals (Zn, Pb, Cd and Cr) in fish, water and sediments sampled form Southern Caspian Sea, Iran. Toxicology and Industrial Health, 26(10): 649-656.
Youssef, M. 2015. Heavy metals contamination and distribution of benthic foraminifera from the Red Sea coastal area, Jeddah, Saudi Arabia. Oceanologia, 57: 236-250.
Zhu, H.N., Yuan, X.Z., Zeng, G.M., Jiang, M., Liang, J., Zhang, C., Yin, J., Huang, H.H., Liu, Z.F. and Jiang, H.W. 2012. Ecological risk assessment of heavy metals in sediments of Xiawan Port based on modified potential ecological risk index. Trans. Nonferrous Met. Soc. China., 22: 1470-1477.