Bull Environ Contam Toxicol (2012) 89:82–85
DOI 10.1007/s00128-012-0646-3

Lead Bioaccumulation and Toxicity in Tissues of Economically Fish Species from River and Marine Water

Abolfazl Askary Sary · Maryam Mohammadi

Received: 14 December 2011 / Accepted: 6 April 2012 / Published online: 25 April 2012

Abstract Bioaccumulation of lead was determined in muscle and liver of *Barbus xanthopterus*, *Liza abu*, *Barbus grypus*, *Acanthopagrus latus*, *Platycephalus indicus*, *Otolithes ruber* exposed to lead contaminated river and marine in Khouzestan. Significant variations in metal values were evaluated using student's *t* test at $p < 0.05$. In river fish, liver was polluted in comparison with muscle and high level was in *B. xanthopterus* (2.80 mg kg^{-1} wet weight) except for *B. grypus* in Karkhe River (1.73 mg kg^{-1}wet weight). In marine fish, muscle was contaminated than liver and high level was in *O. ruber* (47.18 mg kg^{-1}wet weight) except for *O. ruber* in Mahshahr seaport (17.85 mg kg^{-1} wet weight).

Keywords Lead · Fish · River · Marine

A great number of major pollutants have entered aquatic systems such as rivers, lakes, marine and oceans. Several pollutants such as heavy metals (e.g., lead) are very toxic, stable and not easily biodegradable. The ingestion of food is known as an important way of exposure to heavy metals. Heavy metals such as lead can be very harmful even at low concentrations when ingested over a long time. Amongst food, fish are constantly exposed to heavy metals present in polluted water. Thus, fish have been found to be good bioindicators or biosensor of heavy metal contamination in aquatic systems. Consumption of fish is very popular amongst people all around the world because it has high protein content, low saturated fatty acids and high omega fatty acids content (Tuzen and Soylak 2007).

The release of heavy metals into the environment has alarmingly increased because of emissions from automobiles, coal burning, mining, industrial activities and trash incineration. Most heavy metals are released into the environment then find their way into the aquatic phase as a result of direct input, atmospheric deposition and erosion caused by rains. Therefore, aquatic animals may be exposed to elevated levels of heavy metals. Contamination of the aquatic ecosystem by heavy metals can be monitored in water, sediment and organisms (Agarwal et al. 2007). The high accumulation of heavy metals in the aforementioned components can result in serious ecologic changes. Lead is globally well-distributed environmental heavy metal pollutant released from natural and anthropogenic sources. Once it is released into the environment, it circulates between air, water, soil and biota in various forms (Altindag and Yigit 2005).

There are considerable rivers in Khouzestan including Karoon, Dez, Bahmanshir and Karkhe Rivers. Also, Mahshahr and Abadan Seaports are important marine waters in Khouzestan, Iran. They play an important role in water and fish supply which have great economic values. *Barbus xanthopterus*, *Barbus grypus*, *Liza abu*, *Acanthopagrus latus*, *Platycephalus indicus* and *Otolithes ruber* have high market value and are the main fish products in water resources in Khouzestan.

Fish serve as a valuable and nutritious component of the human diet. Lead through this important food source is major threats to health. Humans who consume significant amounts of contaminated fish may be at risk. Fish are important indicators of surface and groundwater pollution through municipal waste and industrial effluents. Because heavy metals constitute an important segment of chemical

A. Askary Sary · M. Mohammadi (✉)
Department of Fisheries, Ahvaz Branch, Islamic Azad University, P.O. Box 1915, 618491-8411 Ahvaz, Khouzestan, Islamic Republic of Iran
e-mail: M40.mohammadi@gmail.com

pollutants, it was considered worthwhile to investigate a major toxic metal (i.e., lead) in edible economically fish species available in the water resources of Khouzestan that might cause adverse health effects for the consumer.

Materials and Methods

The concentrations of lead were measured in the muscle and liver of *B. xanthopterus*, *B. grypus* and *L. abu* from river, *A. latus*, *P. indicus* and *O. ruber* from marine caught by gillnet in Khouzestan in summer 2010. The number of samples was 48 fish in each river and seaport. After capture, fishes were placed in plastic bags and transported to the laboratory in freezer bags with ice and then fish were immediately frozen at −20°C.

All reagents were of analytical reagent grade unless otherwise stated. Double deionised water (Milli-Q Millipore 18.2 MΩ cm^{-1} resistivity) was used for all dilutions. HNO_3, H_2O_2 and HCl were of suprapur quality (E. Merck, Darmstadt, Germany). All the plastic and glassware were cleaned by soaking in dilute HNO_3 (1/9, v v^{-1}) and were rinsed with distilled water prior to use. The element standard solutions used for calibration were produced by diluting a stock solution of 1,000 mg L^{-1} of the given element supplied by Sigma Chem. Co. St. Louis, USA. Lead was determined in graphite furnace. For graphite furnace measurements, argon was used as inert gas. Pyrolytic-coated graphite tubes (Perkin Elmer Part No. B3 001264) with a platform were used. Samples were injected into the graphite furnace using Perkin Elmer AS-800 autosampler. The atomic absorption signal was measured as a peak height mode against an analytical curve. Milestone Ethos D microwave (Sorisole-Bg, Italy) closed system (maximum pressure 1,450 psi, maximum temperature 300°C) was used.

One gram of sample was digested with 6 mL of concentrated HNO_3 (65 %) (Suprapure, Merck, Darmstadt, Germany) and 2 mL of concentrated H_2O_2 (30 %) (Suprapure, Merck, Darmstadt, Germany) in microwave digestion system and diluted to 10 mL with double deionized water (Milli-Q Millipore 18.2 M cm^{-1} resistivity). A blank digest was carried out in the same way (digestion conditions for microwave system were applied as 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, vent: 8 min, respectively) (Tuzen 2009). The whole data were subjected to a statistical analysis and correlation matrices were produced to examine the inter-relationships between the investigated trace metal concentrations of the samples. Data statistics were performed using SPSS 17 software. Paired samples *T* Test were used to compare differences between samples. A *p* value less of 0.05 was considered statistically significant.

Results and Discussion

Lead levels in muscles and liver of marine fish (*A. latus*, *P. indicus* and *O. ruber*) were high in comparision with river fish (*B. xanthopterus*, *B. grypus* and *L. abu*) (Tables 1 and 2). Lead levels in muscle and liver of *O. ruber* in Abadan seaport were higher than other species in river and marine waters. In this research lead levels have significant differences ($p < 0.05$) in muscle and liver between marine and river fish except for lead levels in liver of *B. xanthopterus* in Karoon River and *A. latus* in Mahshahr Seaport.

In river species, lead level in muscle of *B. xanthopterus* in Karoon River was higher than other species in rivers and the levels of lead in *B. grypus* in Karoon and Karkhe Rivers were higher than *B. xanthopterus* in Dez River. *B. grypus* in Karkhe River was polluted than *B. grypus* in Karoon River. Lead levels in muscles of *L. abu* in Bahmanshir, Karoon and Dez Rivers were higher than those in *L. abu* in Karkhe River which *L. abu* in Bahmanshir, Karoon, Dez and Karkhe Rivers were less polluted in comparision with *B. xanthopterus* in Karoon and Dez Rivers and *B. grypus* in Karoon and Karkhe Rivers. Generally, in this research in rivers the muscles of *B. xanthopterus* in Karoon River and *L. abu* in Karkhe River had the maximum and minimum levels of lead. In marine species, lead level in muscle of *O. ruber* in Abadan seaport was high in comparision with other marine species and lead level in *O. ruber* in Mahshahr Seaport was higher than *A. latus* and *P. indicus* and *P. indicus* was polluted in comparision with *A. latus*. Also, the muscle of *A. latus* in Mahshahr Seaport had the lowest cadmium level (Table 1).

In river fish, lead level in liver of *B. xanthopterus* in Karoon River was higher than other species in rivers and the level of lead in *B. grypus* in Karoon River was higher than *B. grypus* in Karkhe River and *B. xanthopterus* in Dez River which *B. xanthopterus* in Dez River was polluted in comparision with *B. grypus* in Karkhe River and *L. abu* in Bahmanshir, Karoon, Dez and Karkhe Rivers. The lead levels in *L. abu* in Bahmanshir and Karoon Rivers were the same (1.03 mg kg^{-1}) and higher than *L. abu* in Dez and Karkhe Rivers. In this research in rivers the liver of *B. xanthopterus* in Karoon River and *L. abu* in Karkhe River had the maximum and minimum levels of lead which was similar to the muscle of river fish. In marine fish, lead level in liver of *O. ruber* in Abadan seaport was high in comparision with other marine species and lead level in *O. ruber* in Mahshahr Seaport was higher than *A. latus* and *P. indicus* and *P. indicus* was polluted in comparision with *A. latus*. Also, the liver of *A. latus* in Mahshahr Seaport had the lowest cadmium level (Table 2).

Concentrations of lead detected in the muscle and liver samples showed different capacities for accumulating. In this research the results showed that the liver of river fish have higher levels of lead than muscle and was polluted in

Table 1 Lead levels (mg kg^{-1} wet weight) in muscle of river and marine fish

Species	n	Location	Mean ± SD	Min	Max
B. xanthopterus (a)	48	Karoon River	2.240 ± 0.37^{a}	1.87	2.69
B. xanthopterus (b)	48	Dez River	1.00 ± 0.08^{b}	0.79	1.04
B. grypus (a)	48	Karoon River	1.69 ± 0.16^{c}	1.52	1.87
B. grypus (c)	48	Karkhe River	1.73 ± 0.09^{d}	1.67	1.81
L. abu (d)	48	Bahmanshir River	0.92 ± 0.11^{e}	0.91	0.93
L. abu (a)	48	Karoon River	0.91 ± 0.06^{f}	0.90	0.92
L. abu (b)	48	Dez River	0.91 ± 0.03^{g}	0.90	0.92
L. abu (c)	48	Karkhe River	0.71 ± 0.21^{h}	0.49	0.82
A. latus (e)	48	Mahshahr Seaport	3.02 ± 0.57^{i}	2.65	3.56
P. indicus (e)	48	Mahshahr Seaport	9.84 ± 1.67^{j}	8.16	10.64
O. ruber (e)	48	Mahshahr Seaport	16.17 ± 4.30^{k}	13.15	19.87
O. ruber (f)	48	Abadan Seaport	47.18 ± 6.56^{l}	41.14	59.16
WHO			0.3		Czarnezki (1985)
FAO			0.5		FAO (1983)
MAFF			2		MAFF (1995)
NHMRC			1.5		Darmono and Denton (1990)

[a, b, c, d, e, f, g, h, i, j, k, l] $p < 0.05$, significantly different in muscle of fish in river and marine of Khouzestan. (a), (b), (c), (d) Fish is sampled from river and (e), (f) Fish is sampled from marine. n = number of sample

Table 2 Lead levels (mg kg^{-1} wet weight) in liver of river and marine fish

Species	n	Location	Mean ± SD	Min	Max
B. xanthopterus (a)	48	Karoon River	2.80 ± 0.25^{a}	2.61	3.06
B. xanthopterus (b)	48	Dez River	1.30 ± 0.06^{b}	1.24	1.37
B. grypus (a)	48	Karoon River	2.02 ± 0.29^{c}	1.87	2.17
B. grypus (c)	48	Karkhe River	0.91 ± 0.17^{d}	0.79	1.01
L. abu (d)	48	Bahmanshir River	1.03 ± 0.12^{e}	0.99	1.41
L. abu (a)	48	Karoon River	1.03 ± 0.20^{f}	1.00	1.11
L. abu (b)	48	Dez River	0.92 ± 0.07^{g}	0.91	0.93
L. abu (c)	48	Karkhe River	0.80 ± 0.11^{h}	0.71	0.88
A. latus (e)	48	Mahshahr Seaport	$2.96 \pm 0.29^{i,a}$	2.76	3.14
P. indicus (e)	48	Mahshahr Seaport	7.64 ± 2.46^{j}	5.04	9.69
O. ruber (e)	48	Mahshahr Seaport	17.85 ± 1.69^{k}	16.11	20.01
O. ruber (f)	48	Abadan Seaport	29.60 ± 3.22^{l}	25.90	31.20

[a, b, c, d, e, f, g, h, i, j, k, l] $p < 0.05$, significantly different in liver of fish in river and marine of Khouzestan. (a), (b), (c), (d) Fish is sampled from river and (e), (f) Fish is sampled from marine. n = number of sample

comparision with muscle ($p < 0.05$) except for *B. grypus* in Karkhe River which lead level in muscle was higher than liver.

The liver in fish is more often recommended as environmental indicator organ of water pollution than other fish organs. The relatively high concentrations of heavy metals in liver were also found in different species of fish in Tigris River and Atatürk Dam Lake (Karadede and Ünlü 2000). The accumulation of metals in the liver could be due to the greater tendency of the elements to react with the oxygen carboxylate, amino group, nitrogen and/or sulphur of the mercapto group in the metal-lothionein protein, whose concentration is highest in the liver. The liver has the ability to accumulate large quantities of pollutants from the external environment and also plays an important role in storage, redistribution, detoxification and transformation of pollutants. The Liver accumulates high concentration of metal regardless of the uptake route. It is one of the major sites of metal metabolism and detoxication in fish, and it is considered as a good monitor of water pollution (Jezierska and Witeska 2006).

Similarly to what we have said in relation to the liver, the mean lead concentrations in the muscle of marine fish were higher than those found in the liver ($p < 0.05$) except for *O. ruber* in Mahshahr Seaport which lead level in liver was higher than muscle. The metal concentration in muscle is important for the edible parts of the fish. Fish generally accumulate contaminants from aquatic environments, have been largely used in food safety studies. Muscles are often examined for metal content due to their use for animal and human consumption. They were also implicated in long-term metal storage in fish organisms (Alibabic et al. 2007).

The maximum lead level permitted is 0.3 mg kg^{-1} for WHO (Czarnezki 1985), 0.5 mg kg^{-1} for FAO (1983), 2.0 mg kg^{-1} for MAFF (1995) and 1.5 mg kg^{-1} for NHMRC (1990). Generally, lead levels in muscle of analyzed fish samples were found to be higher than guidelines except for *B. xanthopterus* in Dez River, *L. abu* in Bahmanshir, Karoon, Dez, Karkhe Rivers which lead levels were lower than MAFF and NHMRC guidelines. Also, lead levels in *B. grypus* in Karoon and Karkhe Rivers were lower than MAFF guideline (Table 1). Contaminants in fish can pose a health risk to the fish themselves and to humans who consume them.

In the literature lead contents in the muscle of fish have been reported as 0.39 mg kg^{-1} in *Labeo rohita* and 1.32 mg kg^{-1} in *Ctenopharyngodon idella* in lake of Bhopal, India (Malik et al. 2010), 1.23 mg kg^{-1} in *Tor grypus* in Atatürk Dam Lake, Turkey (Oymak et al. 2009). Also, the mean of lead concentrations in muscle of *B. grypus* and *B. xanthopterus* in Karoon and Dez Rivers in Khouzestan, Iran, were reported as: 1.75, 1.29 and 2.37, 0.95 mg kg^{-1} respectively (Mohammadi et al. 2011).

Lead is known to induce reduced cognitive development and intellectual performance in children and increased blood pressure and cardiovascular disease in adult (Commission of the European Communities 2001).

Lead is a cumulative poison that cause both chronic and acute intoxication. Chronic exposure to lead results in its deposition and immobilization in the bone, from where lead can be mobilized following disturbance. Acute lead toxicity symptoms in man are lassitude, vomiting, loss of appetite, unco-ordinated body movements, convulsions and coma. Chronic lead toxicity symptoms are renal malfunction, anemia, brain and liver damage, cancer, hyperactivity and general psychologic impairment. Children suffer permanent damage to the central nervous system (Ryan et al. 2000). To protect man from the harmful effects of lead, the weekly intake by human should not exceed the levels given by the World Health Organization (WHO, 1978). This level is 300 μg/60 kg of mean body weight. For young children, it should not exceed 25 μg kg^{-1} body weight (WHO 1987).

The current data indicate that some fish in the river and marine water in Khouzestan is contaminated with lead so as to cause health risk. The data of the study may be helpful in the follow-up investigation on the monitoring of river and marine water pollution as a biomarker.

References

Agarwal R, Kumar R, Behari JR (2007) Mercury and lead content in fish species from the river Gomti, Lucknow, India, as biomarkers of contamination. Bull Environ Contam Toxicol 78:118–122

Alibabic V, Vahcic N, Bajramovic M (2007) Bioaccumulation of metals in fish of salmonidae family and the impact on fish meat quality. Environ Monit Assess 131:349–364

Altindag A, Yigit S (2005) Assessment of heavy metal concentrations in the food web of lake Beysehir, Turkey. Chemosphere 60: 552–556

Commission of the European Communities (2001) Commission regulation (EC) No. 221/2002 of 6 February 2002 amending regulation (EC) No. 466/2002 setting maximum levels for certain contaminants in foodstuffs. Official Journal of the European Communities, Brussels, 6 Feb 2002

Czarnezki JM (1985) Accumulation of lead in fish from Missouri streams impacted by lead mining. Bull Environ Contam Toxicol 34:736–745

Darmono D, Denton GRW (1990) Heavy metal concentration in the banana prawn (*Penaeus merguiensis*) and leader prawn (*P. monodon*)in the Townsvile region of Australia. Bull Environ Contam Toxicol 44:479–486

FAO (Food and Agriculture Organization) (1983) Compilation of legal limits for hazardous substances in fish and fishery products, FAO Fishery Circular, Food and Agriculture Organization of the United Nations, Rome. No. 464, pp 5–10

Jezierska B, Witeska M (2006) The metal uptake and accumulation in fish living in polluted waters. In: Twardowska I et al (eds) Soil and water pollution monitoring, protection and remediation. Springer, New York, pp 3–23

Karadede H, Ünlü E (2000) Concentrations of some heavy metals in water, sediment and fish species from the Atatürk Dam Lake (Euphrates), Turkey. Chemosphere 41:1371–1376

MAFF (1995) Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1993. Aquatic Environment Monitoring Report No. 44. Direcorate of Fisheries Research, Lowestoft

Malik N, Biswas AK, Qureshi TA, Borana K, Virha R (2010) Bioaccumulation of heavy metals in fish tissues of a freshwater lake of Bhopal. J Environ Monit Assess 160(4):267–276

Mohammadi M, Askary sary A, Khodadadi M (2011) Determination of heavy metals in two barbs, *Barbus grypus* and *Barbus xanthopterus* in Karoon and Dez Rivers, Khoozestan, Iran. Bull Environ Contam Toxicol 87:158–162

Oymak SA, Karadede-Akin H, Dogan N (2009) Heavy metal in tissues of *Tor grypus* from Atatürk Dam Lake, Euphrates River-Turkey. Biologia 64(1):151–155

Ryan PB, Huet N, Maclntosh D (2000) Longitudinal investigation of exposure to arsenic, cadmium and lead in drinking water. Environ Health Perspect 108:731–735

Tuzen M (2009) Toxic and essential trace elemental contents in fish species from the Black Sea, Turkey. Food Chem Toxicol 47(8): 1785–1790

Tuzen M, Soylak M (2007) Determination of trace metals in canned fish marketed in Turkey. Food Chem 10:1378–1382

WHO (1978) Air quality guidelines for Europe. WHO Regional Publications, European Series No. 23. Copenhagen. WHO Regional Office for Europe, Geneva

WHO (1987) Evaluation of certain food additives and contamination, Technical Report Series No. 631. WHO, Geneva