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Arsenic concentrations in commercial fish from freshwater and saltwater

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Abstract

Research was performed to investigate the concentration of arsenic in muscle and liver of fish species from freshwater, *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus* in Karoon Rivers and saltwater, *Liza dussumieri*, *Liza klunzingeri*, *Liza macrolepis*, *Scomberomorus commerson*, *Otolithes ruber*, *Scomberomorus guttatus*, in Persian Gulf, Iran. Arsenic levels in muscles of seaport fish were high in comparision with riverine fish. Arsenic levels in muscle of *Scomberomorus guttatus* in Hendijan Seaport were higher than other species in freshwater and saltwater. Generally, in this research arsenic levels have significant differences ($P<0.05$) in muscles of fish between freshwater and saltwater except for *Liza macrolepis* in Hendijan Seaport which did not have significant differences with *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus* in Karoon River. Arsenic levels in muscle of *Barbus luteus* in Karoon River were higher than other species in freshwater. In saltwater species, arsenic level in muscle of *Scomberomorus guttatus* in Hendijan Seaport was high in comparision with other saltwater species. The results indicated that the muscles of fishes were highly contaminated by arsenic and exceeded WHO 0.02 mg kg^{-1} legal limits.

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Introduction

Iran has various water resources such as freshwater and saltwater and it is located in southern part of Iran. These water resources supply the water demands of numerous cities, several villages, thousands hectares of agricultural lands and several hydropower plants. The Persian Gulf is located in the south of Iran with average area and depth of 240,000 km² and 35 m, respectively. Hendijan Seaport are important saltwater

Resources in Khouzestan from Persian Gulf. They play an important role in water and fish supply which have great economic values. *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus*, *Liza dussumieri, Liza klunzingeri*, *Liza macrolepis*, *Scomberomorus commerson*, *Otolithes ruber*, *Scomberomorus guttatus* have high market value and are the main fish products in water resources in Iran.

Fish are a major part of the human diet and it is therefore not surprising that numerous studies have been carried out on metal pollution in different species of edible fish. In recent years, fish lipids have also assumed great nutritional significance, because of their high polyunsaturated fatty acid levels and good source of digestible protein, vitamins, minerals (Prudente *et al.*, 1997; Puwastien *et al.*, 1999; Kucuksezgin *et al.*, 2001; Lewis *et al.*, 2002; Ikem & Egiebor, 2005).

Anthropogenic sources such as industrial wastes, agriculture and urban sewage, geochemical structure and mining of metals create a potential source of heavy metals pollution in the aquatic environment and its contamination has been identified as a concern in coastal environments. The contamination chain of heavy metals almost always follows the cyclic order: industry, atmosphere, soil, water, phytoplankton, zooplankton, fish and human. Heavy metals can be accumulated by aquatic organisms through a variety of pathways, including respiration, adsorption and ingestion and often reach the human body by ingestion (Mendil *et al.*, 2010). It is known that arsenic, mercury, lead and cadmium are the most commonly distributed environmental metal poisons (Castro-Gonzalez & Mendez-Armenta, 2008). Arsenic (As) is a non-essential element to both humans and plants (Shamberger, 1979; Kabata-Pendias & Pendias, 1986). Arsenic accumulated in human tissues and may be the cause of some diseases (Rodriguez *et al.*, 2003; Yilmaz *et al.*, 2007). Toxicity of As greatly depends on its chemical form or species, with inorganic arsenic more toxic than organic arsenic (Korte & Fernando 1991; Lin *et al.*, 2008). Very little data is available on arsenic speciation in freshwater and saltwater fish.

The main objective of this study was to determinate the contents of arsenic in the muscle and liver of some commercial fish such as *Barbus luteus*, Aspius *vorax*, *Cyprinion macrostomus*, *Liza dussumieri, Liza klunzingeri*, *Liza macrolepis*, *Scomberomorus commerson*, *Otolithes ruber*, *Scomberomorus guttatus* in water resources of Persian Gulf and Karoon River, Iran, in order to assess fish quality and to assess the health risk for humans. This could help us understand the enrichment behavior of arsenic in freshwater and saltwater in iran and emphasize the need to discard the most polluted tissues of the fish.

Materials and methods

Collection of samples

The concentrations of arsenic were measured in the muscle and liver of *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus*, *Liza dussumieri, Liza klunzingeri*, *Liza macrolepis*, *Scomberomorus commerson*, *Otolithes ruber*, *Scomberomorus guttatus* from freshwater and saltwater caught by gillnet in Persian Gulf (Hendijan Seaport) and Karoon Rivers in winter 2011. The number of samples was 36 fish in each river and seaport. After capture, fish were placed in plastic bags and transported to the laboratory in freezer bags with ice and then fish were immediately frozen at -20° C.

Sample analysis

All reagents were of analytical reagent grade unless otherwise stated. Double deionised water (Milli-Q

Millipore 18.2 MX cm-1 resistivity) was used for all dilutions. HNO3, H2O2 and HCl were of suprapur quality (E. Merck, Darmstadt, Germany). All the plastic and glassware were cleaned by soaking in dilute HNO3 (1/9, v/v) 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 of the given element supplied by Sigma Chem. Co. St. Louis, USA. Perkin Elmer Analyst 700 model AAS equipped with MHS 15 CVAAS system was used for mercury determination. A hallow cathode lamp operating at 6 mA was used and a Spectral bandwidth of 0.7 nm was selected to isolate the 253.7 nm mercury line. NaBH4 (1.5%) (w/v) in NaOH (0.5%) (w/v) was used as reducing agent. The analytical measurement was based on peak height. Reading time and argon flow rate was selected as 10 s and 50 ml min-1. 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 HNO3 (65%) (Suprapure, Merck, Darmstadt, Germany) and 2 ml of concentrated H2O2 (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).

Statistical analysis

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

The concentrations of arsenic (mg kg-1 wet weight) in muscle and liver of *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus* from freshwater, *Liza dussumieri, Liza klunzingeri*, *Liza macrolepis*, *Scomberomorus commerson*, *Otolithes ruber*, *Scomberomorus guttatus* from saltwater are summarized in Tables 1 and 2. Arsenic levels in muscles of seaport fish were high in comparision with riverine fish. The arsenic species distribution in marine ecosystems has been relatively well known for some time. On the other hand, not much is known about arsenic species in terrestrial and freshwater systems (Slejkovec *et al.*, 2004).

Arsenic levels in muscle of *Scomberomorus guttatus* in Hendijan Seaport were higher than other species in freshwater and saltwater. Generally, in this research arsenic levels have significant differences ($P<0.05$) in muscles of fish between freshwater and saltwater except for *Liza macrolepis* in Hendijan Seaport which did not have significant differences with *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus* in Karoon River. Also, arsenic levels in muscle of *Scomberomorus commerson* in Hendijan Seaport which did not have significant differences with *Otolithes ruber* and *Scomberomorus guttatus*. Arsenic levels in muscle of *Barbus luteus* in Karoon River were higher than other species in freshwater. In saltwater species, arsenic level in muscle of *Scomberomorus guttatus* in Hendijan Seaport was high in comparision with other saltwater species.

Fig 1. Arsenic levels (mg kg-1 wet weight) in muscle of freshwater and saltwater fish

Species	n	Location	Mean ± SD
Barbus luteus	36	Karoon River	0.079±0.001[a]
Aspius vorax	36	Karoon River	0.077±0.002[a]
Cyprinion macrostomus	36	Karoon River	0.073±0.00[a]
Liza dussumieri	36	Boshehr Seaport	0.106±0.005[b]

Species	n	Location	Mean ± SD
Liza klunzingeri	36	Hendijan Seaport	0.097±0.004[c]
Liza macrolepis	36	Hendijan Seaport	0.086±0.002[d]
Scomberomorus commerson	36	Hendijan Seaport	0.272±0.027[e]
Otolithes ruber	36	Hendijan Seaport	0.175±0.024[f]
Scomberomorus guttatus	36	Hendijan Seaport	0.294±0.019[e]

a, b, c, d, e, f P>0.05, significantly different in muscle of fish, n= number of sample

This study arsenic levels in the muscles of the analyzed fish ranged from 0.073 $mgKg^{-1}$ in *Cyprinion macrostomus* to 0.249 $mgKg^{-1}$ in *Scomberomorus guttatus*. Also concentration of this element in the liver of the analyzed fish ranged from 0.082 $mgKg^{-1}$ in *Cyprinion macrostomus* to 0.309 $mgKg^{-1}$ in *Scomberomorus guttatus*. According to the report by the GESAMP (IMO/ FAO/ UNESCO/ WMO/ WHO/ IAEA/ UN/ UNEP joint group experts on the scientific aspects of marine pollution) (GESAMP 1986), the As content in most commercial fish species was 1 mg/kg (Lin *et al*., 2008). Bashir *et al*. (2012) that among ranges of arsenic concentrations in the muscle of *Arius thalassinus* and *Pennahia anea* 12.58 and 3.28 $mgKg^{-1}$. Also As in the liver *Arius thalassinus* and *Pennahia anea* 14.17 and 11.75 $mgKg^{-1}$, which are well below the arsenic levels detected in fish tissues by this study.

Fig 2. Arsenic levels (mg kg-1 wet weight) in liver of freshwater and saltwater fish

Species	n	Location	Mean ± SD
Barbus luteus	36	Karoon River	0.088±0.001[a]
Aspius vorax	36	Karoon River	0.087±0.001[a]
Cyprinion macrostomus	36	Karoon River	0.082±0.001[a]
Liza dussumieri	36	Boshehr Seaport	0.159±0.009[b]
Liza klunzingeri	36	Hendijan Seaport	0.155±0.009[b]
Liza macrolepis	36	Hendijan Seaport	0.133±0.004[c]
Scomberomorus commerson	36	Hendijan Seaport	0.305±0.020[d]
Otolithes ruber	36	Hendijan Seaport	0.203±0.021[e]
Scomberomorus guttatus	36	Hendijan Seaport	0.309±0.016[d]

a, b, c, d, e P>0.05, significantly different in muscle of fish, n= number of sample

Arsenic levels in liver of seaport fish were high in comparison with reverie fish. Arsenic levels in liver of *Scomberomorus guttatus* in Hendijan Seaport were higher than other species in freshwater and saltwater. Generally, in this research arsenic levels have significant differences (P<0.05) in livers of fish between freshwater and saltwater except for *Liza macrolepis* in Hendijan Seaport which did not have significant differences with *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus* in Karoon River. Also, arsenic levels in liver of *Scomberomorus commerson* in Hendijan Seaport which did not have significant differences with *Otolithes ruber* and *Scomberomorus guttatus*. Arsenic levels in liver of *Barbus luteus* in Karoon River were higher than other species in freshwater. In saltwater species, arsenic level in liver of *Scomberomorus guttatus* in Hendijan Seaport was high in comparision with other saltwater species. In this study concentration of arsenic in liver were higher than muscle of *Barbus luteus*, *Aspius vorax*, *Cyprinion macrostomus* from Karoon River and *Liza dussumieri, Liza klunzingeri*, *Liza macrolepis*, *Scomberomorus commerson*, *Otolithes ruber*, *Scomberomorus guttatus* from Hendijan Seaport, these results are consistent with other study (Suhendrayatna *et al*., 2001; De Rosemond *et al*., 2008; Shah *et al*., 2009).

Estimation of the levels of various elements in different fish species as a measure of environmental pollution has been of great concern over decades. A variable range of different metal concentrations has

been observed by various researchers worldwide (Ashraf *et al.*, 2006). Shah *et al.,* (2009) studied the arsenic levels in muscle of *Labeo calbasu, Cirrhinus mrigala, Cirrhinus reba, Mystus gullio, Catla catla, Mystus seenghara, Mastacembelus armatus, Tilapia mossambicus, Labeo rohita, Labeo gonius* were 9.1, 2, 2.6, 8.2, 14.8, 12, 3, 2.3, 7.3 and 2 mg kg-1. de Rosemond *et al.*, (2008) that among arsenic in five fishes from Back Bay near Yellowknife, Canada, which concentration of *Coregonus clupeaformis, Stizostedion vitreum, Esox lucius, Catostomus commersoni* and *Catostomus catostomus* were 0.77, 0.57, 0.97, 0.91 and 1.15 mg Kg-1. In other study concentration of arsenic in muscle of Grunt (*Pomadasys sp*.), Flathead (*Platycephalus sp*), Greasy grouper (*Epinephelus tauvina*), Tiger-tooth (*Otolithes rubber*) and Silver pomfret (*Pampus argenteus*) were 1, 0.6, 0.3, 0.4, 0.9 mg kg-1 (Agah *et al*., 2009). Another study conducted showed that arsenic content of fish from Indian coastal waters was within the range of 0.01–0.63 mg Kg-1 (Deshpande *et al*., 2008).

Shah *et al*., (2009) studied the arsenic levels in liver of *Labeo calbasu, Cirrhinus mrigala, Cirrhinus reba, Mystus gullio, Catla catla, Mystus seenghara, Mastacembelus armatus, Tilapia mossambicus, Labeo rohita, Labeo gonius* were 5.6, 8.3, 9.3, 4.8, 3.5, 4.4, 8.8, 9, 8.5 and 10.1 mg kg-1. de Rosemond *et al*., (2008) that among arsenic in five fishes from Back Bay near Yellowknife, Canada, which concentration of *Coregonus clupeaformis, Stizostedion vitreum, Esox lucius, Catostomus commersoni* and *Catostomus catostomus* were 1.07, 1.22, 0.42, 2.52 and 1.33 mg Kg-1. The observed variability of heavy metal levels such as Zn and Pb in different species depends on feeding habits (Romeo *et al,.* 1999), ecological needs, metabolism (Canli & Furness 1993), age, size and length of the fish (Linde *et al*., 1998) and their habitats (Canli & Atli, 2003; Tuzen & Soylak, 2007). Concentrations of arsenic detected in the muscle and liver samples showed different capacities for accumulating.

According to the results in this study, arsenic levels in liver were higher than muscle of fishes in Karoon River and Hendijan Seaport. Also arsenic levels in liver of seaport fish were high in comparision with riverine fish. The results indicated that the muscle of fishes were highly contaminated by arsenic and exceeded WHO 0.02 mg kg-1 (WHO, 1989) legal limits, but As in muscle of fishes were upper than FAO standard 7.88 mg kg -1 (FAO, 1983).

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