Research Journal of Fisheries and Hydrobiology, 7(1): 14-18, 2012
ISSN 1816-9112
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ORIGINAL ARTICLES

Comparison of Mercury and Cadmium Toxicity in Fish species from Marine water

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ABSTRACT

The bioaccumulation of mercury and cadmium were measured in muscle and liver tissues of fish species from marine water in Khouzestan, Iran. Mercury and cadmium were contaminated in tissues of *Cynoglossus arel*, *Periophthalmus waltoni* and *Acanthopagrus latus*, *Platycephalus indicus* respectively. Cadmium level in fish samples was analyzed by Perkin Elmer AS-800 autosampler and Perkin Elmer Analyst 700 model AAS equipped with MHS 15 CVAAS system was used for mercury determination. Significant variations in metals values were evaluated using student's t test at $p<0.05$. Mercury levels in liver of *Periophthalmus waltoni* (0.98 $mgkg^{-1}$wet weight) was higher than muscle except for *Cynoglossus arel* (0.73 $mgkg^{-1}$wet weight) high levels of mercury was measured in muscle. Cadmium levels in liver of *Acanthopagrus latus* and *Platycephalus indicus* in Mahshahr Seaport (2.16 and 4.67 $mgkg^{-1}$wet weight) was higher than muscle. The overall results indicated that the muscles of marine fish species from Khouzestan was highly contaminated by mercury and cadmium exceeded WHO standard.

Key words: Mercury, Cadmium, Toxicity, Muscle, Liver, Fish, Marine water

Introduction

Khouzestan has various water resources and it is located in southern part of Iran. There is considerable marine water resource in Khouzestan including Mahshahr Seaport that is important saltwater resource in Khouzestan, Iran. It plays an important role in water and fish supply which have great economic values. *Cynoglossus arel*, *Periophthalmus waltoni, Acanthopagrus latus* and *Platycephalus indicus* have high market value and are the main fish products in water resources in Khouzestan.

Fish species are often the top consumers in aquatic ecosystems (Dallinger et al., 1987) and thus metal concentrations in fish can act as an environmental indicator of the state of environment (Widianarko et al., 2000). 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). These health concerns are quite considerable. For example, cancer, damage to the nervous system has all been documented in humans as a result of metal consumption (Zwieg et al., 1999).

Mercury (Hg) is a persistent and hazardous environmental pollutant. Mercury species can undergo a variety of transformations in the environment, and ionic Hg can be transformed into one of the most toxic forms, methylmercury (MeHg), by both abiotic and biotic pathways (He et al., 2007). Cadmium (Cd) as a widespread environmental pollutant is highly toxic and considered to have no biological function. Due to the deleterious effects of cadmium (Cd) on aquatic ecosystems, it is necessary to monitor its bioaccumulation and toxicity in key species, and thus give an indication of the temporal and spatial extent of the process, as well as an assessment of the potential impact on organism health (Viarengo, 1989).

The main objective of this study was to determinate the contents of mercury and cadmium in the muscle and liver of some commercial fishes in marine water resources of Khouzestan, Iran, in order to assess fish quality and to assess the health risk for humans.

Materials and Methods

The concentrations of mercury and cadmium were measured in the muscle and liver of *Cynoglossus arel*, *Periophthalmus waltoni, Acanthopagrus latus* and *Platycephalus indicus* from marine water caught by gillnet in Khouzestan in summer 2010. The number of samples was 48 fish for each species. 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

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(E. Merck, Darmstadt, Germany). All the plastic and glassware were cleaned by soaking in dilute HNO_3 (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 1000 mg/l of the given element supplied by Sigma Chem. Co. St. Louis, USA. A Perkin Elmer AAnalyst 700 (Norwalk, CT, USA) atomic absorption spectrometer equipped with HGA graphite furnace and with deuterium background corrector was used.

Cadmium 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.

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. $NaBH_4$ (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 1450 psi, maximum temperature 300 ^{0}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 250W, 5 min for 400 W, 8 min for 550 W, vent: 8 min, respectively) (Tuzen, 2003).

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 was used to compare differences between samples. A P-value less of 0.05 was considered statistically significant.

Results and Discussion

The concentrations of mercury and cadmium ($mgkg^{-1}$ wet weight) in muscle and liver of *Cynoglossus arel*, *Periophthalmus waltoni, Acanthopagrus latus* and *Platycephalus indicus* from marine water are summarized in Tables 1 and 2.

Table1: Mercury levels ($mgkg^{-1}$wet weight) in muscle and liver of marine fish.

Tissue	Species	n	Mean ± SD	Min	Max
Muscle	*Cynoglossus arel*	48	0.73±0.07^a	0.55	0.90
	Periophthalmus waltoni	48	0.90±0.04^b	0.80	1.00
Liver	*Cynoglossus arel*	48	0.65±0.14^c	0.48	0.82
	Periophthalmus waltoni	48	0.98±0.11^d	0.73	1.01

Note: a, b: P<0.05, significantly different in muscle and liver of fish species in marine (Mahshahr Seaport) of Khouzestan, Iran.

Table 2: Cadmium levels ($mgkg^{-1}$wet weight) in muscle and liver of marine fish

Tissue	Species	n	Mean ± SD	Min	Max
Muscle	*Acanthopagrus latus*	48	1.91±0.11^a	1.81	2.06
	Platycephalus indicus	48	4.64±0.76^b	3.85	5.20
Liver	*Acanthopagrus latus*	48	2.16±0.23^c	1.79	2.28
	Platycephalus indicus	48	4.67±0.72^d	4.01	5.28

Note: a, b: P<0.05, significantly different in muscle and liver of fish species in marine (Mahshahr Seaport) of Khouzestan, Iran.

In marine water species, mercury levels in muscle and liver of *Periophthalmus waltoni* in Mahshahr Seaport were high in comparision with *Cynoglossus arel* (P<0.05). Mercury level in liver of *Periophthalmus waltoni* in Mahshahr Seaport was high in comparision with muscle (P<0.05) and mercury level in muscle of *Cynoglossus arel* in Mahshahr Seaport was higher than liver (P<0.05).

In marine species, cadmium levels in muscle and liver of *Platycephalus indicus* in Mahshahr Seaport were high in comparision with *Acanthopagrus latus* (P<0.05). Cadmium level in liver of *Platycephalus indicus* and *Acanthopagrus latus* in Mahshahr Seaport was high in comparision with muscle (P<0.05). The highest level of Hg in the liver has been corroborated by Kennedy (Kennedy, 2003). Havelkova et al., (2008) reported that the target organ for Hg accumulation in fish from heavily contaminated localities was 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 (Evans et al., 1993). Studies carried out with various fish species have shown that heavy metals accumulate mainly in metabolic organs such as liver that stores metals to detoxificate by producing metallothioneins (Hogstrand and Haux, 1991).

In general, the levels of mercury and cadmium in the liver of *Periophthalmus waltoni, Acanthopagrus latus* and *Platycephalus indicus* in Mahshahr Seaport were higher than those found in the muscle except for *Cynoglossus arel* that mercury level in muscle was higher than liver. The high concentrations of mercury in muscles were also found in *Abramis brama* from the Western basin of Lake Balaton and in *Liza aurata* and *Solea vulgaris* from Southern Atlantic Coast of Spain (Farkas et al., 2003; Usero et al., 2003).

Concentrations of mercury detected in the muscle and liver samples showed different capacities for accumulating. The observed variability of heavy metal levels in different species depends on feeding habits (Romeoa et al., 1999), ecological needs, metabolism (Canli and Furness, 1993), age, size and length of the fish (Linde et al., 1998) and their habitats (Canli and Atli, 2003).

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. The maximum mercury level permitted in fish is 0.1 mg/kg for WHO (1985), 1 mg/kg for NHMRC (1990) and 0.1-0.5 mg/kg for FDA (1996) standards. Generally, mercury levels in analyzed fish samples were found to be higher than WHO and FDA standards except for mercury levels in comparison with NHMRC which were lower than NHMRC standard and mercury levels have significant differences ($P<0.05$) in fish samples with WHO and FDA standards (Table 3).

The maximum cadmium level permitted in fish is 0.2 mg/kg for WHO (1985), 0.05 mg/kg for NHMRC (1990) and 2 mg/kg for FDA (1996). Generally, in this research cadmium levels in fish were found to be higher than standards and have significant differences ($P<0.05$) in fish samples with WHO, NHMRC standards except for *Acanthopagrus latus* in comparison with FDA which cadmium level in this fish was lower than FDA standard (Table 4).

Table 3: Comparison of mercury (mgkg^{-1}wet weight) in muscle of marine fish with standard

Species	n	Mean ± SD	Min	Max
Cynoglossus arel	48	0.73±0.07^{a}	0.55	0.90
Periophthalmus waltoni	48	0.90±0.04^{b}	0.80	1.00
WHO		0.1^{c}	-	-
NHMRC		1^{a,b}	-	-
FDA		0.1-0.5^{d}	-	-

Reference: WHO, 1985; Colling et al., 1996; Darmono and Denton, 1990.

Table 4: Comparison of cadmium (mgkg^{-1}wet weight) in muscle of marine fish with standard

Species	n	Mean ± SD	Min	Max
Acanthopagrus latus	48	1.91±0.11^{a}	1.81	2.06
Platycephalus indicus	48	4.64±0.76^{b}	3.85	5.20
WHO		0.2^{c}	-	-
NHMRC		0.05^{d}	-	-
FDA		2^{a,b}	-	-

Reference: WHO, 1985; Colling et al., 1996; Darmono and Denton, 1990.

Contaminants in fish can pose a health risk to the fish themselves and to humans who consume them. Mercury toxicity cause growth deficits and affects fish organs. In humans, mercury is toxic to the developing fetus and considered a possible carcinogen (Ikem and Egilla, 2008). Cadmium may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies (Commission of the European Communities, 2001).

In the literature mercury levels in muscle and liver of fish samples have been reported as 0.12 and 0.65 μgg^{-1} respectively, in *Liza parsia* in Sunderban mangrove wetland of northeast India (Saha et al., 2006). Cadmium levels in the muscles of fish samples have been reported as 0.42 mg/kg in *Labeo rohita* and 0.41 mg/kg in *Ctenopharyngodon idella* in the lake of Bhopal, India (Malik et al., 2010). Also, the mean of mercury and cadmium concentrations in muscle and liver of *Barbus grypus* and *Barbus xanthopterus* in Karoon and Dez Rivers in Khouzestan, Iran, were reported as: 0.73, 0.90; 0.79, 1.06 mgkg^{-1} and 1.28, 0.77; 1.42, 0.95 mgkg^{-1} for mercury and 0.84, 1.09; 1.07, 1.34 mgkg^{-1} and 1.67, 0.79; 1.91, 1.04 mgkg^{-1} for cadmium, respectively (Mohammadi et al., 2011).

Data on contaminant levels in fish from particular regions of the world could allow people to make informed decisions about which fish to eat to reduce their risk from the contaminants. The high levels of mercury and cadmium in water resources of Khouzestan have toxic effects on fish metabolism, it is important to consider the biological effects of contamination on fish health in saltwater from Khouzestan. The active monitoring of heavy metals in all fish in water resources of Khouzestan should be routinely carried out to assure the safety of the public.

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