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ASSESSMENT LEVEL OF HEAVY METALS (PB, CD, HG) IN FOUR FISH SPECIES OF PERSIAN GULF (BUSHEHR- IRAN)

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Abstract

In order to assessment the bioaccumulation of heavy metals in fishes of Persian Gulf, four fish species (Scomberomorus Commerson, Otolithes Ruber, Acanthpagrus Latus, Euryglossa orientalis) were sampled from Persian Gulf northwest coasts of Iran (Bushehr: N 50 ^{o} 51', E 28 ^{o} 59') and heavy metals (Cd^{+2}, Pb^{+2}, Hg^{+2}) levels were determined in different tissues (muscle, liver and gill) of fishes, by voltammetry methods. In each of species the sequence of metal concentrations in different tissues was as following: Liver> Gill> muscle, and in the different fishes, this order was : Euryglossa orientalis > Acanthpagrus Latus > Otolithes Ruber > Scomberomorus Commerson. Cd^{+2} and Hg^{+2} concentrations in the tissues of *Acanthpagrus Latus* and *Euryglossa orientalis* and the Pb^{+2} level in the liver of this species also Cd^{+2} concentration in liver of *Scomberomorus Commerson*, were found higher than the permissible limits set by FAO/WHO. The relationships between fish size and metal concentrations (µg g^{-1} d.w.) in the tissues were surveyed by linear regression analysis. Results showed that, relationships between size and metal concentrations in four species (in confidence level %95) is significant, positive and negative. Highly significant positive and negative relationships were found between fish length and Hg^{+2}, Cd^{+2} levels in muscle of *Otolithes Ruber*. These relationships were discussed, in this article.

Keywords: Bioaccumulation, Heavy metal, Fish, Relationship, Persian Gulf

Introduction

Heavy metal discharges to the marine environment are of great concern all over the world, and have a great ecological significance due to their toxicity and accumulative behavior [1].

Marine organisms concentrate in their tissues the contaminants present in sea water and . heavy metals are critical in this regard because of their easy uptake into the food chain and because of bioaccumulation processes [2].

Because of toxicity and accumulative behavior of heavy metals, they can make different changes in aquatic environment such as species diversity. These metals concentrated at different contents in organs of fish body [3].

Fish is the final chain of aquatic food web and an important food source for human. Therefore, heavy metals in aquatic environments are transferred through food chain into humans. Since, fish are highly consumed by human being and may accumulate large amounts of some metals from the water, it is important to determine the concentration of heavy metals in commercial fish in order to evaluate the possible risk of fish consumption for human health [4].

Studies from the field and laboratory experiments showed that accumulation of heavy metals in a tissue is mainly dependent upon water concentrations of metals and exposure period [5, 6].

The harmful effects of heavy metals and metalloids to biota in the marine environment have been recognized. Fish and shellfish are good bio indicators of trace element contamination in the marine environment since they occupy different trophic levels and can display large bioaccumulation factors. In certain studies, have been showed a positive relationship between sizes of marine animals and Hg content of tissues. But, there is not such relationship for other metals because they do not have a consistent and strong trend for a relationship with animal sizes [7, 8, 9, 10, 11, 12].

Results of linear regression analysis between heavy metal concentrations in six fish species from the northeast Mediterranean and fish size (length and weight) showed that, except in a few cases, significant relationships between metal concentrations and fish size were negative [13].

So, assessment the relationships between animal size and concentrations (essential and non-essential) metals is very important . In this study heavy metal (essential and non-essential) concentrations in different tissues of four fish species of Persian Gulf northwest coasts of Iran (Bushehr) was determined and relationships between fish size and metal concentrations in the different tissues were discussed. this research was carried out for first time in this region.

Materials and methods

Marine fish samples (Scomberomorus Commerson, Otolithes Ruber, Acanthpagrus Latus, Euryglossa orientalis) were obtained from the site (Bushehr beach). fish samples, were washed with clean sea water at the point of collection, separated by species and packed in polyethylene plastic bags. The collected samples were transferred to the laboratory under ice boxed. In laboratory, total length and weight was recorded for all specimens (N=10, for each of species) and then each sample was dissected for its muscle and liver tissues by polyethylene knife. The tissues were kept under freezer at -20^{o}C until analyzed. For analysis heavy metals, each tissue is freeze dried, then in order to determination Cd^{+2} and Pb^{+2} tissues are digested by concentrated sulfuric acid and peroxide hydrogen 30% (1:1 v/v) and for determination Hg^{+2}, each of tissue is digested by concentrated HCl and H_2O_2 30%. Digested samples were diluted to 100 ml with deionized water. Metal concentrations in muscle, gill and liver tissues were measured by polarograph (Metrohm – 797). Cd^{+2} and Pb^{+2} are determined on hanging mercury drop electrode (HMDE) and Hg^{+2} is measured on rotating gold electrode (RDE- Au). All metals analyzed by voltammetry methods. The solutions were deaerated with pure argon for 5 min prior to the measurements, while a argon blanket was maintained above the solution during the analysis. The solutions were deaerated for 2 min after each standard addition.

All reagents used were of the highest purity available (from Merck Germany). The solutions were prepared by deionized water. The stock solution of metals were prepared by diluting their standard solutions (1000 mg l^{-1}).

The glasswares were washed in nitric acid 10% solutions and rinsed with deionized water before used.

Statistical analysis were carried out using the SPSS 19 statistical package program. The same and different tissues from each of species were compared by one-way analysis variance (Tukey test). The significance level (α) was set at 0.05. Also the relationships between size and heavy metal concentrations in the tissues were compared by the linear regression (stepwise) analyses.

Results and Disscustion

Length and weight ranges and their relationships is shown in table 1, the relationships between length and weight of fishes is significant ($p<0.05$) and positive ($r>0$). Table 2 shows mean metal concentrations in the tissues of fishes. Statistical comparisons revealed that metal concentrations were significantly different in each of fish species ($p<0.05$). Highest and lowest metal concentrations were found in the Euryglossa orientalis and Scomberomorus Commerson species, respectively. This may be related to the differences in ecological needs, swimming behaviors and the metabolic activities among different fish species. Also, the difference in concentration of these metals in fish samples can suggest to what degree a particular specie picks up the matter from the sediment and water during feeding. It is well known fact that bottom feeders are known to concentrate more metal levels than the surface feeders.

Table 1: Ranges of weight(W) and length(L) and their relationships for the fishes Scomberomorus Commerson, Otolithes Ruber, Acanthpagrus Latus, Euryglossa orientalis captured from the northeast Persian Gulf (Bushehr – Iran)

Specices of fish	Number of Species	Length (cm) (min-max)	Weight(g) (min-max)	Relation between length & weight
Scomberomorus Commerson	18	13.2-34	597-983	L= 387.89 + 17.96W r^2= 0.989
Otolithes Ruber	18	8.2-36	542-993	L=440.84+16.27W r^2=0.981
Acanthpagrus Latus	18	11.8-33.4	312-996	L=76.49+29.54W r^2=0.953
Euryglossa orientalis	18	11.1-29	517-997	L=257.564+25.45W r^2=0.993

Table 2: Mean concentrations of heavy metals (μgg^{-1} d.w.) in the tissues of the fishes Scomberomorus Commerson, Otolithes Ruber, Acanthpagrus Latus, Euryglossa orientalis captured from the northeast Persian Gulf (Bushehr – Iran)

Species of fish	Tissue	Metal (μgg^{-1} d.w.)		
		Cd^{+2}	Pb^{+2}	Hg^{+2}
Scomberomorus Commerson	muscle	0.036±0.001	0.264±0.002	0.414±0.001
	liver	0.101±0.002	0.408±0.001	0.470±0.001
Otolithes Ruber	muscle	0.043±0.002	0.278±0.001	0.423±0.001
	liver	0.091±0.003	0.416±0.001	0.462±0.006
Acanthpagrus Latus	muscle	0.103±0.001	1.020±0.012	1.089±0.003
	liver	0.182±0.002	1.767±0.040	1.040±0.009
Euryglossa orientalis	muscle	0.107±0.001	1.188±0.012	1.514±0.002
	liver	0.247±0.001	2.166±0.012	1.231±0.009
Permissible limits (FAO/WHO)* (ppm)		0.1	1.5	*0.14*

In recent studies have been indicated that different fish species from the same area contained different metal levels in their tissues [8,9,14]. Heavy metals bioaccumulation of fish is species-dependent. Feeding habits and life style of species are strongly related to accumulation level [15, 16].

The accumulation orders of heavy metals in the tissues (muscle and liver) were nearly similar (Pb^{+2}>Cd^{+2}>Hg^{+2}). On the other hand, there were great variations among amounts of heavy metals accumulation in investigated tissues of the species. Muscle, generally, accumulated the lowest levels of metals and highest levels of metals concentration were observed in the liver. It was informed that active metabolite organs such as gill, liver and kidney accumulate more amount of heavy metals than other tissues like muscle [17]. In other words, the liver was a key role in basic metabolism and is the major site of accumulation, biotransformation of contaminants in fish. It was also reported that the differences in metals concentration of the tissues might be a result of their capacity to induce metal-binding proteins such as metallothioneins [13, 18]. It is well known that a large amount of metallothionein induction, caused by contamination, occurs in liver tissues of fish. In contrast, the muscle tissues are not considered an active site for metal accumulation.

Contamination levels of heavy metals in fish are normally compared to the permissible limits recommended by Food and Agriculture Organization [19].

In table 2 is shown mean concentrations of heavy metals in different kinds of fish compared to the permissible limits set by FAO/WHO. In the tissues (muscle and liver) of *Acanthpagrus Latus* and *Euryglossa orientalis* and liver of *Scomberomorus Commerson*, the concentration of cadmium was found higher compared to the permissible limit set by FAO/WHO. Also the Pb^{+2} level, in the liver of *Acanthpagrus Latus* and *Euryglossa orientalis* species, and the Hg^{+2} level in the tissues (muscle and liver) each of species were found higher than the permissible limits.

Table 3 is shown relationships between mean metals concentration and total fish length. In the *Scomberomorus Commerson* and *Otolithes Ruber* species, there were negative relationships between Cd^{+2} and Pb^{+2} levels in tissues (muscle and liver) and total length. Relationships between mercury level in the muscle of each species and length is positive ($P < 0.05$). In *Acanthpagrus Latus* species, there was only significant relationship between mercury level in liver and size of fish. For *Euryglossa orientalis* species, the relationships between total fish length and Cd^{+2} (in liver), Pb^{+2} (in muscle), Hg^{+2} (in liver) levels were positive and significant (in confidence level %95).

Since, mercury with methyl mercury organic compound (a high biological half-life in the living body) have very close bio correlation, mercury level is increased by increasing the fish size. Recent researches is recognized that mercury accumulates in the body of the marine organisms. Thus, it is getting increased by increasing the age and therefore the size of organism [20, 21, 22]. High concentration of mercury in muscle tissue of *Scomberomorus Commerson* and *Otolithes ruber* can be justified by its carnivorous diet [23]. This species feeding from other aquatics contaminated with mercury metal can be a justification for high levels of heavy elements in their body. Heavy metals can accumulate with very high concentrations in the body of mollusks, so fish feeding of these aquatics usually contains high contamination level of heavy metals [24].

Table 3: The relationships between heavy metal concentrations and size of fishes in the tissues of the Scomberomorus Commerson, Otolithes Ruber, Acanthpagrus Latus, Euryglossa orientalis captured from the northeast Persian Gulf (Bushehr – Iran) [a]

Species of fish	Tissue	Metal (μgg^{-1} d.w.) Cd^{+2}	Pb^{+2}	Hg^{+2}
Scombero-morus Commerson	muscle	Y=0.048-0.001X r= -0.716	Y=0.292-0.001X r= -0.842	Y=0.019-0.001X r= 0.717
	liver	[b]Y=0.088+0.002X r = 0.060	Y=0.418-0.004X r= -0.793	[b] Y=0.052-0.001X r= 0.184
Otolithes Ruber	muscle	Y=0.053- 0.004X r= -0.929	Y=0.272+0.003X r= -0.921	*Y=0.0299 - 0.003X r= 0.935*
	liver	Y=0.102- 0.003X r= -0.554	Y=0.411+0.002X r= -0.559	[b] Y=0.051+0.002X r=0.354
Acanthpagrus Latus	muscle	[b] Y=0.105- 0.001X r=0.255	[b] Y=0.998+0.001X r=0.134	[b] Y=-1.828+0.133X r= 0.374
	liver	[b] Y=-0.195-.003X r=0.315	[b]Y=-1.751+ 0.003X r=0.039	Y=-1.751+0.003X r=0.680
Euryglossa orientalis	muscle	[b] Y=0.109-0.004X r=0.190	Y=1.413 - 0.011X r= 0.626	[b] *Y=4.896 - 0.159X r= 0.239*
	liver	Y=0.213 - 0.002X r= 0.513	[b] Y=2.531 - 0.017X r= 0.358	*Y=1.361 - 0.006X r= 0.799*

[a] Y: metal concentration (μgg^{-1} d.w.) & X: total fish length (cm)

[b]. the relation is not significant, $P > 0.05$

basis, Negative relationships between accumulation of cadmium and lead in two species *Scomberomorus Commerson* and *Otolithes ruber*, increasing in body length of the fish is accompanied by a reduction in concentrations of Cd^{+2} and Pb^{+2}. With growth of the fish, its physiological adaptation with the environment is simultaneously developed. This evolution is so essential in removal or neutralization of heavy metals in muscles [25]. In liver and muscle of fish, Metallothionein Protein is responsible for removal or neutralization of heavy metals and their toxic effects. Thus, following increscent of weight and length of the fish and consequently compatibility with the environment, the concentration of metals in the muscles is reduced and added to their rates in paunch and viscera [26]. Another explanation for the negative relationships between metal concentrations and total length, may be the difference in metabolic activity between younger and older fish. In an organism, The difference between uptake and depuration is the most important factor. Because, the bioaccumulation of heavy metals in an organism is a result of this parameter.

Therefore, on obtained results of this research (negative relationships between metal levels and size of fishes), may also lead us to say that heavy metals concentrations in the northwest Persian Gulf are in levels that the fishes may control their tissue levels with the growth. However, if metal concentrations in water are higher than the capacity of these factors, the reduction of metal concentrations in tissue due to growth or lowered metabolic activity in older individuals may not be seen. Therefore, in this case, continues accumulation of metals may occur and positive relationships may be seen between animal size and metal concentrations in tissues [27]. High concentration of metals (both essential and non-essential) in aquatic ecosystems can retard fish development causing possible alterations in fish size.

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