Heavy metal concentrations in different tissues of *Euryglossa orientalis, Chirocentrus nudus* and sediments in Bahrekan Bay (the northwest of Persian Gulf)

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Abstract

Concentrations of Ni, V, Pb and Cu were determined in bottom sediments and liver, gills and fillet of *Euryglossa orientalis and Chirocentrus nudus* along the Bahrekan Bay in the Northwest part of the Persian Gulf in Iran. Sediment samples and fish species were collected during winter 2013 and spring 2014. Heavy metal analysis was performed by atomic absorption spectrophotometer. Results showed that mean concentrations of heavy metals were high in liver and gills of *E. orientali*. Also heavy metals had the most accumulation in liver of *E. orientali*. Target tissue for accumulation of Ni, V, Cu and Pb were gills and liver in *E. orientali* and *C. nudus*. In tissues of two fish species fillet has the minimum concentration level of trace elements. The concentrations of heavy metals were lower than legal limits in the fillet (edible part), except for Pb that was higher than permitted limits for human consumption. Bioaccumulation factors (BAFs) were determined for different tissues of fish species with respect to elemental concentrations in sediment. Results of BAFs indicated that all BAFs in liver were more than that in gills which were higher than that in fillet. Also BAF of Cu in liver and gills of *E. orientali* was more than 1.

Keywords: Heavy metals, Sediments; *Euryglossa orientalis, Chirocentrus nudus,* Persian Gulf

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Introduction

The coastal zone is considered as the place of action and reaction between terrestrial and marine ecosystems that is very important for the survival of a large variety of marine species (Castro *et al*., 1999). On the other hand, coastal zones receive a large amount of metal pollution from coastal towns, industrial sewages and polluted rivers. Pollution by heavy metals is an important problem due to their toxicity and their ability to accumulate in the biota (Islam and Tanaka, 2004; Reyahi-khoram et al., 2016).

Heavy metal contamination may have damaging effects on the ecological balance and diversity of aquatic organisms and marine species (Farombi *et al*., 2007; Ayandiran *et al*., 2009; Mohammadi Rouzbahani., 2017). Heavy metals also can affect water and sediment quality and may affect fish health and other biological attributes like taxonomic richness, trophic structure, and health of individual organisms will be changed (Fernandes *et al*., 2007; Batzias and Siontorou, 2008). They can also accumulate in food chains because of their persistence. (Feng Li *et al*., 2008). Therefore, determination of metal accumulation in organisms should be part of any assessment and monitoring program in the coastal zone. Heavy metal concentrations in aquatic ecosystems are usually monitored by detecting their concentration in water, sediments and aquatic organisms (Camusso *et al*., 1995). Also, sediments are important sinks for various pollutants such as heavy metals and play a useful role in the assessment of heavy metal pollution (Clements and Newman, 2002; Ho *et al*., 2003; Ikem *et al*., 2003).

Most heavy metals are essential for the functioning of physiological processes in fish. However, tolerable limits and environmental changes may in turn affect the metals bio-kinetics of the fish leading to mortality, while sub-lethal concentrations may lead to behavioral and biochemical changes in fish (Wang, 2002; Amin *et al*., 2003). So, fish samples are considered to be one of the most indicative factors, in aquatic systems, for the estimation of heavy metal pollution. Many studies were published about heavy metal accumulation in fish (Rashed, 2001; Papagiannis *et al*., 2004; Koca *et al*., 2008; Erdogrul and Erbilir, 2007; Qiao-qiao *et al*., 2007). In aquatic ecosystems risk assessment, bio accumulation factors (BAFs) are used to quantify chemical accumulation in tissues relative to their concentration in water or sediment (Thomann *et al*., 1995; Fairbrother *et al*., 2007). Bioaccumulation of heavy metals is the net accumulation of a metal in the tissue of interest or the whole organism that results from all environmental exposure media, including air, water, solid phases, and diet (Fairbrother *et al*., 2007).

The Bahrekan Bay is located in the northwest of the Persian Gulf in Iran. That is around 60 km from the

Hendijan Town (in Khouzestan Province). There are many sources of pollution on this coast such as wastes from coastal towns, rivers and oil ships transportations. Also Bahrekan Bay is one of the most important oil fields in Iran (Mohammadi Rouzbahani *et al*., 2013).

The main objectives of this study are as follows: (i) determining heavy metal concentrations in sediment and tissues of two fishes, (ii) comparing and contrasting metal concentrations in sediment and fish tissue (liver, gills and fillet), (iii) determining bioaccumulation factor for fillet and liver tissues of selected fish species (iv) determining heavy metals correlation between sediments and tissues. The results obtained from this study will provide valuable information on heavy metal pollution along the northwest part of the Persian Gulf coasts.

Materials and methods

Study area

The study was carried out in the Bahrekan Bay in the northwest of the Persian Gulf in Iran. The Persian Gulf is located in the southwest of Iran, between longitudes 48°25' and 56°25'' East and latitudes 24°30'' and 30°30' North (ROPME, 1999). There is an important fishery wharf in the study area. Also it is one of the most important oil fields in Iran located in the region.

Sampling

Samples of sediments and fish species were collected between (49° 42' 300'' and 49° 46' 232''N, and 30° 03' 140'' and 30° 05' 556''E) from 15 coastal localities in Bahrekan Bay (Fig. 1). Sediment samples were collected from 5 stations by Van Veen grab. Six replicates were collected at each station. The sediment samples were immediately sealed and stored at 4°C until arriving at the laboratory. In each station, sediment samples were collected according to the standard procedures described in USEPA sediment sampling guide (USEPA, 1994).

Fish samples were collected from 15 stations by fishing net (Fig. 1). In the period of sampling *Euryglossa orientalis* and *Chirocentrus nudus* had wide distribution in the area. Also in the Bahrekan Bay these two fish species are of the most important endemic fish species. All fish samples were collected from the same stations as sediments and were transported to the laboratory in a thermos flask with ice on the same day. Fish samples were cleaned by deionized distilled water, stored in pre-cleaned plastic, and kept at -20°C until analysis. Preparation of all samples was carried out according to ROPME (ROPME, 1999). In the laboratory fillet, liver, gill, gonads, and kidney were dissected, washed with distilled water, weighed, packed in polyethylene bags and stored according to USEPA (2000). Samples of tissues from each fish were dried at 65°C for 24 h.

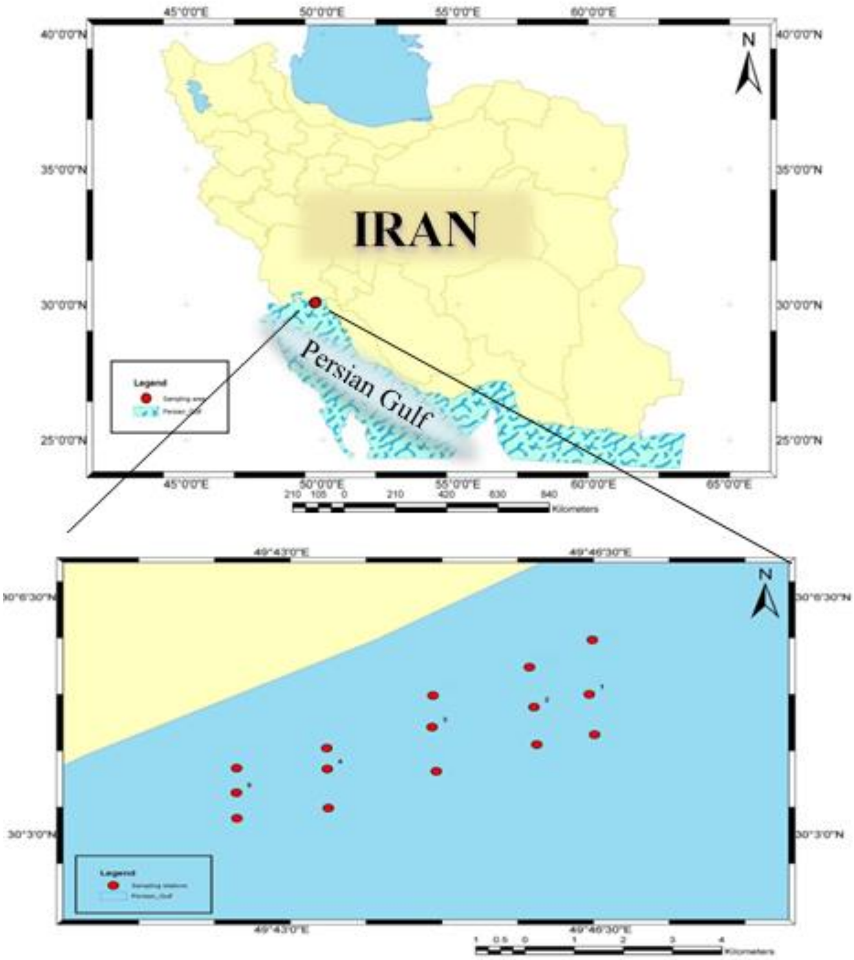

Figure 1: Study area showing the location of the sampling sites.

Analytical methods

Sediment samples were dried at 70°C for 48 h. The dried sediments were ground into fine powder and were passed from a 63-μm mesh. About 0.5 g of the powdered sample was treated with 5 mL aqua regia. After evaporation, it was allowed to cool. Then 3 mL of perchloric acid were added. Finally, samples were filtered and cooled to room temperature. The filtrates samples were transferred to 50-mL volumetric flasks and brought to volume with 1 N HCl (Chester and Hughes, 1967; Tessier *et al*., 1979). For analysis of fish samples, 1 g of each tissue sample was weighed and digested with concentrated nitric acid and perchloric acid (2:1 *v*/*v*; Merck) at 60°C. Digested samples were filtered and diluted to 20 mL by deionized water. All studied metals were measured by inductively coupled plasma atomic emission spectrometry (Macfarlane and Booth, 2001).

Calculations and statistical analysis

To calculate the bioaccumulation factor for each element in fillet, gills and liver tissues of the fishes the following equation was used:

$$BAF = Co \text{ (mg g}^{-1}\text{ d.w.)} / C_s \text{ (mgg}^{-1}\text{ d.w.)}$$

Where Co is mean concentrations of metal in the organism and C_s is the mean concentrations of heavy metal in sediments. BAF values indicate relative ability of organisms to absorb selected metals from the ecosystem in which they live (Adjei-Boateng *et al*., 2010; Hendozko *et al*., 2010).

To understand relationships among various metals and environmental indicators multivariable statistical programs were used. The ANOVA and Student's *t* comparison tests have been used to compare the mean concentrations of heavy metals in different fishes and organs of the selected fish species. Also Pearson correlation was used to test the relations between the metal concentrations in the fish tissues and the sediments.

Results

The concentration of heavy metals sediment samples of Bahrekan Bay are provided in Table 1. As this table shows total concentrations of heavy metals in sediment decreases as Ni>V>Cu>Pb.

Table 2 shows concentration of heavy metals in different tissues of studied fish species. As Table 2 reveals, all studied elements in *E. orientalis* and *C. nudus* have the highest accumulation in liver.

Table 1: Heavy metal concentrations in sediment samples from Bahrekan Bay (mg kg^{-1} d.w.).

Sampling site	Element							
	Ni		V		Cu		Pb	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	56.33	0.57	29	1.00	10.66	0.57	6.33	1.52
2	67.66	1.52	58.33	17.09	19.33	1.52	11	1.00
3	69.66	0.57	56.66	2.88	32.66	2.51	12.33	0.57
4	90.00	1.00	77.33	2.08	39.66	1.52	15.33	1.52
5	105	4.35	97.66	1.52	52.66	2.08	20.66	1.51
Total	79.53	16.12	63.80	24.61	31	15.40	13.13	5.02

Table 2: Heavy metal concentrations in the fillet, liver and the gills of *Euryglossa orientalis*, *Chirocentrus nudus* and guide lines (mg kg^{-1} d.w.).

Species	Tissue	Ni	V	Cu	Pb
Euryglossa orientalis	Fillet	0.92±0.49	0.22±0.07	2.34±0.71	1.05±0.48
	Liver	5.78±1.01	2.29±0.67	87.36±24.31	7.50±1.14
	Gill	2.79±0.63	1.08±0.52	37.96±7.77	4.22±0.78
Chirocentrus nudus	Fillet	0.91±0.54	0.20±0.07	1.32±0.62	0.64±0.42
	Liver	5.96±1.61	1.86±0.93	4.71±1.51	6.75±1.76
	Gill	2.00±0.43	1.67±0.62	3.15±0.59	2.29±0.78
FAO-WHO, 1989		1.00	0.5	5	0.5

Also Ni, V, Cu and Pb concentrations in tissues of *E. orientalis and C. nudus* decreases as liver>gills>fillet. It indicates that target tissue for accumulation of Ni, V, Cu and Pb are gills and liver. Generally, in tissues of the two fish species, fillet has the minimum concentration level of trace elements. Regarding statistical analysis in *E. orientalis* tissues, there was significant difference in Ni, Cu and Pb concentrations between gills, liver and fillet ($p<0.05$). However, there was no significant differences for V concentration between gills, liver and fillet ($p>0.05$). Based on statistical analysis in *C. nudus* tissues, there was no significant differences in Cu concentrations between gills and liver ($p>0.05$). Also there was significant differences in Cu concentrations between fillet and other tissues ($p<0.05$). There were no significant differences in V concentration between gills, liver and fillet ($p>0.05$). Also there were significant differences in Ni and Pb concentrations between gills, liver and fillet ($p<0.05$). Based on the statistical analysis between *E. orientalis tissiues* and *C. nudus* tissues, no significant differences were recoded for V, Ni and Pb concentrations between fillet, liver and gills ($p>0.05$) except for Pb in the gills of *E. orientalis* and *C. nudus*.

In the fillet of two fish species, V, Ni, Pb and Cu levels were lower than FAO-WHO limits. For *E. orientalis* the concentrations of V, Ni, Pb and Cu were above the limits in the liver and gills. Also in the liver and gills of *C. nudus* V, Ni and Pb concentration were above the limits.

The permissible limits proposed by the WHO are indicated in Table 2 (FAO- WHO, 1989; WHO, 1993). The concentrations of these metals in the fillet of *E. orientalis* and *C. nudus* were lower than maximum levels for V and Cu. Also for Ni it was closest to the legal limit and for Pb it was higher than permitted limits. We can, therefore, conclude that V and Cu present no problem for the consumption of edible parts of these fishes at this time. Nevertheless, in the future, bioaccumulation of metals, especially Ni and Pb can pose a risk for the consumption of these fishes. In the gills and liver of *E. orientalis* and *C. nudus*, Ni, V, Pb and Cu levels were above FAO-WHO limits except for Cu in the gills and liver of *C. nudus*. It also had been resulted in other studies. (Hosseini *et al*., 2015).

Metal concentration in the gills could be due to mixing of the elements with mucus, which is impossible to remove completely from between the lamellae, before tissue analysis preparation. Thus, high concentrations of various metals can be observed (Heath, 1987).

Bioaccumulation factor of trace elements in fillet, liver and gills of fish species in regard to concentrations of metals in sediment are cited in Table 3. As Table 3 Indicates, almost all BAFs in liver are more than that in gills which are higher than that in fillet. Also BAF of Cu in liver and gills of *E. orientali* is more than 1.

Table 3: Results of BAFs in studied species tissues.

Species	Tissue	Ni	V	Cu	Pb
Euryglossa orientalis	Fillet	0.01	0.00	0.07	0.07
	Liver	0.07	0.03	2.81	0.57
	Gill	0.03	0.01	1.20	0.32
Chirocentrus nudus	Fillet	0.01	0.00	0.04	0.04
	Liver	0.07	0.02	0.15	0.51
	Gill	0.02	0.02	0.10	0.17

According to Rashed (2001) BAF more than 1, indicates bioaccumulation in an organism (Rashed, 2001). It should be noted that Cu is a micronutrient and also has toxic effects. It is highly toxic in aquatic environments and organisms.

Table 4 shows the correlation between heavy metals in sediment and fillet, liver and gills of two species. The Pearson's correlation coefficient matrix for the element pairs was performed, if there was a linear relationship among the element pairs. The results indicate that Ni, V, Pb and Cu were found to have relatively higher positive correlation coefficients with tissues (for Ni, r=0.87 between sediments and liver of *E. orientalis*, r=0.586 between sediments and gills of *E. orientalis*, r=0.731 between sediments and fillet of *C. nudus*; for V, r=0.67 between sediments and liver of *E. orientalis*; for Pb, r = 0.57 between sediments and fillet of *C. nudus*; for Cu, r=0.57 between sediments and fillet of *E. orientalis*, r=0.83 between sediments and liver of *C. nudus*, r=0.54 between sediments and fillet of *C. nudus*). In tissues of *E. orientalis* correlation coefficient between sediment and liver was found to be higher than the correlation coefficient between sediment and gills which in turn was higher than that between sediment and fillet. Also, in tissues of *C. nudus* correlation coefficient between sediment and liver was found to be higher than the correlation coefficient between sediment and fillet. Hence, we can argue that Ni and V concentrations in the liver of *E. orientalis* and Cu concentrations in the liver of *C. nudus* can be used as a bio-indicator for monitoring the degree of the pollution in the study area. It should be noted that there was higher positive correlation coefficients between heavy metals in sediments (for Ni and V, r=0.88, for Ni and Cu, r=0.91, for Ni and Pb, r=0.91, for V and Cu, r=0.90, for V and Pb, r=0.94, for Cu and Pb, r=0.96). Given that Ni and V are two indicators for oil indices, high correlation between metals indicates that Cu and Pb also related to oil pollution in the region.

Table 4: Correlation coefficients between metal concentrations in sediments and fishes tissues.

Species	Tissue	Metals			
		Ni	**V**	**Pb**	**Cu**
Euryglossa orientalis	Liver	0.870**	0.673**	0.354	-0.136
	Gills	0.586*	0.420	-0.060	0.459
	Fillet	0.464	0.131	0.385	0.570*
Chirocentrus nudus	Liver	0.448	0.449	-0.045	0.832**
	Gills	0.485	-0.127	-0.534	0.022
	Fillet	0.731**	-0.660	0.577*	0.540*

Discussion

Total concentrations of heavy metals decrease as Ni>V>Cu> in sediments of Bakrekan Bay. In comparison to other sites in the world, concentrations of studied trace elements are high in sediment samples of the study area (Karadede and Unlu, 2000; Bakac and Kumru, 2001; Ruiz, 2001; Mora *et al*., 2004).

All studied elements in *E. orientalis* and *C. nudus* have the highest accumulation in liver. Also Ni, V, Cu and Pb concentration in tissues of *E. orientalis* and *C. nudus* decreases as liver>gills>fillet. It indicates that the target tissue for accumulation of Ni, V, Cu and Pb are gills and liver. Generally, in tissues of two fish species fillet has the minimum concentration level of trace elements that is a positive point for consumption by human. Although the concentrations of these metals in the fillet (edible part) of *E. orientalis* and *C. nudus* were lower than maximum levels for V and Cu and for Ni were closest to the legal limit, but for Pb it was higher than permitted limits.

It should be noted that Ni and V are considered as indices of oil pollution, and there is an oil field in the Bahrekan Bay. Also it seems that release of different contaminants from various sources such as oil transportations, and polluted rivers lead to high concentrations of heavy metals in Bahrekan Bay. But with regard to high correlation coefficient between Ni, V, Cu, and Pb in sediments it is more probable that Cu and Pb are related to oil pollution in the region.

The metal with the concentration higher than the legal limit for fish was Pb that is in agreement with Demirak (2006). Also the metal with the concentration close to legal limit was Ni. The reason for this is the high concentration of these metals in sediments. Also feed habits of fishes are important. There were significant differences in Cu concentrations between liver and gills of *E. orientalis* and *C. nudus* ($p<0.05$). That is probably related to the feeding habits of the two species. *E. orientalis* is a benthic fish that feeds on sediments and benthic organisms but *C. nudus* feeds on other fishes. Several authors indicate the interspecific differences observed in the metal differentia of fish tissues to variations in diet (Canli and Atli, 2003; Monikh *et al*., 2013; Merciaia *et al*., 2014). High concentrations of heavy metals in gills and liver have been found in different fish species in other studies (Alam *et al*., 2002; Karadede *et al*., 2004; Mendil *et al*., 2005). In this study, Cu levels in gills, liver and fillet were high for *E. orientalis* and was the same as those reported previously, but Cu levels in gills and liver for *C. nudus* were lower those reported previously (Karadede *et al*., 2004; Mendil *et al*., 2005). Pb values in the two fishes were found to be lower than those reported previously (Mendil *et al*., 2005). Mean concentration of Ni in gills and liver for *E. orientalis* and *C. nudus* were almost higher than that in other sites (Vinodhini and Narayanan, 2009). The concentrations of Ni, V, Cu and Pb in liver and gills were higher than in fillet in these two species; The observed variability of metal levels in different species depends on feeding habits (Amundsen *et al*., 1997; Romeoa *et al*., 1999; Watanabe *et al*., 2003), ecological needs, metabolism (Canli and Furness, 1993; Canli and Kalay, 1998), age, size and length of the fish (Linde *et al*., 1998) and their habitats (Canli and Atli, 2003).

The results of this study supplied valuable information on the metal levels in *E. orientalis* and *C. nudus* from the Bahrekan Bay. With regard to high correlation between elements in sediment and fillet, liver and gills of two species we can say that Ni and V concentrations in the liver of *E. orientalis* and Cu concentrations in the liver of *C. nudus* can be used as a bio-indicator for monitoring the degree of the pollution in the study area. Also, *E. orientalis* and *C. nudus* could be considered as bio-indicators of environmental contamination in the region.

Finally, the high concentrations of heavy metals in the tissues of *E. orientalis* and *C. nudus* in Bahrekan Bay is a cause of concern and requires regular monitoring of water quality and sediment quality around the region. The heavy metal accumulation in the different tissues and sediments increases as the exposure time increases. So, heavy metal will reach the tissues of human beings through the food chain. Therefore, it should be monitored through comprehensive studies in the future.

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