Accumulation of trace metals in the muscle tissues of tiger tooth croaker in Persian Gulf

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Abstract

In order to examine and compare lead, vanadium, nickel and selenium metals accumulation levels in muscle tissues of *Otolithes ruber*, sampling fish was done in both Bushehr and Asalouyeh stations during the summer 2013. After biometry of the samples, muscle tissues were separated and chemical digestion was done. Lead, vanadium, nickel and selenium accumulation levels in tissues were measured by using a graphic furnace atomic absorption instrument. Based on the obtained results, mean concentrations of lead, vanadium, nickel and selenium in Bushehr station were $0.335 \pm 0.165$, $0.245 \pm 0.003$, $0.262 \pm 0.014$, $3.109 \pm 0.551 \text{ mg kg}^{-1} \text{ dw}$, respectively and in Asalouyeh station were $2.684 \pm 0.488$, $0.245 \pm 0.007$, $0.293 \pm 0.011$, $3.088 \pm 0.254 \text{ mg kg}^{-1} \text{ dw}$, respectively. Based on the obtained concentrations and comparison done it as specified that based on WHO and FAO standards, the amount of lead in Bushehr station was lower than the standard permissible levels and in Asalouyeh station was upper than standard permissible levels, the amount of vanadium in both stations was lower than standard permissible levels and the amount of nickel and selenium in both stations was upper than the standard permissible levels.

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Introduction

*Otolithes ruber* is one of the migratory and coastal fish (Scianidae). This species is found in coastal waters highly in regions with muddy bed. The species is Benthopleagic to the effect that they live both in bed and water surface. *Otolithis ruber* feeds on smaller fish, crustaceans like shrimps and the other invertebrates (Ield Bianc., 1985).

Heavy metals are constant pollutants which their constant consequences are biomagnifications in food chain in such a way that as a result of this process, their amount in food chain can increase several times as much their amount found in water or air. As a result of the transference of these pollutants to aquatic environments, the probability is that the fish absorbs an amount of some metals through food chain or water from environment (Chale., 2002).

Heavy metal concentration in organism tissues can be due to severe diseases and cause serious harms in population (Barlas., 1999; Holocombe et al., 1976). Heavy metal rate has been developed especially in coastal environments due to the rapid development of industries, city planning, and human population. Anthropogenic sources including industrial wastes, agriculture and urban sewages, geochemical structure and mining of metals create a potential resource of heavy metal contamination in aquatic environments and their pollution have caused concern about coastal environments (Askary Sary & Mohammadi., 2012; Mendil et al., 2010). These types of pollutions may affect them directly by concentrating in aquatic animal bodies and indirectly by transporting to the next tropical level from food chain. One of their most serious exposure results is biological amplification in food chain (Kalay & Canli., 2000; ülnü & Gümgüm., 1993).

The Persian Gulf is a shallow water basin in the south area of the Iranian plateau on the edge of the Indian ocean located in west-northern Oman sea. Its area is almost about 232850 km² and its average depth is 30 to 35 m (Al-Awadhi., 2002). The water exchange time in this basin is between 3 to 5 years indicating the pollutants remain in the Persian Gulf for a significant period (Sheppard et al., 2010). The north parts of the Persian Gulf are much more influenced by the pollutants due to the shallowness, water limited rotation, great vaporization, salinity and high temperature (Pourang et al., 2005). Therefore, studies done in the field of heavy metal contamination in aquatic ecosystems are very important from the human health and public sanitation viewpoints. On the other hand, in these studies, balance state preservation of the aquatic ecosystems is considered as a secondary objective. Thus, the objective of this study is to measure the lead, vanadium, nickel and selenium levels in muscle tissues of *Otolithes ruber* in the Persian Gulf waters (Bushehr and Asalouyeh seaports) and to compare them with the international standards.

Material and method

*Study area*

Bushehr is located in 28°55´19.84” N and 50°50´4.76” E of southwestern Iran and on the edge of the Persian Gulf. Asalouyeh is located in 28°28´24.48” N and 52°36´49.79” E on the edge of the Persian Gulf, 300 kms east of Bushehr and 570 kms west of Bandar Abbas and has a distance of 100 kms to the South Pars gas area located along the Persian Gulf (Figure 1).

*Sampling*

20 samples were caught by trawl net in both regions, Bushehr and Asalouyeh seaport during summer season 2013 to do this research. Then, the samples were placed in a plastic bag and coded and were placed in an ice bucket full of ice in order to be transferred in the laboratory. The samples were transferred to Islamic Azad University Bushehr branch laboratory after fishing. The fish samples were kept at a temperature of -30º C by the analysis time in the laboratory.

*Sample preparation*

First all lab dishes which were going to be used were placed in HNO₃ for 24 hours and then they were washed by using distilled water and finally they were placed in an oven at a temperature of 80ºC to prevent
contamination. The samples were removed from the fridge. When they reached the environment temperature, biometry operation (total length, standard length, total weight) was done. All muscle samples were dried at 80°C for 12 h. Homogenized samples (1 g) were weighted and then digested, using a microwave digester (Milestone ETHOS1 advanced microwave digestion system, Italy) with 1 mL H2O2 (30 %) and 7 mL HNO3 (65 %). After digestion, the residues were diluted to 50 mL with distilled water in volumetric flasks. All digested samples were analyzed for lead, vanadium, nickel and selenium using Furnaco auto sampler atomic absorption spectrometer (FS95) (MOOPAM., 1999).

Fig. 1. Location of the sampling areas.

Statistical analysis
One sample Kolgorov-Smirnov test in SPSS®18 was used to check the validity of the data normalization. Then, one way sample T-test was used to check interactions between heavy metals and stations. Data have been presented in diagrams as Mean±SDs with 95% of the confidence interval. Excel software was used to draw diagrams (Zar., 1999).

Results
Biometric results
Biometric results indicated that mean weight in Bushehr was 376.82 g and mean weight in Asalouyeh was 369.4 g. Biometric results are presented in Table 1.

<table>
<thead>
<tr>
<th></th>
<th>Bushehr Station</th>
<th>Asalouyeh Station</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Total weight</td>
<td>376.82</td>
<td>14.9</td>
</tr>
<tr>
<td>Total length</td>
<td>34.25</td>
<td>1.46</td>
</tr>
<tr>
<td>Standard length</td>
<td>30.14</td>
<td>1.55</td>
</tr>
</tbody>
</table>

Metal concentrations
According to the obtained statistical results mean and standard deviation (SD) with the confidence interval in 95% level of lead in Bushehr station was 0.335±0.165 mgkg⁻¹ dw and in Asalouyeh station was 2.684±0.488 mgkg⁻¹ dw. Based on T-test analysis, significant differences were observed between lead levels in muscle tissues in both stations (P=0.003). According to the obtained statistical results mean and standard deviation (SD) with the confidence interval in 95% level of vanadium in Bushehr station was 0.245±0.003 mgkg⁻¹ dw and in Asalouyeh station was 0.245±0.007 mgkg⁻¹ dw. Based on T-test analysis, no significant differences were observed between
vanadium levels in muscle tissues in both stations (P=0.859). According to the obtained statistical results mean and standard deviation (SD) with the confidence interval in 95% level for nickel in Bushehr station was 0.262±0.014 mgkg⁻¹ dw and in Asalouyeh station was 0.293±0.011 mgkg⁻¹ dw. Based on T-test analysis, no significant differences were observed between nickel levels in muscle tissues in both stations (P=0.626). According to the obtained statistical results mean and standard deviation (SD) with the confidence interval in 95% level of selenium in Bushehr station was 3.109±0.551 mgkg⁻¹ dw and in Asalouyeh station was 3.088±0.254 mgkg⁻¹ dw. Based on T-test analysis, no significant differences were observed between selenium levels in muscle tissues in both stations (P=0.921) (Table 2).

### Table 2. Heavy metal levels in muscle tissues of *Otolithes ruber* in Bushehr and Asalouyeh stations (mgkg⁻¹ dw).

<table>
<thead>
<tr>
<th>Heavy Metals</th>
<th>Stations</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>Bushehr</td>
<td>0.335±0.165</td>
</tr>
<tr>
<td></td>
<td>Asalouyeh</td>
<td>2.684±0.488</td>
</tr>
<tr>
<td>V</td>
<td>Bushehr</td>
<td>0.245±0.003</td>
</tr>
<tr>
<td></td>
<td>Asalouyeh</td>
<td>0.245±0.007</td>
</tr>
<tr>
<td>Ni</td>
<td>Bushehr</td>
<td>0.262±0.014</td>
</tr>
<tr>
<td></td>
<td>Asalouyeh</td>
<td>0.293±0.011</td>
</tr>
<tr>
<td>Se</td>
<td>Bushehr</td>
<td>3.109±0.551</td>
</tr>
<tr>
<td></td>
<td>Asalouyeh</td>
<td>3.088±0.254</td>
</tr>
</tbody>
</table>

Based on the obtained concentrations and comparison done it as specified that based on WHO and FAO standards, the amount of lead in Bushehr station was lower than the standard permissible levels and in Asalouyeh station was upper than standard permissible levels. Based on WHO standard, the amount of vanadium in both stations was lower than standard permissible levels. Based on WHO and FAO standards, the amount of nickel and selenium in both stations was upper than the standard permissible levels (Table 3).

### Table 3. Comparison of heavy metal concentrations in muscle tissues of *Otolithes ruber* with WHO and FAO standards (mgkg⁻¹ dw).

<table>
<thead>
<tr>
<th>Standard</th>
<th>Pb</th>
<th>V</th>
<th>Ni</th>
<th>Se</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO (FAO., 1976)</td>
<td>0.5</td>
<td>0.5</td>
<td>0.2</td>
<td>-</td>
</tr>
<tr>
<td>FAO (Burger &amp; Gochfeld., 2005; Dural et al., 2006)</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td><em>Otolithes ruber</em> in Bushehr</td>
<td>0.335</td>
<td>0.245</td>
<td>0.262</td>
<td>3.109</td>
</tr>
<tr>
<td><em>Otolithes ruber</em> in Asalouyeh</td>
<td>2.684</td>
<td>0.245</td>
<td>0.293</td>
<td>3.088</td>
</tr>
</tbody>
</table>

### Discussion

Nowadays, the environment pollution especially aquatic resources have created a lot of problems in the environment. Entering the pollutants including a chief part of the environmental pollution into the waters due to dangers they caused to human and their accumulation in aquatic animals reveal the importance of attention to the protection of water resources and their economic value more than before. Discharging heavy metals into marine environments is a big concern all over the world. There are documents and evidence showing heavy metals have great ecological significance due to their accumulation behavior and their toxicity and can decrease diversity of marine species and ecosystems. Moreover, consumption of polluted marine food put human health in danger (Ghanbari et al., 2014; Moghdani et al., 2014; Al-Saleh & Shinwari., 2002). Heavy metals unlike the most contaminants in the environment are not ruined and pass an ecological cycle during which natural waters are the main pass. According to different researches the highest
concentration of heavy metals is usually found in aquatic environments and aquatic environment bed sediments. Therefore, being informed of heavy metal concentration and their dispersion in sediments and aquatic creature bodies can play a major role in pollution resources in aquatic systems (Moghdani et al., 2014; Ghanbari et al., 2014; Pazira et al., 2014). Therefore, determination of heavy metals in living creatures should be a part of every assessment and monitoring program in coastal region (Usero et al., 2005). 

*Otolithes ruber* is one of the migratory and coastal fish. This species is found in coastal waters highly in regions with muddy bed. The species is Benthopelagic to the effect that they live both in bed and water surface. *Otolithis ruber* feeds on smaller fish, crustaceans like shrimps and the other invertebrates (Ield Bianche., 1985). Heavy metal accumulation in Benthopelagic species in comparison with benthic species probably has a relation with the fish diet (Boustamant et al., 2003). Lead, from the dispersion viewpoint is the widest heavy and toxic element in the environment and is highly found in the aquatic environment and if it is absorbed through food, it is very toxic for the consumers. This element enters the environment as a result of utilizing mines, battery manufacturing industries, fossil fuels, paint manufacturing, glass industries, acid rains and vehicles (Merian., 1992). This metal is one of the four metals having the most effects on human health. Disorders in hemoglobin biosynthesis and anemia, blood pressure increase, injury to the kidney, abortion of fetus, disorders in nervous system, injury to the brain, men infertility, decrease in learning ability and behavior disorders in children are the negative results of lead increase in human body (Berlin., 1985). Nickel is widely spread in the environment and its concentration is a function of fossil fuel and its meaning from the oil fields and refineries. In other words we can say that the highest concentrations of nickel in sediments are mainly caused by human sources such as ship traffic, oil tankers, petroleum and industrial and domestic wastewaters (De Astudillo et al., 2005; Pourang et al., 2005; Beg et al., 2001). Vanadium element in the creature bodies cause the prevention of some enzyme activities such as nervous, respiratory disorders and paralysis of the organs and it has also negative effects on kidney and liver. An increase in vanadium consumption in humans can cause harms including anemia, inflammation, swelling around the eyes, inflammation of the lungs, cataract, cognitive deficits, diarrhea, and decrease in appetite in consumers (Arias et al., 2001). Selenium is micronutrient element. Selenium concentration in food is affected by geochemical position. Aquatic animals especially fish are selenium-rich resources and since selenium is among rare elements and in small quantities are necessary for the body and in large quantities are very toxic, it is very important. Selenium has positive effects on the health of heart, liver, pancreas, different kinds of cancers, elasticity characteristic of the muscles and most of the other diseases. Selenium rate in people not receiving enough selenium in their diet such as vegetarians, old people and pregnant and breastfeeding women decreases. Shortage and also extreme selenium rate in the body cause weakness, muscle pain, neural performance disorders (seizure, paralysis, mental retardation), nail bed turning white, cataract, hypertension, infertility, liver necrosis, kidney damages, and loss of hair melanocytes (Nettleton., 1987).

Bushehr which is a fishing region is also a place for mooring the fishing boats. Beside this fishing pier, the Bushehr nuclear power station, the customs, and the National Shrimp Research Institute was located. The National Shrimp Research Institute has some shrimp farming pools and its discharge drainage is directly discharged into the sea. In Asalouyeh station, in addition to the fishing pier which is located near Asalouyeh city, the largest world gas and oil installations, South Pars oil particular region are located there influencing the environment directly and indirectly. Turkmen et al. (2004) examined heavy metal concentrations on 3 economical fish species of the Mediterranean sea named *Saurida undosquamis, Sparus aurata, Mullus barbatus*. The results indicated that the lead metal limit was 0.09 to 6.95 mg/kg dw. In the study of Franca et al. (2005) the rate of lead in *Solea senegulensis* was calculated
as 2.9±0.7 µg/kg dw. In the study of Stavros et al. (2007) the rate of lead in the skin of Tursips truncates of the south coasts of the Atlantic was calculated as 0.14±0.11µg/g ww. Sepe et al. (2003) obtained the vanadium rate existing in species of anchovy, red mullet and mackerel of Adriatic Sea as follows 89.9, 79.1, and 43.5 mg/kg respectively. Lavilla et al. (2008) also during study on species of fish, seashell and crustaceans in Spain, obtained that the vanadium rate in these species is in 0.82 – 5.14 mg/g limits. According to the results of the study of Fatih Fidan et al. (2008) which was done on the heavy metal concentration levels in muscle tissues, gills and livers of Carassius Carassius in Eber lake in Turkey, the highest concentration levels of nickel in muscle were related to the winter season with the amount of 0.12±0.03 µg/g fish weight. In addition, Alkan et al. (2012) in the study on heavy metal levels in spices including Mullus barbatus ponticus and Merlangius merlangus euxinus in southwestern region of the Black sea, calculated the nickel levels in spices Mullus barbatus ponticus 0.02-0.67 µg/g and in species Merlangius merlangus euxinus 0.01-0.71 µg/g respectively. Rezayi et al. (2011) examined selenium in Otolithes ruber and Psettodes erumei in Khouzestan Province coasts. The results showed that selenium contents in livers of both species were higher than the edible part of that species and also there were significant differences between selenium levels between both species. Moreover, in both species no significant differences were observed between selenium levels and its length and weight. Therefore, Based on the high levels of lead, nickel and selenium metals in this study it can be concluded that the use of this species in these regions are rather dangerous and will naturally have bad effects on the consumers of these products.

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