AACL BIOFLUX
Aquaculture, Aquarium, Conservation & Legislation
International Journal of the Bioflux Society

Vanadium concentration levels in muscle tissues of two commercial fish species in Persian Gulf waters

[1]Saeid Moghdani, [2]Abdol R. Pazira, [1]Farshad Ghanbari, [3]Narges Javad Zadeh

[1] Young Researchers and Elite Club, Bushehr Branch, Islamic Azad University, Bushehr, Iran; [2] Department of Engineering, College of Natural Resources, Islamic Azad University, Bushehr Branch, Iran; [3] Department of Fisheries Sciences, College of Agricultural Sciences and Natural Resources, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran. Corresponding author: S. Moghdani, s.moghdani@gmail.com

Abstract. In order to examine and compare vanadium accumulation levels in muscle tissues of *Brachirus orientalis* and *Otolithes ruber* in Persian Gulf waters (Bushehr province region), sampling was done in both Bushehr and Asalouyeh stations during the summer 2013. After biometry (measurment of total length and weight), muscle tissues of the samples were separated and chemical digestion was done. Vanadium accumulation levels in tissues were measured by using graphite furnace atomic absorption instrument. Based on the obtained results, mean concentrations of vanadium in muscle tissues of *B. orientalis* were 0.246 ± 0.006 mg kg^{-1} dw (dry weight) in Bushehr station and 0.288 ± 0.087 mg kg^{-1} dw in Asalouyeh station, and mean concentrations of vanadium in muscle tissues of *O. ruber* were 0.245 ± 0.003 mg kg^{-1} dw in Bushehr station and 0.245 ± 0.007 mg kg^{-1} dw in Asalouyeh station, and it indicated no statistically significant differences between the two stations ($p > 0.05$). The obtained concentrations and analysis done indicate that based on the WHO, Canada and Italy standards, the amount of vanadium was lower than the standard levels.
Key Words: Persian Gulf, *Brachirus orientalis*, *Otolithes ruber*, heavy metals, vanadium, muscle.

Introduction. 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; Ünlü & Gümgüm 1993).

Heavy metal concentration in organism tissues can be due to severe diseases and cause serious harms in population (Barlas 1999; Holcombe et al 1976). Moreover, exogenous pesticides, heavy metals, chemical mutagenes, radiation and different stressful factors cause an increase in free radicals and oxidative stress. As a results of the increase in these stresses, lipid peroxidation, protein denaturation and DNA harms happen in living organism cells. These changes can have a great risk for life and productivity of organisms (Fatih Fidan et al 2008). Biological and ecological factors such as size, sex (Al-Yousuf et al 2000), ecological needs, habitat, feeding habits (Bustamante et al 2003), and season (Navarro et al 2006) have various and significant influences on bioaccumulation and metal bioavailability.

Heavy metals are accumulated in tissues and organs of the fish after they entered the aquatic ecosystems and finally they enter the food chains and are considered as a potentially toxic factor for microorganisms (Chen & Chen 1999).

Persian Gulf is a shallow-water basin with an average depth of 35-40 meters and an area about 240 km^2. This area is connected to the international waters via Hormuz strait (Saeidi et al 2008; Banat et al 1998; Payam-e Darya 1995).

Water exchange time is between three to five years in this basin that show the pollutants remain in the Persian Gulf for a significant period. The north parts of the Persian Gulf are much more influenced by pollutants due to the shallowness, limited rotation, salinity and high temperature (Sheppard et al 2010; Saeed et al 1995). Generally it was specified that about 30 percent of the total world oil transference is done in Persian Gulf (Pourang et al 2005a).

Brachirus orientalis is a benthic fish species which lives in shallow territorial waters on muddy and sandy beds (Ghanbari et al 2014). *Otolithes ruber* is one of the migratory and coastal fishes. 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. *O. ruber* feeds on smaller fish, crustaceans like shrimps and other invertebrates (Pazira et al 2014). From a fisheries viewpoint, *B. orientalis* and *O. ruber* are among commercially valuable fishes and have an important role in human food programs (Dìaz de Astarloa & Munroe 1998).

Therefore, because of the oil instalation in Bushehr and Asalouyeh, and the metal which is used in this areas is vanadium, and also because of the little information about the concentration of this metal in these study areas, the objective of this study is to measure the vanadium levels in muscle tissues of *B. orientalis* and *O. ruber* in Persian Gulf waters (Bushehr province region) and compare it 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. Asalouyeh is located in 28°28´24.48" N and 52°36´49.79" E on the edge of the Persian Gulf (Figure 1) (Moghdani 2013).

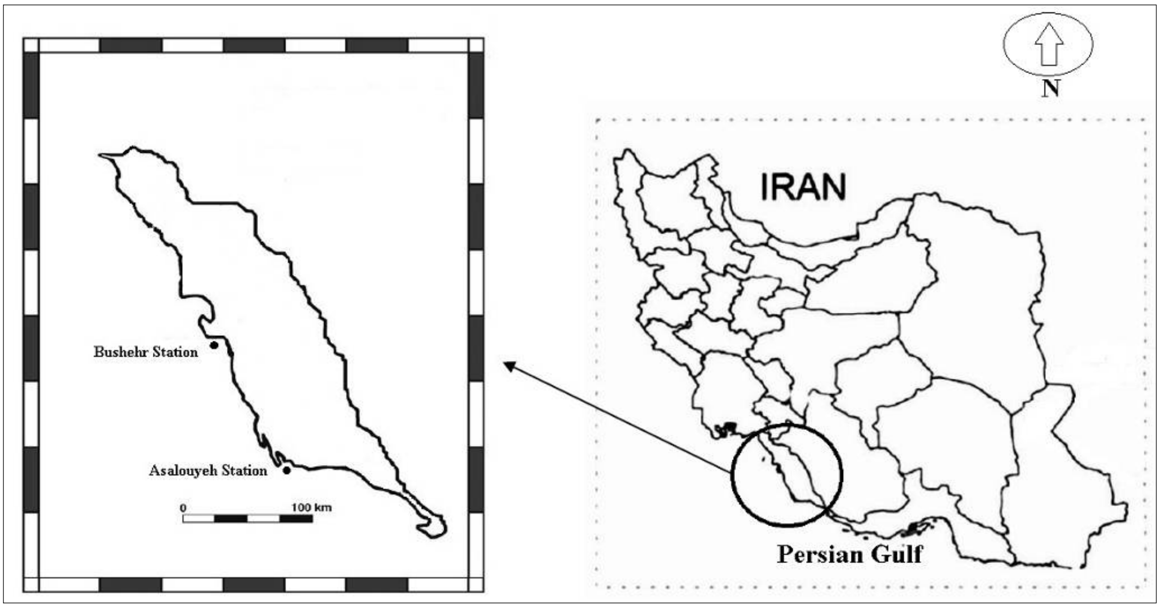

Figure 1. Location of the sampling areas (original drawing).

Sampling. Twenty samples of *B. orientalis* and other twenty samples of *O. ruber* were caught by trawl net in both regions, Bushehr and Asalouyeh seaports during August 2013. 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 -30°C by the analysis time in the laboratory.

Sample preparation. First all lab dishes which were going to be used were placed in HNO_3 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 heater with 10 mL HNO_3. After digestion, the residues were diluted to 25 mL with distilled water in volumetric flasks. All digested samples were analyzed for vanadium using Furnaco auto sampler atomic absorption spectrometer (FS95) (MOOPAM 1999).

Statistical analysis. One sample Kologorov-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 as Mean±SDs with 95% of the confidence interval (Zar 1999).

Results

Biometric results. Biometric results of *B. orientalis* indicated that mean weight in Bushehr was higher in comparison to Asalouyeh station. Mean weight in Bushehr was 358.96 g and mean weight in Asalouyeh was 212.38 g. Biometric results of *O. ruber* indicated that there was no significant different between the mean weight in both stations. Mean weight in Bushehr was 376.82 g and mean weight in Asalouyeh was 369.40g. Biometric results are presented in Tables 1 and 2. Also Table 3 shows the correlation between length and weight in *B. orientalis* and *O. ruber*.

Table 1

Biometric results of *B. orientalis* in Bushehr and Asalouyeh stations (N = 20)

Biometrics features	*Bushehr station*		*Asalouyeh station*	
	Mean	*SD*	*Mean*	*SD*
Total weight	358.96	13.1	212.38	11.96
Total length	27.81	1.53	27.05	1.36
Standard length	24.57	1.28	22.79	0.96

Table 2

Biometric results of *O. ruber* in Bushehr and Asalouyeh stations (N = 20)

Biometrics features	*Bushehr station*		*Asalouyeh station*	
	Mean	*SD*	*Mean*	*SD*
Total weight	376.82	14.9	369.4	4.96
Total length	34.25	1.46	33.7	0.33
Standard length	30.14	1.55	29	0.67

Table 3

Correlation between length and weight indices in *B. orientalis* and *O. ruber* in Bushehr and Asalouyeh

Species	*Station*	*R*	R^2	*Sig.*
Brachirus orientalis	Bushehr	0.982	0.964	0.000
	Asalouyeh	0.937	0.877	0.000
Otolithes ruber	Bushehr	0.948	0.898	0.000
	Asalouyeh	0.868	0.753	0.001

***Vanadium concentration**.* The obtained results show that the lowest and the highest vanadium concentration levels in muscle tissues of *B. orientalis* in Bushehr station was equal to 0.231 and 0.255 mg kg^{-1} dw and in Asalouyeh was 0.233 and 0.475 mg kg^{-1} dw, respectively. According to the obtained statistical results mean and standard deviation (SD) with the confidence interval in 95% level of vanadium in Bushehr station was 0.246±0.006 mg kg^{-1} dw and in Asalouyeh station was 0.288±0.087 mg kg^{-1} dw. Based on T-test analysis, no significant differences were observed between vanadium levels in muscle tissues in both stations ($p = 0.181$).

The obtained results show that the lowest and the highest vanadium concentration levels in muscle tissues of *O. ruber* in Bushehr station was equal to 0.238 and 0.250 mg kg^{-1} dw and in Asalouyeh was 0.232 and 0.258 mg kg^{-1} dw, respectively. 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 mg kg^{-1} dw and in Asalouyeh station was 0.245±0.007 mg kg^{-1} dw. Based on T-test analysis, no significant differences were observed between vanadium levels in muscle tissues in both stations ($p = 0.859$).

Based on the obtained concentrations and comparison done it as specified that based on WHO, Canada and Italy standards, the amount of vanadium in *B. orientalis* and *O. ruber* tissues was lower than the standard permissible levels (Table 4).

Table 4

Comparison of vanadium concentrations in muscle tissues of *B. orientalis* and *O. ruber* with WHO, Canada and Italy standards (mg kg^{-1})

Standard	*Vanadium concentration*
WHO (FAO 1976)	0.5
Canada (Goyer 1986)	0.5
Italy (Goyer 1986)	0.7
Brachirus orientalis, Bushehr	0.246
Brachirus orientalis, Asalouyeh	0.288
Otolithes ruber, Bushehr	0.245
Otolithes ruber, Asalouyeh	0.245

Discussion. 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 Abdolahpour Monikh et al (2012) and Pourang et al (2005a, 2005b) 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).

Heavy metals are concentrated in tissues and organs of aquatic animals especially fish after entering the aquatic ecosystems and they finally enter the food chain. Since fish formed a main part of human diet, these heavy metals can enter the human body via feeding contaminated fish. The absorption and concentration levels of heavy metals in aquatic animals especially fish are dependent on biological, chemical, physical and ecological conditions of water, element type, aquatic animal and physiology of the creature body (Jaffar et al 1998). Metal concentration in fish usually depends on the species, habitat, fish activity, diet, or other related behaviours (Henry et al 2004). Total mean concentrations of vanadium in *B. orientalis* in Bushehr station was 0.246±0.006 mg kg^{-1} dw and in Asalouyeh station was 0.288±0.087 mg kg^{-1} dw. Also total mean concentration in *O. ruber* in Bushehr station was 0.245±0.003 mg kg^{-1} dw and in Asalouyeh station was 0.245±0.007 mg kg^{-1} dw. The results of previous studies in the same area showed that different species of fish have different vanadium levels in their tissues (Table 5). In different regions of the Persian Gulf, oil pollution along with the other urban, industrial and agricultural pollutions cause the destruction of this valuable ecosystem and the valuable resources of the aquatic animals present in it, are exposed to different pollution risk and have posed a threat to the aquatic animal populations present in it (Pourang et al 2005b).

Feeding habits, ecological needs, heavy metal concentration in water and sediment, fish exposure period in aquatic environment, fishing season and physical and chemical characteristics of water (salinity, pH, hardness and temperature) are effective factors in heavy metal accumulation in different organs of fish (Canli & Atli 2003). Heavy metals have caused a concern about fish consumption due to different negative effects such as decrease of growth, temperature changes, genetic changes and also mortality in aquatic animals and because of their toxicity and tendency to accumulate in food chain (Kalay et al 1999). Thus, taking measurements of concentration of these metals in order to determine the standards of public health and protect the sea environment is significant.

Toxicity with heavy metals in fish toxemia having symptoms such as loss of reproductive ability, deformation of skeleton, changes in blood factors, an increase in sensitivity to infectious factors and finally death may be due to the sustained harms to the fish immune system (Roberts 2001). Based on Viarengo (1989), creatures' abilities for absorption, accumulation, removal or detoxification of heavy metals mainly vary with each other. Species having specific quantities of metallothioneins and lysosomes can remove the toxicity of these metals. According to the obtained results, we can attribute one of the probable reasons of concentration fluctuation of heavy metals in different species of fish to this matter. However, according to Roesijadi (1994), if the amount of heavy metals is high, their toxicity will increase since the ability of metallothioneins and lysosomes to remove their toxic effect is limited. On the other hand, according to Cappuzo (1985), when heavy metals exist excessively in the environment, they act as enzyme inhibitors. Also, the absorption and concentration level of heavy metals in fish can be under the influence of physicochemical conditions of water, heavy metals concentration in water and sediment, feeding habits and the other factors (Canli & Atli 2003).

Vanadium element is found in algae, plants, invertebrates and the other aquatic animal species. This element concentration in seashells and crabs is about 10^5 to 10^6 times more than the vanadium concentration in sea water. Seashells and crabs as two biological indexes can store this element in their organs in large quantities. A research done regarding the level and effect of vanadium element in *Mugil curema* gonads shows that due to the existence of high fat in tissues of *M. curema*, heavy metals, especially vanadium element, are absorbed and can have an effect on its genetic and evolutionary balance. This element is exchangeable and can be simplified inside gonad tissues biologically VO^{2+} and VO^{3+}. Although vanadium element is not stored as mentioned forms while passing through the digestive system. It is likely to be stored during the larval or fingerling stage (Arias de Diaz et al 2001). An increase in vanadium element in the creatures 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 (Esmaeili Sari 2002).

Sepe et al (2003) obtained the vanadium rate existing in species of anchovy (*Engraulis encrasicolus*), red mullet (*Mullus barbatus*) and mackerel (*Scomber scombrus*) of Adriatic Sea as follows 89.9, 79.1, and 43.5 mg kg^{-1} respectively. Lavilla et al (2008) also during a 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^{-1} limits.

The results of this study generally showed that the measured vanadium levels in muscle tissues of *B. orientalis* and *O. ruber* in both Bushehr and Asalouyeh stations didn't have significant differences. Also the concentration level was lower than standard permissible. This indicated that consumption of fish in these areas, does not create a risk of vanadium to consumers. 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. All installations of the South Pars region located near the Asalouyeh city and pier are located along the shoreline due to the location of oil and gas fields in the sea and also several oil rigs are located on the sea near it. Table 5 shows the comparison of vanadium concentrations in the present study with the other researches.

Table 5

Comparison of vanadium concentrations in the present study with the other researches (mg kg^{-1})

Reference	*V conc.*	*Region*	*Species*
Pourang et al (2005a)	1.17	Northern Persian Gulf	*Epinephelus coioides*
Pourang et al (2005a)	0.1-0.4	Northern Persian Gulf	*Solea elongata*
Pourang et al (2005a)	0.03-2	Northern Persian Gulf	*Psettodes erumei*
Pourang et al (2005b)	0.011	Southern Caspian Sea	*Acipenser persicus*
Bu-Olayan & Subrahmanyan (1996)	1.1	Persian Gulf, Kuwait shores	*Solea bleekeri*
Bu-Olayan & Subrahmanyan (1996)	0.7	Persian Gulf, Kuwait shores	*Gastrophysus lunaris*
Bu-Olayan & Subrahmanyan (1996)	2.2	Persian Gulf, Kuwait shores	*Acanthopagrus latus*
Bu-Olayan & Subrahmanyan (1996)	4.6	Persian Gulf, Kuwait shores	*Sillego sihana*
Current study	0.246	Persian Gulf, Bushehr	*Brachirus orientalis*
Current study	0.288	Persian Gulf, Asalouyeh	*Brachirus orientalis*
Current study	0.245	Persian Gulf, Bushehr	*Otolithes ruber*
Current study	0.245	Persian Gulf, Asalouyeh	*Otolithes ruber*

Conclusions. Vanadium usually enters the environment through the natural resources as well as fossil fuels and remains in water, soil, and air for a long time. Another characteristic of this element is that it is combined with other elements and materials in water and sticks to oil sediments. Generally speaking and based on the obtained concentrations and made comparisons it was specified that according to the standards of WHO, Canada and Italy, vanadium level in muscles of *B. orientalis* and *O. rubber* from Persian Gulf is lower than the permissible standards.

References

Abdolahpour Monikh F., Peery S., Karami O., Hosseini M., Abdi Bastami A., Ghasemi A. F., 2012 Distribution of metals in the tissues of benthic, *Euryglossa orientalis* and *Cynoglossus arel*., and bentho-pelagic, *Johnius belangerii*., fish from three estuaries, Persian Gulf. Bulletin of Environmental Contamination and Toxicology 89:489–494.

Al-Yousuf M. H., El-Shahawi M. S., Al-Ghaisc S. M., 2000 Trace metals in liver, skin and muscle of *Lethrinus lentjan* fish species in relation to body length and sex. Science of the Total Environment 256(2-3): 87–94.

Arias de Diaz A., Gamboa N., Garcia J., 2001 Vanadium levels in gonads of white mullet (*Mugil curema*) in the Cariaco Gulf, Venezuela. Zootecnia Tropical 19(2):165-172.

Askary Sary A., Mohammadi M., 2012 Mercury concentrations in commercial fish from freshwater and saltwater. Bulletin of Environmental Contamination and Toxicology 88(2):162–165.

Banat I. M., Hassan E. S., El-Shahawi M. S., Abu-Hilal A. H., 1998 Post-Persian Gulf war assessment of nutrients, heavy metal ions, hydrocarbons and bacterial pollution levels in the United Arab Emirates coastal waters. Environment International 24(1/2):109-116.

Barlas N., 1999 A pilot study of heavy metal concentration in various environments and fishes in the upper Sakaryia River basin, Turkey. Environmental Toxicology 14(3):367–373.

Bu-Olayan A. H., Subrahmanyam M. N. V., 1996 Trace metals in fish from the Kuwait coast using the microwave acid digestion technique. Environment International 22(6):753-758.

Bustamante P., Bocher P., Cherel Y., Miramand P., Caurant F., 2003 Distribution of trace elements in the tissues of benthic and pelagic fish from the Kerguelen Islands. Science of the Total Environment 313(1-3):25–39.
Canli M., Atli G., 2003 The relationships between heavy metal (Cd, Cr, Cu, Fe, Pb, Zn) levels and the size of six Mediterranean fish species. Environmental Pollution 121(1):129-136.
Cappuzzo J. M., Burt W. V., Duedall I. W., Park P. K., Kester D. R., 1985 The impact of waste disposal in nearshore environment. In: Wastes in the Ocean. Vol. 6. Nearshore waste disposal. John Wiley & Sons, New York, 534 pp.
Chen M. H., Chen C. Y., 1999 Bioaccumulation of sediment-bound heavy metals in grey mullet, *Liza macrolepis*. Marine Pollution Bulletin 39(1-12):238–243.
Dìaz de Astarloa J. M., Munroe T. A., 1998 Systematics, distribution and ecology of commercially important paralichthyd flounders occurring in Argentinean-Uruguayan waters (Paralichthys, Paralichthyidae): an overview. Journal of Sea Research 39(1-2):1-9.
Esmaeili Sari A., 2002 [Pollution, health and environmental standards]. Naghshmehr, Iran, pp. 67-81 [in Persian].
FAO/WHO, 1976 List of maximum levels recommended for contaminants by the Joint FAO/WHO codex alimentarius commission. Second Ser CAC/FAL Rome 3:1–8.
Fatih Fidan A., Hakki Cigerci I., Konuk M., Kucukkurt I., Aslan R., Dundar Y., 2008 Determination of some heavy metal levels and oxidative status in *Carassius carassius* from Eber Lake. Environmental Monitoring and Assessment 147(1-3):35–41.
Ghanbari F., Pazira A. R., Javad Zadeh N., 2014 The measurement of heavy metal (Lead) concentration in muscle tissues of *Brachirus orientalis* in Bushehr and Asalouyeh seaports (Persian Gulf, Iran). Journal of Biodiversity and Environmental Sciences 4(2):237-244.
Goyer R. A., 1986 Toxic effects of metals. In: Casarett and Doull's Toxicology: the basic science of poisons. 3rd Edition. Klaassen C. D. Amdur M. O., Doull J. (eds), Macmillan Publishing Company, New York, pp. 582–635.
Henry F., Amara R., Courcot L., Lacouture D., Bertho M. L., 2004 Heavy metals in four fish species from the French coast of the Eastern English Channel and Southern Bight of the North Sea. Environment International 30:675–683.
Holcombe G. W., Benoit D. A., Leonard E. N., McKim J. M., 1976 Long-term effects of lead exposure on three generations of brook trout (*Salvelinus fontinalis*). Journal of the Fisheries Research Board of Canada 33:1731–1741.
Jaffar M., Ashraf M., Rasoal A., 1998 Heavy metal contents in some selected local freshwater fish and relevant waters. Pakistan Journal of Scientific and Industrial Research 31(3):189-193.
Kalay M., Canli M., 2000 Elimination of essential (Cu, Zn) and nonessential (Cd, Pb) metals from tissue of a freshwater fish *Tilapia zilli*. Turkish Journal of Zoology 24:429–436.
Kalay M., Ay O., Canli M., 1999 Heavy metal concentrations in fish tissues from the northeast Mediterranean Sea. Bulletin of Environmental Contamination and Toxicology 63(5):673-681.
Lavilla I., Vilas P., Bendicho C., 2008 Fast determination of arsenic, selenium, nickel and vanadium in fish and shellfish by electrothermal atomic absorption spectrometry following ultrasound-assisted extraction. Food Chemistry 106(1):403-409.
Manual of Oceanographic Observations and Pollutant Analyses Methods (MOOPAM), 1999 Regional Organization for the Protection of the Marine Environment, Kuwait, PP. V-28.
Mendil D., Demirci Z., Tuzen M., Soylak M., 2010 Seasonal investigation of trace element contents in commercially valuable fish species from the Black sea, Turkey. Food and Chemical Toxicology 48(3):865–870.
Moghdani S., 2013 Concentrations of Ni, Cd and V in muscle tissues of *Otolithes ruber* and *Brachirus orientalis* in Bushehr and Asaluyeh Seaports. MSc. Thesis, Islamic Azad University, Khouzestan Science and Research Branch, Ahvaz, Iran, 100 pp.
Moghdani S., Pazira A. R., Javad Zadeh N., 2014 Effects of oil contamination on nickel concentration in muscle tissues of *Brachirus orientalis* in Persian Gulf waters. Journal of Biodiversity and Environmental Sciences 4(1):141–148.
Navarro M. C., Perez-Sirvent C., Martinez-Sanchez M. J., Vidal J., Marimon J., 2006 Lead, cadmium and arsenic bioavailability in the abandoned mine site of Cabezo Rajao (Murcia, SE Spain). Chemosphere 63(3):484–489.

Payam-e Darya, 1995 Water pollution in the Persian Gulf and Caspian sea. The Shiping Organization of the Islamic Republic of Iran 32:13-20.
Pazira A. R., Moghdani S., Ghanbari F., Javad Zadeh N., 2014 The measurement of nickel concentration in muscle tissues of *Otolithes ruber* in Persian Gulf waters, Iran. International Journal of Biosciences 5(1): 265-272.
Pourang N., Nikouyan A., Dennis J. H., 2005a Trace element concentration in fish, surficial sediments and water from northern part of the Persian Gulf. Environmental Monitoring and Assessment 109(1-3):293-316.
Pourang N., Tanabe S., Rezvani S., Dennis J. H., 2005b Trace elements accumulation in edible tissues of five sturgeon species from the Caspian Sea. Environmental Monitoring and Assessment 100(1-3):89-108.
Roberts R. J., 2001 Fish pathology. 3rd edition. Sawnders W. B. (ed), Harcornt Publishers Co. LTD. London, England, 472 pp.
Roesijadi G., 1994 Behavior of metallothionein-bound metals in a natural population of an estuarine mollusk. Marine Environmental Research 38:147-168.
Saeed T., Al Yakoob S., Al-Hashash H., Al-Bahloul M., 1995 Preliminary exposure assessment for Kuwaiti consumers to polycyclic aromatic hydrocarbons in seafood. Environment International 21(3):255-263.
Saeidi M., Abtahi B., Mortazavi M. S., Aghajery N., Ghodrati Shojaeii M., 2008 Zinc concentration in tissues of spangled emperor (*Lethrinus nebulosus*) caught in northern part of the Persian Gulf. Environmental Sciences 6(1):75–82.
Sepe A., Ciaralli L., Ciprotti M., Giordano R., Funari E., Costantini S., 2003 Determination of cadmium, chromium, lead and vanadium in six fish species from the Adriatic Sea. Food Additives and Contaminants 20(6):543-552.
Sheppard C., Al-Husiani M., Al-Jamali F., Al-Yamani F., Baldwin R., Bishop J., Benzoni F., Dutrieux E., Dulvy N. K., Durvasula S. R. V., Jones D. A., Loughland R., Medio D., Nithyanandan M., Pilling G. M., Polikarpov I., Price A. R. G., Purkis S. J., Riegl B. M., Saburova M., Samimi Namin K., Taylor O., Wilson S., Zainal Z., 2010 The Gulf: a young sea in decline. Marine Pollution Bulletin 60(1):13–38.
Ünlü E., Gümgüm B., 1993 Concentrations of copper and zinc in fish and sediments from the Tigris River in Turkey. Chemosphere 26(11):2055–2061.
Viarengo A., 1989 Heavy metals in marine invertebrates: mechanisms of regulation and toxicity at the cellular level. CRC Critical Reviews in Aquatic Sciences 1:295-317.
Zar J. H., 1999 Biostatistical analysis. 4th edition. Prentice Hall, Upper Saddle River, New Jersey, 663 pp.

Received: 03 September 2014. Accepted: 07 November 2014. Published online: 12 December 2014.
Authors:
Saeid Moghdani, Young Researchers and Elite Club, Bushehr Branch, Islamic Azad University, Bushehr, Iran, Alishahr, postal code 75196-38479, e-mail: s.moghdani@gmail.com
Abdol-Rahim Pazira, Department of Engineering, College of Natural Resources, Islamic Azad University, Bushehr Branch, Iran, Alishahr, postal code 75196-38479, e-mail: abpzira@gmail.com
Farshad Ghanbari, Young Researchers and Elite Club, Bushehr Branch, Islamic Azad University, Bushehr, Iran, Alishahr, postal code 75196-38479, e-mail: msc.ghanbari@gmail.com
Narges Javad Zadeh, Department of Fisheries Sciences, College of Agricultural Sciences and Natural Resources, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran, Golestan Street, Farhangshahr Square, postal code 68875-61349, P. O. Box 1915, e-mail: nargesjavadzadeh@yahoo.com

How to cite this article:
Moghdani S., Pazira A. R., Ghanbari F., Javad Zadeh N., 2014 Vanadium concentration levels in muscle tissues of two commercial fish species in Persian Gulf waters. AACL 7(6):489-496.