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Bioaccumulation of Arsenic in Blue Swimmer Crab

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Abstract. Accumulation of toxic metals in marine organisms can significantly affect the public health and economic performance. The present study was conducted to evaluate the concentration of arsenic in blue swimmer crab, *Portunus pelagicus*, collected from the Persian Gulf waters in Asalouyeh, Iran as a bio-indicator of metal pollution. Sampling was carried out over the winter months in 2014. Arsenic analysis was performed using an atomic spectrophotometer. The results showed that the mean concentration (mg/kg dry weight) of arsenic in the soft tissue of *Portunus pelagicus* in January, February and March were 0.08, 0.21 and 0.22 mg/kg respectively. Significant variation was found between months ($P<0.05$). The lowest concentration of arsenic was for station 2 (0.13) and the highest was for station 3 (0.23). Arsenic concentrations in the crabs from three stations were lower than the standard limits and thus safe for human consumption.

Keywords: arsenic, bio-accumulation, industrial pollution, Portunus pelagicus, toxic metals.

1. Introduction

Environmental sustainability has become a growing concern for many organizations worldwide [1]. Anthropogenic activities are increasingly influencing the quality and function of natural ecosystems. The frequent extinction of species, deforestation, natural resources depletion, and pollution are mainly attributed to the human activities and regarded as major threats to sustainable development [2].

Economic development in many countries, especially in developing countries, has resulted in adverse effects on natural ecosystems [1]. Industrial pollution can cause damage to different sectors in an economy. Industrialisation and urbanization may cause social, health and environmental effects [3]. The change in land use from natural areas to industrial use can have harmful effects on bio-diversity. Marine pollution is one of the most common and serious consequences of industrial activities. Marine organisms are highly exposed to toxic metals as a result of natural and human activities [4].

Heavy metals are considered as toxic chemicals that are not bio-degradable, and thus have a strong ability to accumulate in organisms [5], [6]. These metals find their way into the human body through food chain, and cause serious health problems or even death [7]. In addition to the public health effects, toxic metals can have serious negative economic consequences, such as damage to fisheries industry (commercial and recreational), negative implications on tourism industry, and management and monitoring costs [8].

Arsenic (As) is released into the environment from both anthropogenic and natural sources. Examples of natural sources are soil, wind, and volcanoes [9]-[11]. The main routes of non-occupational human exposure to As are ingestion of food and water. Seafood contains considerable amounts of As [10]. This chemical element can also be considered a major threat to marine life [7]. As chemistry in marine environment is very complex; different compounds of both organic and inorganic species have been determined in aquatic ecosystems [12]. Aquatic organisms accumulate As in their bodies through food chain, water, and sediments [7]. Hence, it is important to find out the levels of this contaminant in marine organisms to determine whether they are safe for human consumption.

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The blue swimmer crab, *Portunus pelagicus*, is one of the commercial species [13], which is widely distributed in the Persian Gulf region. In addition to human consumption, blue crabs also have many commercial uses. For example, this crab is a rich source of chitin and chitosan [14] which are useful substances for several medical and industrial purposes. *Portunus pelagicus* crabs are prey for a variety of marine organisms, and play an influential role in marine food webs [15]. Benthic crustaceans have direct contact with contaminated sediments. They have long been used as a food source for human and therefore can have an important role in transferring metal contaminants from marine ecosystem to human body [16]. Therefore, they are appropriate species for pollution studies [13].

The Persian Gulf is a semi-enclosed shallow sea situated between Iran and the Arabian Peninsula. The environmental quality of the Gulf has been seriously impaired by exploitation of oil and gas resources, recent wars, and industrial activities. Large amounts of toxic chemicals including heavy metals have been released into the gulf [13], [17]. Asalouyeh is a city located on the shore of the Persian Gulf, and it is the most important economic centre of Iran. This city has large-scale petrochemical and refinery units, producing variety of chemicals. Up to sixty thousand workers are employed in the Asalouyeh [18]. Industrialisation has led to a rapid increase in population growth in the region. Unfortunately, industrial activities and economic development in the Asalouyeh area have inflicted widespread damage to coastal and marine environment.

Much research has been done to investigate the levels of metals in marine ecosystem of the Persian Gulf. However, far too little attention has been paid to measure the concentration of metals in crustaceans from Asalouyeh region. *Portunus pelagicus* crab is one of the most frequently consumed crab species in the study area. The purpose of this paper is to determine the levels of As in *Portunus pelagicus* crabs from Asalouyeh as bio-indicators of metal pollution.

2. Materials and Methods

The present study was performed in Asalouyeh, a city in south of Iran. This city is considered as the biggest energy production centre in the world. The huge gas field in this area supports many refineries, petrochemical plants and their subdivision industries. The discharge of waste waters into the Persian Gulf is mostly associated with the industrial activities in this region. After preliminary researches on the natural habitat of the crabs and the main pollution sources in the study area, three sampling stations were selected along the Asalouyeh port. The geographical co-ordinates of the stations are listed in Table 1. A total of 27 crab samples were collected from three sampling stations over a three-month period (January- March) in 2014. Collected crabs were transferred to the laboratory within 2 h in polystyrene foam boxes packed in ice.

Table 1: Geographical co-ordinates of sampling stations

Sampling Stations	Latitude	Longitude
Station 1	27° 28' 13.56" N	52 °36' 24.41" E
Station 2	27° 28' 11.55" N	52 °36' 27.29" E
Station 3	27° 28' 9.54" N	52 °36' 30.14" E

The crabs of each station were washed with deionized water separately and kept at a temperature of -20˚C until they prepared for chemical digestion. Following this, the soft tissues of crabs were dissected and homogenized. The tissues were then placed on clean watch glasses, and weighed to 5 g using an electronic weighing balance. The weighted samples were dry-ashed at 550˚C for 8 h, ground into a fine powder using a mortar and pestle and placed in glass beakers for acid digestion. Samples were digested with concentrated HNO_3. Deionized water was then added to bring the solution up to 50 ml. The solution filtered through Whatman No. 1 filter paper [17]. Finally, Liquid samples were injected into a graphite furnace atomic absorption spectrophotometer (Varian Spectrum AA-600 Zeeman) for As determination.

All statistical analyses were done using SPSS version 22 statistical package for windows. The two-way analysis of variance test was applied to specify any significant variations between three stations and the months. LSD test was used to compare the group means. Significance for all tests was set at 0.05.

3. Results and Discussion

As contamination of natural waters is one of the major threats facing the world today. Bio-accumulation of this element in marine food chains can cause serious health problems in humans [12] and it is costly, both in human and economic terms. Hence, As levels in aquatic systems must be monitored periodically.

Fig. 1 summarises the concentrations of As in three stations. The results show that the highest level of As was detected in station 3 (0.23), and the lowest in station 2 (0.13). Station 3 is far from industrial area when compared to other stations. However, it is the closest one to the mangrove forests of Nayband, one of the crab's preferred habitats in the area. Plants can absorb As from contaminated soil, water, and air [19]. This result could be a reflection of the crab diet preferences in this station. *Portunus pelagicus* species are primarily omnivorous. Higher concentration of As in station 3 could be contributed to the high levels of As in Nayband algae that the crabs fed on them. A previous study indicated that there was a direct relationship between the rate of metal accumulation in the mangrove trees, and crabs *Ucides cordatus* that fed on them [20]. The results obtained by Raissy el al. [21] suggest that the mean concentration of As in muscle of lobster (*Panulirus homarus*) samples from the Persian Gulf was 184.3 μg/kg. Baboli and Velayatzadeh [22] found the mean concentration of As in the marine shrimp, *Fenneropenaeus merguiensis*, from the Persian Gulf was 0.117±0.07 μg/g dry weight. Our results also indicated that the second highest level of As was in station 1 (0.15) which was the nearest station to the industrial zone of Asalouyeh.

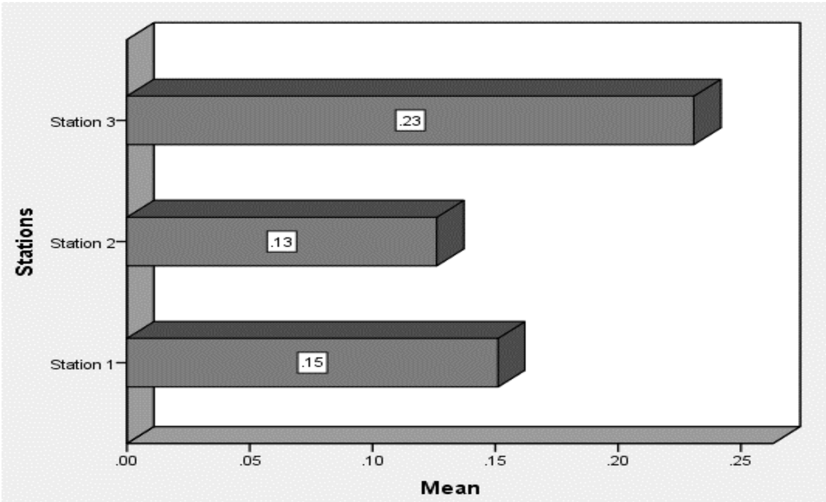

Fig. 1: The mean concentration of As (mg/kg dry weight) in crab samples in the stations.

As can be seen from Table 2, the highest level of As (0.22) was found in March and the lowest (0.08) was in January. These observations support the idea about the effects of temperature and salinity on changing the concentration of As in tissues of different organisms [9], [21]. It seems possible that the rate of metabolism increased with increase in temperature during the winter. As a consequence, we see a higher uptake of As in the crabs in March. It is also clear that the salinity levels rise as the temperature rise. This finding of the current study is consistent with those of previous studies [9], [23] who found there was a positive linear relationship between As concentration and salinity. However, Saei-Dehkordi et al. [6] reported As concentrations in some fish species from the Persian Gulf were higher in winter compared to summer.

Table 2: The mean concentration of As (mg/kg dry weight) in the crab samples over a three month period

Sampling Months	n	As Concentration
January	9	0.08
February	9	0.21
March	9	0.22

The bar chart illustrates the changes in As levels in the crab samples from three stations during three-month sampling period (Fig. 2). We can see from the chart that the highest level of As was in station 3 in March, but the lowest level was in station 1 in January over the sampling months. Besides temperature and salinity, other factors like available food, reproductive cycle and growth can also change the accumulation rate of metals in organisms [6]. The concentration of As increased in the stations 1 and 3 whilst As level in station 2 fell sharply from 0.22 in February to 0.10 in March. A significant rise in the concentration of As in February may be due to various reasons, including the presence of an As-rich source of food, or rock weathering.

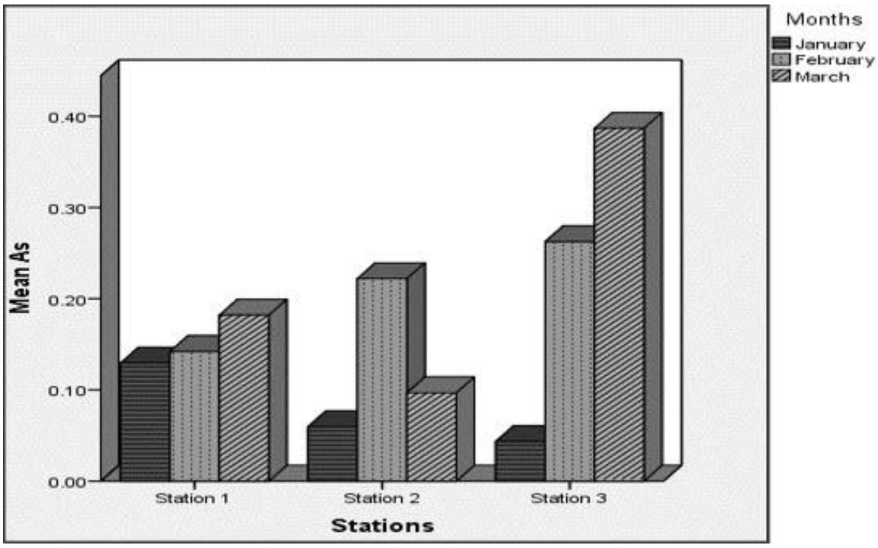

Fig. 2: The mean concentration of As (mg/kg dry weight) in the crabs in the stations during the sampling.

The results of analysis of variance for As concentrations in the samples showed that there were significant variations between the levels of As in the sampling months, but no significant differences (P>0.05) were found between the stations. LSD test revealed that there were no significant differences (P>0.05) in As concentration between February and March, and the least concentration of this metal was obtained in January.

Considering Table 3, the results from present study in comparison with the maximum levels (MLs) of As in food established by Food Standards Australia New Zealand (FSANZ), United Kingdom (UK) and Singapore standards suggest that As levels in all three stations and months were below the MLs and therefore safe for human consumption. The As concentrations observed for blue swimmer crabs from Bundu-Ama, Nigeria were higher than US Environmental Protection Agency and World Health Organization standards [24]. Sayyad [25] studied As concentrations in the crab, *Barytelphusa Cunicularis* from Godavari River in India and reported that the levels of this element in different parts of the crab in summer, monsoon, and winter seasons were higher than the recommended maximum allowable values in food. The differences among the results of different studies might be accounted for by differences in geographic location and industry types.

Table 3: International standards for maximum levels (MLs) of As concentrations (mg/kg) in food.

Standards	As	References
FSANZ	2	[26]
UK	1	[27]
Singapore	1	[28]

4. Conclusion

To sum up, industrial sites need effective management strategies to achieve a balance between development and maintenance of natural resources such as marine and biological systems. As contamination in the Persian Gulf fisheries poses significant risk to public health and economic development. Considering blue crabs are consumed by local people, it is necessary to monitor As levels in these species regularly. However, studies on metal concentrations in crabs from the Persian Gulf are still lacking. Since the exposure to inorganic As, which is more toxic than organic form, is mainly through drinking water and grain products, further study of the issue is still required.

5. References

[1] N. V. Attah. Environmental sustainability and sustainable growth: a global outlook (Master of Science in organizational dynamics theses). University of Pennsylvania, 2010.

[2] A. A. Asici. Economic growth and its impact on environment: A panel data analysis. *Ecol. Indic.* 2013, 24: 324-333.

[3] S. Singh, P. Jain, and A. Kumar. Impact of industrialisation on environmental pollution. *The Indian Forester*. 2009, 135 (9): 1259-1270.

[4] B.Y. Kamaruzzaman, Z. Rina, J. B. Akbar, and K.C.A. Jalal. Heavy metal accumulation in commercially important fishes of south west malaysian coast. *Res. J. Environ. Sci.* 2011, 5: 595-602.

[5] I. G. David, M. L. Matache, A. Tudorache, G. Chisamera, L. Rozylowicz, and G. L. Radu. Food chain biomagnification of heavy metals in samples from the lower prut floodplain natural park. *Environ. Eng. Manage. J.* 2012, 11(1), 69-73.

[6] S. S. Saei-Dehkordi, A. A. Fallah, and A. Nematollahi. Arsenic and mercury in commercially valuable fish species from the Persian Gulf: Influence of season and habitat. *Food. Chem. Toxicol*. 2010, 48 (10): 2945-2950.

[7] M. A. Rahman, H. Hasegawa, and R. P. Lim. Bioaccumulation, biotransformation and trophic transfer of arsenic in the aquatic food chain. *Environ. Res.* 2012, 116: 118-135.

[8] T. M. Willson, and R. F. Kazmierczak. The public health and economic impacts of persistent, bioaccumulative, and toxic (PBT) contaminants on U.S. fisheries. Southern agricultural economics association annual meetings, Mobile, Alabama. February 4-7, 2007.

[9] J. Ventura-Lima, D. Fattorini, A. Notti, J. M. Monserrat, and F. Regoli. Bioaccumulation patterns and biological effects of arsenic in aquatic organisms. In: J. D. Gosselin, and I. M. Fancher (eds.). *Environmental Health Risks*. Nova Science Publishers, Inc, New York, 2009, pp. 1-24.

[10] S. S. H. Tao. Toxic Metals: Arsenic. *Encyclopedia of Food Safety*. 2014, 2: 342-345.

[11] Agency for toxic substances and disease registry. Toxicological profile for arsenic. 2007. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=22&tid=3

[12] W. Zhang, L. Huang, and W. X. Wang. Arsenic bioaccumulation in a marine juvenile fish Terapon jarbua. *Aquat. Toxicol.* 2011, 105: 582-588.

[13] A. R. Sarasiab, and M. Hosseini. Study on PCB 101, PCB 153, mercury and methyl mercury content in blue crab Portunus pelagicus from Khuzestan shore (Persian Gulf). *Toxicol. Environ. Health Sci*, 2014, 6(2): 81-86.

[14] P. Raja, C. Chellaram, and A. A. John. Antibacterial Properties of Chitin from Shell Wastes. *Indian J. Innovations Dev.* 2012, 1(S8): 7-11.

[15] D. H. Adams, and M. E. Engel. Mercury, lead, and cadmium in blue crabs, Callinectes sapidus, from the Atlantic coast of Florida, USA: a multipredator approach. *Ecotoxicol. Environ. Saf.* 2014, 102: 196-201.

[16] S. McMurtrie. Heavy Metals in Fish and Shellfish from Christchurch rivers and Estuary: prepared for Christchurch City Council. Report No. R10/148. 2010.

[17] S. Salahshour, and A. R. Bakhtiari .Use of Solen brevis as a Biomonitor for Cd, Pb and Zn on the Intertidal Zones of Bushehr–Persian Gulf, Iran. *Bull. Environ. Contam. Toxicol.* 2012, 88: 951-955.

[18] H. Alipour, H. Darabi, T. Dabbaghmanesh, and M. Bonyani. Entomological study of sand flies (Diptera: Psychodidae: Phlebotominae) in Asalouyeh, the heartland of an Iranian petrochemical industry. *Asian Pac. J. Trop. Biomed.* 2014, 4(Suppl 1): 242-245.

[19] C. Bergqvist. Arsenic accumulation in various plant types. Licentiate of Philosophy Thesis, Department of Botany Stockholm University Sweden. 2011.

[20] M. A. Pinheiro, P. P. Silva, L. F. Duarte, A. A. Almeida, and F. P. Zanotto. Accumulation of six metals in the mangrove crab Ucides cordatus (Crustacea: Ucididae) and its food source, the red mangrove Rhizophora mangle

(Angiosperma: Rhizophoraceae). *Ecotoxicol. Environ. Saf.* 2012, 81: 114-121.

[21] M. Raissy, M. Ansari, and E. Rahimi. Mercury, arsenic, cadmium and lead in lobster (Panulirus homarus) from the Persian Gulf. *Toxicol. Ind. Health*. 2011, 27(7): 655-659.

[22] M. J. Baboli, and M. Velayatzadeh. Determination of heavy metals and trace elements in the muscles of marine shrimp, Fenneropenaus merguiensis from Persian Gulf, Iran. *J. Anim. Plant Sci.* 2013, 23(3): 786-791.

[23] E. H. Larsen, and K.A. Francesconi. Arsenic concentrations correlate with salinity for fish taken from the North Sea and Baltic waters. *J. Mar. Biol. Assoc. U. K*. 2003, 83(2): 283-284.

[24] E. U. Johnbosco, and O. A. Steve. Bioaccumulation of heavy metals in crabs at Bundu-Ama community, Port Harcourt. *J. Environ. Earth Sci*. 2013, 3(14): 11-21.

[25] N. R. Sayyad. Heavy metal concentrations in different body part of crab, Barytelphusa Cunicularis from Godavari River. *Int .J. Adv. Agric. Environ. Eng*. 2014, 1(1): 51-53.

[26] Food Standards Australia New Zealand. Australia New Zealand Food Standards Code - Standard 1.4.1 - Contaminants and Natural Toxicants. 2011.

[27] C. Reilly. *Metals in food and the law*. Oxford: Blackwell Science, 2002.

[28] F. Suhaimi, S. P. Wong, V. L. L. Lee, and L. K. Low. Heavy metals in fish and shellfish found in local wet markets. *Singapore J. Primary Ind.* 2006, 32: 1-18.