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Mercury Concentrations in Tissues of Blue Swimming Crab *Portunus pelagicus* and Sediments from Khark Island

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Abstract: Persian Gulf supports diverse ecosystems and biota in need of remediation and protection and metal data from this region is needed. The levels of mercury (Hg) in tissues of blue swimming crab, *Portunus pelagicus* and sediments in the Persian Gulf coasts, south Iran were investigated. Hg analysis was performed by Atomic Absorption Spectrophotometer. The distribution pattern of Hg in the tissues of *P. palagicus* and sediments was as follows: sediment > hepatopancreasn > muscle > exoskeleton. Total mercury levels in the tissues of *P. palagicus* from the other 5 sampling stations ranged between (4.65±0.33 µg/g) and (0.34±0.01 µg/g). In present study recorded that there was negligible differences in Hg levels between *P. pelagicus* sexes. Maximum concentration of the total Hg in sediments and all tissues of *P. pelagicus* observes in C-Island station ($p<0.05$) during different seasons. There was no significant difference ($p<0.05$) between the level of Hg in the tissues of the crab *P. pelagicus*. Differences in Hg levels could have resulted from diverse pollution source, ecological particularity, industries and human activities.

Key words: Concentrations · Mercury · *Portunus pelagicus* · Persian Gulf

INTRODUCTION

The Persian Gulf is a body of water in the Middle East between the Arabian Peninsula and Iran. This inland sea is connected to the Gulf of Oman by the Strait of Hormuz [1]. Persian Gulf is a semi-enclosed formation and heavy discharges of the surrounding industries have been ongoing for many decades. Other sources of Persian Gulf pollution include invasions and bombardments that have been staggering in the recent years and are yet to be fully investigated. Heavy metal used a widely in modern industry. Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms [2]. Heavy metals do not exist in soluble forms for a long time in waters. They are present mainly as suspended colloids or are fixed by organic and mineral substances [3]. Several factors such as size, nature of the environment, seasonal variation and variability in species have been identified as important independent variable influencing metal levels in marine organisms [4]. Metals that are naturally introduced into the river come primarily from sources such as rock weathering, soil erosion, or the dissolution of the water-soluble salts. Depending on physicochemical conditions, the pollutants in dissolved form can later be precipitated [5].

Hg naturally occurs in the environment as a result of the volcanic degassing of the Earth's crust and weathering of mercury rich geology. While water from areas rich in Hg ores may exhibit high local Hg concentrations, industrial processes, agriculture and the combustion of fossil fuel are the most significant sources of aquatic contamination. Common sources include caustic soda, pulp and paper and paint manufacturing. Hg is also used in batteries, dental amalgam and in bactericides [6, 7, 8]. Hg has as, far as we know, no necessary function in any living organism and is

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considered as a nonessential metal. On the contrary, mercury is among the most toxic elements to man and many higher animals [9, 10]. In addition to that the concentrations of total Hg in crabs tissues are generally low, aquatic invertebrates, also, accumulate Hg to high concentrations. As for most metals, factors known to influence Hg concentrations and accumulation in the marine organisms include metal bioavailability, season of sampling, hydrodynamics of the environment, size, sex and changes in tissue composition and reproductive cycle [11]. Accumulation of these metals only begins after the organisms are faced with high concentration in the surrounding medium [12], but body levels of nonessential metals such as mercury were not found to be regulated by crustacean [13].

Hg concentrations in aquatic ecosystems are usually monitored by measuring its concentration in water, sediments and biota [14]. Sediments are important sinks for various pollutants such as heavy metals [15, 16] and also play a useful role in the assessment of heavy metal contamination [17]. Sediments, particularly surficial sediments, may serve as a metal pool that can release metals to the overlaying water via natural anthropogenic processes, causing potential adverse health effects to the ecosystems because of their serious toxicity and persistence [18, 19]. The deposition of Hg metal in sediments occurs through an interaction between sediment and water, whereby variations of metal contents of sediment and water depend on variation of water chemistry, for example temperature, pH and solute concentration [20].

Crabs belong to a group of animals knows as decapods crustaceans. Most of the marine crabs occurring along the Persian Gulf coasts belong to the family Portunidae. The blue swimming crab, *Portunus pelagicus* is widely distributed throughout the coastal and estuarine areas of the tropical western Pacific and Indian oceans [21]. *P. pelagicus* is one of the important representatives of decapod crustacean and a species commonly found in Persian Gulf coasts, Iran. Crabs are infrequently reported on in the toxicology literature and metal toxicity data is needed for crustacean from Persian Gulf area. Crabs has the capability of accumulating heavy metals and is thus a suitable bioindicator for environmental contamination with these agents hepatopancreas, the key site of heavy metal accumulation in Crustacean [22], is one of the most important organs that play important roles in metal detoxification [23]. Therefore, it is of great interest to investigate the toxicity of heavy metal on hepatopancreas in *P. pelagicus*. Crabs are an excellent bioindicator of metal contamination and can be used to effectively and accurately monitor metal level for several reasons. Anthropogenic pollutants such as industrial, municipal and agricultural wastes finally end up in wetlands; exposing waterfowl to a variety of environmental pollutants. This seasonal variation study to determine the distribution and concentration of Hg in sediments and tissues (hepatopancreas, muscle, exoskeleton) of species *P. pelagicus* was done from Persian Gulf coasts located in south Iran.

MATERIALS AND METHODS

Study Area: The study was carried out in the Persian Gulf coasts (Khark Island) in south Iran (Fig. 1). The Persian Gulf lies on the South Iran, between longitudes 48°25' and 56°25" East and latitudes 24°30" and30°30' North. It has an estimated area of 260 km^2 and extends 600 km offshore to a depth average of about 30-40 m [1]. Specifically, the Khark Island lies between Longitudes 50°6' and 52°58'East and Latitudes 27°14' and 30°16' North and it is about 21 km long.

Sampling Stations: Samples of surficial sediments and available species of *P. pelagicus* were collected from 5 coastal localities during two seasons (between Feb and Sept 2011) in Persian Gulf coasts a distance of about 909 km. The 5 sampling station are shows in Fig. 1. Sampling covered areas of the direct or indirect influence of urban and industrial releases, those located near the mouth of the tributary rivers which carry industrial discharges of pollutants to the offshore waters and a locality not under the influence of industrial or urban releases. The sampling stations were selected to reflect progression of pollution, ecological particularity and human activities in the area.

Sampling and Analytical Methods: Sediment sampling was performed with Van Veen grab from the bottom at all stations. After sampling, the samples were packed in plastic bags, preserved and transferred to laboratory for analysis. Samples of biological material and sediment were immediately transferred to new polyethylene bags. All samples were frozen or stored at about 5°C until further processing. Each aliquot of sediment was digested for 4 h in a water bath at 60°C, after adding 3 mL each of concentrated HNO_3, $H_2S\ O_4$ and HF. $H_2S\ O_4$ was used because the sediment from most of the sampling sites contains 8 to 10% of organic matter [24]. The digestion of each sample of sediment was made in duplicate.

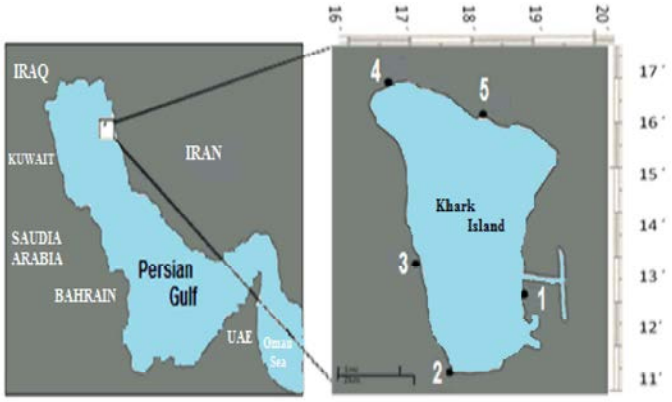

Fig. 1: Map of Persian Gulf coasts showing sampling stations and the study Site

Each sample of crabs was homogenized in an acid-cleaned mortar and 2 g were digested in triplicate in a water bath at 60°C for 6 h after adding 2.5 mL each of concentrated HNO_3 and $H_2S\,O_4$.

Crabs sampling was performed with shrimp trawl. After sampling, samples were transferred to the laboratory for further analysis. Each crab was properly cleaned by rinsing with distilled water to remove debris, planktons and other external adherent and then they were dissected for collect tissues hepatopancreas, muscle and exoskeleton. It was then drained under folds of filter, weighed, wrapped in aluminum foil and then frozen at 10°C prior to analysis. The tissues were placed in clean watch glasses and were oven dried at 105°C for 1 hour and later cooled in the desiccators.

The analysis of total Hg were done by the cold vapor method [25] using a Perkin-Elmer Atomic Absorption System AA-2380 with automatic background correction and a Perkin-Elmer Mercury Analysis System 303-0830. Replicate (3 to 5) measurements were made on each sample. All glass-ware used was cleaned by the procedure described by *Ober et al.* [26]. All the reagents used were of spectroscopic grade and ultra-high purity (99.9 %). In all experiences several blanks were performed with the reagents used, in order to check for possible contamination. The data obtained were statistically analyzed for confirmation of the results. Metal toxicity from different tissues and sediments was calculated by using regression equation and results were expressed in µg /gm dry weight.

Statistical Analyses: Data were analyzed using the one-way analysis of variance (ANOVA) and group means were compared using Duncans multiple range test. The difference was displayed as statistically significant when $p<0.05$.

RESULTS

Total Hg levels in the tissues of *P. palagicus* from the 5 sampling stations ranged between (4.65±0.33) and (0.35±0.05 µg/g) for female crab and between (4.15±0.03) and (0.34±0.01 µg/g) for male crab. The results of the levels of concentration of Hg in the tissues of the female crab *P. palagicus* are presented in Tables 1. In present study, results showed that Hg mean concentration was highest in hepatopancreas, followed by muscle and exoskeleton during different seasons. The highest mean concentration of Hg in the tissues of female crab was found in hepatopancreas (4.65 ±0.33 µg/g) during Summer season and least mean concentration found in exoskeleton (0.35±0.05 µg/g) during Winter season. Results indicated that Hg mean concentration in hepatopancreas tissue was higher than muscle and exoskeleton. Tables 2 showed the Hg mean concentration in the tissues of the male crab *P. palagicus*. The highest mean concentration of Hg in the tissues of male crab was found in hepatopancreas (4.15±0.10 µg/g) during Summer season and least mean concentration found in exoskeleton (0.34±0.01 µg/g) during Winter season. In present study recorded that there was negligible differences in Hg levels between sexes. We found that Hg levels were larger in tissues of female of the s than the males. There were no significant differences in Hg levels between sexes of *P. pelagicus*. There was significant difference ($p<0.05$) between the level of Hg in the different stations. The maximum mean concentration of Hg (4.65±0.33 µg/g) was noted in C-Island station during Summer season and minimum mean concentration (0.34±0.01 µg/g) was in Parke Saheli station during Winter season. In the present study, results showed that mean concentrations of Hg in the sediments and tissues of crabs in C-Island station were significantly higher

Table 1: Mean concentration of Hg (μ g/g dry weight) in tissues the female of *P. pelagicus* from 5 different stations along Persian Gulf coasts

		Sampling stations				
Season	Tissue	T-Island	G-Z	C-Island	Site NGL	Parke Saheli
Summer	Hepatopancrean	1.79±0.05	2.70±0.80	4.65±0.33	2.34±0.09	0.83±0.04
	Muscle	0.88±0.01	1.28±0.40	1.90±0.51	1.53±0.05	0.65±0.02
	Exoskeleton	0.80±0.08	0.80±0.19	0.80±0.72	0.77±0.02	0.54±0.02
Winter	Hepatopancrean	1.48±0.05	1.69±0.05	1.65±0.15	1.80±0.02	0.65±0.02
	Muscle	0.69±0.02	1.03±0.10	0.89±0.33	1.38±0.04	0.44±0.09
	Exoskeleton	0.55±0.05	0.65±0.12	0.64±0.23	0.55±0.04	0.35±0.05

Table 2: Mean concentration of Hg (μ g/g dry weight) in tissues the male of *P. pelagicus* from 5 different stations along Persian Gulf coasts

		Sampling stations				
Season	Tissue	T-Island	G-Z	C-Islan	Site NGL	Parke Saheli
Summer	Hepatopancrean	1.29±0.05	2.10±0.80	4.15±0.03	2.01±0.39	0.65±0.04
	Muscle	0.75±0.01	1.08±0.40	1.20±0.01	1.10±0.45	0.55±0.02
	Exoskeleton	0.58±0.08	0.30±0.19	0.66±0.02	0.65±0.30	0.44±0.02
Winter	Hepatopancrean	1.14±0.05	1.89±0.05	3.90±0.05	1.67±0.04	0.55±0.02
	Muscle	0.59±0.04	0.89±0.04	0.88±0.03	0.88±0.04	0.43±0.09
	Exoskeleton	0.47±0.05	0.26±0.02	0.50±0.03	0.50±0.04	0.34±0.01

Table 3: Mean concentration of Hg (μ g/g dry weight) in sediments from 5 different stations along Persian Gulf coasts

	Sampling stations				
Season	T-Island	G-Z	C-Islan	Site NGL	Parke Saheli
Summer	2.85±0.05	3.55±0.02	5.32±0.01	2.90±0.02	1.97±0.02
Winter	2.09±0.01	2.81±0.02	4.20±0.07	1.85±0.01	1.15±0.08

($p< 0.05$) than the other stations during different seasons. There is a growing concern about the physiological and behavioral effects of environmental trace metals in human population and probably due to nearby to petrochemical industries and a high amount wastewaters containing Hg always dumped at this station. The results indicated that mean concentrations of Hg in the sediments and tissues of crab during Summer season was higher than mean concentrations of Hg during Winter season. There was no significant difference ($p<0.05$) between the level of Hg during different seasons. In present study recorded that there was negligible differences in Hg levels between different seasons.

Total Hg levels in sediment from the other 5 sampling stations ranged between (5.32±0.01 μg/g) during Summer season and (1.15±0.08 μg/g) during Winter season (Table 3). Higher levels of total Hg in sediment were seen at C-Island station during Summer season. This station is located near the mouth of rivers which carry petrochemical industrial discharge to offshore waters. Results showed that mean levels in sediment from the other six sampling stations were higher than tissues of crab samples. However, total Hg mean concentration in sediments was always higher than the mercury levels found in tissues of *P. pelagicus* samples at the same locality (Table 3). In our samples, we found significant correlations between mercury in sediments and tissues of crab ($p<0.05$), but there were no significant differences in Hg levels between tissues of *P. pelagicus*. The magnification order of Hg in the sediments and tissues of crab was as follow: sediments > tissues. It can be concluded from the present study that the tissues of crabs studied contain Hg less than the sediments.

DISCUSSION

In present study, results showed that Hg concentration was highest in hepatopancreas, followed by muscle and exoskeleton. According to field and experimental studies, tissue distribution and accumulation of Hg in crabs varies widely depending on size, sex, growth stage, molting, migration, season of sampling, metal bioavailability, hydrodynamics of the environment, changes in tissue composition and reproductive cycle [11]. In our samples, we found significant correlations between Hg in sediments and tissues of crab ($p<0.05$). Crabs in this study have very similar diets; they are all intermediate consumers which feed mainly on invertebrates for example: shrimp, bivalve and vegetation. Foraging grounds of these crabs are also somewhat

Table 4: Comparison of Hg mean levels in tissues of various crab species from different parts of the world

Spices	Tissues	Hg	Location	Reference
P. pelagicus	Muscle	23.39±6.23	Egypt	[30]
P. pelagicus	Hepatopancreas	41.1±13.43	Egypt	[30]
P. pelagicus	Gill	16.99±5.06	Egypt	[30]
P. pelagicus	Muscle	0.068±0.30	Egypt	[31]
P. pelagicus	Muscle	0.19±1.80	Egypt	[31]
P. pelagicus	Muscle	0.19±0.50	Philippines	[32]
Scylla serrate	Muscle	0.37±0.90	Philippines	[32]
Mercenaria sp	Muscle	1.42±0.30	Philippines	[32]
Cardisoma guahumi	Muscle	0.15±1.44	Nigeria	[33]
Carcinus sp	Muscle	01.22±0.03	Nigeria	[34]
P. pelagicus	Hepatopancreas	02.22±0.60	Iran	Present study
P. pelagicus	Muscle	01.55±0.63	Iran	Present study
P. pelagicus	Exoskeleton	00.85±0.33	Iran	Present study

different which leads to differences in prey size and ultimately Hg intake. Crabs also, spends more time in shallow waters and coastal and in in terrestrial areas where anthropogenic Hg is less widely present. We therefore expected to see dissimilar levels of Hg in tissues of this specie. Despite the fact that there were no significant differences in Hg levels between tissues of *P. pelagicus*.

Seasonal variation may effect metal concentration in body organism. This variation could result in internal biological cycle in organism or variation in bioavailability of metal in environment. Temperature, food availability and water could increase metal concentration in Summer than Winter [27] such this condition was happened during present study and Hg levels in different tissues showed higher in Summer season compared to Winter season. In other words, most levels of Hg in body organism is in the form methy1 Hg which is soluble in fatty tissues, thus seasonal reproduction could be cause reduce mercury in Winter season. Similarly in the present study, less metal uptake was showed during Winter season. According to different studies the heavy metal concentrations in invertebrates showed higher in Winter and early Spring [28, 29]. It was revealed that algae and invertebrates all show similar seasonal patterns in metal concentrations it would seem likely that environmental factors (discharges to the estuary, pH, salinity, suspended matter, etc.) are having a greater overall influence on seasonality than biological factors (metabolism, reproduction, fluctuations in tissue weight, etc.). Seasonal variation in metal levels may be caused by such factors as land drainage to the marine environment availability of food, temperature and reproductive cycle and condition of the organism.

Although Hg levels marine organisms are important to know and from an ecotoxicological point of view, there is limited research findings related to Portunidae crab. For instance, in the region of the Persian Gulf, no results on Hg mean levels in Portunidae crab have been published, therefore it is not possible to compare the results directly. In relation to other species and other conditions, concentration of Hg in *P. pelagicus* in this study was compared with other studies around the world (Table 4). The mean concentration of Hg in Hepatopancreas of *P. pelagicus* showed almost higher than other tissues during present study and other studies around the world. In present study, the concentration of Hg in tissues of *P. pelagicus* showed that higher than other conditions except in Lake Timsah, Egypt. However, in this study, concentration of Hg in tissues of *P. pelagicus* was compared WHO, FAO, UKMAFF and USFDA standard values. Concentration of Hg in C-Island and Site NGL stations showed higher than UKMAFF but low than other standards values. Meanwhile, concentration of Hg in other stations was lower than all standards values.

In present study recorded that there was negligible differences in Hg levels between sexes. We found that Hg levels were larger in tissues of female of the *P. pelagicus* than the males. There were no significant differences in Hg levels between sexes of *P. pelagicus*. Therefore the small difference that has been reported in Hg body burdens in male and female is consistent with our current data of the present study. Therefore the negligible difference in Hg levels between sexes can be attributed to depuration in eggs, sexual dimorphism and niche partitioning of the forage base. Differences in Hg concentrations the species is likely to have resulted from metal bioavailability, hydrodynamics of the environment, changes in tissue composition, reproductive cycle different feeding mechanism, temperature, salinity, stations of collection and sources of pollution within Persian Gulf.

CONCLUSION

The knowledge of heavy metal concentrations in crustaceans are very important with respect to nature management, human consumption of these species and to determine the most useful biomonitor species and the most polluted area. Information on the distribution pattern of toxic Hg pollutants in aquatic environment becomes important so as to know the accumulation of such pollutants in the organisms and final transfer to man through sea foods. The International official regulatory agencies have set limits for Hg concentrations above which the crab is considered unsuitable for human consumption. The present study is important not only from the human health point of view, but it also presents a comparative account of Hg in edible crabs from six different stations of Persian Gulf that are physic-chemically different. The results of this study suggested that the accumulation of Hg in the aquatic organisms of the present study may be dependent on some factors such as metal bioavailability, hydrodynamics of the environment, stations of collection, temperature, salinity, crab sexes and sources of pollution. The Hg accumulation in the different tissues and sediments increased as the exposure time increased. So, Hg will reach the tissues of human beings through the food chain. Therefore, it should be mentioned by industrialists and they should take steps to reduce the aquatic pollution. The magnification order of Hg in the sediments and tissues of *P. pelagicus* was as follow: sediments > tissues. It can be concluded from the present study that the tissues of crabs studied contain Hg less than the sediments and is safe for human consumption according to WHO criteria.

Very limited data on Hg exposure in Persian Gulf invertebrates are available. The data suggests that sediments have higher Hg levels than crab species. Information for evaluating the ecological risk implications of these isolated observations is lacking and more information on Hg in sediments and in invertebrates is needed. To understand the impacts of Hg on biota and ecosystems, it is necessary to systematically collect data on a group of representative species (bioindicators) from a wide variety of ecosystems, stratified by presumed exposure to Hg. A systematic assessment of Hg should be carried out in conjunction with other bioaccumulative pollutants and other heavy metals in Persian Gulf animals.

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