World Journal of Fish and Marine Sciences 3 (3): 227-231, 2011
ISSN 2078-4589

Distribution and Contamination of Mercury in *Metapenaues affinis* Shrimp and Sediments from Musa Creek (Northwestern Part of the Persian Gulf), I.R. Iran

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Abstract: The goal of the present study was to examine the specific bioaccumulation of total mercury in muscle, exoskeleton and hepatopancreas of *Metapenaeus affinis* shrimp and sediments from the Musa Creek region. Samples were collected during two seasons winter (February) and summer (August) of 2009 from five stations namely: Jafari, Ahmadi, Qanam, Qazale and Doraq, Shrimp and sediment samples were collected using trawl bottom and Van Veen grab, respectively. All samples of shrimp and sediment, dried by freeze dryer, digested based on EPA method by using HNO_3/HCl 2:1 v/v and potassium permanganate and analyzed by cold vapor AAS (UNICAM 919). In this study, maximum concentration of total mercury in sediments and all tissues of *Metapenaeus affinis* observed in Jafari station ($p<0.05$), probably because of its closeness to Bandar Imam Petrochemical Industries and high amount of wastewaters containing mercury dumped to this station. The general tendency in most element concentrations among different tissues were hepatopancreas > exoskeleton > muscle tissues. In this study, concentration of mercury in muscle tissue of *Metapenaus affinis* was compared with WHO, FAO, UKMAFF and USFDA standard values. Findings indicated concentration of mercury in Jafari and Ahmadi stations were higher than UKMAFF, but lower than other standard values. Meanwhile, concentration of mercury in other stations was lower than international standards. Regression and ANOVA analysis were used to compare mercury level in different stations and shrimp tissues.

Key words: Mercury · Persian Gulf · Musa Creek · Shrimp · Sediment and Bioaccumulation

INTRODUCTION

Heavy metals concentration in seawater is very low, but their levels have increased due to anthropogenic pollutants [1] over time. It has been known that metals are accumulated in tissues of aquatic animals and hence their determining in their tissues can reflect past exposures [2]. Due to anthropogenic activities such as agricultural and industrial activities, aquatic environments are increasingly contaminated by different kinds of pollutants, many of which can interfere with hormonal signaling invertebrates. Heavy metals accumulation by crustaceans living in various aquatic environments can be through feeding and direct uptake from water and sediments. There are several possible fates of a metal once inside the crustacean: binding to metallothionein, transport to the mitochondria, accumulation by lysosomes and transfer to the endoplasmic reticulum, or discharge back to the blood [3]. Nowadays, almost researchers support the idea that probably all of these processes are important and the organism probably uses a combination of these.

Toxic metals in marine environment are potentially accumulated in sediments and marine organisms and subsequently transferred to people through the food chain. Thus, it has become increasingly important to determine and assess values of heavy metals in marine organisms due to nutritional and safety conditions especially for edible marine organisms as they are a potential dietary source of protein [4]. Several investigations have been carried out on the heavy metals

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mercury contents in shrimp from all of the word. Among these, there is not any report found on heavy metals mercury contents in shrimp from the Musa Creek. Hence, this study was undertaken to determine the seasonal variation in level of total Hg in the muscle, exoskeleton and hepatopancreas of shrimp *Metapenaeus affinis* and sediment from 5 different stations to compare them with the previous studies and standard values.

MATERIALS AND METHODS

The area of sample collection is depicted in figure 1. *Metapenaeus affinis* specimens with sediment adjacent were sampled from 5 stations (Jafari, Ahmadi, Qanam, Doraq and Qazale) during two seasons (February and August 2009) in the northwestern part of the Persian Gulf (Musa Creek).

The *Metapenaeus affinis* specimens were collected from Musa Creek using shrimp trawl and brought to the laboratory on ice immediately. Upon arrival to the laboratory, the samples were separated into their size and the same sizes (10.75-13.20 cm) are separated to analyze. They were washed with double distilled water and dissected to collect muscle, exoskeleton and hepatopancreas. All tissues samples were dried using Freeze Dryer (ZIRBUS Model Vaco5II) for 72 hr. The dried samples were ground to powder by using a glass mortar to a fine powder and then redried for 3 hours and stored in clean plastic vials in a fridge until digestion.

A Van Veen grab was used to collect sediments from the bottom at all stations. In each station, sediment samples were collected at 3 random locations. Samples were kept in pre-cleaned glass jars and stored in ice-chest and immediately transferred to laboratory. Any visible materials and shells were removed from the samples. In the Laboratory, sediment samples were freeze dried and ground to powder using a glass mortar to a fine powder and then redried for 3 hours and stored in clean plastic vials in a fridge until digestion.

To minimize any contamination, all glassware were washed first with detergent and tap water and then soaked in 10% nitric acid for 24 h [5], rinsed repeatedly in deionized water and then dried. Furthermore, to minimize contamination of the samples, all chemicals used were of a supra pure (Merck) grade. About 1 gram of each samples were digested in a capped flask using 10 ml of HNO_3/HCl 2:1 v/v and potassium permanganate were added to the glass flask which was capped and allowed to digest for 4-5 hours at 130°C [6]. These were passed through a paper filter and diluted to 25 ml with double distilled water. After digestion, mercury in the samples was reduction with $SnCl_2$ and then samples were analyzed using Cold Vapor Atomic Absorption spectrometry (UNICAM model 919). Accuracies of the methods were assessed using certified reference material DORM-2 (National Research Council of Canada) in triplicate and recoveries of mercury ranged from 98% to 101% of the certified values.

Statistical analyses were performed using SPSS 11.5 for Windows. All data were tested for goodness of fit to a normal distribution with Kolmogorov–Smirnov's one sample test. Two-way analysis of variance (ANOVA) was used for comparison of mercury concentrations in muscle, exoskeleton and hepatopancreas tissues of shrimp and also in sediments. Tukey's Multiple-range test was used for comparison of mercury concentrations in shrimp from different sites. One-way ANOVA was used for comparison of more than two stations. Values are expressed in means standard error, μg g^{-1} of dry weight for samples; significance levels were put at $p< 0.05$.

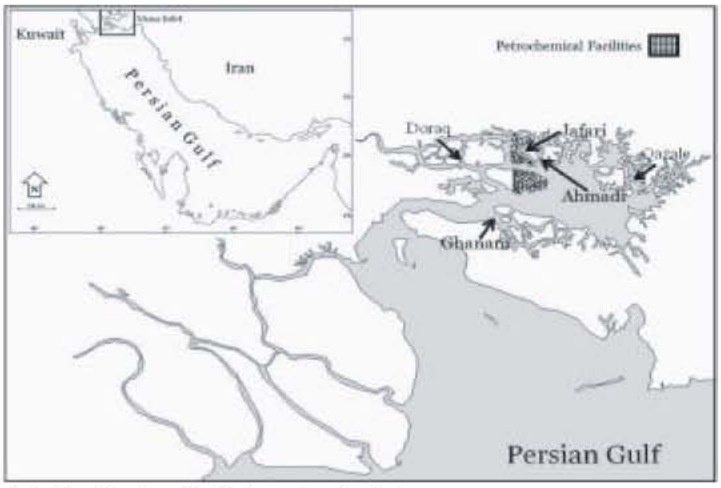

Fig. 1: Map of Musa Creek in the Persian Gulf, showing studying areas.

Table 1: Mean concentrations of Hg (μg g^{-1} dry wt) in tissues of *Metapenaeus affinis* during two seasons

		Sampling site				
Season	Tissue	Jafari	Qazale	Ahmadi	Qanam	Doraq
Summer	Muscle	1.70±0.47	0.97±0.38	1.33±0.31	0.81±0.15	0.92±0.08
	Exoskleton	2.46±0.31	1.19±0.27	1.68±0.19	1.16±0.22	1.09±0.18
	Hepatopancreas	4.85±0.72	1.81±0.42	2.43±0.42	1.97±0.47	1.70±0.53
Winter	Muscle	1.82±0.42	0.75±0.09	1.40±0.32	0.75±0.32	0.80±0.24
	Exoskleton	5.15±0.85	1.38±0.14	2.34±0.84	1.86±0.75	1.33±0.18
	Hepatopancreas	7.24±0.97	2.64±0.44	5.75±0.84	2.04±o.88	3.18±0.49

Table 2: Total mercury in sediments (μg g^{-1}) from five channels of Musa Creek

	Stations				
Season	Jafari	Qazale	Ahmadi	Qanam	Doraq
Summer	4.11±0.68	0.37±0.04	0.61±0.08	0.29±0.01	0.30±0.02
Winter	4.25±0.33	0.44±0.02	0.78±0.08	0.42±0.01	0.24±0.05

RESULTS

The highest values of 1.82, 5.15 and 7.24 μg g^{-1} dry wt of mercury were found in muscle, exosklelton and hepatopancreas during winter season in Jafari station, respectively (Table 1). Results indicated that mercury concentration in hepatopancreas tissue was higher than muscle and exoskeleton (Table 1). On basis of the present study, Hg concentration in Jafari station is significantly higher ($p < 0.05$) than the other stations to all tissues, probably due to nearby to Bandar Imam petrochemical industries and a high amount of wastewaters containing mercury always dumped at this station.

As far as heavy metal concentration in sediments is concerned, the maximum of 4.25 and 4.11 μg g^{-1} dry wt were noted in Jafari station during two seasons (Table 2). In sediments highest concentration of total mercury was in recent station during both seasons and it showed significantly ($p < 0.05$) higher than other stations. As already noted it could be related to nearby petrochemical industries which discharged amounts of mercury into this station. During present study, there was no significant variable between different seasons. However, at almost stations (except to station 5) maximum mercury concentration in sediments was observed during winter season.

DISCUSSION

The extent of occurrence or accumulation of heavy metals by organisms in different tissues is dependent on the route of entry, that is, either from surrounding medium or in the form of food or chemical form of material available in the media [7]. Concentrations of trace metals in tissues of marine invertebrates depend on the accumulation strategy adopted by all species for each metal; such strategy results from the balance between uptake and excretion rates. Biological features in organisms can affect relative rates of metal uptake and excretion [8].

According to Frıas-Espericueta and his colleges [9], the body concentrations of some elements considered as non-essential (e.g., Cd and Hg) and are not regulated by crustaceans. Thus, these elements may be accumulated in large quantities in tissues. Hepatopancreas of penaeid shrimps is a target organ that accumulates metals therefore in this study analyzed species followed the same pattern. During present investigation, the uptake of mercury by the hepatopancreas was found to be high in the tissues collected among the all seasons and stations. Bryan [10] has reported that the role of hepatopancreas appears to be such as "sponge" to collect heavy metals from the blood and keep the heavy metal level in blood fairly normal. However in present study, it has been showed that the mercury concentration in hepatopancreas was found to be high when compared to other tissues and this subject was in agree with Soundarapandian [7]. Andersen and Baatrup [11] also found Hg accumulation by gills, hepatopancreas and abdominal muscle using ^{203}Hg under controlled conditions was higher in hepatopancreas and gills in *Crangon crangon*.

Although Hg levels in marine organisms are important to know and from an ecotoxicological point of view, there is limited research findings related to penaeid shrimps. For instance, in the region of the Persian Gulf,

Table 3: Comparison of Hg levels (μg g^{-1} dry wt) in muscle of shrimp from different parts of the world

Spices	Hg	Location	Reference
Pink Shrimp	0.100-0.400	Indian	[15]
Metapencæus stebbingi	0.006-0.016	Egypt	[16]
Xiphopenæus kroyeri	0.13	Gulf of California	[17]
Aristeus antennatus	1.43-4.88	Mediterranean Sea	[18]
Xiphopenæus kroyeri	0.38	Brazil	[19]
Penæus monodon	<0.05	Vietnam	[20]
Metapenæus affinis	1.104	Musa Creek	This study

no results on Hg levels in penaeid shrimps have been published, therefore it is not possible to compare the results directly. In relation to other species and other conditions, concentration of mercury in *Metapenaus affinis* in this study was compared with other studies around the world (Table 3). During present study, concentration of mercury in muscle of *Metapenaeus affinis* showed almost higher than other conditions except in Mediterranean Sea. However, in this work, concentration of mercury in muscle tissue of *Metapenaus affinis* was compared with WHO, FAO, UKMAFF and USFDA standard values. Concentration of mercury in Jafari and Ahmadi stations showed higher than UKMAFF but lower than other standards values. Meanwhile, mercury concentration in other stations was lower than all standards values.

Seasonal variation may affect metal concentration in body organism. This variation could result in internal biological cycle in organism or variation in bioavailability of metals in the environment. Temperature, food availability and water could increase metal concentration in winter than summer [12] such this condition was happened during present study and mercury levels in different tissues showed higher in winter season compared to summer season. In other words, most amount of Hg in body organism is in the form of methyl mercury which is soluble in fatty tissue, thus seasonal reproduction could be cause reduce mercury in summer season. Similarly in the present study, less metal uptake was showed during summer season. According to different studies [13, 14] the metal concentrations in invertebrates showed also higher in winter and early spring. 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 variations in metal levels may be caused by such factors as land drainage to the marine environment, availability of food, temperature and the reproductive cycle and condition of the organism.

In this investigation, mercury levels in sediments found to be higher in Jafari station; this may be due to the high mercury content in industrial effluents at nearby this station. Usually the metal concentration in sediment was found to be lower during summer compared to winter season. However, concentration of mercury in sediment was compared with different tissues of *Metapenaus affinis* shrimp. Meanwhile, significant positive coloration ($r=0.751$ $p<0.05$) was observed between mercury concentration in hepatopancreas and sediment. On the other hand, there were significant positive correlation between Hg in sediment and exoskeleton tissue ($r=0.796$, $p<0.01$) and muscle tissue ($r=0.867$, $p<0.01$).

The heavy metal accumulation in the different tissues and sediments increased as the exposure time increased. So, heavy metal 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 effluents must be treated and diluted and the industrialists should monitor the aquatic pollution at regular intervals. Then only the disturbance to the ecology of all things (living and nonliving) will be reduced. The industrialists usually concentrate on the products they produce, they never care for the waste produced by the industries, usually if they concentrate on all the subjects related to industry there are many ways to reduce the harmfulness produced by the effluents to the environment, not only the water pollution, industries causes air pollution, noise pollution, land pollution, radiation pollution etc.

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