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Distribution of Pb in Sediment and Shell of Rocky Oysters (*Saccostrea cucullata*) of Lengeh Port, Qeshm and Hormoz Islands in Persian Gulf, Iran

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ABSTRACT Concentrations of lead (Pb) were found in the shells of the oyster *Saccostrea cucullata* and sediments in May 2010. Samples were obtained at four sites on Qeshm Island, at three sites on Hormoz Island, and at three sites in Lengeh Port along the intertidal coast of the Persian Gulf of Iran. The levels of Pb in sediments and shells were analyzed by graphite furnace atomic absorption spectrophotometer. Mean Pb concentrations in the different sampling stations varied between 613.94 and 0.06 µg g^{-1} in the shells of *S. cucullata* and 180.78 and 0.86µg g^{-1} in sediments. Biological effects criteria suggest that Pb concentrations in sediments in three sites from Lengeh Port were higher than ERL (effects range low), but at the all sites were lower than ERM (effects range medium). The present results support the significant differences in shell and sediments' accumulated concentrations of Pb among sites attributed to input sources of human activities including urban, domestic, industrial, agricultural, shipping and transport, mining activities, and ports and harbors.

Key words: *Biomonitoring, Hormoz Island, Human activities, Lengeh Port, Qeshm Island, Saccostrea cucullata*

1 INTRODUCTION

Contamination of marine ecosystems by potentially toxic metals is a growing concern in today's society and monitoring of metal concentration in marine biota is indicative of recent pollution status (Fang *et al.*, 2008; Protasowicki *et al.*, 2008). In aquatic environments, heavy metals are derived from a variety of natural and anthropogenic sources. Urban and industrial developments along the coastal areas, rivers and estuaries contribute to the major part of the anthropogenic metal load of the sea and those may be rapidly removed from the water column and transported to bottom sediment and aquatic sediments (Fung and Lo, 1997; Chong and Wang, 2000; Cobelo-García *et al.*, 2004; Protasowicki *et al.*, 2008). Many mussels, especially *S. cucullata*, accumulate metals in their tissues in proportion to the degree of environmental contamination and can be used as indicators of marine metallic pollution (Mackay *et al.*, 1975; Abdullah *et al.*, 2007). *S. cucullata* has the ability to accumulate trace metals without lethal effects; they are sedentary in nature,

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easy to sample, and provide sufficient tissue for contaminant analysis (Rainbow, 2002; Spooner *et al.*, 2003; Fung *et al.*, 2004; Maanan, 2008). Previous studies showed that *S. cucullata* can be used as an ideal biomonitor (Rainbow, 2002; Frías-Espericueta *et al.*, 2005; Maanan, 2008; Peer *et al.*, 2010). Also, human activities have led to the accumulation of toxins in aquatic sediments (Karbassi, 1998; Karbassi and Bayati, 2005). Sediments of most aquatic systems are known to act as a reservoir or sink for toxic metals that enter the estuary. Sediment also plays a very important role in the physicochemical and ecological dynamics of trace metals in aquatic ecosystems (Jain, 2004; Singh *et al.*, 2005).

The Persian Gulf is a semi-enclosed marginal sea surrounded by land masses and is located in the subtropical northwest of the Indian Ocean. The Gulf is a very shallow sea with an average depth of about 35 meters, high evaporation rates, an actual flushing time of 3-5.5 years, with salinity ranging from 38 to 70 g l^{-1} (parts per thousand). This naturally reflects the Persian Gulf's highly stressful environment (Sheppard, 1993; Akhter and Al-Jowder, 1997; Agah *et al.*, 2009). The Gulf is also affected by human activities including industrial, urban and domestic, economic, mining and agricultural activities (de Mora *et al.*, 2004; Karbassi and Bayati, 2005; Tolosa *et al.*, 2005).

This study was aimed to investigate the spatial distribution of Pb concentrations in the shells of *S. cucullata* and sediments on the coastal region of the Persian Gulf and to compare this region based on contaminant source input.

2 MATERIALS AND METHODS

Concentrations of Pb were measured in the shells of *S. cucullata* and sediments collected in May 2010 from ten sites in Lengeh Port, Qeshm Island, and Hormoz Island in the Persian Gulf of Iran (Table 1 and Figure 1). Sites were selected in each region based on contaminant source input. At each sampling site *S. cucullata* samples of similar sizes and sediments were collected from the intertidal coastal region. The samples were transported to the laboratory by ice box, and then all samples were stored at -20°C until further analysis. In the laboratory, cleaning shells with a jet of tap water, they were washed with deionized distilled water (DDW) and 0.5% of concentrated HNO_3, and then the shells were dried in an oven at 105 ºC for 72 h and sediments at 105ºC for 24 h (Akhter and Al-Jowder, 1997; Yap *et al.*, 2006). After drying, samples were pulverized to a uniform particle size for chemical analysis.

For the analyses of total Pb concentrations in the sediment and shells of *S. cucullata,* about 1 g of dried shell samples was digested in 10 ml concentrated HNO_3 and about 1 g of sediment samples was digested in 10 ml mixture of concentrated HNO_3 and $HClO_4$ in the ratio of 4:1 (v:v). Trace metal analyses of the sediments were performed on the <63µm fraction which was separated by sieving. The shells and sediment samples were put in a hot-block digester at temperature (40ºC) for 1 h and then fully digested at 140ºC for at least 3h (Yap *et al.*, 2003). After digestion and filtration, samples were diluted with deionized water to 25 ml for further analysis. The samples were analyzed for Pb using a graphite furnace atomic absorption spectrophotometer Model 67OG.

All statistical analyses were performed using SPSS 17.0 and Excel 2007. Variation in Pb concentrations in shells of *S. cucullata* collected from different sites was tested by analysis of variance (ANOVA). Pb concentrations in sediments for determination from different sites were tested by nonparametric comparisons (Kruskal-Wallis test). The level of significance was set at $p<0.05$.

Table 1 Location of sampling sites for sediments samples and Distribution Type Region Development.

station	Location	Site description
1	26°37'33"N, 54°59'48"E	Urban Area, Industrial, Harbors, and Shipbuilding Plants
2	26°38'21"N, 55°01'37"E	Urban Area, Industrial, Harbors, and Desalination Facilities
3	26°30'17"N, 54°39'42"E	Urban Area, Industrial, Shipping and Transport, Harbors, and Agriculture
4	27°04'23"N, 56°43'36"E	Pristine Area
5	27°10'25"N, 56°45'30"E	Mining Activity
6	27°04'23"N, 56°49'20"E	Urban Area with Less Development
7	26°55'28"N, 56°16'04"E	Urban Area with Less Development
8	26°53'27"N, 56°09'37"E	Recreational Area
9	26°48'49"N, 56°06'56"E	Pristine Area
10	26°41'16"N, 55°55'45"E	Pristine Area

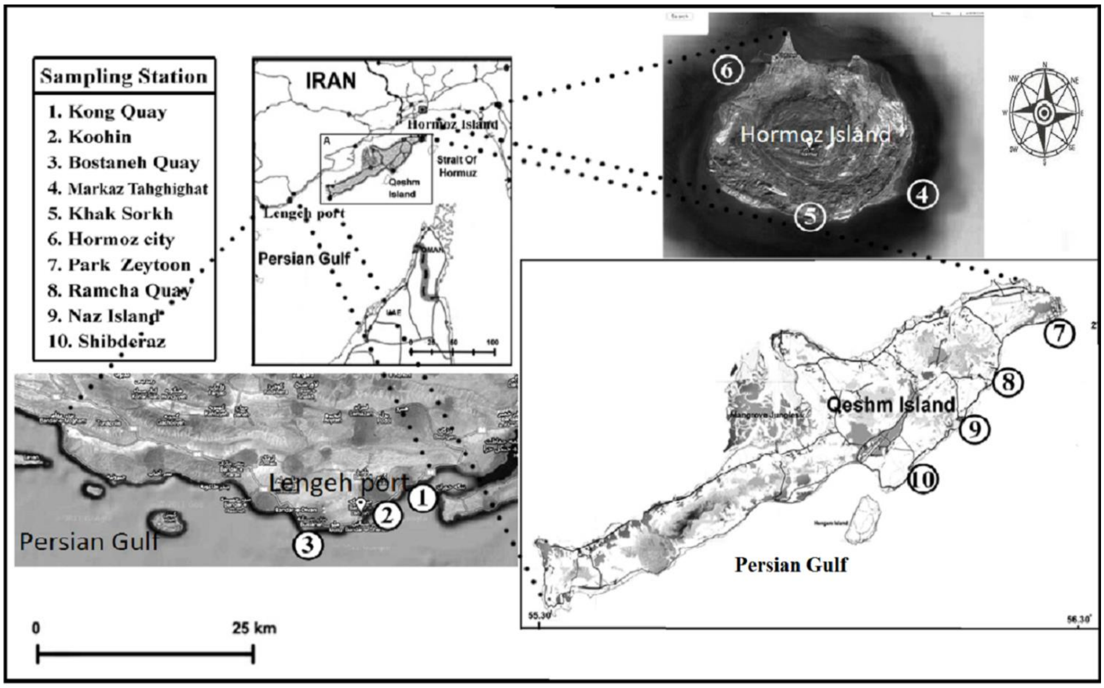

Figure 1 Location of all sampling sites for *S. cucullata* and sediments on the intertidal Coast of Persian Gulf of ran.

3 RESULTS

The mean concentration and range of individual concentrations of Pb in the shells of *S. cucullata* and sediments collected from ten sites on the intertidal coast of the Persian Gulf of Iran are presented in Table 2. All rock oysters have nearly the same shell length (Table 1). In oysters, concentrations of Pb showed significant variation among different sites (see Table 2). The results in Table 2 showed that concentrations of Pb in the shells of *S. cucullata* in different sites are of high values to low values 5>6>4>3>1>2>9>8>7>10 respectively.

Concentrations of Pb in the sediment samples collected from different sites were compared. The results showed that Pb concentrations ranged from 180.78 to 0.86µg g^{-1} and tended to order 3>2>1>5>6>4>7>8>10>9 in the stations. That result revealed that the higher Pb concentrations were found at sites 3, 2, and 1 of Lengeh Port, than at sites 5, 6, and 4 of Hormoz Island, and the lowest Pb concentrations were detected at sites 7, 8, 10, and 9 of Qeshm Island. Sediment Quality Guidelines (SQGs) can be used to assess the potential hazard to biota. Effects range low (ERL) and effects range median (ERM) guidelines for Pb concentrations in sediments are 46.7 and 218 (µg g^{-1} dry weight) respectively (Long *et al.*, 1995). ERL represents concentrations below which adverse effects are expected to occur only rarely. Concentrations equal to or above the ERL, but below the ERM, represent a probability range within which effects would occasionally occur. The concentrations equal to or higher than the ERM value represent a probability range within which effects would frequently occur (Long *et al.*, 1995). The measured concentrations of Pb were compared with ERL and ERM (Table 2). The results indicated that at sites 1, 2, and 3 Pb values exceed the ERL guidelines, and the sediments samples collected did not exceed the ERM guidelines.

Table 2 Means±SE concentration (µg g^{-1}dry weight) of Pb in shells of *S.cucullata* and sediments and comparison with sediment quality guidelines.

Station	Pb (shell)	Pb (sediment)
1	122.97* ± 2.78	180.78 ± 4.06
2	117.14* ± 2.04	153.07 ± 5.53
3	130.61* ± 2.79	142.72 ± 11.71
4	175.62 ± 3.13	1.87 ± 0.07
5	613.94 ± 6.98	24.93 ± 0.29
6	359.25 ± 8.79	5.03 ± 0.09
7	0.17 ± 0.02	1.47 ± 0.06
8	0.21 ± 0.01	0.95 ± 0.09
9	0.37 ± 0.04	0.86 ± 0.11
10	0.06 ± 0.01	0.91 ± 0.06

SE: Standard Error * Exceeds ERL

4 DISCUSSION

Human activities (urban and industrial) in coastal areas input significant amounts of heavy metals into the marine environment, and cause permanent disturbances in marine ecosystems (Price, 1993; Maanan, 2008). In order to biomonitor Pb concentrations on the intertidal coastal zones of Persian Gulf, the results of Pb analysis in the shells of *S. cucullata* were used. The results indicated a significant difference in the accumulated Pb concentrations in each of the ten sites. Results also showed that the contamination levels of Pb in *S. cucullata* were mainly related to local and regional sources. The level of Pb in the shell of *S. cucullata* was significantly higher at sites 5, 6, and 4 of Hormoz Island compared to those from stations 3, 1, and 2 of Lengeh Port. This may be due to the fact that Hormoz Island is located near the Straits of Hormoz, and its offshore area east of the Persian Gulf is now one of the world's most important shipping lanes (Price, 1993; Elhakeem *et al.*, 2007). On the other hand, the results obtained from the Pb concentrations in the shells of *S. cucullata* revealed higher Pb from stations 3, 1, and 2 of Lengeh Port than those of sites 9, 8, 7, and 10 of Qeshm Island. This can be attributed to the fact that high population density is found in Lengeh Port, and also most industrial areas are concentrated here as compared to the stations at Qeshm Island. The results of the present study agree with the results obtained from previous studies in which higher heavy metals concentrations were related to human activities such as manufacturing industries, urbanization activities, sewage disposal, solid waste disposal, shipping, and mining activities (de Mora *et al.*, 2004; Rojas de Astudillo *et al.*, 2005; Yap *et al.*, 2006; Maanan, 2008; María-Cervantes *et al.*, 2009; Peer *et al.*, 2010).

The results of this study indicated that the differences of concentrations of Pb in sediments collected from ten sites could be attributed to variations of contaminant sources input. The highest concentration of Pb was found in sediments from Kong Quay, the Kohin area, and Bostaneh Quay in Lengeh Port, and the lowest at Shib Deraz, the Naz Islands, and Ramchah Quay on Qeshm Island. These results suggest that these areas with high concentrations of Pb could be affected by human activities including urban, domestic, and industrial wastewater, agriculture, shipping and transport, coastal activities (i.e., marinas, jetties, ports and harbors), and mining activities. These results agree with the results of previous studies (Price, 1993; Ahmed *et al.*, 1998; de Mora *et al.*, 2004; Pak and Farajzadeh, 2007).

Heavy metal concentrations such as Pb are useful in evaluating the environmental criteria of aquatic environments, but even more important is whether toxicants are available to biota and whether they are entering the food chain. Since Iran has no established sediment quality guidelines at this time, the US National Oceanic and Atmospheric Administration (NOAA) guidelines were used as interim measures to assess whether the concentrations of heavy metals in sediments could have adverse biological impacts. The Pb concentrations obtained from the sediment samples were compared with the Sediment Quality Guideline. Results showed that these concentrations exceed those of the ERL levels in sites 3, 2, and 1 by approximately 287%, 227%, and 205% respectively. The results of present study are consistent with those of other studies in the Persian Gulf (Karbassi, 1998; Pourang *et al.*, 2005).

5 CONCLUSIONS

This study underscores: that *S. cucullata* and sediments are as reliable indicators of contaminants, for monitoring contaminants in the coastal environment that attributed to input sources of human activities including urban, domestic, industrial, agricultural, shipping and transport, mining activities, and ports and harbors.

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پراکنش سرب در رسوبات و پوسته صدف صخره‌ای (*Saccostrea cucullata*) جزایر قشم، هرمز و بندر لنگه در خلیج فارس، ایران

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چکیده مقادیری از سرب در رسوبات و پوسته صدف صخره‌ای *Saccostrea cucullata* در خرداد ماه سال ۱۳۹۰ در نمونه‌های چهار ایستگاه از جزیره قشم، سه ایستگاه در جزیره هرمز و سه ایستگاه در بندر لنگه در طول سواحل خلیج فارس یافت شد. مقادیر سرب در رسوبات و پوسته‌ها با دستگاه کوره گرافیتی آنالیز شدند. میانگین غلظت سرب در ایستگاه‌های مختلف بین ۶۱۳/۹۴ و ۰/۰۶ میکروگرم در گرم در پوسته‌های صدف صخره‌ای *Saccostrea cucullata* و بین ۱۸۰/۷۸ و ۰/۸۶ میکروگرم در گرم در رسوبات متفاوت بودند. معیار اثرات بیولوژیکی نشان می‌دهد که غلظت سرب در رسوبات در سه ایستگاه از بندرلنگه بالاتر از ERL بود، اما در همه ایستگاه‌ها غلظت سرب در رسوبات کم‌تر از ERM بوده است. نتایج مطالعه حاضر از اختلاف معنادار در غلظت‌های تجمع داده شده سرب در پوسته و رسوبات در طول ایستگاه‌ها حمایت می‌کند و این اختلاف معنادار منصوب به منابع ورودی از فعالیت‌های انسانی شامل فعالیت‌های شهری، خانگی، صنعتی، کشاورزی، کشتی‌سازی، حمل و نقل، فعالیت‌های معدنی، بندرگاه‌ها و اسکله‌ها است.

کلمات کلیدی: بندر لنگه، پایش زیستی، جزیره قشم، جزیره هرمز، فعالیت‌های انسانی