Biomonitoring of Pb, Fe and Zn using corals as bioindicator species, Qeshm Island, the Persian Gulf

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Present study consist biomonitor of lead, iron and zinc levels in sediment of Qeshm Island using two species of corals, Faviidae and Poritidae. Comparison of heavy metals among the stations indicated that the order of stations were PZ > SD > JN, SD > JN = PZ and JN > PZ > SD for Pb, Fe and Zn respectively. The results of liner regression analyzes showed that there were significant correlations (p<0.05) between Pb and Zn elements in sediment and the skeleton of Faviidae and between Pb in sediment and the skeleton of Poritidae. These phenomena suggest that Faviidae could be a biomonitor of Pb and Zn in sediment of Qeshm Island.

[Keywords: Sediment, Qeshm Island, Lead, Iron, Zinc, Coral]

Introduction

Coral reefs are one of the most diverse and complex ecosystems of marine environments, and they are the target of international conservation efforts6,12. There are many studies considered corals as historical recorders of heavy metals in marine environment5,3. Due to their sensitivity to physical and chemical changes in the marine environment (as they precipitate their CaCO3 skeletons directly from seawater)13, remaining in the same place throughout their lifetimes, ease of sampling and wide distribution6, corals are widely used as environmental indicators.

Tremendous quantities of pollutants are discharged directly or indirectly into marine environment every day. Of these, heavy metals are considered as serious pollutants of the aquatic environment because of their accumulative behavior1. Since they are not biodegradable, they could enter aquatic food chain and then accumulate in organisms of various trophic levels2. They can impose harmful effects on plant, animal, and human life depending upon their levels in the environment.

Sediments have a high storage capacity for heavy metals both in river and sea water9,21. According to previous study far less than 1% of heavy metals are actually dissolved in the water, more than 99% are stored in the sediments1. The capacity of sediments to adsorb and retain heavy metals highly depends on their composition and biological activity within the sediment10. However, the adsorbing capacity of sediment is strongly linked with the surface area of the particles22.

Qeshm Island is the largest Island in the Persian Gulf receiving a large number of visitors to its coral reefs. This island is situated closed to the Hormoz strait in the north part of the Persian Gulf9. There are several sources of anthropogenic pollutants including oil-related industries, oil transportations and ship-painting factories, which produce and release substantial amount of contaminants such as heavy metal into Qeshm seawater2. Like many other islands, Qeshm Island is an important place for fisheries and aquaculture activities. Considerable amount of fish and shrimp are caught from corals structures and mangrove forests of this island annually. The presence of high concentrations of
heavy metals in aquatic environment could result in metal accumulation by marine organisms and increase the risk of metal toxicity both in the people and in aquatic organisms who consume contaminated seafood. Therefore, in this study, concentrations of heavy metals (Pb, Fe and Zn) have been measured in two coral species and sediment of Qeshm coral reefs. The specific aim of this study is to assess the suitability of the species as bioindicators for heavy metal contamination and the load of heavy metal contamination in the island coral reefs.

Materials and Methods

The coral species (*Faviidae* and *Poritidae*) and sediment samples were collected from three sampling sites including Parke Zeyton (PZ), Jazaire Naz (JN) and Shib Deraz (SD) in July 2011 (Fig. 1) in the summer of 2011.

Coral heads were sampled by scuba divers and the sediment samples were collected by Van Veen grab. Samples of corals, representing around the last three years of growth, were collected from depths ranging between 2-8 m. The samples were placed on ice and brought daily to the laboratory then frozen at -20 °C until analysis.

After recognizing the coral species, according to18, the skeleton was separated using Air Brush, bathed in a deionized water solution and then was sonicated for 30 minute to eliminate the remaining tissue. Coral samples were pulverized in an acid-cleaned agate mortar and pestle and dried using Freeze-drier (OPERON, OPR-FDU-7012). Sediment samples from each station were oven-dried for 24 h at 105 °C, powdered in an agate mortar and then sieved through a 63-µm mesh. About 1g of the coral samples were digested with concentrated nitric acid and perchloric acid in the ratio of 4:1(Merck, Darmstadt, Germany) on hot plate until all the skeleton were dissolved. For sediment analysis, about 1g of sediment was digested with a solution of concentrated nitric acid and perchloric acid (5:1) (Merck, Darmstadt, Germany). After digestion, the samples were diluted with double distilled water and then filtered by a 42-µm paper filter. All reagents used were of analytical grade. Blank samples and standard reference material DORM 2 (National Research Council of Canada; dogfish muscle) were applied in order to avoid possible contamination during analysis and to check the accuracy of analytical procedures. The recovery rates of metals were between 92.1% and 108.4%. A flame atomic absorption spectrometer (SHIMADZU, AA 670) and graphite furnace atomic absorption (SHIMADZU, AA 670G) were employed to determine the concentrations of Pb, Fe and Zn in the samples.

Significant differences between heavy metals concentration in various stations were determined using one-way analysis of variance (ANOVA) followed by Duncan post hoc test. Linear regression analyses were used to compare the relationships between metal concentration in sediment and corals. The level of significance was set at α = 0.05.

Results and Discussion

The mean concentrations of the metals Pb, Fe and Zn measured in sediment of the three stations along Qeshm Island are given in Table 1. Zinc concentrations in sediments from JN,
which is adjacent to Qeshm refinery, Industrialized Zone of Qeshm and ship-painting factory, revealed remarkable differences from other sampling stations. Highest mean levels of Zn (59.4 µg/g) were found at this sampling station. Highest concentration of Fe was observed in the sediment of SD. This station is close to the urban of Qeshm, thus receives different quantities of domestic effluents from surrounding area. The concentrations of Pb in the sediment of the three stations were considerably high. These sampling sites are close to the Strait of Hormoz, where considerable number of oil tankers enters the Persian Gulf. It is likely that the high concentration of Pb in the three stations was related to the oil pollution transported from the Persian Gulf into the Qeshm Island coasts by tidal currents.

A comparison between our findings and those of previous studies in the Persian Gulf and elsewhere in the world is shown in Table 1. The concentration of Pb obtained in this study are remarkably higher than those reported in Khor-Jafari by Safahieh et al, Mouth of Arvand River, Mouth of Meleh Estuary, Mouth of Musa Estuary by Abdolahpur Monikh et al, except in sediment of SD, and lower than those reported in Southeastern Louisiana by Aucoin et al and Southeastern Aegean Sea by Dalman et al. To understand the contamination of heavy metals in the sediment, the levels observed in this study were compared with standard guidelines (Table 1). Generally, the concentrations of Pb measured in current study exceed the guidelines established by ROPME, ISQG and Canadian SQG and NOAA. However, the elevated Zn level do not exceeds maximum concentration of Zn reported by the sediment quality guidelines.

Table 1 — Heavy metals concentration (µg/g d.w) in sediment taken from Qeshm Island and compared to previous studies and guidelines.

<table>
<thead>
<tr>
<th>Location</th>
<th>Pb</th>
<th>Fe</th>
<th>Zn</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parke Zeyton (PZ)</td>
<td>1515.3 ± 371.2</td>
<td>110.9 ± 161.1</td>
<td>49.3 ± 38.3</td>
<td>This study</td>
</tr>
<tr>
<td>Jazaiere Naz (JN)</td>
<td>1478.8 ± 242.6</td>
<td>117.3 ± 24.9</td>
<td>59.4 ± 35.3</td>
<td></td>
</tr>
<tr>
<td>Shib Deraz (SD)</td>
<td>1511.4 ± 195.5</td>
<td>784.9 ± 24.7</td>
<td>19.2 ± 6.9</td>
<td></td>
</tr>
<tr>
<td>Khor-Jafari</td>
<td>3.16</td>
<td></td>
<td></td>
<td>[17]</td>
</tr>
<tr>
<td>Mouth of Arvand River</td>
<td>25.21</td>
<td></td>
<td>47.09</td>
<td></td>
</tr>
<tr>
<td>Mouth of Meleh Estuary</td>
<td>8.98</td>
<td></td>
<td>45.10</td>
<td>[1]</td>
</tr>
<tr>
<td>Mouth of Musa Estuary</td>
<td>5.92</td>
<td></td>
<td>38.7</td>
<td></td>
</tr>
<tr>
<td>Bahrain-Askar</td>
<td>13.2</td>
<td>1091</td>
<td>8.92</td>
<td></td>
</tr>
<tr>
<td>Bahrain-BAPCO-refinery</td>
<td>99</td>
<td>6475</td>
<td>4.96</td>
<td>[7]</td>
</tr>
<tr>
<td>Oman, Mina Al Fahal</td>
<td>1.59</td>
<td>5540</td>
<td>6.48</td>
<td></td>
</tr>
<tr>
<td>Lake Boeuf, Southeastern Louisiana</td>
<td>21.1</td>
<td></td>
<td>64.7</td>
<td>[4]</td>
</tr>
<tr>
<td>Southeastern Aegean</td>
<td>20</td>
<td>80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Sea

Dipsiz stream, Turkey

ROPME (1999) 15-30 - 124
ISQG f 30.2 - 271
PEL (Canadian SQG) 112 - 271
ERL (NOAA) 47 - 150
PEL (NOAA) 112.2 - 271
ERM (NOAA) 218 - 410
PEC (NOAA) 128 - 459

a,b,c show significant differences of metal concentration between stations. ISQG = interim marine sediment quality guideline. PEL = probable effects levels. ERL = effects range low. ERM = effects range medium. PEC = probable effect concentration.

Table 2 — The relationships between heavy metal levels in the skeleton of corals (Faviidae and Poritidae) and sediments

<table>
<thead>
<tr>
<th>Metal</th>
<th>Faviidae</th>
<th></th>
<th></th>
<th>Poritidae</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pb</td>
<td>0.93</td>
<td>&lt; 0.05</td>
<td>0.93</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>0.1651</td>
<td>NS</td>
<td>0.112</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>0.71</td>
<td>&lt; 0.05</td>
<td>0.429</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NS: Not Significant, \( P > 0.05 \)

Liner analysis was carried out to establish the relationship between the levels of Pb, Fe and Zn in the skeleton of Faviidae and Poritidae and sediment. This correlation was used to recognize the ability of these species as bioindicators for monitoring the level of the heavy metals in Qeshm Island sediments. There were positive correlation coefficients for Pb (\( r = 0.93, p < 0.05 \)) and Zn (\( r = 0.71, p < 0.05 \)) metals between sediment and Faviidae skeleton, while for Poritidae, there was a positive correlation coefficient for Pb (\( r = 0.93, p < 0.001 \)) metal between sediment and the skeleton. These findings indicate that Fe concentrations in both species cannot reflect the levels of sediment contamination. Studies of relationships between Fe levels in sediments and in the tissues of aquatic organisms showed that the concentrations of Fe within marine organisms are relatively constant regardless of the Fe levels in sediment. In addition, because Fe is an essential metal, most fauna have evolved mechanisms to regulate levels of this metal in their tissues in the presence of variable levels in the Environment. However, whenever the concentrations of essential elements around the organisms exceed the limit of the regulation mechanisms they are accumulated to high levels in the organisms. This can explain the fact that for Zn element, which is an essential nutrient, alone, we found a relationship between skeleton of Faviidae and sediment, while we don’t find such relationship for Poritidae and sediment. This observation seems to confirm the fact that although corals are benthic species, in touch with bottom sediment and do not migrate, however they cannot be bioindicator for all metals and this factor vary from species to species. Based on the observed relationships between Pb and Zn metals in the skeleton and sediment, it seems reasonable to conclude that Faviidae are better than Poritidae to be candidate as biomonitor of the metal pollution along the Qeshm Island.

Conclusion

This study provides information on the ability of Faviidae and Poritidae as
bioindicators of Pb, Fe and Zn elements in Qeshm Island and to assess the load of heavy metal contamination in the sediment of the island. Results showed that anthropogenic activities such as waste water of the refinery and industrialized zoon, and urban effluents are the responsible for heavy metal contamination in Qeshm Island. Between the studied species, *Faviidae* apparently have the suitability to be the biomonitor of Pb and Zn concentration in sediment of Qeshm Island.

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**References**


