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Assessment of heavy metal contamination in intertidal gastropod and bivalve shells from central Arabian Gulf coastline, Saudi Arabia

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ABSTRACT

In order to assess pollutants and impact of environmental changes along the Saudi Arabian Gulf coast, forty specimens of gastropod and bivalve shells belonging to *Diodora funiculata*, *Lunella coronata*, *Cerithium caeruleum*, *Barbatia parva*, *Pinctada margaritifera*, *Amiantis umbonella*, *Acrosterigma assimile* and *Asaphis violascens* from five localities are selected for Fe, Cu, Pb, Mn, Cd, Se, As, Co, B, Cr, Hg, Mo analysis. The analysis indicated that heavy metal values (except Fe) were less than those recorded in molluscan shells from Gulf of Oman, Red Sea and Indian Ocean. *D. funiculate*, *L. coronata*, *B. parva* and *P. margaritifera* are good accumulators of Cu, As, Cr. The other species gave a nearly constant concentration in all the studied areas. Al Jubail coast recorded the highest heavy metal concentrations (except Mn at Ras Al-Ghar and Se at Al Jubail industrial city). Heavy metal contamination is mostly attributed to anthropogenic sources, especially effluents from petrochemical industries, sewage and desalination plants.

1. Introduction

The molluscan capacity to magnify and integrate aquatic pollutants is considered to play a key role in monitoring environmental quality (Bourgoin, 1990). The tolerance and adaptability of the bivalve molluscs have made them a preferred organism as indicator of the quality of ecosystems (Conti and Cecchetti, 2003). Heavy metal contamination level in a given organism results from the net balance between the processes of metal uptake and metal loss (Goodfriend et al., 1989).

Heavy metals can enter into the coastal environments from different sources including natural weathering processes and anthropogenic activities (Sadiq and Alam, 1989; Sadiq et al., 1992; Ziko et al., 2001; Abd El-Wahab and El-Sorogy, 2003; Krishna and Govil, 2007; Badr et al., 2009; Venkatramanan et al., 2012; Garali et al., 2010; Madkour, 2013; El-Sorogy et al., 2012, 2013a, b). Many studies have been dealt with fauna, environmental assessment, and sedimentology of the Arabian and Oman gulfs (Dance and Eames, 1966; Dance et al., 1992; Bosch et al., 1995; Al-Homaidan, 2006; Loughland et al., 2012; El-Sorogy et al., 2015; Almasoud et al., 2015).

The Arabian Gulf is a shallow and semi-enclosed basin, therefore, the impact of pollutants on marine environment as a result of intensive anthropogenic activities may be significant (Pourang et al., 2005; Naser, 2013). Industrial and sewage effluents, and wastewater discharges from desalination plants are considered as anthropogenic sources that may significantly contribute to damage the environment of the Arabian Gulf (Sheppard et al., 2010; Naser, 2013). It has been reported that oil can also be considered as a significant and chronic pollution source in the Gulf environment (Naser, 2013). Additionally, chimney emissions of many industrial complexes may contribute to the metal pollution in the Gulf, leading to disturbance to the coastal environment (Sadiq and Alam, 1989).

There is a rapid industrial development at the coast of the Arabian Gulf in Saudi Arabia, which may be the source of pollution to marine organisms. Therefore, the main objectives of the present study are to evaluate the levels of pollution along the central Arabian Gulf from Ras Abu Aly to Ras Tanura in order to provide a successful management of the marine ecosystems.

2. Material and methods

Gastropod and bivalve shells are collected from the intertidal

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coastal areas of Ras Abu Aly, Al Jubail, Al Jubail Industrial city, Ras Al-Ghar and Ras Tanura along the central Arabian Gulf, Saudi Arabia (Fig. 1). Due to their occurrence throughout the five studied areas, three gastropods species, *Diodora rueppellii* (Sowerby, 1834), *Lunella coronata* (Gmelin, 1791) and *Cerithium caeruleum* (Sowerby, 1855) and five bivalve ones, *Barbatia parva* (Sowerby, 1833), *Pinctada margaritifera* (Linnaeus, 1758), *Amiantis umbonella* (Lamarck, 1818), *Acrosterigma assimile* (Reeve, 1845) and *Asaphis violascens* (Forsskål, 1775) have been chosen for chemical analysis (Fig. 2, Table 1). 40 specimens were analyzed for Fe, Cu, Pb, Mn, Cd, Se, As, Co, B, Cr, Hg, Mo with Inductively Coupled Plasma Mass Spectrometer (ICP-MS): NexION 300 D (Perkin Elmer, USA). Triplicate samples were collected and analyzed. The shell samples were ground, sieved through 2 mm sieve and transferred to plastics bags. 200 mg of samples were placed in a dry and clean Teflon digestion beaker, and 6 mL of HNO_3, 2 mL HCl and 2 mL HF were added to the Teflon beaker. Samples were digested on the hot plate at 120–150 °C for approximately 40 min. The resulting digest was filtered through Whatman filtered paper No. 42. The filtrate was transferred to volumetric flask and the volume was adjusted to 50 mL with deionized water. A blank digest was carried out in the same way. 500 mg of rock-powdered samples were placed in a dry and clean Teflon digestion beaker and 2 mL of HNO_3 and 6 mL HCl were added. Samples were digested, filtered and diluted with deionized water.

3. Study areas

3.1. Ras Abu Aly

This locality lies at about 18 km to the north of Al Jubail city, at N 27° 10′ 00″ and E 49° 33′ 03″ (Fig. 1). The beach is sandy, with high diverse gastropod and bivalve shells belonging to genera of *Diodora*, *Lunella*, *Clanculus*, *Cerithium*, *Nassarius*, *Ancilla*, *Mitra*, *Conus*, *Potamides*, *Calliostoma*, *Barbatia*, *Glycymeris*, *Ctena*, *Divalinga*, *Pinctada*, *Acrosterigma*, *Mactra*, *Asaphis*, *Amiantis*, *Circe*, *Circenita*, *Gafrarium*, *Calista*, *Dosinia*, *Maria*. Field survey indicated that Ras Abu Aly beach is situated under human impacts in the form of crowded diving boats and their supplementary activities (Fig. 3A).

3.2. Al Jubail city

This locality lies at about 18 km to the south of Ras Abu Aly, at N 27° 01′ 46″ and E 49° 38′ 23″ (Fig. 1). The beach is made up artificial rocky blocks, which act as wave breaker to protect neighboring residential areas. This beach is characterized by low diversity of gastropods and bivalves, except some which hide among rocks and in crevices under rocks such as *Diodora*, *Lunella*, *Nerita*, *Cerithium*, *Cypraea*, *Barbatia*, *Brachidontes*, *Madiolus*, *Pinctada*, *Amiantis*, *Plicatula*, *Chlamys*, *Spondylus*, *Chama*, *Asaphis*, *Acrosterigma*. There are accumulations of black, very fine sediments, which may be polluted from nearby petrochemical industries (Fig. 3B).

Fig. 1. Location map of the study areas along the Arabian Gulf coast.