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Baseline

Metal pollution in Al-Khobar seawater, Arabian Gulf, Saudi Arabia

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ABSTRACT

In order to assess heavy metals pollution along the Al-Khobar coastline, 30 seawater samples and 15 sediment ones were collected for Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Sr, Mo, Cd, Hg and Pb analysis by Inductively Coupled Plasma-Mass Spectrometer (ICP-MS). The analysis indicated a southward decreasing pattern in most heavy metal concentrations and the average values of Zn, Fe, Mn, Cu, As and Cr were higher than the ones reported from some worldwide seas and gulfs. Most of the highest levels were recorded within the bays and were related with in situ under sediments especially that composed of clays and very fine sands, and in localities characterized with anthropogenic activities like landfilling, desalination plants, fishing boats, oil spills and solid rubbish. The results of the present study provide useful background for further marine investigation and management in the Arabian Gulf region.

The increase in the levels of trace metals in the marine environment, as a result to rapid development of industrialization and urbanization along the coasts is a worldwide problem (Shriadah et al., 2004). Many obvious impacts have resulted from the increase in residue levels in water, sediments, and biota such as decrease productivity, and increase in exposure of humans to harmful substances (El-Sorogy et al., 2012, 2013). The high concentrations of some metals in seawater are indicative of anthropogenic sources. However, natural sources and processes were also investigated and remain a potential source (Al-Taani et al., 2014, El-Sorogy et al., 2016a, 2016b, 2016c).

In the Arabian Gulf region, which is one of the most arid regions of the world, the typical sources of metal contamination are represented by oil industry, platforms, housing projects, industrial cities, oil terminals, offshore oil, ships, stainless steel, and cement industries, in addition to power stations and many industries expanded along the coastline and adjacent to nearby small cities from 1970 to 1990, and continued to the present (Loughland et al., 2012).

The present study is designed to assess the current status and spatial distribution of heavy metals along the Al-Khobar coast, on the Arabian Gulf of Saudi Arabia to identify the potential sources of contamination and compare between the rate of pollution in Al-Khobar coastal area and other neighboring and worldwide coasts. This evaluation helps develop effective coastal management guidelines and strategies for better management of coastal activities, where the Arabian Gulf is an important area in terms of marine waterways, tourism and various commercial and industrial activities.

The Al-Khobar coast is located in the south of Saudi Arabian Gulf between longitudes 49°58′–50°14′ E and latitudes 25°56′–26°18′ N (Fig. 1). The studied coast is distinguished into three types (Fig. 2): 1) Sandy-dominated shores, composed of coarse sand, sandy mud and very few biogenic materials (e.g. sediment samples 13 and 20). Biogenic materials include abundance of bivalves, gastropods, echinoids, foraminifers, ostracods and sea grass. 2) Biogenic-dominated shores composed of seashells and calcareous sands (e.g. samples 22, 27 and 30). Seashells are represented by accumulations of gastropods (mostly cerithiids) and bivalves (mostly venerids). Calcareous sands showed abundant foraminiferes (*Peneroplis*, *Sorites*, *Quinqueloculina*, *Spiroloculina*, *Triloculina*, *Ammonia* spp.), ostracods, bryozoans (*Membranipora*, *Holloporella* spp.) echinoid fragments and embryonic stages of molluscs. 3) Artificial and natural rocky shores. The artificial ones were constructed to protect cities and tourist villages from high tides and sea erosion. The natural rocky shores composed of highly consolidated sands and found in limited areas, especially in the southern part (e.g. samples 24 and 28).

Thirty surface seawater and fifteen representative sediment samples were collected from Al-Sahil, Al Buhairah and Half Moon bays and from the coastline of Al-Khobar coast in April 2016 (Fig. 1). Unfiltered samples were collected in 1-liter pre-acidified polyethylene containers, kept in an icebox (at 4 °C) and transported to the water laboratory for subsequent chemical analyses. Total dissolved solids (TDS), redox potential (Eh) and electrical conductivity (EC) were directly measured in-situ. Al, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Sr, Mo, Cd, Hg and Pb

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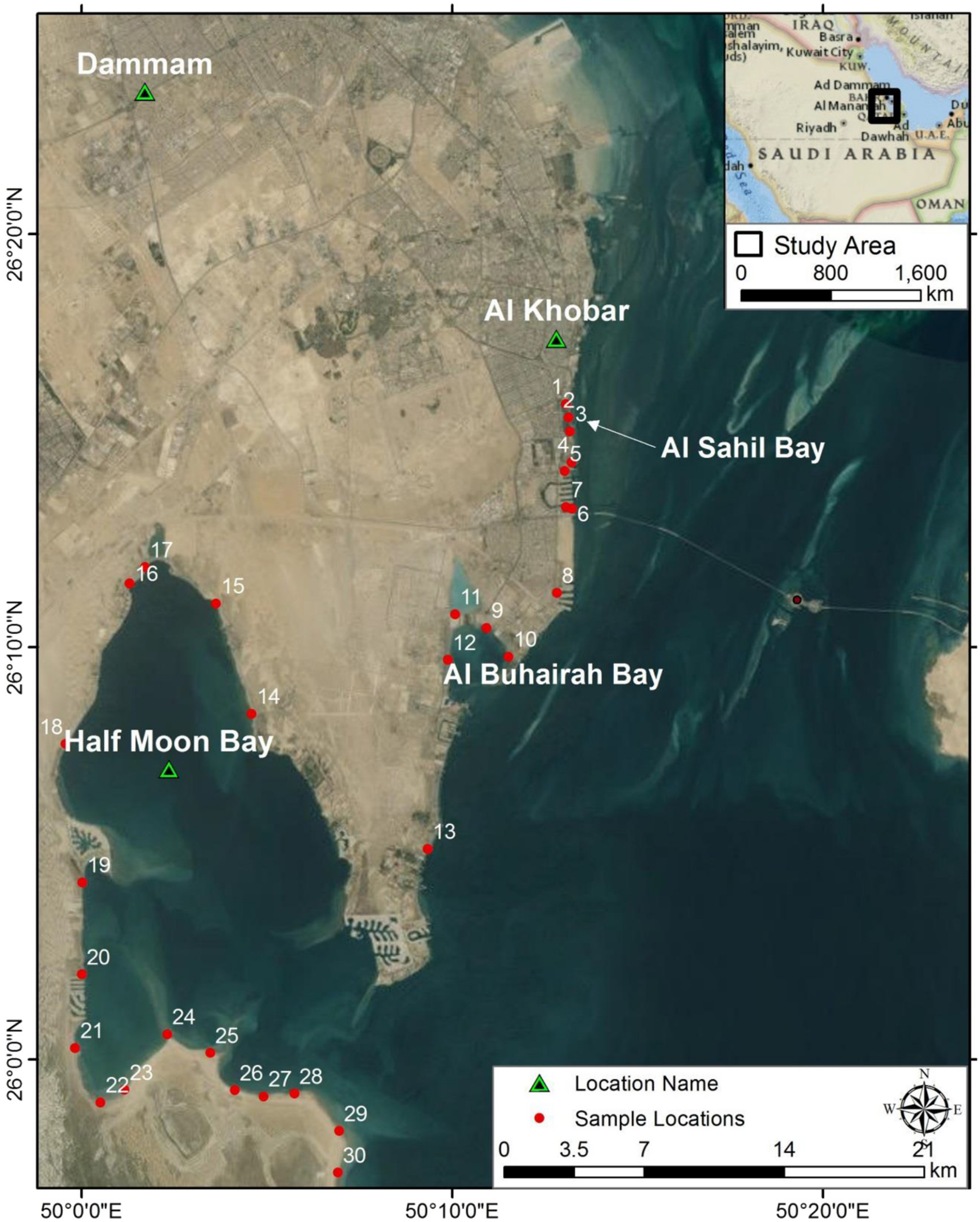

Fig. 1. Location map of Al-Khobar coastline and the locations of the collected samples.

were measured with Inductively Coupled Plasma Mass Spectrometer (ICP-MS): NexION 300 D (Perkin Elmer, USA). Triplicate samples were collected and analyzed.

The sediment samples were ground and sieved through 2 mm sieve. 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 (Trabzuni et al., 2014). 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 similar to soil samples.

Table 1 shows the coordinates of the collected samples and the results of the in situ physical properties (pH, Ec and TDS). Tables 2 and 3 show the results of the heavy metal analyses in seawater and representative sediment samples respectively. The pH ranges from 7.82 in sample 26 to 8.10 in sample 8. EC values of surface seawater ranged between 67,900 and 81,400 μS/cm. The TDS values showed spatial variability, with concentrations ranging between 45,490 and 54,540 mg/L. The higher TDS levels observed in the southward side in general, indicating dissolution and leaching of the adjacent deposits. Mineral dissolution primarily occurred due to wave activity and irregular flash floods, where salts (and trace elements) are transported coastward (Al-Taani et al., 2014).

The spatial distribution of Zinc in seawater samples showed decreasing pattern towards the southward direction, except sample 20 which