Marine Pollution Bulletin 128 (2018) 8–16

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Distribution and metal contamination in the coastal sediments of Dammam Al-Jubail area, Arabian Gulf, Saudi Arabia

Abdelbaset El-Sorogy[a,b,*], Khaled Al-Kahtany[a], Mohamed Youssef[a,c], Fahd Al-Kahtany[d], Mazen Al-Malky[a]

[a] Geology and Geophysics Department, College of Science, King Saud University, Saudi Arabia
[b] Geology Department, Faculty of Science, Zagazig University, Egypt
[c] Geology Department, Faculty of Science, South Valley University, Egypt
[d] Ministry of Energy and Industry and Mineral Resources, Riyadh, Saudi Arabia

ARTICLE INFO

Keywords:
Metal contamination
Coastal sediments
Dammam Al-Jubail
Arabian Gulf
Saudi Arabia

ABSTRACT

Present work aims to document the distribution and metal contamination in the coastal sediments of the Dammam Al-Jubail area, Saudi Arabian Gulf. Twenty-six samples were collected for Al, V, Cr, Mn, Cu, Zn, Cd, Pb, Hg, Sr, As, Fe, Co and Ni analysis. Results of enrichment factor indicated that Sr, Cd, Cu, Hg, V, As, Ni, Cr and Zn gave enrichment factors higher than 2 (98.87, 40.28, 33.20, 27.87, 26.11, 14.10, 6.15, 3.72 and 2.62 respectively) implying anthropogenic sources, while Pb, Mn and Al have very low background level (1.37, 0.71, 0.124 respectively), probably originated from natural sources. Average concentrations of Sr, V, Hg, Cd and As were mostly higher than those from the background shale and the earth crust, the Caspian Sea, the Mediterranean Sea, the sediment quality guidelines, the Red Sea, the Gulf of Aqaba and the Gulf of Oman. The higher levels of the studied metals are mostly related samples with high Al and TOM content, as well as the visible anthropogenic pollutants along the studied coastline. The most recorded anthropogenic pollutants were sewage effluent, landfilling due to coastal infrastructure development, oil spills, petrochemical industries and desalination plants in Al-Jubail industrial city.

Coastal environments are subjected to heavy metal pollutants as a result of industrial development along littoral zones worldwide (El Zrelli et al., 2015). The sources of heavy metals in coastal environments include anthropogenic activities and natural weathering processes (El-Sorogy et al., 2012, 2013a, 2013b; Alharbi et al., 2017). Many complex processes of material exchange govern distribution of metals within the aquatic environments. These processes are affected by various anthropogenic activities and industrial wastewaters (Christophoridis et al., 2009).

Most of the previous studies used coastal sediments (e.g. Abrahim and Parker, 2008; Cevik et al., 2009; Diaz-de Alba et al., 2011; Hahladakis et al., 2013; Nour and El-Sorogy, 2017). Carman et al. (2007) stated that, “most of the anthropogenic metals in coastal environments are of terrestrial origin, coming from industrial and urban development and other human practices”. Many studies have dealt with assessment of heavy metal pollution worldwide on coastal areas.

Almasoud et al. (2015) concluded enrichment with Zn, Cu, Cr and Pb of anthropogenic sources along the Arabia Gulf coast. Youssef et al. (2015) concluded very high arsenic and high mercury concentrations along the Tarut Island coast due to landfilling, dredging, sewage, and oil pollution. Also, Nour and El-Sorogy (2017) concluded enrichment with Pb, Ni, Cd, Co, Cu and Za on the Sabratha coastline, Libya due to different anthropogenic activities.

Field survey along Dammam Al-Jubail coastal area indicated different human inputs, such extension of infrastructure development, landfilling of mangrove swamps and effluents due to sewages and industries. Therefore, the main objectives of the present work are to document the spatial distribution of metals along Dammam-Al-Jubail coastal area, to evaluate the human activities and to compare the rate of pollution in Dammam Al-Jubail coastal area with other worldwide coasts.

The Dammam Al-Jubail coast is located at the central part of the Saudi Arabian Gulf, between latitudes 26 28 01–27 07 09N and longitudes 49 34 19–50 04 34E (Fig. 1). According to sediment type, the studied coast is differentiated into three types: artificial and natural rocky shores, mangrove swamps and sandy shores (Fig. 2). Twenty-six surficial coastal sediment samples (from 1 to 30 cm deep)

* Corresponding author at: Geology and Geophysics Department, College of Science, King Saud University, Saudi Arabia.
E-mail address: asmohamed@ksu.edu.sa (A. El-Sorogy).

https://doi.org/10.1016/j.marpolbul.2017.12.066
Received 16 September 2017; Received in revised form 22 December 2017; Accepted 30 December 2017

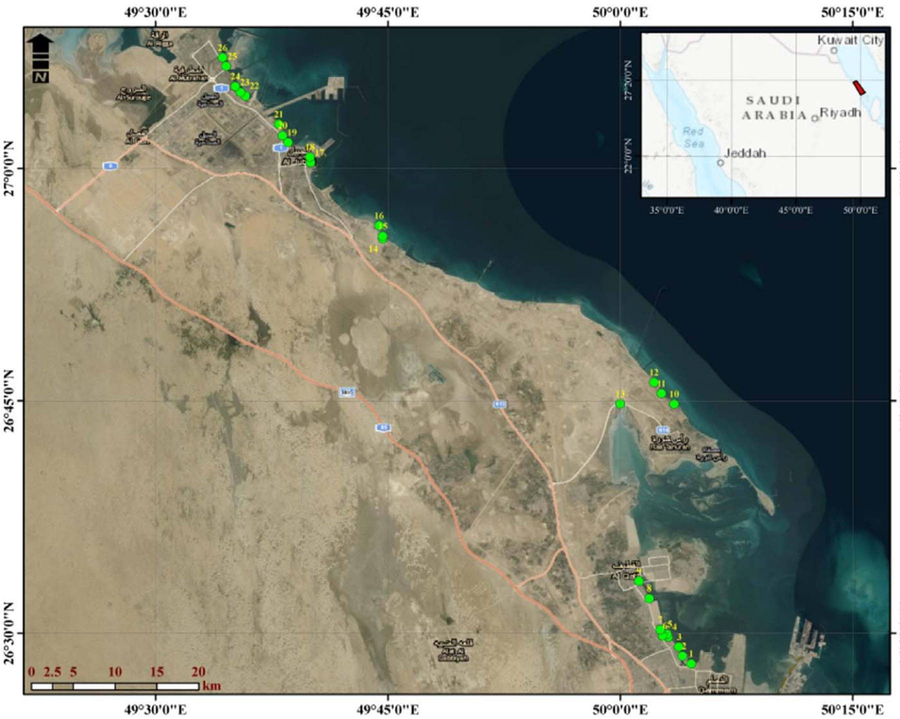

Fig. 1. Location map of Dammam-Al-Jubail coastline and location of the sediment samples.

were collected from the littoral zone. Grain size analysis was determined according to Folk (1974). A composite sample is taken (after mixing three at each site and excluding snails, seagrass, shells and other foreign objects). The samples were transferred to the laboratory, dried, sieved and then homogenized in a mortar to a fine powder by known methods.

Analysis of V, Al, Cr, Cu, Zn, Cd, Hg, Mn, Sr, As, Fe, Pb, Co and Ni was carried out by ICP-MS: NexION 300D (Perkin Elmer, USA) in King Saud University. The sediment samples were prepared by adding 2 ml of HNO_3, 6 ml HCl and 2 ml HF. Samples were digested, transferred to a 15 ml plastic volumetric tube and made up to mark using deionized water. The ICP-MS calibration was carried out by external calibration. The calibration curves Al, Cr, Cd, Cu, Pb, Co, Ni, Fe, Sr, and Mn were obtained using the blank and three working standards 0, 50, 100, and 200 µg/L. It started from a 100 mg/L multielement standard solution for ICP-MS (Panreac, 766333. 1208). The blank and three working standards 0, 50, 100, and 200 µg/L starting from a 1000 mg/L single standard solutions were used for As, V, Zn and Hg with ICP-MS (Aristar grade, BDH laboratory supplies, England). Calibration curves showed an excellent linearity for all elements. For calculating pollutant indicators of metal pollution in the studied coastal sediments, Enrichment Factor (EF), Geoaccumulation Index (Igeo) and Contamination Factor (CF), were taken in consideration.

Al, Fe exhibited a similar pattern with an inverse manner to Sr (Fig. 3). Al and Fe show five hot spots in samples 8, 13–14, 19–21, 23–24 and 26, while As shows four hot spots in samples 10–12, 15–19, 22 and 25. Al values varied between 555 µg/g in samples 10 and 16 to 3602 µg/g in sample 24 (Table 1). Table 2 illustrates a comparison among our average values and those from coastal samples worldwide. Al value (1887.07 µg/g) is lower than that recorded from the Arabian Gulf and the background of the earth crust. The highest concentration of Fe (10,204 µg/g) is recorded in sample 26 and the lowest one (6988 µg/g) in sample 15. Average value of Fe is lower than the one recorded Mediterranean Sea, Caspian Sea, the background shale and the background of the earth crust and Gokcekaya Dam Lake in Turkey (Table 2). It is higher than the ones recorded from the Red Sea coast and Salaam coast (Tanzania). Strontium levels ranged from 928 µg/g in sample 26 to 10,310 µg/g in sample 16 (Table 1). The average value (4801.71 µg/g) is higher than those recorded along the coasts of Kazakhstan, Iran and Azerbaijan, Mediterranean coast (Egypt), as well as the values reported in the background shale and the background of the earth crust. The average Igeo (2.79), CF (16.01) and EF (98.87), values suggest moderately to strongly polluted, very high contaminated and extremely severe enriched with Sr (Table 3).

Lead, cadmium, cobalt and mercury exhibit a similar distribution pattern throughout the studied coast, except that mercury exhibits a nearly stable levels in samples from 15 to 26 (Fig. 4). The highest concentration of Pb (9.4 µg/g) is recorded in sample 21, while the lowest one (0.6 µg/g) is recorded in samples 11 and 18. The average value (5.25 µg/g) is lower than the Interim Sediment Quality Guideline (ISQG), the Red Sea, the Gokcekaya Dam Lake (Turkey), the Mediterranean coast, Azerbaijan and Iran coasts and the background shale (Table 2). It is higher than the ones recorded from coasts of Qatar and Oman and Salaam coast (Tanzania). The highest Cd level (2.13 µg/g) is recorded in sample 7, while the lowest one is recorded in sample 12 (0.75 µg/g). The average value (2.13 µg/g) decreased the Effect Range Low (ERL) value, the Canadian value and the Rosetta beach (Egypt). It increased the average values from the Red Sea (Saudi Arabia), Mediterranean Sea (Libya) and Arabian Gulf (Saudi Arabia) and the background shale and the background of the earth crust. According to Hökanson (1980), the studied sediments are moderately polluted, very high contaminated and very severe enriched with Cd (Igeo = 1.96, CF = 7.11, EF = 40.28). The highest value of Co (5.8 µg/g) is recorded in sample 8, while the lowest one (2.8 µg/g) is recorded in sample 25. The average value (4.01 µg/g) is lower than the ones from the background shale, the Mediterranean coast, the Caspian Sea coast and the background of the earth crust. It increased the average value recorded from Qatar and Bahrain coasts, the Gulf of Aqaba and the Salaam coast (Tanzania). The concentrations of Hg