Assessment of some heavy metals in surface sediments of the Aqaba Gulf, Egypt

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Abstract Aqaba Gulf is an economically important marine environment in Egypt. Its coastal area was subjected to anthropogenic impact of urbanization and economic development during the last decades. The study was oriented to investigate the distribution as well as assess the heavy metal pollution status (Fe, Mn, Zn, Ni, Co, Cr, Cu, and Cd) in its surface sediment. Large heavy metals fluctuations were detected along the studied area. The results pointed out to the highly significant correlations among Fe, Cu, Ni, and Co heavy metals and their similar lithogenic origin beside their input sources. The sediment quality was performed by using the geo-accumulation index ($I_{geo}$) and different sediment criteria guidelines; China State Bureau of Quality and Technical Supervision (CSBTS), and Canadian guidelines. Among the studied heavy metals, Cd was the only metal that showed moderate pollution for $I_{geo}$ as well as it exceeded the primary and the secondary criteria of CSBTS and the threshold effect level of the Canadian guidelines (TEL). On the other hand, the other heavy metals were within the natural background levels.

Keywords Heavy metals · Surface sediments · Pollution assessment · Aqaba Gulf · Egypt

Introduction

The Aqaba Gulf is a large semi-closed basin of Red Sea. It lies between longitudes: 34°23′ and 35°00′ E and latitudes: 28°00′ and 29°33′ N along the eastern side of the Sinai Peninsula. Egypt, Israel, Jordan, and Saudi Arabia have coastlines on the Gulf. It is about 180 km long and nearly 24 km width in the south, and it is narrowing to about 17 km in the north with a depth of ≤1,800 m. The water of the Gulf is exceptionally clear and the euphotic zone extends to about 80–90 m depth. It has a hot and dry climate with rare rainfall (Shridah et al. 2004). The lack of regular freshwater input and the high evaporation rate are heavily contributing in the high salinity of the Gulf (40.4–40.6‰; Manasrah et al. 2004). This Gulf, like the coastal waters of the Red Sea, is one of the world’s premier sites for diving. Its area is especially rich with coral reefs and other marine biodiversities. It contains number of underwater wrecks of some accidental shipwrecks and others vessels which deliberately sunk during their tries to obtain some of the habitat marine organisms and bolster the local dive tourism industry. Due to the lack of peace efforts in this region, the Gulf of Aqaba has not received much scientific studies.
before 1980s. Accordingly, the fragmentation of the physical, chemical, and biological knowledge of Aqaba Gulf was result for this fact. Most of the scientific efforts on the Gulf were carried out on the Jordanian coast (Al-Rousan et al. 2007; Al-Horani et al. 2006; Al-Ouran 2005; Abu-Hilal and Al-Najjar 2004; Khalaf and Kochzius 2002; Badran and Foster 1998). In contrast, little studies on the Egyptian coast of the Gulf were performed (Abdel-Halim et al. 2007; Shridah et al. 2004; Okbah et al. 1999).

Nowadays, the Gulf is highly affected by urban and industrial pollution (Walker and Ormond 1982; Abelson et al. 1999), shipping and port activities (Abu-Hilal 1985; Badran and Foster 1998), as well as tourism (Riegl and Velimirov 1991; Hawkins and Roberts 1994). Moreover, land-based operations, including clinker production and fertilizer manufacture as well as sea–water desalination in Eilat, may also affect the heavy metals’ presence (CASE NUMBER: 380). These anthropogenic activities may elevate the concentration of some pollutants in the Aqaba Gulf region. Among these pollutants are heavy metals that are known by their toxic serious threats on marine environments. Heavy metals have a considerable environmental concern. Also, they possess wide sources, non-biodegradable properties, and accumulative behaviors. When metals enter into the marine environment, most of them will settle down. Additionally, heavy metals can incorporate marine sediments together with organic matters, Fe/Mn oxides, sulfides, and clay (Wang and Chen 2000). Indeed, sediments act as scavengers for trace metals and often provide an excellent proof of man’s impact (Guevara et al. 2005).

The objectives of this study are to investigate current heavy metal (Fe, Mn, Zn, Ni, Co, Cr, Cu, and Cd) distribution and concentration in the sediments of the Egyptian coast of Aqaba Gulf and to assess the contamination extent by the heavy metals using marine sediment quality criteria and geo-accumulation index ($I_{geo}$) related to the anthropogenic impact during decades of urbanization and economic development along the coastal area of the Gulf.

### Materials and methods

#### Sampling

Nine intertidal zone surface sediments samples (0–5 cm) were collected from the Egyptian coast of the Aqaba Gulf during 2004 (Fig. 1 and Table 1). The sampling locations were selected to cover some expected polluted regions as well as number of nature reserves (protected areas). Regions 1, 4, and 8 (Ras Mohamed, Nahlat Al Tel, and Mersa Muqibila, respectively) are nature reserves. Sites 2 and 3 are harbors for yachts in...