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Trace Metals in the water column of the coastal zone in the Red Sea and the Gulf of Aqaba

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Abstract In this study trace metals concentrations in the water column are presented along the coastal zone of the Gulf of Aqaba and the Red Sea (Saudi Arabia). This is a baseline assessment of the metal pollution status of the water using trace metals (Cd, Co, Cr, Cu, Ni, Pb and Zn) measurements obtained at 69 sampling stations along the coastal zone of the Saudi Arabia in June–July, 2021. Spatial variability was observed with higher concentrations to be recorded in Al-Shuqaiq, and Jeddah lagoon waters. The metal concentrations were linked to the different anthropogenic pressures in the coastal zone of the Kingdom of Saudi Arabia. This is the first research extended throughout the Saudi coastline, giving the baseline information of the metal pollution in the water column. The study was carried out under the framework of Task 6 (Field Surveillance) of the MCEC project (https://mcep.kaust.edu.sa/).

Keywords: Coastal marine environment of Saudi Arabia; trace metals; Red Sea; Gulf of Aqaba.

1. Introduction

Metals are naturally occurring substances, and some (e.g., Cu, Zn) are essential micronutrients to organisms. They are present in various chemical forms in the aquatic environment, with metal-organic matter complexes being the least bioavailable fraction and free metal ions, the most bioavailable faction. The bioavailability/toxicity of metals depends on the local physicochemical parameters of the water, such as the pH, ionic strength, and concentrations of alkalis and natural organic matter (Florence et al., 1992). Furthermore, the varied nature of the geological substrates and the degree of anthropogenic inputs in both the past and present have led to variable spatial distributions of metals in seawater, especially in inland and coastal waters (Martin and Meybeck, 1979). The concentrations of heavy metals in the coastal zone are typically 1.5 to 2 times higher than in the open sea. Moreover, metals may lead to deleterious effects to biota and humans when present at elevated concentrations in the environment, water, or food.

Under the framework of Task 6 (Field Surveillance) of the MCEC project, fifteen areas in the Red Sea were visited during June and July 2021, in order to study the pollution status of the coastal zone of the Gulf of Aqaba and the Red Sea (Saudi Arabia). Metals concentrations were compared with the maximum allowable values defined by the National Environmental Standard for Ambient Water Quality of the Kingdom of Saudi Arabia (Table 1).**Table 1.** Environmental Quality Standards for metals in surface waters according to the Saudi Arabian Legislation.

Environmental Quality Standards - Saudi Arabian Legislation			
	Industrial µg/L	High value µg/L	Marine µg/L
Cd	40	8	8
Co	1000	50	50
Cu	13.5	3	3
Cr	50	2	50
Hg	0.1	0.4	0.4
Ni	200	50	50
Pb	210	5	8
Zn	90	80	80

2. Methodology

One litter of seawater was collected in pre-cleaned polyethylene bottles. The samples are stored at -20 ºC until the analysis in the laboratory. For Hg, 250 mL of seawater were collected in pre-cleaned glass bottles and after the addition of 1.2 mL of HCl 37% as conservative they were stored in the refrigerator until the analysis in the laboratory. Water samples for dissolved metals determination were kept frozen until transported to the clean laboratory of HCMR (class 10,000 US Stds). After thawing, the samples were filtered through 0.45µm filters (Whatman sterile mixed cellulose ester membranes) previously soaked in diluted HCl and washed with Milli-Q water. Samples were acidified with suprapur HNO_3 to pH<2. The pH value of each sample was set to 8.2 using ammonium acetate. Samples were pre-concentrated by the Toyopearl AF Chelate 650M resin to separate from interfering matrix components (Willie el al., 1998, Milne et al., 2010). The preconcentration step consists of a

semi-automated off-line extraction using a micro-column of the Toyopearl Chelate resin with a flow manifold. About 30 ml of sample passed through the resin via a peristaltic pump. The trace metals eluted on the resin were collected with suprapur $HNO_3$1M.A pre-concentration factor of 10 times was achieved. The pretreatment and the trace metal pre-concentration were carried out in the clean room environment using trace metals handling techniques. The determination of the metals Cd, Co, Cu, Ni, Pb, V, Zn in the collected eluent was carried out using Inductively Couple Plasma Mass Spectrometry (ICPMS, Thermo-Elemental X-series II) in a regular laboratory.

3. Results and Discussion

This study widely covered the Saudi Arabian coastal waters in the Red Sea and the Gulf of Aqaba, providing a baseline assessment for the pollution status of seawater using trace metals. The results highlighted the areas of Al-Shuqaiq and Jeddah lagoon as the mostly affected considering trace metals. This is related to the anthropogenic pressures in the Jeddah lagoon, mainly domestic sewages, whereas in A-Shuqaiq a desalination plant operates, which, according to data provided by the National Center of Environmental Compliance (NCEC), has the largest output capacity of any desalination plant on the Saudi coast of the Red Sea. However, the concentrations of the considered trace metals, for which environmental standards exist (Table 1), according to the Saudi Arabia's National Environmental Standards for Ambient Water Quality, fall well below the threshold values in all studied sites. Figure 1 presents the concentrations of metal measured at the Red Sea coastal sites. The mapping shows the average concentration of the individual metals in each coastal area (average from all stations sampled in the site; average of mean integrated concentrations of the stations included in each study site). The color scale indicates the range of the average values for all study sites.

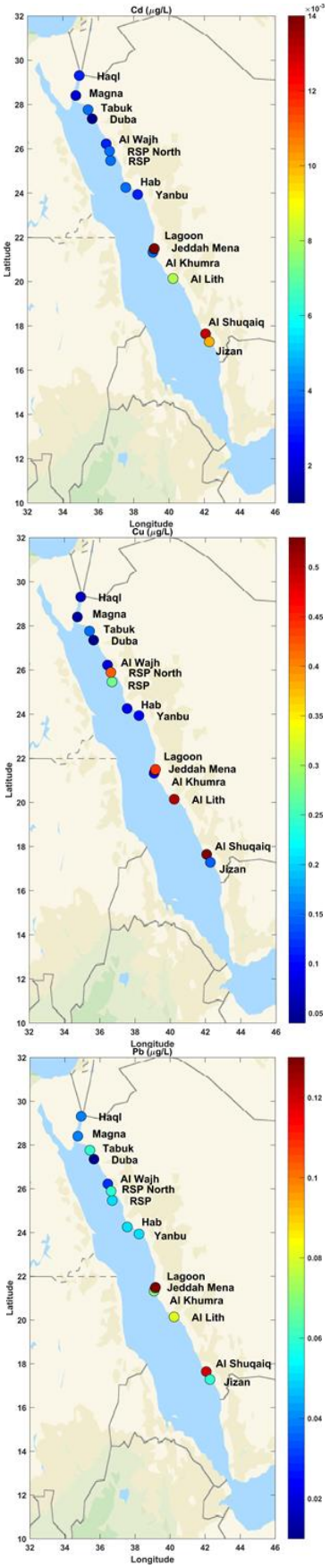

Figure 1. Average concentrations of metals in the sampled marine areas along the coastline of the Red Sea. The color scale indicates the minimum and maximum average concentrations of each metal for all of the study sites.

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