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# Heavy Metal (Ni, Hg and Co) Pollution of Oil-Related in Sediment from Musa Estuary, Northwest of the Persian Gulf

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**Abstract:** The concentration of Ni, Co and Hg were measured in the surface sediments samples taken from Bahrekan estuary, Meleh estuary and Musa estuary in the northeast Persian Gulf. Concentration of heavy metals varied depending on sampling sites. The concentration order of heavy metals in sediment was Ni > Hg > Co Heavy metals analysis was performed by Atomic Absorption Spectrophotometer. There was significant difference ($p<0.05$) in metals levels between different stations. The highest concentrations of metals were detected in Musa estuary. The analysed heavy metals were found in sediment samples at mean concentration in the sediment quality guideline proposed by NOAA and ROPME, except for Hg concentrations in some cases.

**Key words:** Heavy Metal · Oil · Sediment · Musa estuary

## INTRODUCTION

The Persian Gulf is a shallow and semi-enclosed sea that its environment is changing rapidly [1]. The discovery of oil in this sea led to a massive increase in anthropogenic activities in the area. In general, petrochemical and oil industries are the major sources of pollution in this area [1]. For instance, this sea has about 800 offshore oil platforms and tolerates the traffic of about 25,000 oil tankers each year.

Other sources of Persian Gulf pollution include invasions and bombardments that have been staggering in the recent years and are yet to be fully investigated [1]. Although heavy metals are very toxic to both humans and the wildlife, limited research is available on heavy metals pollution in the Persian Gulf area. Aquatic environments, such as Persian Gulf, are especially at high risk for heavy metals contamination since much of the atmospheric deposition and all of the industrial water-runoffs culminate in these ecosystems. Large areas of agricultural lands, local fisheries, oil export facilities and a petrochemical plant operate in the general area. Trace elements are found in natural water bodies at varying concentrations. The most potentially dangerous of these elements are heavy metals.

Heavy metals concentrations in aquatic ecosystems are usually monitored by measuring its concentration in water, sediments and biota [2]. Sediments are important sinks for various pollutants such as heavy metals and also play a useful role in the assessment of heavy metal contamination [3, 4]. Sediments, particularly surficial sediments, may serve as a metal pool that can release metals to the overlaying water via natural anthropogenic processes, causing potential adverse health effects to the ecosystems because of their serious toxicity and persistence [4-6]. In this study, the concentration of oil-related heavy metals nickel (Ni), cobalt (Co) and mercury (Hg) were measured in the surface sediments samples taken from Bahrekan estuary, Meleh estuary and Musa estuary in the northeast Persian Gulf.

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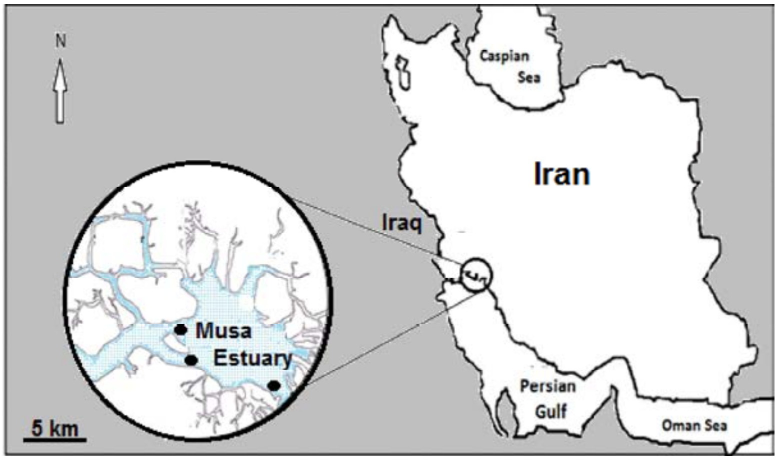


Fig. 1: Map of Persian Gulf and the study sites

## MATERIAL AND METHODS

Surface sediments were collected in Summer (July) of 210, using a Van Veen Grab from 4 stations in the Persian Gulf (Fig. 1) across the upper, mid, and lower regions, covering a distance of 50 km and a range of salinities from freshwater in the upstream area to seawater at the mouth. Subsamples were taken from the uppermost layer of the sediment taking care to minimize contamination. The samples were frozen after collection and later thawed, dried at 50-60°C in an oven and disaggregated in an agate mortar, before chemical treatment for total metal analysis. For each sample a known quantity (1 g) of sediment was digested with a solution of concentrated $HClO_4$ (2 ml) and HF (10 ml) to near dryness. Subsequently, a second addition of $HClO_4$ (1 ml) and HF (10 ml) was made and the mixture was evaporated to near dryness. Finally, $HClO_4$ (1 ml) alone was added and the sample was evaporated until white fumes appeared. The residue was dissolved in concentrated HCl and diluted to 25 ml [7].

Metals concentrations were determined by a cold vapor atomic absorption spectrometer (Unicam, model 919). The accuracy of the analytical procedures was assessed using the certified reference material BCR-1 and yielded results within the reference value range [8]. The recovery means for Hg, Ni and Co ranged 92.1%, 98% and 102.4% respectively.

All data were tested for normal distribution with Shapiro-wilk normality test. Significant differences between heavy metals concentration in the samples of various stations and between seasons were determined using One-Way analysis of variance (ANOVA) fallowed by Duncan post hoc test.

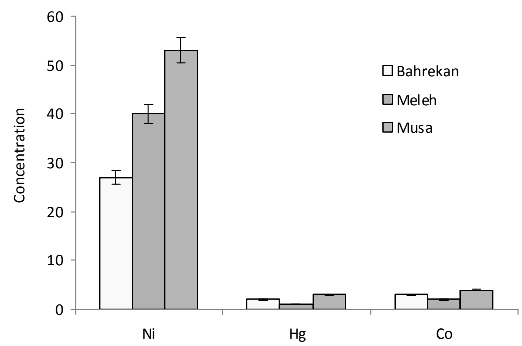


Fig. 2: The mean concentration (µg g-1) of heavy metals (Ni, Co and Hg) between different stations from northwest of the Persian Gulf

Table 1: Concentration of heavy metal ( µg g-1) in sediment from three estuary from northwest of Persian Gulf

| Stations | Hg | Ni | Co |
|---|---|---|---|
| Bahrekan estuary | 0.46±0.02 | 27.34±0.65 | 0.43±0.58 |
| Meleh estuary | 0.15±0.03 | 40.75±0.54 | 0.32±0.86 |
| Musa estuary | 1.02±0.03 | 53.14±0.33 | 0.76±0.30 |

## RESULTS

The concentrations of the heavy metals in the sediments from different stations are presented in Table 1. The results showed that the heavy metal concentration in sediments at all sampling stations occurs in descending order of Ni > Hg > Co. The highest concentrations of the heavy metal in sediment were recorded in Bahrekan estuary and the least was in Zangi estuary. There was significant difference ($p<0.05$) between the level of heavy metals in the different stations. In the sediments at all sampling station, concentration of Ni ranged from of 23 $\mu g\ g^{-1}$ to 55.5$\mu g\ g^{-1}$ with an average of

31.2 μg $g^{-1}$. The highest concentration of Ni (55.5 μg $g^{-1}$) was detected in Musa estuary. The concentration of Co ranged from 0.32 μg $g^{-1}$ to 0.76 μg $g^{-1}$ with an average of0.17 μg $g^{-1}$. The highest concentration of Pb (0.76 μg $g^{-1}$) was detected in Musa estuary. The concentration of Hg ranged from 0.15 μg $g^{-1}$ to 1.02 μg $g^{-1}$ with an average of 0.41μg $g^{-1}$. The highest concentration of Hg (1.02 μg $g^{-1}$) was detected in Musa estuary.

## DISCUSSION

This study demonstrated the concentration of metals in sediments from different estuary in Persian Gulf. Higher levels metals occurred at Musa estuary's mouth that discharge in the Persian Gulf. Musa estuary is surrounded by more than 19 petrochemical units such as chlor-alkali plant and superphosphate plant. The fact that total concentration of some petrochemical-related metals such as Hg, Ni, Co in the northwest of Persian Gulf decreased with distance from Musa estuary is a strong evidence reflects that the metals in this estuary were sourced from petrochemical activities, and not from background geological sources. Besides, some main creeks of this estuary flow into two crowded and industrialized cities and consequently receive huge amounts of domestic effluents and urban wastewaters [9].

The comparison between the sampling stations showed that the amount of metals varied from site to site, and the variation could be related to variability in the sources of metals input. Maximum concentration of metals along the Musa estuary was observed in Musa estuary. The Musa estuary is the nearest creek to Mahshahr City, petrochemical units, and constructions of PETZONE [10]. In addition, Imam Port that is one of the biggest ports in Iran is located in the mouth of this creek. Therefore, Musa estuary receives different types of pollution such as heavy metal from the surrounding areas. The lowest heavy metal concentration was observed in Zangi estuary. There is no industrial activity near this station, which is a relatively remote area compared to other stations.

Many environmental geochemistry studies report higher concentration of trace metals in surface layers than deeper one [9-11] due to development of industries and other man activities. Since natural variations of heavy metal concentrations in sediments can result from differences in the grain size, the mineralogy, and the redox of the sediment, we tried to limit these sources of variability by applying the grain-size normalization approach, completed by a geochemical correction; this treatment should allow better insight into the anthropogenic influence on the heavy metal distribution in the surface sediment [10-12].

Table 2: Permissible upper limits of heavy metals in various standards (in micrograms per gram wet weight)

| Location | Co | Ni | Hg |
|---|---|---|---|
| FAO (2002) | | 70 | 1 |
| WHO (1996) | | 42.8 | 1 |
| ROPME (1999) | | 70-80 | 0.5 |
| NOAA (2009) | | 52 | 0.5 |

NOAA: national oceanic and atmospheric administration; FAO: Food and Agriculture Organization; WHO: World Health Organization; ROPME Regional Organization for the Protection of the Marine Environment.

A comparison between our results and those of previous studies in the Persian Gulf and elsewhere in the world is shown in Table 2. The concentration of heavy metal obtained in this study is generally higher than those reported in Jebel Ali (UAE), Ras Laffan (Qatar) and Askar (Bahrain) along the south Persian Gulf [13-15]. The concentration of heavy metal in the northern part of the Persian Gulf [16] was considerably greater than those observed in current study. Generally, the concentrations of heavy metal measured in current study do not exceed the guidelines that established by Canadian ISQG and NOAA. Apart from these, fortunately in case of heavy metal, our findings are approximately within the range of those in the guideline that was established by RSA (ROPME Sea Area) for the Persian Gulf, expect for Musa estuary [17, 18].

## CONCLUSION

This study provides new information on the distribution of metals in surface sediments along northwest Persian Gulf. The results showed that the concentration of metals varied among station sampling. The heavy metal concentration in the sediments are described in the descending order of Ni > Hg > Co at all sampling sites. Results of this study also showed sediments from Musa estuary showed greater concentration of the metals than those from the other areas. The high concentration of metals in sediments at the Musa estuary sampling could result from industrial effluents. BAFs showed that the risk of Ni is higher than the risk of other metals in this study. Therefore, the Musa estuary as a major source of sediments and a source of metals can affect the concentration of metals in sediment of the area.

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