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ORIGINAL ARTICLE

Monitoring of Heavy Metal Concentration in Sediment and Water from the Arvand River, northwest Persian Gulf

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ABSTRACT
Concentrations of some heavy metals (Pb, Zn, Cu and Ni) were determined in water and sediment collected from Arvand River during summer 2014. The results showed that the sediment concentrated more heavy metals than the water. Significant differences among the sampling sites could be found for concentrations of all the four metals in water and sediment. The quality of the sediments was evaluated based on sediment quality guidelines (effects range-low (ERL) and effects range-medium (ERM) indexes. The most of heavy metal in water and sediment lower than guidelines, except concentration Ni in sediment. The present results support the concept that human activities in each region could be a major source of metals pollution input in the aquatic environment.
Keywords: *Heavy metal, Persian Gulf, Monitoring, Arvand River*

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INTRODUCTION

The presence of heavy metals in aquatic ecosystems is the result of two main sources of contamination: natural processes or natural occurring deposits, and anthropogenic activities. Pollution of heavy metals in aquatic ecosystem is growing at an alarming rate and has become an important worldwide problem [1]. Increase in population, urbanization, industrialization and agriculture practices have further aggravated the situation [2, 3]. As heavy metals cannot be degraded, they are deposited, assimilated or incorporated in water, sediment and aquatic animals [4] and thus, causing heavy metal pollution in water bodies [1]. The main source of heavy metal contamination and the threat of heavy metal pollution to life forms is invariably the result of anthropogenic activities [5, 6]. In the aquatic environment toxic metals are potentially accumulated in sediments and marine organisms, and subsequently transferred to man through the food chain.

The Persian Gulf is a shallow basin with an average depth of 35–40 m and a total area of around 240 sq. km. It joins free international waters through the Strait of Hormuz [7, 8]. The turnover and flushing time have been estimated to be in the range of 3–5 yr indicating that pollutants are likely to reside in the Persian Gulf for a considerable time [9].

Because of geographical characteristics, rapid evaporation, shallow depth, limited circulation of water [10], high turbidity and more fluvial receiving [11], the northwestern part of the Persian Gulf tends to concentrate and assemble large quantity of contaminants relative to other parts of the sea. On the other hand, fresh water and mud sediments that are transported into this area via the Arvand river (the biggest river flowing in the Persian Gulf) make it special and proper for various marine organisms.

The main objective of this study was to determine the levels of Ni, Pb, Cu and Zn in sediments and water from the Arvand River, northern part of Persian Gulf.

MATERIAL AND METHODS

Study area

The samples were collected from 3 sampling sites (St 1: Khorramshahr (Faisal) St 2: Minoo Island; St 3: Abadan (Abadan Refinery)) located in the arvand river northern part of the Persian Gulf. The distance between sampling sites ranged from 1 to 2 miles. The locations of the sampling sites are depicted in Figure 1.

Figure 1. Map of Persian Gulf showing location of sampling sites.

Sampling, Transportation and Storage

15 sediment samples were collected from each station in the summer of 2014. For each station samples, the surface sediment (the top 5cm layer of bottom sediments) samples were collected using a stainless steel Van Veen Grab EIJ04.30.01 (Hydro-Bios Apparatus GmbH, Kiel, Germany).

Sample Preparation

Sediment samples were prepared for analysis in accordance with the ROPME Instruction (1999) [12]. The water samples were prepared for analysis according to chelation-extraction method [13]. The samples were transferred to tightly sealed linear polyethylene (Nalgene) containers to avoid adsorption of metals from digested solution and kept at 4^0C prior to further analysis.

Analytical Methods

To determine the metals in the samples, a GBC (Savant AA Sigma) flame atomic absorption spectrometer (AAS) was used. All chemical regents were analytical reagent grade (Merck). The glassware and plastic containers were acid washed with nitric acid 10% and rinsed with double distilled water before use. To avoid samples contamination and check the accuracy of the method, blank samples and CRM (Dorm-2, muscle of Dogfish, National Research Council of Canada) were analyzed. The recovery values for all metals were satisfactory and were fallen between90% to 113%.

Data Analyses

Statistical analyses were performed using SPSS 11.5 software. Kolmogorov-Smirnov's method was conducted to test normal variable distribution and the paired *t*-test was used for comparisons and the results were defined as statistically significant for a given level of $P < 0.05$.

RESULTS

Sediment

The mean concentration (mg/g d.w.) and standard deviation of studied metals in sediment are given in Table 1. The table also shows significant differences among stations. Besides, these have been compared with permissible limits and some studies carried out by other researchers. The highest concentration of Ni (65.15 µg/g), Pb (24.25 µg/g), Cu (21.05 µg/g) and Zn (43.80 µg/g) were detected in Abadan refinery. The order of heavy metal accumulation in water was Ni> ZN> Pb> Cu.

Water

In the water samples, the average concentration of heavy metals, Ni, Pb, Cu and Zn were 5.07, 6.56, 4.14 and 6.16 *µg/g*, respectively (Table 3). Pb content was the highest and that of Cu was the lowest in water. The order of heavy metal accumulation in water was Pb > Zn > Ni > Cu.

Table 1. Heavy metal concentration (mg/g dw) in samples of surface sediment (number of samples n = 15 for each station) taken from the northwest Persian Gulf and compared to previous studies and guidelines.

Location	Ni	Pb	Cu	Zn
St 1(Khorramshar (Faisal))	44.84±1.54a	8.77±0.74a	12.64±0.42a	35.16±1.07a
St 2 (Minoo Island)	59.29±1.10b	10.33±0.94a	16.10±1.32b	36.87±1.39a
St 3 (Abadan (Abadan refinery))	65.15±0.67c	24.25±0.74b	21.05±1.36c	43.80±1.33b

a,b,c Significant differences in metal concentration between stations.

Table2. Heavy metal concentration (mg/g dw) in samples of surface sediment taken from the northwest Persian Gulf and compared to previous studies and guidelines.

Location	Ni	Pb	Cu	Zn	References
North part of the Persian Gulf	64.89	90.47	-	-	[14]
UAE, Jebel Ali	8.3	2.10	1.92	-	[15]
ROPME (1999)	70-80	15-30	-	-	[14]
ISQG	15.9	30.2	18.7	124	[16, 17]
ERL (NOAA)	21	47	34	150	[16, 17]
PEL (NOAA)	42.8	112.2	108.2	271	[16, 17]
ERM (NOAA)	52	218	270	410	[16, 17]
PEC (NOAA)	-	128	149	459	[17]

ISQG: interim marine sediment quality guideline; PELs: probable effect levels; ERL: effect range low; ERM: effect range medium; PEC: probable effect concentration.

Table 3. Mean heavy metal concentrations in seawater from this study (μg/L)

Location	Ni	Pb	Cu	Zn
St 1(Khorramshar (Faisal))	2.41±0.54a	3.82±1.38a	1.92±0.60a	3.71±1.70a
St 2 (Minoo Island)	3.03±1.21a	4.28±0.84b	2.71±0.90a	4.34±1.22a
St 3 (Abadan (Abadan refinery))	5.07±0.87b	6.56±1.27c	4.14±0.53b	6.16±1.38a

a,b,c Significant differences in metal concentration between stations.

Table 4. Mean heavy metal concentrations in seawater from different regions of the world and several guidelines and standards (μg/L)

Location	Ni	Pb	Cu	Zn	References
Persian Gulf, northern part	2.279	5.388	-	-	[14]
Persian Gulf, UAE coastal waters	0.58	1	2.95	9.96	[8]
Persian Gulf, Kuwait coast	1.27	3.41	2.73	4.79	[18]
Arabian Sea, continental shelf of Pakistan	138	112	-	-	[19]
ANZECC Guidelines	15	5	5	50	[20]
Water quality criteria (CMC)	74	65	4.8	120	[21]

ANZECC: Australian and New Zealand Environment and Conservation Council.

DISCUSSION

In natural aquatic ecosystems, metals occur in low concentrations, normally at the nanogram to microgram per liter level. In recent times however, the occurrence of metal contaminants especially the heavy metals in excess of natural loads has become a problem of increasing concern. The comparison between the sampling stations showed that the amount of heavy metals varied from site to site, and the variation could be related to variability in the sources of metals' input. The sediments accumulated more heavy metals than the water in this study as have been observed [22, 23, 24 and 25]. In this study, concentrations of heavy metals in water and sediments were lower of the guidelines (Tables 2, 4).

The highest values of Pb in sediment and water were found at S3 (Tables 1, 3). These may be related to human activities including shipping and transport, urban and domestic wastewater, agriculture, industrial wastewater at shipbuilding plants and desalination facilities, coastal activities (for example, marinas, jetties, ports and harbors), and fishing boats. The results of the present study agree with the results obtained by [26, 15 and 27].

There was significant difference in Zn concentrations between different stations, and high concentrations of Zn were found at sites 3 (Table 1, 3). These results are consistent with those of other studies and suggest that these stations can be affected by human activities such as industry, urban and domestic activities, economics, and agriculture [26 and 28].
In addition, there were Iran Iraq war, shipping and Abadan refinery activities in the background of St 3 and the high concentrations of Ni, Pb, Cu and Zn in this station may be due to this activity [29 and 15]. The concentration of heavy metals in the northern part of the Persian Gulf [14] was considerably greater than that observed in the northwestern part of the Gulf. The Arvand River, the border between Iraq and Iran, formed by the confluence of Shatt al- Arab in Iraq and the Karoon River in Iran [30]. In addition to receiving pollutants from these rivers, it receives a considerable amount of contaminations from various sources along its course [31 and 32].

CONCLUSION

This study provides new information on the distribution and seasonal variation of metals in surface sediments and water along the Arvand river from northwest of Persian Gulf. The results showed that the concentration of metals varied among station. The sediment and water of station 3 in Abadan showed greater concentration of the metals than those from the other areas. The high concentration of metals in sediment and water at the S3 sampling site could result from anthropogenic influence. The heavy metal concentration in the sediments are described in the descending order of Ni> Zn> Pb > Cu at all sampling sites. Therefore, the Arvand River as a major source of sediment and a source of heavy metals can affect the concentration of metals in sediment of the area. Metals concentrations in sediment were well below sediment quality guideline, except Ni element in some cases.

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