Original Article

Cd and Pb Concentrations in the Surface Sediments of the Asaluyeh Bay, Iran

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Abstract

Introduction: Cadmium (CD) and lead (Pb) are widely used in the industrial and refining activities and are frequently detected in sediments. The main objectives of this research were focused on determining the concentration of Cd and Pb in the sediments of Asaluyeh and compare them with other parts of the world.

Materials and Methods: The concentrations of Pb and Cd in the sediments of Nayband Bay area (contaminated area) and Lavar-e Saheli (control area) were measured. In the summer of 2013, the samples of sediment were collected from 40 stations. The samples were digested using the method Yap 2002 and analyzed by atomic absorption spectrophotometer.

Results: The median concentration of Pb and Cd in the sediments were collected from Nayband ranged from 3.56 to 5.25 µg/gdw and 1.16 to 1.44 µg/gdw, respectively. The concentrations of Pb and Cd in most of the sediment samples in the study area were higher than the Persian Gulf standards.

Conclusion: Therefore, it is essential to use abatement efforts to clean-up the polluted areas in the coastal area of the Asaluyeh Bay and prevent the discharge of the untreated or partially treated wastewater to the Persian Gulf as well.

Keywords: Cadmium, Lead, Sediment, Asaluyeh, Persian Gulf

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Introduction

Major marine pollution is caused by heavy metals[1]. The presence of heavy metals in aquatic environments is very important, due to their toxicity and their ability to accumulate in living organisms[2]. Since heavy metals are persistent and mostly not degradable, they can move up the food chains due to biomagnification and ultimately damage human health. Heavy metals are mostly responsible for the metal toxicity in the aquatic organisms [3].

Cadmium and lead are among the most toxic trace elements [4-5]. When heavy metals enter aquatic environments, they are adsorbed by organic and inorganic substances and ultimately enter sediments. Therefore, high amounts of heavy metals have been observed in coastal sediments. The coastal sediments can be used as sensitive indicators for monitoring contamination the coastal regions [6, 7].

On the other hand, human activities have also contributed to increase heavy metal concentrations in coastal sediments. In areas with high urban and industrial activities, very high concentrations of heavy metals have been observed in sediments[8-10].

Aquatic organisms are able to uptake heavy metals from sediments and bioaccumulate them[11].

Various studies have been done worldwide on the accumulation of heavy metals in water, sediments in the northern parts of the Persian Gulf[12] , the Gulf of Mexico Sanadrey [13], the Southeast of India [14], the coast of Moyan [15], Hendurabi Island, Badar Abbas, Iran [16] and Piodelaplate coasts in Argentina [17].

Since Asaluyeh is an industrial region located on the shore of the Persian Gulf, covers 270 Km southeast of Bushehr province and has the Pars Special Economic Energy Zone and enjoys the highest rank in oil and gas production in the country in recent years, heavy metals especially cadmium and lead have been widely used in the industrial and refining activities in that region.

It is also expected that the pollution level will significantly increase in the near future. Moreover, there is a concern regarding the contamination of sediments and aquatic organisms and its effect on people's health and the environment.

Therefore, the objectives of the study were to (i) determine the concentration of cadmium and lead in the sediments of Nayband bay in Asaluyeh and Lavar-e Saheli, and (ii) compare them with the standards.

Materials and Methods

Sampling

The number and location of the study stations were selected on the geographic orientation map.

The samples of sediments were collected from Nayband Bay (as the contaminated area) and Lavar-e Saheli (as the control area) in Asaluyeh. Sampling was done on the sediments during summer 2013.

The forty samples of sediment (20 sediment samples from each of the contaminated and control areas) were collected with a hand-driven soil auger at a (0-10 Cm) soil depth. The samples of sediments were transported to the laboratory in polyethylene containers using an icebox [18]. All samples were refrigerated at 4 °*C* or less until they were ready for chemical analysis [19].

Sample preparation

The sediment samples were dried in an oven for 24 hr at 105°C and then any foreign objects were removed. The sediments were screened through a 25 µm sieve for maintaining homogeneity of sediments, while kept in polyethylene containers until digestion [20].

For sample digestion, 1 gram of sieved sediment sample was poured into a round bottom flask and mixed with 10 mm of 65% HNO_3 and 60% $HClO_4$ at a ratio of 4:1. Then, the samples were digested using a hot plate digester (HC: 6040, UK).

Initially, the sediments were digested at low temperature (40°C) for one hour and then fully digested at high temperature (140°C) for three hours. After cooling at room temperature, the digested samples were transferred into a 25 ml volumetric flask and brought to volume with deionized water. Then, it passed through a Whatman 42 filter paper.

The filtered samples were kept in the refrigerator prior to the analysis by atomic absorption spectrophotometer analysis. Atomic absorption spectrophotometer (Varian 240, USA) was used in this study to determine lead and cadmium concentrations in the samples [21].

Data analysis

Data were analyzed using SPSS software, version 18 and $P<0.05$ was considered as statistically significant.

Results

The median concentration of lead in the sediments at Nayband bay were in the range of 3.56-5.25 µg/gdrw and the maximum and minimum concentrations were related to stations 15 (7.19±1.22 µg/gdrw) and 14 (2.28±1.49 µg/gdrw), respectively (Figure 1).

Discussion

Results regarding the concentration of cadmium in the sediments at Nayband bay showed that the maximum and minimum concentrations belonged to stations 6 (1.92±1.44 µg/gdrw) and 12 (0.81±1.26 µg/gdrw), respectively and the concentration of median ranged from 1.16 to 1.44 µg/gdrw (Figure 2).

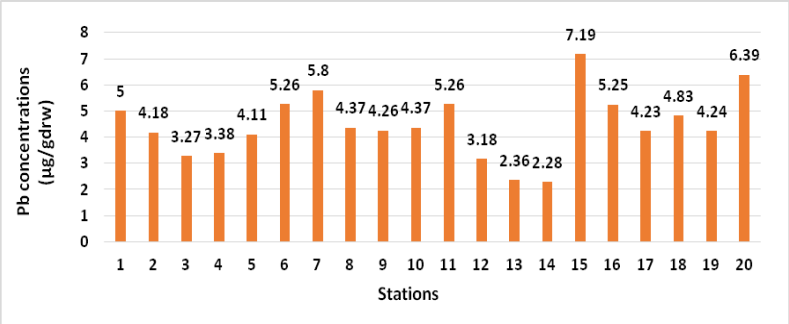

Figure 1: The concentration of lead in the sediments of the Nayband Bay stations

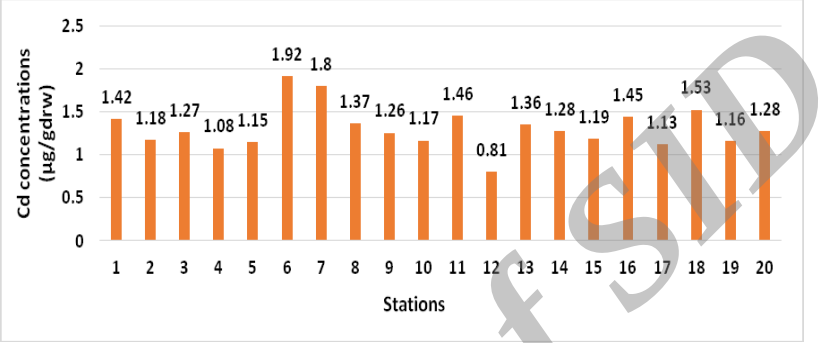

Figure 2: The concentration of cadmium in the sediments of the Nayband Bay stations

According to Karbaci study, due to the specific geology of the region, the heavy metal concentrations and their resource in the sediments in the Persian Gulf region should not be compared with the world standards of heavy metals in sediments and soil.

Therefore, the need for setting new standards is evident and the pollution levels of the sediments in the Persian Gulf should be compared with the region's standards [22]. According to data obtained in the current study, the lead concentration in the sediments of Nayband bay are much higher than the same value in Qatar, Oman, Bahrain, Kuwait, and Kish and Hendurabi Islands, but less than the United Arab Emirates (UAE), Mahshahr bay, Bushehr and Chabahar coasts.

Moreover, the concentrations of cadmium in the sediment were higher compared with Bahrain, Qatar, Mahshahr bay, Imam Khomeini port, and Hendurabi Island (Table 1).

Table 1: Comparison of lead and cadmium concentrations (µg/g) in the sediments of the Nayband bay with other parts of the world

Area	Cd	Pb	References
Bahrain	0.04-0.18	0.67-0.99	De Mora et al., 2004 [23]
Oman	0.14-0.21	0.25-1.82	De Mora et al., 2004 [23]
United Arab Emirates	0.02-0.11	0.69-5.88	De Mora et al., 2004 [23]
Qatar	0.03-0.09	0.43-3.88	De Mora et al., 2004 [23]
Kuwait	–	0.4	Beg et al., 2001[24]
Mahshahr gulf	0.6	14.7	Mediseh Dehghan, 2007[25]
Khuzestan	2.1	23.5	SabzAli Zadeh, 2008 [26]
Bushehr coast	–	8.91-24.22	Islami, 2008 [27]
Chabahar Beaches	–	31.97	Eynolahi, 2008 [28]
Kish Island	–	4.2	Dadollahi and Savari, 2006 [29]
Hendurabi Island	1.11	4.62	Mortazavi, 2005[16]
Bandar Imam Khomeini	0.26–0.12	8.15–3.22	Azimi, 2012[30]
Nayband Bay	1.44–1.16	5.25–3.56	The present study
Persian Gulf Standard	0.2	4.5	–

Data analysis revealed that lead concentrations in the sediments of the stations 1, 6, 7, 11, 15, 16, 18, and 20 at Nayband bay were higher than the Persian Gulf standards (Figure 1 and Table 1). Moreover, cadmium concentrations in all studied stations were higher than the Persian Gulf standards.

The median concentrations of lead in the sediments of Lavare-e Saheli area were in the range of 2.48-3.33 µg/gdrw.

The maximum and minimum concentrations of lead in the sediments of Nayband bay were related to stations 15 (7.19±1.22 µg/gdrw) and 14 (2.28±1.49 µg/gdrw), respectively (Figure 1). Moreover, the maximum and minimum concentrations of lead in the sediments of Lavare-e Saheli area were related to stations 24 (4.97±1.48 µg/gdrw) and 30 (2.11±1.25 µg/gdrw), respectively (Figure 3).

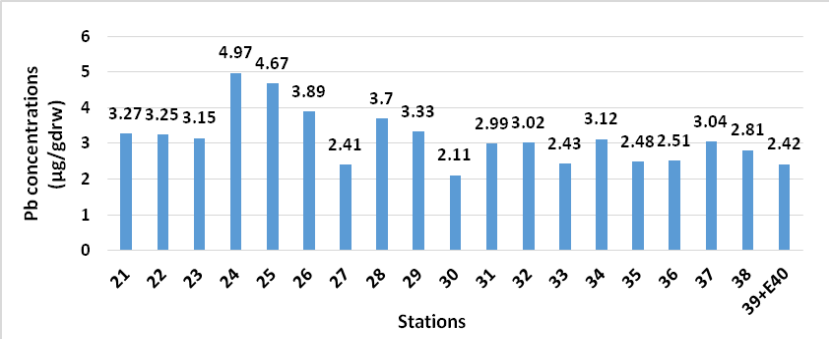

Figure 3: The concentration of lead in the sediments of the Lavar-e Saheli stations

Moreover, the maximum and minimum concentrations of cadmium in the sediments at Lavare-e Saheli area were related to stations 22 (1.35±1.22 µg/gdrw) and 34 (0.04±1.75 µg/gdrvew), respectively and the median concentration ranged from 0.23 to 0.68 µg/gdrw (Figure 4).

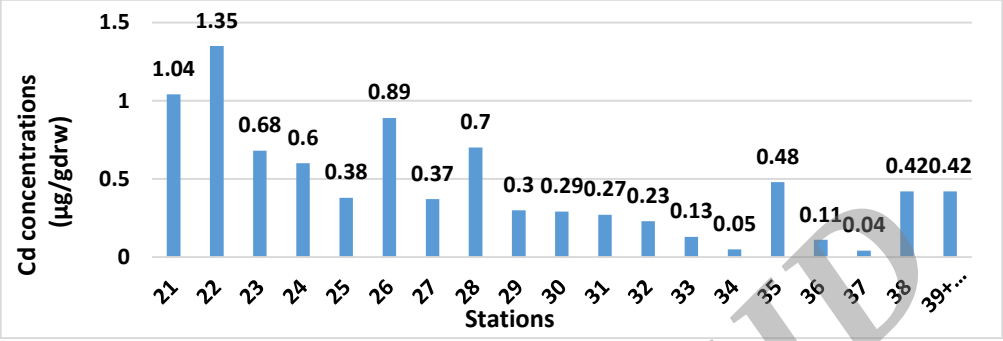

Figure 4: The concentration of cadmium in the sediments of the Lavar-e Saheli stations

There is a tendency to accumulate different contaminants such as heavy metals in the sediments. According to Figures 5 and 6, a significant positive correlation was found between lead and cadmium concentrations in the sediments of this region (n=39, r=0.63, P<0.0001).

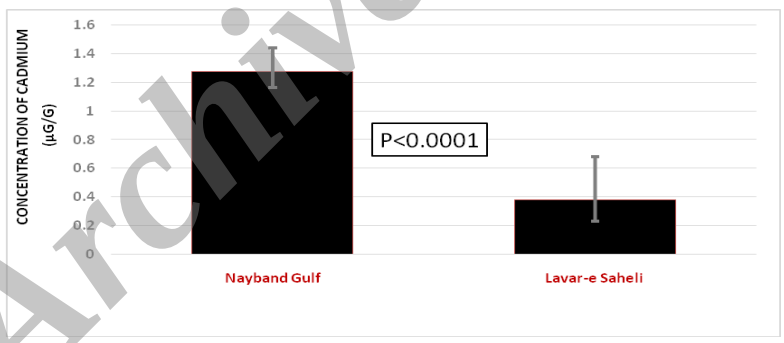

Figure 5: Comparison of cadmium in sediment in the Nayband Bay area (contaminated area) and Lavar-e Saheli (control area)

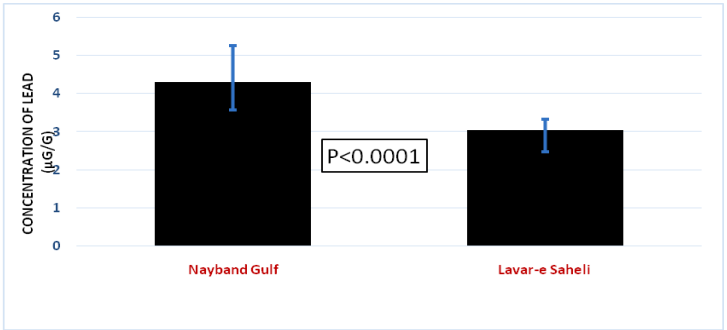

Figure 6:. Comparison of lead in sediment in the Nayband Bay area (contaminated area) and Lavar-e Saheli (control area)

Conclusion

In conclusion, the sources of pollution are refineries and petrochemical complexes in Pars special energy and economic zone as well as other light and heavy industries. Heavy metals especially cadmium and lead enter from the wastewater of refineries, petrochemical complexes and the industry and are subsequently deposited into the sediments in the Nayband Bay region.

These activities accumulate heavy metals in the sediment. There is a risk of secondary water pollution by heavy metals under sediment disturbance or changes in sediment chemistry.

In addition, the concentrations of Pb and Cd in most sediment samples in the study area were higher than the Persian Gulf standards.

Therefore, it is essential to use abatement efforts to clean-up the polluted areas in the coastal area of the Asaluyeh Bay and prevent discharging of the untreated or partially treated wastewater to the Persian Gulf as well.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

The overall implementation of this study including design, experiments, data analysis, and manuscript preparation were the results of the corresponding author's efforts. All authors have made extensive contribution into the review and finalization of this manuscript.

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