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Baseline

Contamination assessment of mercury, lead, cadmium and arsenic in surface sediments of Chabahar Bay

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ABSTRACT

This study aimed to investigate heavy metals content of mercury (Hg), lead (Pb), cadmium (Cd) and arsenic (As) in surface sediments of Chabahar Bay. Sediment samples were taken from 13 stations and then analyzed. The concentration of Hg, Pb, Cd and As ranged between 0.06 and 0.14 ppm, 8 and 23 ppm, 0.05 and 0.9 ppm and 5 and 22 ppm, respectively. Arsenic content was more than ERL at some stations. Statistical analyses indicated critical importance of organic matter and mud in metal dispersion. Also, positive correlation of Al with Pb, Hg and Cd probably implies their terrestrial origination. Average enrichment factor of Hg, Pb, Cd and As were 2.67 ± 0.95, 0.77 ± 0.28, 6.56 ± 9.9, and 7.53 ± 3.44, respectively. Most stations were classified as moderately polluted and non-polluted sites.

Urbanization and industrialization of coastal areas have gradually increased discharge rate of waste and wastewaters containing heavy metals into estuaries and beach ecosystems through rivers and underground runoffs (Islam et al., 2015; Bastami et al., 2015). These contaminants might distribute in water column and form bottom deposits. Deposited heavy metals in sea floor can reenter the upper water via different process, hence; have a potential role in polluting marine water and organisms. Heavy metals in marine environment are considered as a global concern throughout the world. Because of cumulative behavior and toxicity effects, heavy metals are of great ecological importance. They contribute to marine diversity decline and affect the life cycle. Long term consumption of foods containing heavy metals, even in low concentration can have potential detrimental effects (Tuzen and Soylak, 2007). Additionally, these metals are classified as constant non biodegradable contaminants. Heavy metals pollution is recognized as a substantial problem due to their toxicity and bio-accumulation capability (Usero et al., 2005; Bastami et al., 2012). In contrast to other pollutants in aqueous systems, heavy metals are less visible but much severely influenced human life and the whole ecosystem (Edem et al., 2008). Bio-accumulation of heavy metals depends indirectly on their type and concentration in marine systems (Edem et al., 2008). Analyses of water, sediment and marine organisms can determine water pollution content. Metals can be transported to upper trophic levels in a food chain. Usually, a level of these contaminants in aquatics is much higher than surrounding environments due to bio-accumulation and biomagnification. Among heavy metals mercury, cadmium, lead and arsenic are critically significant. Mercury is in liquid form at ambient temperature and found in organic and inorganic forms in nature. Major mineral of mercury in earth crust is Cinnabar, only discovered in few areas throughout the earth. Mercury can be discharged into the water resources by physical or chemical erosion and vapors evaporation of natural phenomena as well. Considering low level of mercury in pristine and natural marine environments, increased levels of this metal in such systems implies its high discharge via human activities. Human activities such as battery production, thermometer, florescent lights, fossil fuel combustion, burning rigid waste, mining, industries such as painting, chloralkali, wood pulp and paper, as well as oil detection introduce mercury into the environment. Recent investigations have demonstrated that chloralkali industry is the biggest mercury consumer (Panda et al., 1990).

Another toxic metal is cadmium, steadily found in earth crust of all ecosystems. Cadmium solubility in water is influenced by factors like pH and its compounds type. Cadmium is discharged into aqueous ecosystems by soil and substrate erosion, wastes of industrial plants and urban sewages. Both sediment-absorbed cadmium and soluble cadmium can enter the food chain (Ma et al., 2017).

From old ages, arsenic has been applied both as a drug and toxin. Arsenic toxicity is a function of its compounds. In water bodies, arsenic is resulted from agricultural activities (organic herbicide), fossil and industrial fuels. Arsenic is naturally found in organic and inorganic forms and regarded as a suitable detector for chemical and biological processes. Many A wide variety of fungi and bacteria are known to contribute arsenic methylation in water ecosystems which reduces arsenic toxicity (Deng et al., 2014).

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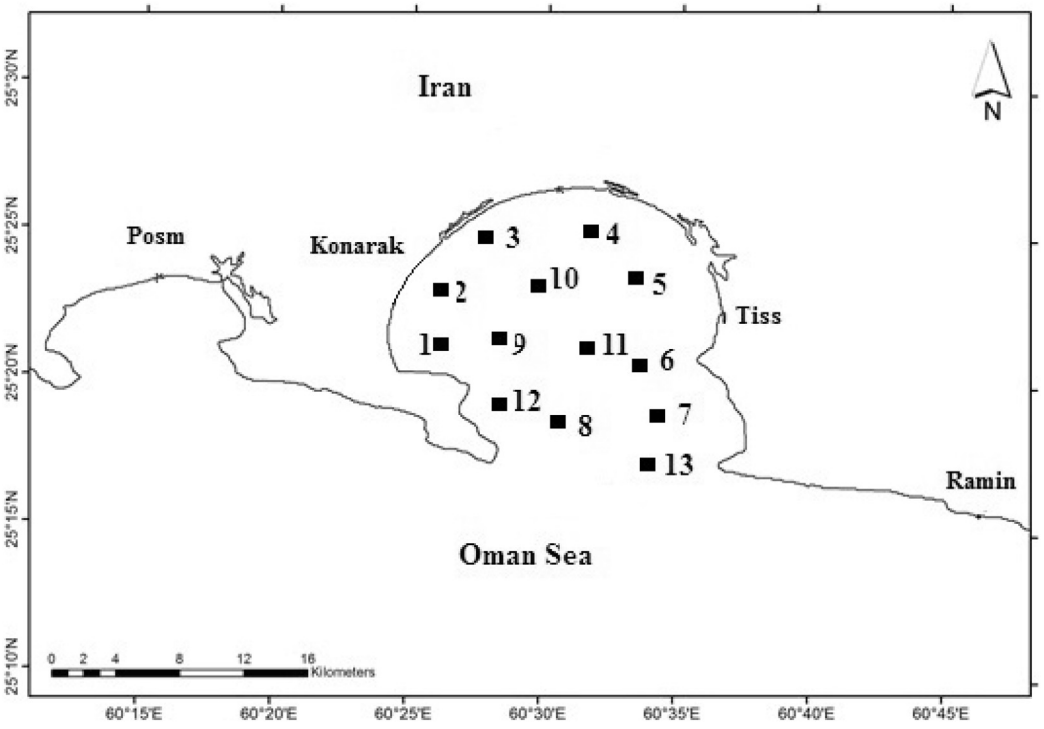

Fig. 1. The locations of the sampling sites at the Chabahar Bay.

Table 1
Heavy metals and general characteristics of sediments (average ± SD) sampled in the Chabahar Bay.

Sampling sites	Hg (ppm)	Cd (ppm)	As (ppm)	Pb (ppm)	Tom (%)	Sand (%)	Mud (%)
1	0.1	0.12	8	12	3.21	86	14
2	0.09	0.1	7.6	14	4	83	17
3	0.12	0.08	9	10	2.5	91.5	8.5
4	0.08	0.14	20	21	7	68	32
5	0.08	0.1	11	17	4	88.79	11.21
6	0.11	0.11	17	19	5.3	78	22
7	0.07	0.09	14	8	3.2	85	15
8	0.14	0.13	5	14	3.5	82	18
9	0.14	0.11	9	23	6	55	45
10	0.13	0.12	22	20	7.5	48	52
11	0.06	0.05	8	10	2.5	92	8
12	0.1	0.9	16	14	4.6	88	12
13	0.14	0.14	12	22	5.7	74	26
Average	0.10	0.17	12.20	15.69	4.54	78.41	21.59
S.D.	0.03	0.22	5.23	4.99	1.64	13.82	13.82
Minimum	0.06	0.05	5	8	2.5	48	8
Maximum	0.14	0.9	22	23	7.5	92	52

Chabahar Bay is located in south-eastern of Iran near the Oman Sea costs (Sistan and Balochestan Province) with average depth of 6 m (maximum depth of 19 m at the opening mouth), area of 290 km^2 and dimeter of 21 km. The aim of present study was to determine mercury, cadmium and arsenic levels in Chabahar Bay sediments and its relation with sedimentology features.

Sediment sampling of Chabahar Bay was conducted at 13 stations in summer 2011 using a Van Veen Grab. Geographical location of stations is illustrated in Fig. 1. Sampled sediments were packed in field, transported to the laboratory in plastic container and then kept at − 20 °C until further analyses. For metal analyses, samples were dried for 24 h in a freeze-dryer and powdered using a porcelain mortar. After removal of particles < 63 μ using a small mesh size screen, 0.1 g of each sample was digested according to the standard method of 6548 by hydrochloric acid (HCL) and Hydrofluoric acid (HF). Following complete digestion, solution was sieved through a whatman paper, then metals of As, Pb and Cd was measured by an ICP-OES. Also, Hg level was then determined using atomic absorption and cold steam technique. For data validation, a standard sample was applied and recovery of the samples was obtained 85–97%. Notably, all the tools applied in digestion process and mercury measurement had been placed in nitric acid 5% for 24 h and finally rinsed with twice distilled water before they were used. A particle analyzer was applied for sediment grain size determination. In addition, dried matter (TOM) was quantified by sample combustion at 550 °C for 2 h.

Pearson correlation test was applied to examine the relationship between measured parameters. Pearson analysis was done by Spss Ver. 18. Multivariate analysis including principle component analysis (PCA) and cluster analysis (CA) were employed using Primer 6 & PERMANOVA software. Cluster analysis, as a mathematical approach determines the similarity of variables among stations based on Euclidean distance index. Principle component analysis was used to identify and interpret the spatial changes and relations among parameters.

In Table 1, results of sediment grain size, organic matter and measured heavy metals in the study area is shown. Organic matter content