Identification of Heavy Metals Contamination at Bushehr Mangroves

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Introduction

Pollution of natural environments by heavy metals has become a global problem. Elevated concentrations of heavy metals have been recorded in mangrove sediments all over the world, which often reflect the long-term pollution caused by human activities. Industrialization and urbanization in recent decade have led to a strong risk of environmental concern, in particular, the heavy metal contamination in the mangrove ecosystems in the (sub) tropics coastlines. Mangroves are productive habitats and may support coastal fisheries for prawns and fishes. Mangroves are also important to humans for a variety of reasons, including aquaculture, agriculture, forestry, protection against shoreline erosion, as a source of fire-wood and building material, and other local subsistence use. Principal components analysis (PCA) is an exploratory, multivariate, statistical technique that can be used to examine data variability. It is frequently applied to environmental data, where datasets may be large and difficult to interpret, and where complex inter-relationships between variables are difficult to identify and visualize. Therefore aims of this study are to investigate current heavy metal distributions and concentrations in Bushehr mangrove intertidal sediments, to assess the contamination extent by heavy metals using marine sediment quality criteria, related to the anthropogenic impact during decades of urbanization and economic development along the coastal area, and update the information for elective environmental management in the region.

Materials and methods

A survey was conducted in April 2009 at Bushehr mangrove forest, a coastal part of northern Persian Gulf. Three mangrove sites in northern Persian Gulf including Bidekhun, Basatin, and Melgonze were investigated. Bidekhun mangrove swamp occupies an area of 80 ha, which is heavily disturbed by human activities, discharging of industrial wastewaters such as south pars gas complex and air. Basatin with an area of 30 ha, is located adjacent to the Bidekhun. Mangrove at Melgonze is a small swamp with an area 10 ha, which is relatively remote and less disturbed by human activities.

Twenty two of 100 m2 quadrat (10 m × 10 m) was established in all sites. Locations were also recorded using a Global Position System (GPS) captured in WGS 84 and decimal degrees. Within each quadrat three surface sediment samples (0–10 cm) were collected, using a clean, acid-washed plastic scoop. Samples were stored in clean acid-washed plastic containers until transportation to the laboratory. In laboratory immediately, sediment samples were dried and ground with a pestle and mortar, and sieved through a 2-mm sieve to remove coarse particles. The sediment samples with a diameter less than 2 mm were stored in polyethylene bottles for further analysis.

Samples were digested using USEPA Methods 3050, and concentrations of the following metals were determined by ICP: aluminum; cadmium; copper; iron; nickel; lead; vanadium; and zinc.

Total organic carbon (TOC) concentrations were obtained by digesting 1 g of sample with dichromate according to the method of Walkley and Black.

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Results

Percentage of <63µm metal fraction distribution and metal concentrations in the sediments of Bushehr mangrove are given in Table 1.

Table 1: Grain size distributions and total organic carbon (TOC) and heavy metal concentrations in Mangrove surface sediments of Bushehr

Site	Sample No.	<63µm fraction (%)	TOC (%)	Al (µg g-1)	Fe (µg g-1)	Cd (µg g-1)	Cu (µg g-1)	Ni (µg g-1)	Pb (µg g-1)	V (µg g-1)	Zn (µg g-1)
Bidekhon	1	79	0.9	20690	44920	1.9	43.4	51.91	101.24	180.28	241.25
	2	77	2.04	20190	45550	1.88	40.5	58.54	93.9	250.36	182.21
	3	83	1.66	25310	47990	1.89	37.5	43.78	92.54	223.7	174
	4	75	2.34	19420	42980	2.61	43.46	71.26	119.12	301.47	228.62
	5	81	1.9	20920	43730	1.77	51.82	49.93	115.6	225.45	196.5
	6	85	3.01	30240	51530	1.98	50.72	204.54	94.24	825.26	214.65
	7	73	2.38	20320	45210	2.03	83.72	110	105.21	560.24	280.65
	8	33	1.06	9870	15690	1.82	38.95	37.95	76.59	125.03	148
	9	21	0.29	4510	12820	1.91	41.29	14.1	81.05	65.38	183.2
	10	33	1.47	11420	27690	1.88	44	42.9	82.31	121.83	162.69
Basatin	11	47	0.3	4284	12660	1.93	49.69	32.38	122.4	207.53	259.25
	12	75	0.75	18570	42760	1.86	56.53	62.75	151.4	417.75	277.49
	13	55	0.86	11920	22535	3.45	71.1	58.4	191.61	322.5	284.1
	14	84	1.05	28480	50620	1.94	18.56	181.68	42.75	781.43	95.5
	15	81	2.47	20140	45270	1.01	91.58	82.5	159.45	230.74	304.7
	16	69	1.99	17980	42830	1	98.27	74.6	160.11	201	306.15
Melegonze	17	65	2.37	14846	31920	1.85	30.15	74.31	70.25	459	189.7
	18	23	0.57	5954	14824	0.6	14.14	20.22	35.21	148.15	44.91
	19	63	1.51	6420	11500	1.89	29.3	39.1	79.86	240	120.1
	20	45	1.62	1795	6425	0.9	34.25	54.36	59.79	319.62	57.19
	21	33	0.62	8628	14841	1.5	21.3	25.1	34.15	154.73	51.69
	22	65	1.97	12463	30210	1.3	28.7	38.25	40.46	394.2	68.6
	Min.	21	0.29	1795	6425	0.6	14.14	14.1	34.15	65.38	44.91
	Max.	85	3.01	30240	51530	3.45	98.27	204.54	191.61	825.26	306.15
	Mean	61.14	1.51	15198.64	32022.95	1.77	46.32	64.93	95.87	307.08	185.05
	S.d.	21.26	0.78	8047.51	15367.27	0.59	22.44	47.08	42.85	199.96	84.42

Discussion

It is well-established that grain size is one of the controlling factors affecting natural concentrations of trace metals in sediments. Fine-grained sediments tend to have relatively high metal concentrations due to the high specific surface area of the smaller particles. This enrichment is mainly due to surface adsorption and ionic attraction. In this study, we found that Al, Fe, Ni, V, and Zn concentrations are significantly correlated with fine (<63µm fraction) grain size ($p < 0.01$ and $p < 0.05$), indicating that Al and Fe concentrations are mainly controlled by the grain size as a result of natural weathering processes. Copper, Lead, and Zinc are significantly correlated with together. We also found that total organic carbon (TOC) is correlated with median grain size ($p < 0.01$) as well, indicating that the grain size also controls TOC concentration to a certain extent in Bushehr mangrove.

Also we found that Al, Fe, Ni, and V concentrations are significantly correlated with TOC ($p < 0.01$ and $p < 0.05$).

Principal component analysis suggested that three factors shaped distribution of heavy metals concentrations in the coasts of the Persian Gulf.

The first Principal Component (PC1) loaded strongly with Pb, Zn, Cu and Cd represents the influence of industrial activities, which are the main source of these metals. PC2 loaded mainly with Al and Fe represents the mineralogy of sediments, as the second source of pollution. PC3 loaded strongly with Ni and V represents oil pollution.

The results have shown that the concentrations of most metals is higher in Bidekhun site, the nearest mangrove site to south pars gas complex (SPGC), than other sites. Also Basatin mangrove site which is approximately 1 km far from Bidekhun habitat has shown high metal concentration. In many cases, metal concentration in Basatin site was higher than Bidekhun site.

Key words

Mangrove forest, Bushehr province, sediment, PCA, contamination, Heavy metal, Normalization