Int. J. Mar. Sci. Eng., 2 (1), 75-80, Winter 2012
ISSN 2251-6743

Study of Metals Concentrations in Surface Sediments of the Persian Gulf Coastal Area

(Bushehr Province)

[1]A. Biati; [2]H. Nikoomaram; [3]A. R. Karbassi*

*[1]*Department of Environmental Science, Science and Research Branch, Islamic Azad University, Tehran, Iran*
[2]Department of Environmental Management, Science and Research Branch, Islamic Azad University, Tehran, Iran
[3]Department of Environmental Engineering, Graduate Faculty of the Environment, University of Tehran, Iran

Received 10 January 2012; Revised 30 January 2012; Accepted 2 February 2012

ABSTRACT: Since heavy metals are considered as one of the major pollutants threatening, the main goal of this study was to bring out the concentrations of Pb, Zn and Mn in the surface sediments off Bushehr in the Persian Gulf. For this purpose, after collection of samples, the concentrations of the three metals in surface sediments were measured through the atomic absorption. The results were compared with the mean of the elemental concentrations of Earth's crust, world's sediments and other areas of the Persian Gulf**.** Although the mean of concentrations in selected stations were higher than the Persian Gulf's central section, in comparison with Earth's crust and world's sediments, it was revealed that the concentrations of Zn and Mn were much lower. Moreover, cluster analysis showed that the two elements, Zn and Mn, had the same behavior and the concentration of Pb was not changed by depth increase.

Keywords: *metal pollution; surface sediments; concentration; coastal area*

INTRODUCTION

Sediments and suspended particulate matters (SPMs) play an important role in absorbing heavy metals in the marine environment. Environmental geochemistry has widely been used in studies related to the pollution of water bodies during recent years and many researchers have utilized sediments to study the behavior of metals during the sedimentation period (Bellucci *et al*., 2003; Bertolotto *et al*., 2003; Al-Marsi *et al*., 2005; Borretzen and Salbu, 2002; Karbassi, 1989).

Trace elements contamination in marine sediments and other aquatic ecosystems, which occurs due to industrialization (Yang and Rose, 2003; Heyvaert *et al*., 2000), has often been reported by researchers worldwide (Al-Marsi, 2003; Cocker *et al*., 1995; Farmer, 1991). Therefore, the study of sediments geochemistry in a water body may result in finding their origin and distribution pattern as well as assessing the current environmental state of its region (Shajan, 2001). Considering the fact that toxic heavy metals have adverse effects on health, the amount and severity of heavy metals toxicity on living organisms depend on the type of the toxin and the duration time of exposure (U.S. EPA, 1997).

Since in the present study the concentrations of three heavy elements, lead, zinc and manganese, have been investigated in sediments, it is necessary to explain them in brief. Lead enters the body through ingestion, inhalation and skin absorption. It is noteworthy that more than 90% of lead entering the body is directly absorbed into the bloodstream and stores in soft tissues (e.g. kidneys, brain and muscles) and bones. Lead can also cause fatigue, brain and memory disorders, decreased neurological sensitivity, weak and slow reactions, distraction etc (ATSDR, 2001;U.S. EPA, 1997). Zinc is fairly well absorbed from the intestine. Very high rate of zinc absorption (1 to 2 gr) in the human body causes headache, nausea, abdominal pains and gastrointestinal spasms. Zinc and copper compete with one another for being absorbed in human body. In other words, increase of zinc absorption from 100 to 300 mg per day results in reduction of copper

*Corresponding Author Email: *bayati_id@yahoo.com*
Tel: +98 912 3777164/ Fax: +98 21 44865002

absorption and anemia (Stanley, 1987). Regarding manganese, when it reaches the bloodstream, it easily enters the central nervous system (Karbassi and Biati, 2008). Epidemiological researches have revealed that low amounts of manganese can cause behavioral and neurological changes, especially in the eye and hand movements (Esmaili Sari, 2003).

Unique ecological conditions of the Persian Gulf and the variety of pollutions threatening this marine environment have led researchers to carry out several relevant studies (Biati *et al*., 2010a; Biati *et al*., 2010b; Biati and Karbassi, 2010). Although numerous studies have so far investigated elemental pollution of the Persian Gulf (Karbassi *et al*., 2005; Abdulrahman, 1985; Abdulrahman, 1992; Basaham, 1993), there have not been well-documented researches analyzing the metals pollution in the surface sediments off Bushehr province. Thus, the present study aims at estimating the concentrations of Pb, Zn, Mn in surface sediments off the province.

Overview of the Study Area

In the present research, the metals concentrations have been estimated through the total digestion of surface sediments off Bushehr, the northwest of the Persian Gulf. The total sediment samples of nine have been collected from three stations off Bushehr province extending in an area of about 25,360 Km^2. Bushehr province is located on the margins of the Persian Gulf in 27° 14´ to 30° 16´ latitude and 50° 06´ to 52° 58´ longitude.

MATERIALS AND METHODS

Surface sediments were sampled using VAN VEEN grab by Qods ship belonging to the Iranian Ports and Shipping Organization in winter 2009. Samples were collected at the interface between Hormuz Island and Mussa Bay in three transects: B (Bushehr), G (Genaveh), and D (Deilam). Each station was sampled at three different depths (Fig. 1). Specifications of the sampling stations are shown in Table 1.

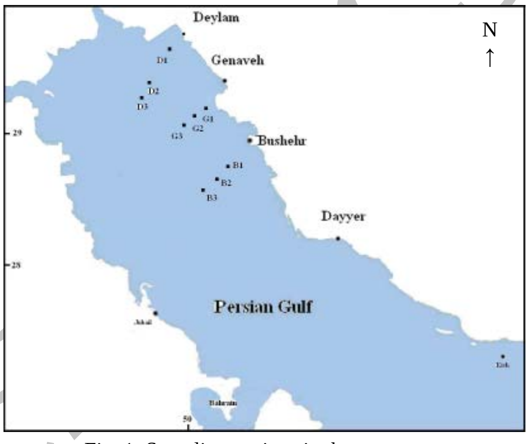

Fig. 1: Sampling stations in three transects

Table 1: Specifications of sampling stations

Sampling Stations	Water Depth (m)	Geographical Position		Temperature (C°)	
		Latitude	Longitude	Ambient Air	Water*
B_1	12	28 ° 57'	50° 43'	19.0	19.5
B_2	32	28 ° 51'	50° 37'	19.5	19.5
B_3	44	28 ° 43'	50° 30'	19.5	19.5
G_1	11	29 ° 31'	50° 27'	20.0	19.5
G_2	28	29 ° 24'	50° 16'	18.5	19.0
G_3	34	29 ° 15'	50° 00'	18.0	19.0
D_1	11	30 ° 00'	50° 02'	18.0	18.0
D_2	13	29 ° 49'	49° 50'	20.0	18.5
D_3	23	29 ° 36'	49° 41'	21.0	18.5

*Temperature was measured at the depth of 1 meter from the surface level.

All samples were transported to the laboratory of University of Tehran to be dried at 70 C° for 24 hours and passed through a mesh smaller than 63 micron meters. The sediment grains were then powdered using an agate mortar and pestle. Bulk digestion was carried out by HF-HNO3-HCl-HClO4.

Metal concentrations were measured by Atomic Absorption (Perkin Elmer 2100). Procedural blanks and duplicates were run with the samples in a similar way for quality assurance of the laboratory analysis. The accuracy of analysis was about ±6 % for all elements. A standard sample (MESS-1) was analyzed in the same manner for analysis accuracy check. Results showed that the errors in the analysis were <5%.

Of the existing clustering techniques (Lance and William, 1966; Anderson, 1971; Davis, 1973) the Weighted Pair Group (WPG) method (Davis, 1973) was used in this study because of its merits. It uses the linear correlation coefficient as a similarity measure. Highest similarities are clustered first. Two variables are connected only if they are highly correlated. After two variables are clustered, their correlations with all of the other variables are averaged. The results of clustering are displayed in the form of a dendrogram.

RESULTS AND DISCUSSION

Concentrations of Pb, Zn and Mn are presented in Table 2. A close look at the data shows that the total average concentration of Pb measured in all stations is 30.56 mg/kg that indicates an increase of 75 to 100% in comparison with the mean Earth's crust and world's sediments. The total average concentrations of Zn and Mn are 44.01 and 381.9 mg/kg, respectively. These concentrations show an approximately 50 to 60% reduction in comparison with the mean Earth's crust and world's sediments. In general, mean concentrations obtained in the present study are as follows:

Mn (382mg/Kg) > Zn (44mg/Kg)> Pb (31mg/Kg)

Further cluster analysis (Davis, 1973) was used to find out inter-relations of studied elements and depths. Correlation coefficients are represented in Table 3.

Table 2: Concentrations of elements in sediment samples (mg/kg)

Sample	Region	Water Depth (m)	Pb	Zn	Mn
B_1	Bushehr	12	30	46	455
B_2	Bushehr	32	30	52	380
B_3	Bushehr	44	32	41	319
Average Standard deviation	-	29.34 16.17	30.67 1.15	46.34 5.51	384.67 68.12
G_1	Genaveh	11.5	30	56	454
G_2	Genaveh	28	31	45	347
G_3	Genaveh	34	30	39	356
Average Standard deviation	-	24.50 11.65	30.34 0.58	46.67 8.62	385.67 59.35
D_1	Deylam	11	32	40	352
D_2	Deylam	12.5	31	42	365
D_3	Deylam	23	29	35	409
Average Standard deviation	-	15.50 6.54	30.67 1.53	39 3.61	375.34 29.87
Total average Standard deviations average	-	-	30.56 1.21	44.01 4.13	381.9 52.17
Minimum	-	-	29	35	319
Maximum	-	-	32	56	455
Mean Earth's crust	-	-	14	75	850
Mean world's sediments	-	-	19	95	770

Cluster analysis resulted from Table 3 is shown in Fig. 2. It should be mentioned that lower concentrations of Zn (44.01 mg/kg) and Mn (381.9 mg/kg) in comparison with the mean Earth's crust (Zn: 75 mg/kg, Mn: 850 mg/kg) and world's sediments (Zn: 95 mg/kg, Mn: 770 mg/kg) does not imply that the sediments are not contaminated because concentrations of elements in various geological outcrops are different. In other words, lower concentrations of these two elements in the sediments show significant differences between the geology of the sampling regions and the geology of the Earth's crust and world's sediments. Table 4 compares the elements concentrations of some studies carried out in different regions of the Persian Gulf. The Table 4 also suggests the concentrations considerably vary in different areas.

Table 3: Correlation coefficients of elements and depths

	Depth	Pb	Zn	Mn
Depth	1.000			
Pb	0.122	1.000		
Zn	-0.206	-0.112	1.000	
Mn	-0.624	-0.682	0.471	1.000

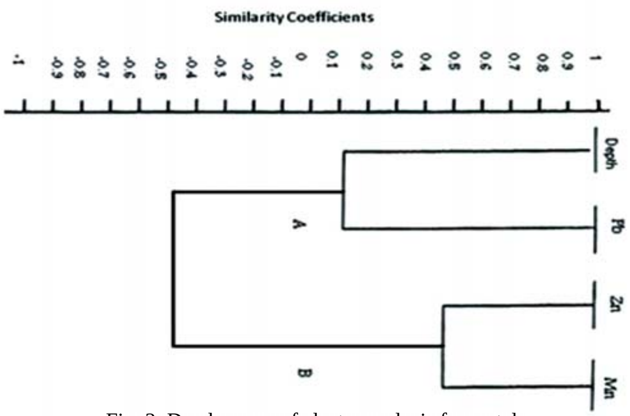

Fig. 2: Dendrogram of cluster analysis for metals

Table 4: Metals concentrations average in the present study and the previous research (mg/kg)

Study region in the Persian Gulf	Pb	Zn	Mn
Present study	30.56	44.1	381.9
Coasts of Kuwait (Basaham, 1993)	-	112	771.6
Coasts of Saudi Arabia (Basaham, 1993)	-	26.3	133.3
Coasts of Bahrain and Qatar (Basaham, 1993)	-	24.4	50.2
Northeastern coasts of Qatar (Basaham, 1993)	-	12.9	34.4
Coasts of Saudi Arabia (Abdulrahman, 1992)	24.03	12.59	101.19
Coasts of Saudi Arabia (Abdulrahman, 1985)	1.54	8.86	35.78
Mean Earth's crust (Bowen, 1979)	14	75	580
Mean world's sediments (Bowen, 1979)	19	95	770

CONCLUSION

Dendrogram of cluster analysis (Fig. 1) is composed of two clusters: A and B. In cluster B, Zn and Mn are linked together with a moderate similarity coefficient (0.5) which indicates they might follow the same behavior. Cluster A does not show any significant relationship between Pb and depth which implies that Pb concentration does not change significantly as per depth. In other words, Pb is dispersed throughout the region. Such dispersion shows that Pb in the region under study may not originate from oil sources. If this happened, Pb concentration in deeper parts would be higher than that of other parts (e.g. coasts). This means that the origin of Pb might be anthropogenic pollution resources by the Persian Gulf such as industries, agricultural wastewaters and gasoline-powered vehicles.

The negative similarity coefficient of clusters A and B indicates the origin and behavior of Pb is different from Zn and Mn. Moreover, this negative coefficient shows that the concentrations of Zn and Mn decrease as depth increases. It means either these elements may exist in lithogenous materials precipitated in coastal regions or they can originate from other pollutants in lower depth parts of the Persian Gulf which have resulted in the increase of Zn and Mn concentrations.

The fact that the concentration of Mn is much lower than the mean Earth's crust and world's sediments is due to its mobility leading Mn to be converted to sulfides in reduction conditions demonstrating pollution. These sulfides are then released from sediments and become soluble. Therefore, it could be suggested that the decrease of Mn concentration might be an indicator for the pollution of water bodies. As mentioned above, Zn might follow the same behavior as Mn (Fig. 2).

Furthermore, lower concentrations of Mn and Zn can be because of fewer minerals in sediments of the Persian Gulf than those of other parts of the world and this is due to the geology of the region (Karbassi, 1996). Besides, the levels of LOI and carbonates are high in the Persian Gulf's sediments (Karbassi, 1996). In this way, sediments are saturated with carbonates, so elements are found in loosely-bonded ions and consequently in shallow and high speed water bodies, elements have a higher tendency to bond with particle matters and show lower concentrations in sediments.

Therefore, lower concentrations of Mn and Zn do not mean lack of elemental pollution. Since concentrations of heavy elements in different geological outcrops are highly varied, it is suggested chemical partitioning studies be carried out to find out the pollution origins. Moreover, such studies would help to develop elements regional standards that enable comparison of elements concentrations with pollution indices such as Igeo (Müller, 1979), EF and Ipoll (Karbassi *et al*., 2008; Karbassi *et al*., 2006). Collection of core samples from different parts of the Persian Gulf determining the sedimentation rate can be another suggestion for further studies.

REFERENCES

Abdulrahman, A.Al., (1985). Report on the physical-chemical studies of water and sediment from Gulf. Internal report, ROPME.

Abdulrahman, A.Al., (1992). Geochemistry of metals in coastal area of Saudi Arabia. Internal report, ROPME.

Al-Masri, M.S.; Aba, A.; Khalil, H.; Al-Hares, Z., (2005). Sedimentation rates and pollution history of a dried lake: Al-Oteibeh Lake. Sci. Total Env., 293, 177-189.

Anderson, A.J.B., (1971). Numerical examination of multivariate of samples. Math. Geol., 3, 1-14.

Basaham, R., (1993). Concentrations of heavy metals in the coastal areas of Kuwait, Qatar, Bahrin and Saudi Arabia. Internal report, ROPME.

Bellucci, L.G.; El Moumni, B.; Collavini, F.; Frignani, M.; Albertazzi, S., (2003). Heavy metals in Morocco Lagoon and River sediments. J. de Phys., 107, 139-142.

Bertolotto, R.M.; Tortarolo, B.; Frignani, M.; Bellucci, L.G.; Albanese, S.; Cuneo, C., (2003). Heavy metals in coastal sediments of the Ligurian Sea off Vado Ligure. Journal de Phys., 107, 159-162.

Biati, A.; Moattar, F.; Karbassi, A.R.; Hassani, A.H., (2010). Role of saline water in removal of heavy elements from industrial wastewaters. Int. J. Environ. Res., 4, 169-176.

Biati, A.; Karbassi, A.R.; Hassani, A.H.; Monavari, S.M.; Moattar, F., (2010). Role of metal species in flocculation rate during estuarine mixing. Int. J. Environ. Sci. Tech., 7, 327-336.

Biati, A.; Karbassi, A.R., (2010). Comparison of controlling mechanisms of flocculation processes in estuaries. Int. J. Environ. Sci. Tech., 7, 731-736.

Borretzen, P.; Salbu, B., (2002). Fixation of Cs to marine sediments estimated by a stochastic modeling approach. J. Environ. Radioactive., 61, 1-20.

Bowen, H.J.M., (1979). Environmental chemistry of the elements. Academic Press, London, England, pp. 333.

Cocker, W.B.; Kettles, I.M.; Shilts, W.W., (1995). Comparison of mercury concentrations in modern lake sediments and glacial drift in the Canadian shield in the region of Ottawa/Kingston to Georgian Bay, Ontario, Canada: Water, Air and Soil Poll. 80, 1025-1029.

Davis, J.B., (1973). Statistic and data analysis in geology. Wiley, New York, pp. 456-473.

Department of Health and Human Services Agency for Toxic Substances and Disease Registry (ATSDR), Division of Health Assessment and Consultation, (2001). Toxic heavy metals, sources and specific effects.

Esmaili Sari, A., (2003). Pollution, health and environmental standards. Naghsh-e-Mehr, Tehran, Iran, pp. 312-320.

Heyvaert, A.C.; Reuter, J.E.; Slotton D.G.; Goldman, C.R., (2000). Paleolimnological reconstruction of historical atmospheric lead and mercury deposition at Lake Tahoe, California-Nevada. Environ. Sci. Tech., 34, 3588-3597.

Karbassi, A.R.; Biati, A.; Moattar, F., (2006). Origin and chemical partitioning of heavy metals in riverbed sediments. Int. J. Environ. Sci. Tech., 3, 35-42.

Karbassi, A.R.; Monavari, S.M.; Nabi-Bidhendi, Gh.R.; Nouri, J.; Nematpour, K., (2008). Metal pollution assessment of sediment and water in the Shur River. Environ. Monit. Assess., 147, 107-116.

Karbassi, A.R., (1989). Geochemical and magnetic studies of riverine, estuarine and marine sediments. Ph.D. thesis, Mangalore University, India.

Karbassi, A.R., (1996). Geochemistry of Ni, Zn, Cu, Pb, Co, Cd, V, Mn, Fe, Al and Ca in sediments of north western part of the Persian Gulf. Intl. J. Env. Studies, 54, 205-212.

Karbassi, A.R.; Biati, A., (2008). Environmental geochemistry. Kavosh Qalam, Tehran, Iran, pp. 102-110.

Karbassi, A.R.; Nabi-Bidhendi, Gh.R.; Bayati, I., (2005). Environmental geochemistry of heavy metals in sediment core off Bushehr, Persian Gulf. Iran. J. Environ. Health. Sci. Eng., 2, 255-260.

Lance, G.N.; William, W.T., (1966). A generalized sorting for computer classification. Nature, 212-218.

Müller, G., (1979). Schwermetalle in den Sediment des Rheins, Verän – derungen Seit 1971. Umschau, 79, 778 -783.

Shajan, K.P., (2001) Geochemistry of bottom sediments from a river- estuary-shelf-mixing zone on the tropical southwest coast of India. Bull. Geol. Surv. Japan, 52, 371-382.

Stanley, S., (1987). Brown and Yasushi Kodama (Editor). Toxicology of metals. Clinical and experimental research. Ellis Horwood Ltd., Chichester, pp. 448.

U.S. Environmental Protection Agency, (1997). Effects of toxic heavy metals.

Yang, H.; Rose N.L., (2003). Distribution of Hg in the lake sediments across the UK, Sci. Total Environ., 304, 391-404.

How to cite this article: (Harvard style)

Biati, A.; Nikoomaram, H.; Karbassi, A. R., (2012). Study of Metals Concentrations in Surface Sediments of the Persian Gulf Coastal Area (Bushehr Province). Int. J. Mar. Sci. Eng., 2 (1), 75-80.