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Assessment of Heavy Metals in Sediments from Coastal Al-Hodiedah Governorate, Yemen

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Abstract:

The special Location of Al-Hodiedah Governorate which is located at an area that links the Red sea and the seasonal monsoon affect marine ecosystem of the Al-Hodiedah coast. Five location at Al-Hodiedah sea shores were selected in order to study the availability of heavy metals and their concentrations in the surficial sediments (<60µm), The concentration of Ten leachable and total metals cadmium (Cd), cobalt (Co), Nickel (Ni) and lead (Pb) were determined by atomic absorption spectrophotometer. Assessment of anthropogenic pollution in sediment Contamination Factor (CF), Index of Geoaccumulation (Igeo) and Pollution Load Index (PLI) is calculated. The concentration of cadmium is indicating very high contamination in all the sampling sites. The PLI value is indicates fast progressive deterioration of the estuarine quality of Al-Hodiedah Governorate in Yemen.

Keywords: Heavy metals, Sediments, Al-Hodiedah coast.

1.0 Introduction:

Metals are the most common in environment. Their occurrence in water and sediment indicate the presence of natural as well as anthropogenic sources. The accumulation of metals in sediments can pose serious environmental problem to the surrounding areas. Metals contamination in sediment could affect the water quality and the bio-assimilation and bio-accumulation of metals in aquatic organisms, resulting in potential long term implications on human health and ecosystem (Nicolau, et. al., 2006). The negative effect of heavy metals depends on the percentage weight of their concentration as well as on a series of physical and chemical soil specific characteristics, such as: texture, organic matter content, pH, redox potential, etc. A large proportion of trace metals in sediment fraction are in a crystalline solid state and are environmentally immobile. On the other hand, fine particles, such as clay and colloidal materials, are generally surface-active and contain organic matter and Fe/Mn oxide surface coatings, and they can play an important role in controlling deposition of trace metals to sediments from an estuary to a coastal area. Anthropogenic activities have greatly altered the geochemical cycle of trace metals, resulting in widespread environmental contamination (Nriagu & Pacyna, 1988). The concentration in sediments depends not only on anthropogenic and lithogenic sources but also upon the textural characteristics, organic matter contents, mineralogical composition and depositional environment of the sediments (Trefry & Parsley, 1976). The list of metal contaminated sites grows every year, which causes serious problem for human health and a fearful danger to the environment (Martin and Meybeck, 1979; Harikumar and Jisha, 2010).

The coastal ecosystem of the Al-Hodiedah coast is an important international waterway. Therefore it is important and essential to conserve the cleanness of marine water and sediments from pollution. Yemen has along coast extending about 2000 Km along the Arabian Sea, Gulf of Aden and red sea cost. This makes Yemen a marine country with so much responsibility from security of navigation to how to deal with major oil pollution. The coastal area receives significant amount of waste containing metal from municipal wastewater, garbage and automobile discharges. The present study was carried out in the month of December 2010. Due to the lack of any previous data and knowledge regarding the concentration of heavy metals in sediments in some areas of the costal Al-Hodiedah Sea shore, the present topic was selected to generate a data base for the potential situation of heavy metals in the surficial sediments in some selected sea shores areas.

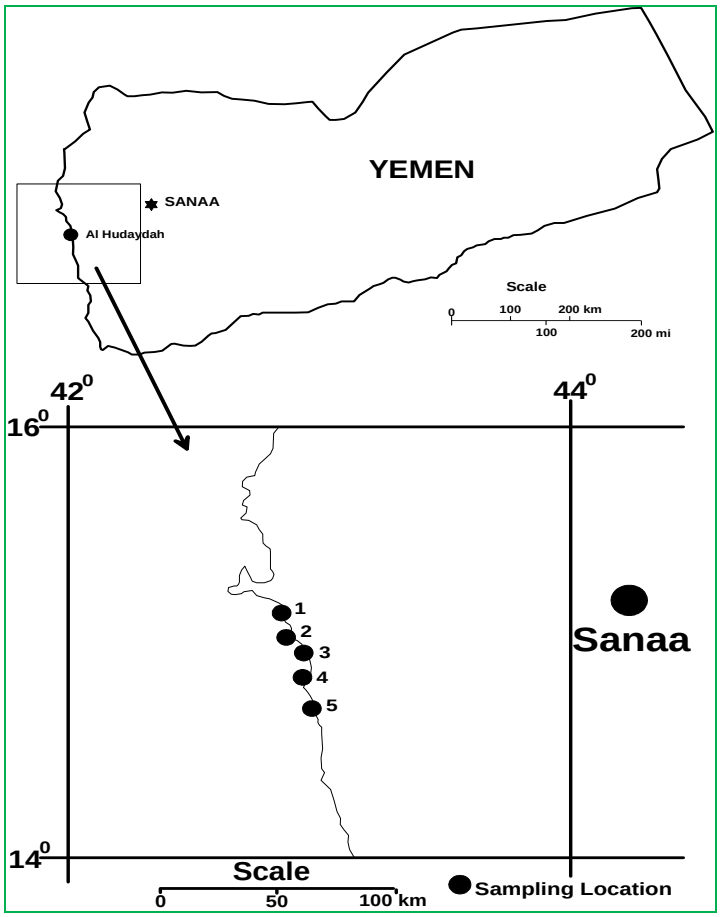

Figure 1: Sediments sampling point with location of the study area.

2.0 Materials and Methods:

A total of five sites in costal Al-Hodiedah Figure 1 were chosen and the sampling was carried during 20th December to 30th December 2010. Ten Surficial sediment samples were collected from five sampling sites (Fig. 1). The estimation of the total metal concentration, from sediments was determined according to Oregioni and Aston (1984). Sediment samples were taken at a depth of 0-15 cm which was quickly packed in air tight plastic bottles. Sub-samples of the material were oven dried at 50^0C for 48 hours and ground using mortal and pestle. Then the samples were sieved by <63 µm sieving net and 2 gm of sub-sediment sample were digested by using acids mixtures (HNO_3^+, $HCLO_4$ and HF) respectively, to obtain the total concentration of the metals in the sediments as been recommended by Balcerzak (2002). Precautions were taken to avoid contamination during drying, grinding and sieving. Cd, Co, Ni, and Pb concentrations were determined with Atomic Absorption Spectrophotometer.

3.0 Results and Discussion:

Table 1: Concentration (M±SD) of the heavy metals pollution in sediments from the study area

Sr. No.	Location/Sites	Concentration (µg/g) Dry Wt.			
		Cd	Co	Ni	Pb
1	Al-Hodiedah	10.17±0.69	25.03±0.26	15.94±0.42	63.63±2.19
2		9.83±0.42	25.50±0.00	16.00±0. 0	65.16±1.29
3	Al-Kateef	9.50±0.0	30.33±0.62	13.50±0. 0	62.32±0.98
4		9.50±0.0	31.50±0.00	13.39±0.35	62.66±0.58
5	Al-Manjer	8.17±0.0	24.00±0.00	17.00±0.0	64.60±2.58
6		8.17±0.0	24.00±0.00	17.12±0.59	64.56±2.58
7	Cornish	7. 67±1.97	30.07±0.53	18.33± 0.0	62.00±0.00
8		8.00±0.0	29.37±0.49	18.35±0.74	61.45±1.25
9	Almehwat	7.50±0.0	32.00±0.00	20.50±0.0	64.21±2.31
10		7.33±0.31	32.00±0.00	20.00±0.0	65.00±0.00
Min		7.33	24	13.39	61.45
Max		10.17	32	20.5	65.16
Mean		8.58	28.38	17.01	63.56

The metal concentration of Cd, Co, Ni and Pb are ranges from 7.33 to 10.17 µg/g, 24 to 32µg/g, 13.39 to 20.5 µg/g and 61.45 to 65.16 µg/g respectively. The total mean concentrations for Cd, Co, Ni and Pb are 8.58 µg/g, 28.38 µg/g, 17.01 µg/g and 63.56 µg/g respectively (Figure 2-5). The concentrations of Cd and Pb metals give minor variations and major variations from Co and Ni metals for all 10 samples in the five sites. These variations are related to the different amounts of anthropogenic inputs such as oil pollution and untreated sewage and waste of factories near the study sites.

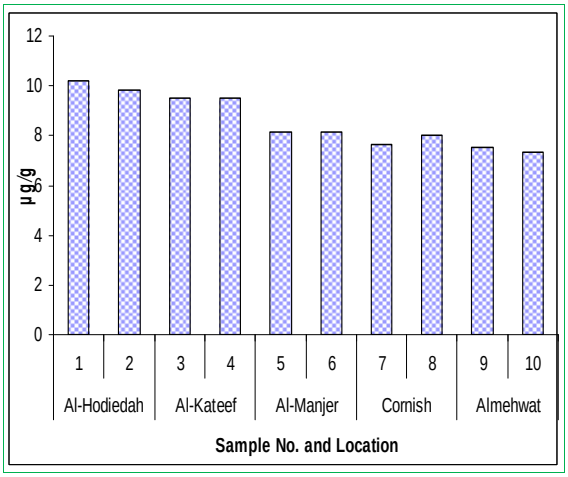

Figure 2: Concentration of Cadmium (Cd) in Sediments from study area

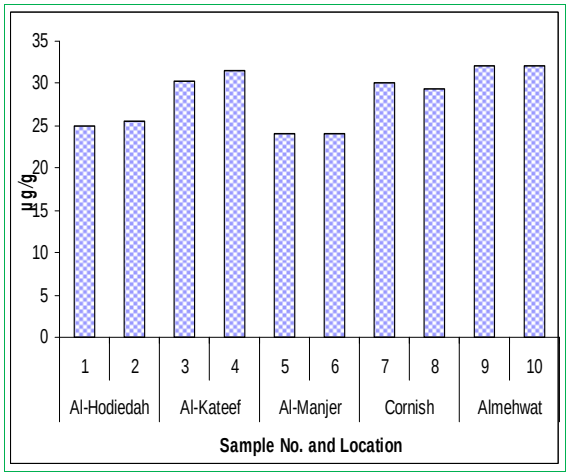

Figure 3: Concentration of Cobalt (Co) in Sediments from study area.

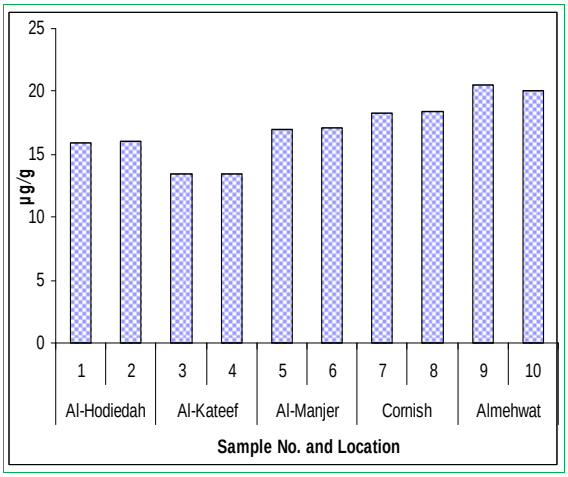

Figure 4: Concentration of Nickel (Ni) in Sediments from study area.

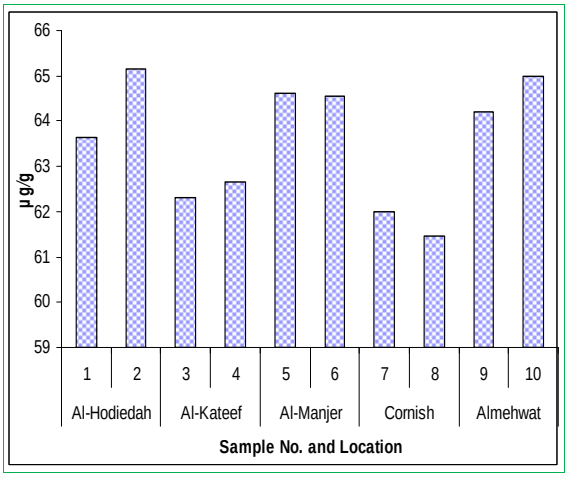

Figure 5: Concentration of Lead (Pb) in Sediments from study area.

3.1 Assessment of Anthropogenic Pollution in Sediments:

3.2 Determination of Contamination Factor

The level of contamination of sediment by a metal is often expressed in terms of a contamination factor calculated as follows,

Contamination Factor (CF) = Metal content in the sediment / Background level of metal

Where CF < 1 refers to low contamination, 1 ≥ CF ≥ 3 means moderate contamination, 3 ≥ CF ≥ 6 indicates considerable contamination, and CF > 6 indicates very high contamination (Harikumar and Jisha, 2010). The contamination factors of the various metals in the sediment of coastal Al-Hodiedah Governorate are presented in Table 2.

Table 2: Contamination Factor (CF) for the metals of coastal Al-Hodiedah Governorate

Sr. No.	Cd	Ni	Pb
1	33.9	0.234	3.18
2	32.76	0.235	3.25
3	31.66	0.198	3.11
4	31.66	0.196	3.13
5	27.23	0.25	3.23
6	27.23	0.251	3.22
7	25.56	0.269	3.1
8	26.66	0.269	3.07
9	25	0.301	3.21
10	24.43	0.294	3.25

The concentration of cadmium is indicating very high contamination in all the sampling sites. Ni was present at much lesser concentrations. The concentration of nickel is refers to low contamination in all the sampling sites. The concentration of lead is indicates considerable contamination in all the sampling sites. From the contamination factor calculations, it was found that a regular monitoring for the concentrations of Cd & Pb is essential since their contamination factor at all the sampling sites exceeded the desirable limit for CF values and can cause potential pollution risk in the future (Harikumar and Jisha, 2010).

3.3 Index of Geoaccumulation (I_{geo}):

The geoaccumulation index Igeo values were calculated for different metals as introduced by Muller (1969) is as follows:

Igeo = log2 (Cn/1.5*Bn)

Where Cn is the measured concentration of element n in the sediment sample and Bn is the geochemical background for the element n which is either directly measured in pre-civilization sediments of the area or taken from the literature (average shale value described by Turekian & Wedepohl, 1961). The factor 1.5 is introduced to include possible variation of the background values that are due to lithogenic variations. Muller (1969) proposed seven grades or classes of the geo accumulation index. Different geo accumulation index classes along with the associated sediment quality are given in table 3,

Table 3: I_{geo} Classes with respect to sediment quality

Igeo	Igeo class	Sediment Quality
0-0	0	Unpolluted
0-1	1	Unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	Moderately polluted to highly polluted
3-4	4	Highly polluted
4-5	5	Highly polluted to very highly polluted
5-6	>5	Very highly polluted

The Igeo class 0 indicates the absence of contamination while the Igeo class 6 represents the upper limit of the contamination. The highest class 6 (very strong contamination) reflects 100-fold enrichment of the metals relative to their background values (Harikumar and Jisha, 2010). The Igeo values of the various metals in the sediment of coastal Al-Hodiedah Governorate are presented in figure 6. The Igeo value of cadmium falls in Igeo class 2, which sediment quality is moderately polluted. The Igeo value of nickel falls in Igeo class 0, which sediment quality is unpolluted. The Igeo value of lead falls in Igeo class 1, which sediment quality is unpolluted to moderately polluted.

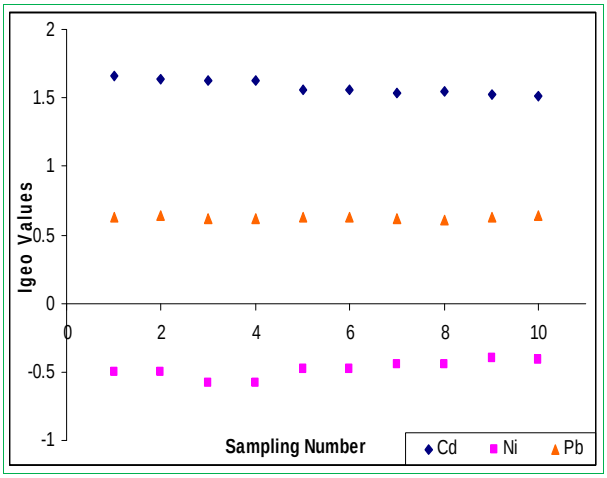

Figure 6: Igeo values of the various metals in the sediment of coastal Al-Hodiedah Governorate

3.4 Pollution Load Index:

The extent of pollution by trace metals has been assessed by employing the method based on Pollution Load Index (PLI) developed by Tomlinson, et. al. (1980) and the relation is shown below

PLI = n √Product of n number of CF values,

Where CF = contamination factor and n= number of metals

PLI provides a simple, comparative means for assessing a site or estuarine quality: a value of zero indicates perfection, a value of one indicates only baseline levels of pollutants present and values above one would indicate progressive deterioration of the site and estuarine quality (Tomlinson, et. al., 1980). The PLI value is ranges 9 to 11, so it indicates fast progressive deterioration of the estuarine quality of Al-Hodiedah Governorate (Figure 7).

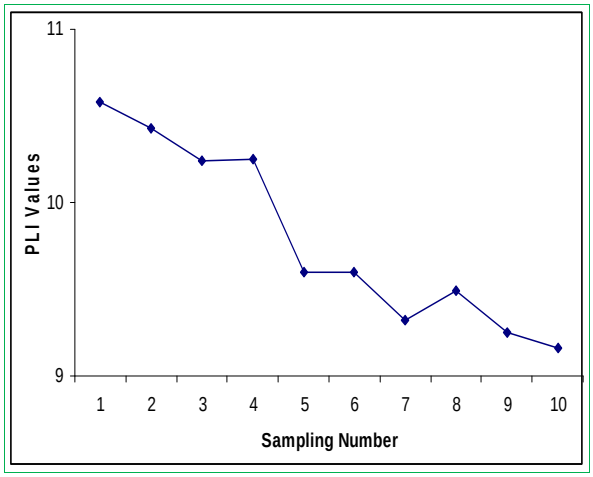

Figure 7: Pollution Load Index of the coastal Al-Hodiedah Governorate

4.0 Conclusion:

The concentration obtained data show significant regional variations concerning both the total and leachable metals. Total metal concentration of Co, Ni and Pb were greatest in sediments from Almehwat site Cd occurred in the highest levels in Al-Hodiedah port sediments, The lowest concentration of Cd in the Almehwat site while The lowest concentration of Co in the Al-Manjer site, while The lowest concentration of Pb in the of Ni in Al-kateef shore site and The lowest concentration the Cornish site. From the contamination factor calculations, it was found that a regular monitoring for the concentrations of Cd & Pb is essential since their contamination factor at all the sampling sites exceeded the desirable limit for CF values and can cause potential pollution risk in the future. The Igeo

value of cadmium falls in Igeo class 2, which sediment quality is moderately polluted. The Igeo value of nickel falls in Igeo class 0, which sediment quality is unpolluted. The Igeo value of lead falls in Igeo class 1, which sediment quality is unpolluted to moderately polluted. The PLI value is ranges 9 to 11, so it indicates fast progressive deterioration of the estuarine quality of Al-Hodiedah Governorate.

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