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Geochemical Assessment of Heavy Metals Concentration in Surface Sediment of West Port, Malaysia

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Abstract**—**One year (November 2009-October 2010) sediment monitoring was used to evaluate pollution status, concentration and distribution of heavy metals (As, Cu, Cd, Cr, Hg, Ni, Pb and Zn) in West Port of Malaysia. Sediment sample were collected from nine stations every four months. Geo-accumulation factor and Pollution Load Index (PLI) were estimated to better understand the pollution level in study area. The heavy metal concentration (Mg/g dry weight) were ranged from 20.2 to 162 for As, 7.4 to 27.6 for Cu, 0.244 to 3.53 for Cd, 11.5 to 61.5 for Cr, 0.11 to 0.409 for Hg, 7.2 to 22.2 for Ni, 22.3 to 80 for Pb and 23 to 98.3 for Zn. In general, concentration some metals (As,Cd, Hg and Pb) was higher than background values that are considered as serious concern for aquatic life and the human health.

Keywords**—**Heavy metals, Sediment Quality, geo-accumulation index, Pollution Load Index

I. INTRODUCTION

AQUATIC life is widely influenced by type of pollutants thus many researcher have focused on assessing contamination to understand source, concentration, distribution and effects in environment especially in the estuarine and coastal water [1] [2]. Heavy metals from lithogenic and anthropogenic sources extensively enter into marine environment; their concentration and distribution are affected by sedimentary structure, mineralogical compound, hydrodynamic transports, industrial discharges, effluents and shipping activities [1] [3] [4]. Adsorption, biological-uptake and accumulation are three mechanisms that cause an important variation of heavy metals concentration in sediment [1] [5].

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Information of concentration and distribution of heavy metals are useful to distinguish the source of contaminates in the marine environment [1] [6] [7]. Heavy metals Contamination is a great worldwide problem and it can directly and indirectly cause adverse effects on aquatic life and the human population because of their bioaccumulation and toxicity during long period [3] [4] [8]. Moreover, it is a serious threat for different marine ecosystems like coral reef, mangrove and sea-grass also increase the human health risk specially for the human population that depend on fishery sources [1]. Several chemical and physical parameters of marine sediment have been frequently applied as environmental indicator to monitor contamination sources and their effects because sediment have high ability to accumulate contaminates in long term to comparison with water [3] [8]. There are many methods to assess sediment quality such as background enrichment index, contamination indexes and risk assessment indexes. Only a few are practical for coastal and estuarine environment like enrichment factor and geo-accumulation index [9] [10]. Hence, the main objectives of present research are: (1) to estimate heavy metals concentration (Al, As, Cd, Cr, Cu, Co, Fe, Hg, Mn, Ni, Pb, Zn) and their relate geochemical index to evaluate the status of contamination level. (2) To prepare a distribution pattern of heavy metals to distinguish vulnerable stations. West Port is the main international ports in west of Malaysia coastal water. It is surrounded by mangrove forest where is known as ecological and biological hot spots in marine environment. The live of people who live around West Port to some extent depend on fishery, tourism and other related activities. Therefore shipping activities and industrial discharges may severely cause adverse effect on marine organisms and human life. There is limit information about heavy metals in West Port. This information just include some trace metals such as cupper, zinc, lead and cobalt thus geochemical assessment is essential in order to estimate heavy metals concentration and distribution, contamination degree and protect living organisms.

II. MATERIAL AND METHODS

A. Study area

West Port is the busiest port of the Malaysia with 22 berths. This port is well developed along mangrove forest and Klang strait. In this research study area is restricted as narrow strait between mangrove forest and coastline, nine stations were selected from three transects parallel to the coastline with three

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different distances in this project (see Fig I and Table I). The study area lies within humid tropical part with rainy season and dry season, its tide is semi-diurnal with variation between 2 meters 5.5 meters [11].

TABLE I
DESCRIBTION OF SAMPLING STATIONS

Stations	Code	Description
100 meter after cement berth	C100	Coastline
500 meter after cement berth	C500	Remote area
1000meter after cement berth	C1000	Mangrove area
100 meter after liquid berth(outlet)	L100	Coastline
500 meter after liquid berth	L500	Remote area
1000 meter after liquid berth	L1000	Mangrove area
100 meter after container berth	T100	coastline
500 meter after container berth	T500	Remote area
1000 meter after container berth	T100	Mangrove area

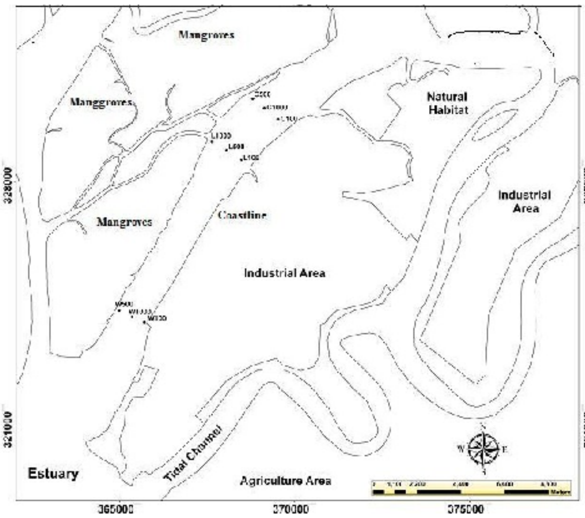

Fig.1 Location of the sampling stations in West Port Malaysia

B. Sampling and Experimental analysis

Surface sediment samples were collected two times in year From November 2009 until October 2010. Peterson Grab sampler was used to collect samples from surface sediment and 10 cm sediment samples were chosen for laboratory analysis. Plasma Mass Spectrometry (ICP/MS) was used for chemical analysis base on standard methods such as valine, Morse and Rauret [12]. Statistical analysis of ANOVA and Duncan were applied to better understand of metals variation and significant differences between stations. Geo-statistical analysis was done by surfer 8 software base on GPS values of stations .This method is practical tool to better understand contamination in each location because this provide the comprehensive distribution pattern along large area [1] [13].In this research two indexes are used, Geo-accumulation Index (Igeo) and Pollution Load Index (PLI). The Geo-accumulation Index (Igeo) introduced by Muller [14] to assess contamination level or degree. It is expressed as in equation and table I shows the geochemical index which includes various degrees of contamination [3] [10] [15].

$$Igeo = Log2\ (Cn\ /1.5Bn) \quad (1)$$

Cn is heavy metal concentration in sediment of study area, Bn is the geochemical background value in average shale of element [16]; 1.5 is the background matrix correction in factor due to lithogenic effects." Equation 3" show the Pollution Load Index (PLI) [17].PLI is obtained as Concentration Factors (CF) (Equation 2). CF is ratio between the concentration of heavy metals in study area and background level. This index is quickly understood by unskilled personal in order to compare the pollution status of different places and it varies from 0 (unpolluted) to 10 (highly polluted).

$$CF = C\ metal\ /C\ Background\ value \quad (2)$$

$$PLI = n\sqrt{CF1 \times CF2 \times} \quad (3)$$

n = number of metals

TABLE II
GEOACCUMULATION INDEX OF HEAVY METAL CONCENTRATION IN SEDIMENT

Geo-accumulation index Class Pollution Intensity	Class	Pollution Intensity
0	0	Background concentration
0-1	1	Unpolluted
1-2	2	Moderately to unpolluted
2-3	3	Moderately polluted
3-4	4	Moderately to highly polluted
4-5	5	Highly polluted
>5	6	Very highly polluted

III. RESULTS

Table III and fig 2 shows the average concentration of heavy metals and their spatial distribution in surface sediment. Distribution of heavy metals were generally homogenous for Zn, Cr, As, pb and Cu and this showed the similar pattern, that was a low to high from north to south direction. The higher concentration of Zn and Cr had high trend in a both a south-easterly and east of strait (along costal line) but Cu and Pb had high trend in a south- westerly direction. The lowest concentration of metals (except Hg and Ni) was found at station L500 and there is significant difference (α level=0.05) between this station and others stations. The content of Cd, Hg and Ni decreased from mangrove line to coastlines and concentration of Hg and Ni peaked at two stations L1000 and L500. Table III shows sediment quality according geochemical indexes.

TABLE III
GEO-ACCUMULATION AND POLLUTION LOAD INDEX FOR HEAVY METALS CONCENTRATION IN WEST PORT

Indexes	Zn	Pb	Cu	Cd	Ni	As	Hg	Cr
Metals concentration	44	51.74	19.9	1.72	17	59.6	0.22	44.5
Igeo	0	1.64	0	2.5	0	4.45	1.11	0
CF	.63	4.1	0.91	8.6	0.22	33.1	2.9	0.44
PLI	2.05							

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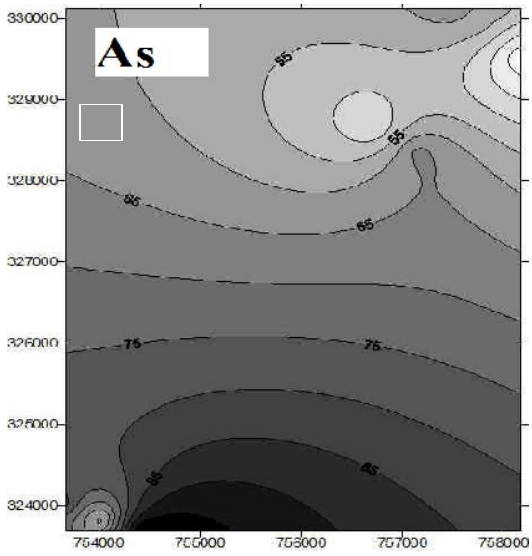

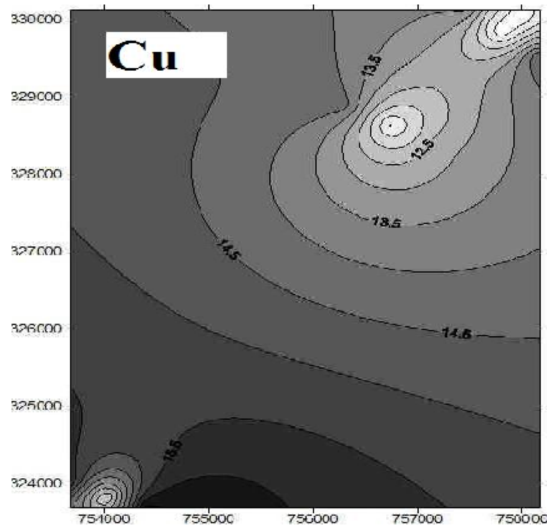

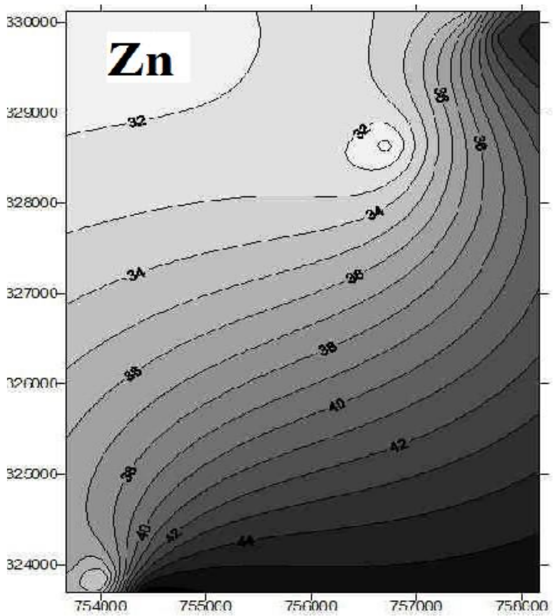

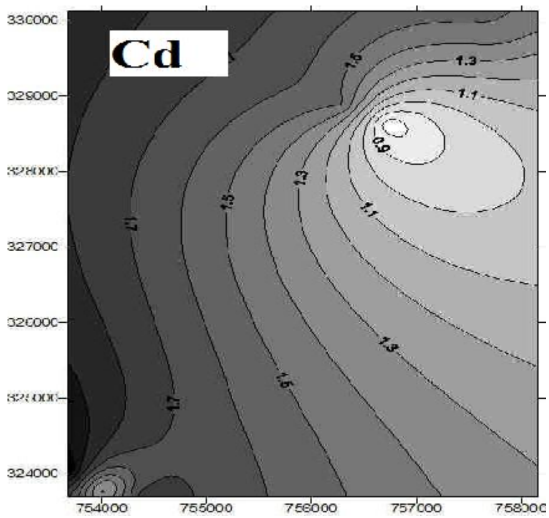

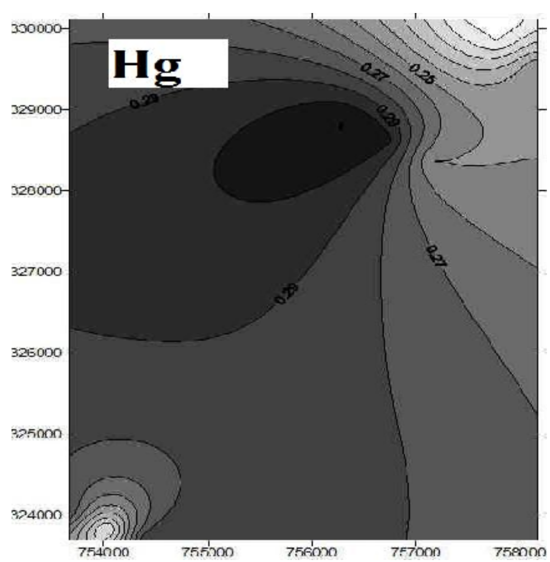

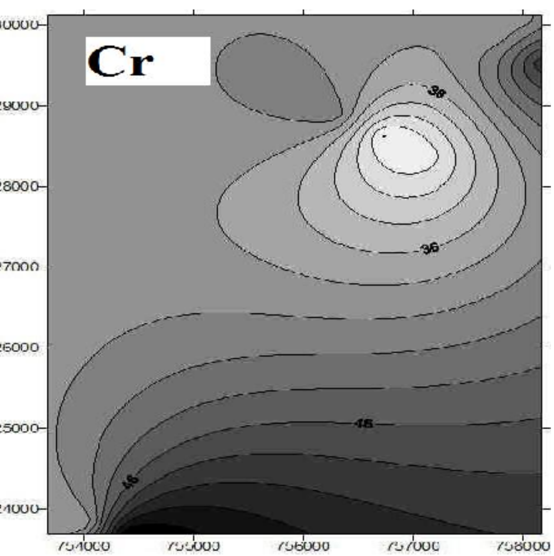

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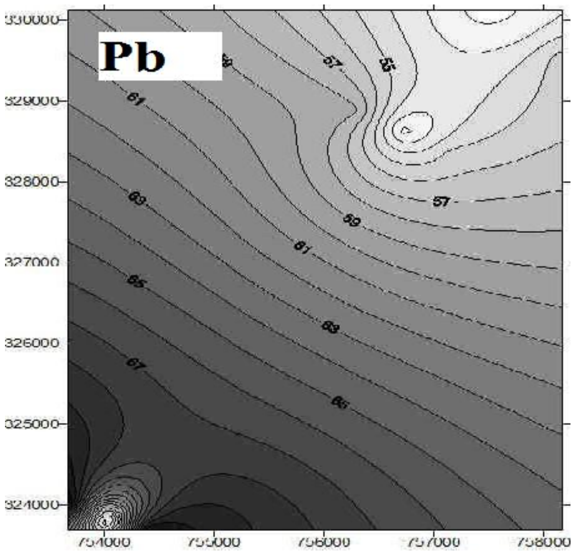

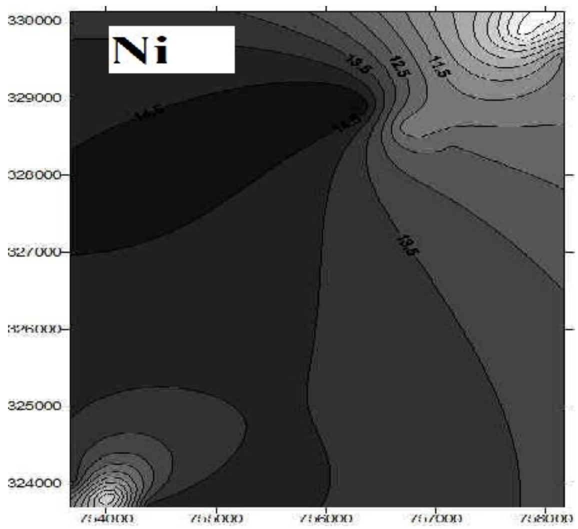

Fig. 2 shows the average concentration of heavy metals and their spatial distribution in surface sediment

IV. Discussion

The most of the metals (Zn, Cr, As, pb, Cu) show same pattern and high concentrations of heavy metals were found in stations are located in south of strait. This result may be due to decrease water current in these parts that causes reduce chemical interactions between metals and sediment such as: suspended solid absorption, surface sediment sorption and rate of re-deposition and the other may results from the mixture of land runoff and marine water in south of west port, which cause increase metals concentration. Moreover, sediment particles size is a significant parameter in effecting the heavy metal concentration because fine particles have high ability to adsorb soluble heavy metals from aquatic area and deposit them to the bottom sediment [1] [18] [19]. This distribution pattern may relate to particle size because these stations which are reported more fine particles composition (silt and clay). Several research reported that silt and clay in sediment play significant role in deposition and entrapment of pollutants during adsorption process [1]. Zn and Cr also showed the high trends in stations are located in east side of strait (along coastal area); these stations were probably affected by industrial waste which is loaded from the industrial outlets that were located along coastline. The content of Cd, Hg and Ni decreased from mangrove line to coastlines. The concentration of Hg and Ni peaked at two stations L1000 and L500 because these stations are influenced both the mangrove sedimentation and industrial waste which is loading from coastline. Many research present that sediment of mangrove forests act as trap for chemical contaminates because their sediment contain high percentage of silt and clay that increase metals adsorption in these stations [3, 20] [21] [22].The result of geo-accumulation index (table3) indicated the Zn, Cu, Cr and Ni elements are unpolluted; Pb and Hg elements are moderately to unpolluted, Cd is moderately polluted and As element is highly polluted. Generally, the Pollution load Index revel that sediment of west port in moderate pollution level. Several research indicated that sources of contamination of Pb, Cr, Hg, Cd and As are widely due to anthropogenic sources from land [23] [24] [25] [26]. Thus the high concentration of these metals (Pb, Cr, Hg, Cd and As) may be due to the industrial discharges (cement, oil and food factories near the berth line), shipping activities and effluents. High concentration of As, Hg and Pb is serious threat because their accumulation and toxicity effects for marine organisms and human population. The information of this research can be used as basic data for future assessment of heavy metals in west port of Malaysia.

V. Conclusion

In general terms, the West Port coastal water current pollution level regarding these elements Zn, Cu, Ni and Cr in sediment may not be considered as alarming; but high level pollution of As, Hg, Cd and Pb is serious threat in future because their accumulation and toxicity effects for marine organisms and the human population. This is especially true for As because its concentration, seem to be enough critical to causes a toxin condition for organisms which is live in sediment. Spatial distribution of heavy metals helps to identify the vulnerable stations that are practical and useful information to manage and protect West Port coastal water and can be used as basic data for future assessment of heavy metals in West Port.

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