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Assessment of Sediment Quality in the West Port based on the Index Analysis Approach

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Abstract—The coastal sediments of West Port of Malaysia was monitored from Nov. 2009 to Oct. 2010 to assess spatial distribution of heavy metals As, Cu, Cd, Cr, Hg, Ni, Zn and Pb. Sediment samples were collected from 10 stations in dry and rainy season in West Port. The range concentrations measured (Mg/g dry weight) were from 23.4 to 98.3 for Zn, 22.3 to 80 for Pb, 7.4 to 27.6 Cu, 0.244 to 3.53 for Cd, 7.2 to 22.2 for Ni, 20.2 to 162 for As, 0.11 to 0.409 for Hg and 11.5 to 61.5 for Cr.

The geochemical indexes used in this study were Geo-accumulation (Igeo), Contamination Factor (CF) and Pollution Load Index (PLI); these indexes were used to evaluate the levels of sediment contaminations. The results of these indexes show that, the status of West Port sediment quality are moderately polluted by heavy metals except in arsenic which shows the high level of pollution.

***Keywords*—**Heavy metals, Sediment Quality, West Port.

I. Introduction

MARINE sediments are sensitive indicators for monitoring contaminants in aquatic ecosystems [1]. The bottom sediments are a reservoir for heavy metals and therefore deserve special Consideration in the planning and design of aquatic pollution research studies [12]. According to Caeiro et al [2] the concentration of metal contaminants' can be classified into three types which are

(i) contamination indices-which compare the contaminants with the clean or polluted stations measured elsewhere;

(ii) background enrichments indices- which compare the results for the contaminants with the baseline or background levels and

(iii) ecological risk indices- which compare the results for the contaminants with Sediment Quality Guidelines (SQG). These indexes are providing comprehensive assessment of environmental quality, planning and management for local and regional researchers [3].

West Port is strategically located midway on the West Coast of Peninsular Malaysia overlooking the world's busiest waterway, the Straits of Malacca. It is in the Free Commercial Zone of Port Klang, in the state of Selangor. It is further complemented by Malaysia's premier business township, the Klang Valley and is only 60 kilometers away from the federal capital, Kuala Lumpur.

The main objectives of this research are; (1) to provide comprehensive data of heavy metals concentration and compare these data with geochemical background value to assess impacts of the industrial and economic activities in West Port of Malaysia in recent decade. (2) To use different types of indices to evaluate the status of heavy metals contamination.

With regard to the importance of the West Port as an international shipping route, and ecological habitat, it is necessary to evaluate environmental properties in order to control pollution occurrence and protect living organisms.

II. Material and Methods

A. Description of Study Area

West Port is one of the Malaysia's principal gateway and busiest port with 22 berths. West port has been developed along the Klang strait and it is well sheltered by surrounding mangrove Islands. In this project, study area is restricted to narrow corridor between Klang Island and Che Mat Zin Island on the west of the Indah Island, 10 points are defined in this project "Fig. 1". The study area lies within humid tropical part with rainy season (North monsoon, November to March) and dry season [4]

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

B. Sampling and Experimental Methods

From November 2009 to October 2010, samples were collected two times in year, from three transects parallel to the berths line with three different distances. Sediments were collected in triplicate from surface of sediments by Petersen

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Grab sampler. Surface sediments were chosen for this study as this layer controls the exchange of metals between sediment and water [5].

Dried samples were sieved through a 2mm sieve, after that About 2g of the sediment to be used for metal analysis was treated with 2ml of48% hydrofluoric acid (HF) and 2ml of 65% nitric acid3 (HNO), heated to dryness, and allowed to cool. 0.5g of 99.99%on boric acid was added to the cooled solution and the resulting suspensions was centrifuged. The decanted solution from the centrifugal operation was filtered using Whatman No. 40 filter-paper and the volume made up to 50 ml with demonized water for measurement of total concentration of heavy metals. Plasma mass spectrometry (ICP/MS) was used to analyze the following suite of metals: preparation procedure described above for the metal analyses is the same as the one adopted in [6].

The indexes used in this research were Enrichment Factor (EF) and Geo-accumulation Index (Igeo). The Geo-accumulation Index (Igeo) introduced by Muller are also used to assess metal pollution in sediments. It is expressed as in Eq. 1, 2 and 3 [7] .

Test of Duncan's multiple range and variance (ANOVA) were used to do statistical analyses among various parameters. The indexes used in this research were Concentration Factor (EF), Geo-accumulation Index (Igeo) and Pollution Load Index (PLI). The Geo-accumulation Index (Igeo) introduced by Muller [6] are also used to assess metal pollution in sediments. it is expressed as in Eq. 1, and "Table I" shows the geochemical index which includes various degrees of enrichment [7].

$$Igeo = Log2\ (Cn/1.5Bn) \tag{1}$$

Cn is of concentration of heavy metal in the West Port sediment. Bn is the geochemical background value in average shale of element [8]; n 1.5 is the background matrix correction in factor due to lithogenic effects. The Pollution Load Index (PLI) Eq. 3, introduced by Tomlinson et al [9].

Load Index (PLI) is obtained as Concentration Factors (CF) Eq. 2. This CF is the quotient obtained by dividing the concentration of each metal. This index is quickly understood by unskilled personal in order to compare the pollution status of different places. Varies from 0 (unpolluted) to 10 (highly polluted).

$$CF = C\ metal\ /C\ Background\ value \tag{2}$$

$$PLI = n\sqrt{CF1 \times CF2 \times \ldots\ldots \times CFn} \tag{3}$$

n = number of metals

TABLE I
GEO-ACCUMULATION INDEX) OF HEAVY METAL CONCENTRATION IN SEDIMENT [6]

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

Statistical analyses were performed using Microsoft Excel and SPSS 17 software. To statistically evaluate the data, the two-way ANOVA test (level of significant is 0.05) were employed to understand the relationship between heavy metals in sediment and other parameters.

III. Results and Discussion

Fig. 2 shows the average concentration of heavy metals in the dry and rainy season during a year. Most of the metals except copper and chromium have higher concentration in dry season compared to rainy season but there are not significant differences (α level=0.05) between the concentrations of metals in these two seasons.

The significant temporal variation of heavy metal concentration is probably due to seasonal fluctuations. This significant difference in metal concentration is unusual during this short period of sampling. However, several studies indicated that chemical properties of metal, water, and sediment, which are associated with other environmental factors such as atmospheric deposition, high dynamics of marine water, tidal and seasonal currents, and change of pollution load of anthropogenic source, can cause this temporal variation in mobility, bioavailability and enrichment of heavy metals during a short time.

For example, several studies recorded that in the rainy season (during monsoon), concentration of heavy metals in sediment is lower than in the dry season; this could be related to high disturbance of the sediment created by huge waves during monsoon. Rain water causes increased mobility and dilution, which decrease heavy metal concentrations in sediment [10]. Moreover, during the rainy season most of pollutants load of anthropogenic activities including shipping and fishing decrease or stop in some locations.

Subsequently, after this reduction of anthropogenic activities, the level of metals input by the vessels might be decreased leading to occurrence of low metals concentration in sediment. In dry season, by the increase of anthropogenic activities, metals input starts to increase. The sediment is more stable, leading metals level to rise up again [10, 11].

"Fig. 3" is comparison between stations in study area and control point station far from study area (14km far from study area). The average metals concentration in the analysis indicates the concentrations of metals have significant differences between control point station with other stations.

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In fact, in control point station metals concentration are generally low and all metals are lower than global average shale value of Turekian and Wedepohl and Julia [8].

This shows that heavy metals are originated from many sources such as runoff due to rainfall and anthropogenic activities in the study area. These sources cause disturbance in environment and change geochemical concentrations ratio of metals and increase metals concentration from their standard range.

Weng et al., studied about stability and relative concentration of metals in sediment. Generally they have stated that, when geochemical metals concentration are suffered from disturbance due to potential change in environmental, the relative concentration ratio of metals goes beyond their standard variation levels in sediment [10], [11].

Metals released into Port Klang by some anthropogenic sources can be adsorbed on sediment particles. Moreover, As, Cd, and Hg are easily absorbed by plants and then nutrient cycling [8].

As, Cd, Pb and Hg originate mostly from industrial activities such as burning of fossil fuels, mining, cement manufacturing, paper and glass production and waste recycling. Several industries such as palm oil, cement manufacturing, and oil/electrical-based power generation release waste into West Port.

Moreover, these metals might be released by atmospheric deposition, terrestrial runoffs, and tsunami sediment deposition, which are the main routes of metal into marine environment. Boat docking and corrosion of ships, organic insecticides (lead-arsenate), pesticides, and fertilizers applied in agriculture activities are other sources of pollution in the West Port coastal waters.

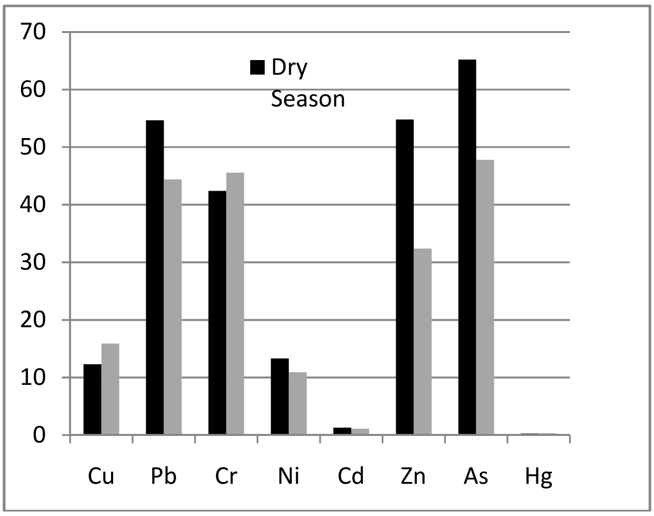

Fig. 2 Concentration of metals (Mg/kg) during dry and rainy season in West Port

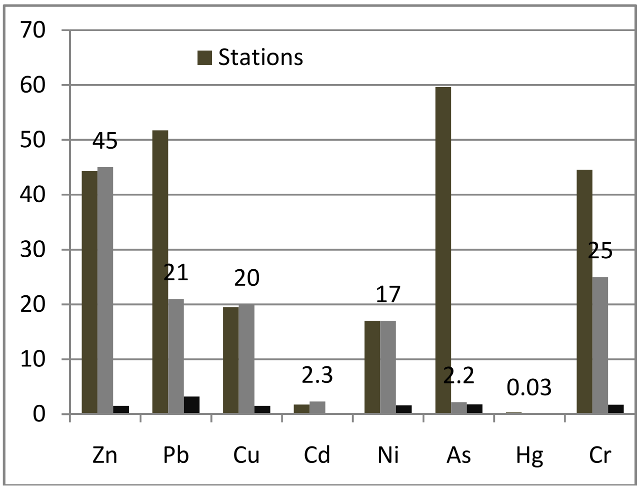

Fig. 3 Comparison of the average concentrations of metals (mg/kg) in all stations with metals concentration in control point station and geochemical background value west port

According to the Geo-accumulation Index, Zn, Cu, Cd and Ni elements are unpolluted, Pb, Cr and Hg elements are moderately polluted and As element is Moderately to highly polluted. Generally, the Pollution load Index shows the moderate pollution level in this study area.

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

Indexes	Zn	Pb	Cu	Cd	Ni	As	Hg	Cr
Metals concentration	44.3	51.7	19.9	1.72	17	59.6	0.23	44.5
Igeo	0	1.64	0	0	0	4.1	2.7	1.18
PLI	2.34							

The results of this study can be used as basic data to indicate that West Port not only has received lithogenic metals load which may be due to soil erosion around mangrove forest but also has received the anthropogenic metals load due to industrializing (cement , oil and food factories near the berth line) and shipping activity, According to geochemical indexes, the heavy metals pollution in the surface sediment of West Port is moderate but the concentration of Arsenic is so high which may be considered as a serious threat for aquatic organism and human being health.

IV. Conclusion

The extent of pollution was clarified by the geo-statistical index to assess the degree of contamination of surface sediments at the temporal scale. This data revealed that the geo-statistical index of sediments is in a pristine state with respect to metal contamination, except for As. Furthermore the concentration of As was significantly greater the background value. Therefore this metal can be considered as serious threat to biological communities and human health. In summary, the present study has provides basic data for the first time in West

Port which is useful for long-term monitoring of heavy metal pollution in future.

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