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Assessment of Sediment Quality According To Heavy Metal Status in the West Port of Malaysia

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Abstract**—**eight heavy metals (Cu, Cr, Zn, Hg, Pb, Cd, Ni and As) were analyzed in sediment samples in the dry and wet seasons from November 2009 to October 2010 in West Port of Peninsular Malaysia. The heavy metal concentrations (mg/kg dry weight) were ranged 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. Metals concentrations in dry season were higher than the rainy season except in cupper and chromium. Analysis of variance with Statistical Analysis System (SAS) shows that the mean concentration of metals in the two seasons (α level=0.05) are not significantly different which shows that the metals were held firmly in the matrix of sediment. Also there are significant differences between control point station with other stations. According to the Interim Sediment Quality guidelines (ISQG), the metal concentrations are moderately polluted, except in arsenic which shows the highest level of pollution.

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

I. INTRODUCTION

HEAVY metals Pollution in the natural environment is a worldwide problem because they are not removed from water as a result of self purification but they can accumulate in reservoirs by biological and geochemical mechanisms and enter the biological chain [1]. There are two main sources for lauding heavy metals into the environment; lithogenic and anthropogenic. Lithogenic is the natural process, such as weathering of rocks and volcanic activities that plays a noticeable role in enriching the water of reservoirs with heavy metals [2].

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Anthropogenic sources are due to the human activities such as industry, agriculture, mining and construction of urban development that can transport pollutants to marine waters by rivers and outlets. During recent decades, urban and industrial activities are increasing heavy metals into marine environment and when they exceed standard concentration, they have toxin effects on living organisms; also they decrease survival, growth and species diversity [3]–[4].

In recent decade, many environmental and geochemical researchers have used Sediment Quality Guidelines (SQGs) as useful tool to assess the sediment chemistry with toxicity testing and biological effects. These guidelines are providing comprehensive assessment of environmental quality, planning and management for local and regional researchers [5]. Generally, objectives of using these guidelines are to evaluate degree of potential for sediment contaminants that might have adverse effects on aquatic organisms that meets the comparisons stable criteria range with international creativity and regulation.

This paper reports the current state of heavy metals concentration in sediments by using four empirical groups of SQGs. The main objectives of this research are:

to provide preliminary data of heavy metal contaminations to assess impacts of the industrial and economic activities in West Port of Malaysia in recent decade.

To compare metals concentration with international standard of sediment quality guidelines (SQGs) to determine the degree of metal contamination or pollution in this area.

With regard to the importance of West Port as an international shipping route, an industrial center and ecological habitat on the west coast of Peninsular Malaysia, it is necessary to do geochemical research in order to evaluate environmental properties, 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 and mudflats which form a natural enclosure such as Klang. 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.

The study area lies within humid tropical part with Rainy season (North monsoon, November to March) and dry season (South monsoon, April to October). Heavy rainfall is normally experienced during the early part of the monsoon, when dry spells occur during the later part. Beginning of the southwest monsoon in May however do not has heavy rain [6].

The Average of salinity has been recorded 30.25‰ (± 1.36), whereas average temperature was 30.04 º C (±0.62). The average surface dissolved oxygen (DO) was reported 5.38 mg /l (±0.17), and monthly average surface and bottom PH values are between7.85 to 8.25, with lower range obtained from October to January because of the higher river charging [6].

According to researches by the British Admiralty, Royal Malaysian Navy, there is semi-diurnal tide in this area and the tidal ranges at Port Klang vary between 2 meters during neaps and 5.5 meters during springs [6].

Ten sampling stations were selected from three transects parallel to the berths line with three different distances (See Fig. 1 and Table I).

TABLE I
DESCRIBTION OF SAMPLING STATIONS

Stations	Code and number	Depth (m)	Description
100 meter after cement berth	1-C100	12.5	Industrial area
500 meter after cement berth	2-C500	18.5	Remote area
1000meter after cement berth	3-C1000	7.8	Mangrove area
100 meter after liquid berth(outlet)	4-L100	12.3	Industrial area
500 meter after liquid berth	5-L500	18.3	Remote area
1000 meter after liquid berth	6-L1000	8.8	Mangrove area
100 meter after container berth	7-T100	15.5	Container berths
500 meter after container berth	8-T500	20.1	Remote area
1000 meter after container berth	9-T100	6.8	Mangrove area
Control point	10-CP2	16.5	Remote area

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 and Sediments were collected in triplicate from surface of sediments by Petersen Grab sampler [7]. Surface sediments were chosen for this study as this layer controls the exchange of metals between sediment and water [8].

The samples were stored at -20 c until analysis of metals. Heavy metals of sediments were dried in oven at 70 c for two days. 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 [9].

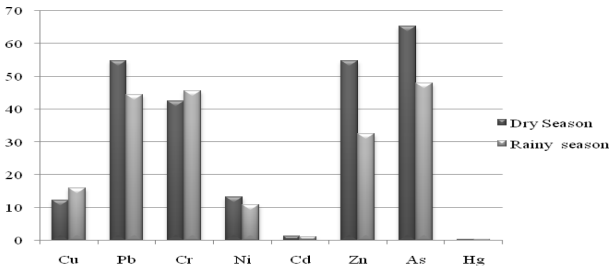
Test of Duncan's multiple range and variance (ANOVA) were used to do statistical analyses between various parameters.

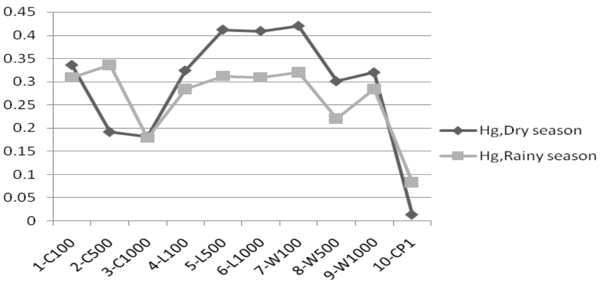
III. Results

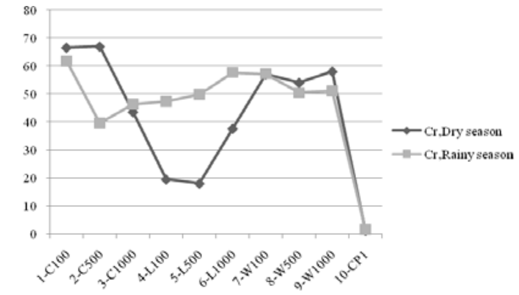
The average concentrations of heavy metals in the dry and rainy season in different stations (see Fig. 2). Most of the metals except copper and chromium have higher concentration in dry season compared to rainy season but there are not significant differences between the concentrations of metals in these two seasons.

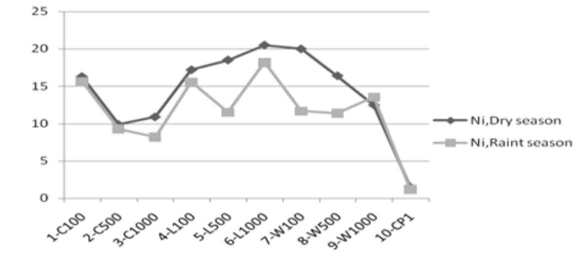
Analysis indicates the concentrations of metals have significant differences (α level=0.05) between control point station with other stations. In fact, in control point station metals concentration are generally low and all metals are lower than global average shale value of Turekian and Wedepohl [10].

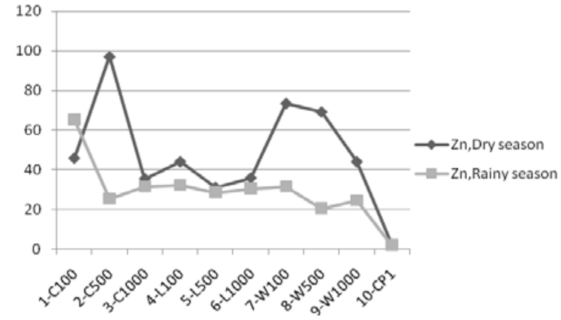
The concentrations of metals were compared with sediment quality guidelines to assess environment condition and impact of industrial and economic activities in this area. Table 3 shows several guidelines which were used in this research such as: sediment criteria proposed by EPA [7]–[15], CBSOG Consensus –Based Sediment Quality Guidelines [11], New York Sediment Criteria for metals [12] and Provincial Sediment Quality Guidelines for metals [13]–[14]–[18].

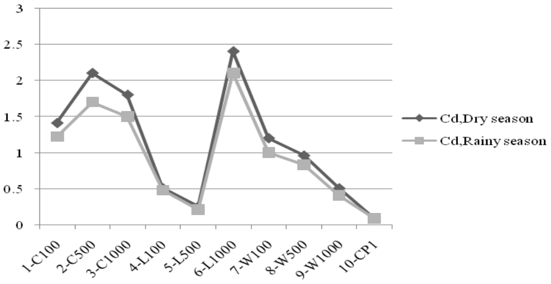


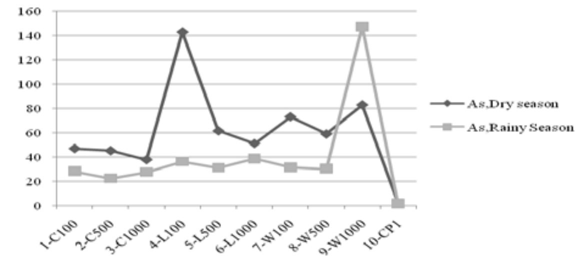


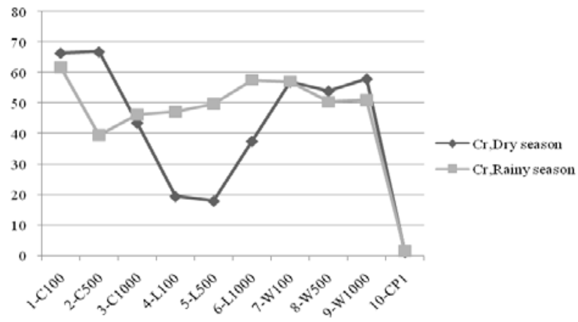












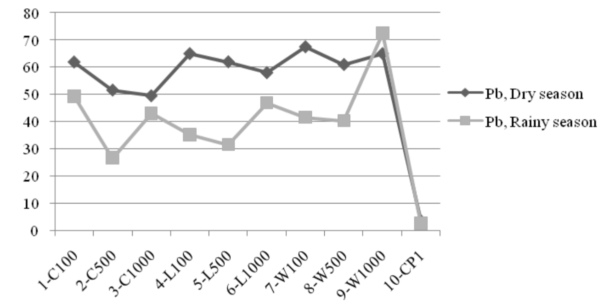


Fig. 2 Line Charts of Heavy Metals analysis in the different stations (Dry and Rainy season)

TABLE II
COMPARISON OF AVERAGE CONCENTRATION OF HEAVY METALS OBTAINED IN THIS RESEARCH WITH SEDIMENT QUALITY GUIDELINES

Elements / Sediment Quality standard	Zn	Pb	Cu	Cd	Ni	As	Hg	Cr
Present study	44.3 23-98.3	51.74 22.3-80	19.7 7.4-27.6	1.72 0.244-3.53	16.92 7.2-22.2	59.62 20.2-162	0.299 0.110-0.409	44.55 11.5-61.5
EPA sediment quality proposed								
Non-Polluted	<90	< 40	< 25	-------	<20	-------	-----	< 25
Slightly polluted	90-200	40-60	25-50		20-50			25-75
Severely polluted	>200	> 60	>50	> 6	>50	-------	------	>76
CBSOG SQG*(2003)								
Non-Polluted	< 90	< 40	< 25	< 0.99	< 23	< 9.8	< 0.18	< 43
Moderately Polluted	90-200	40-70	25-75	0.99-3	23-36	9.8-21.4	0.18- 0.64	43-76
Heavily Polluted	> 200	>70	>75	> 3	> 36	> 21.4	> 0.64	>76
New York sediment Criteria								
Lowest effects range	120	32	16	0.6	16	6	0.15	26
Sever effects range	270	110	110	9	50	33	1.3	110
Sediment quality criteria guideline(1992)**								
Lowest effects range(ISQG-low)	120	31	16	0.6	16	6	0.2	26
high effects range(ISQG-high)	220	250	110	10	75	33	2	110

* Consensus –Based Sediment Quality Guidelines (CBSOG) SQG (2003)
** Interim Sediment quality criteria guideline (ISQG) (1992)

IV. DISCUSSION

The average concentration of Zn, Pb, Hg, As, Cd and Ni are higher in dry season than in the rainy season probably due to heavy rainfall that causes dilution in aquatic area which effects the mobility and influence of heavy metals in sediment; but several researchers have reported that the metal qualities, soil or sediment qualities, and environment factors are as important as total concentration metals on heavy metals mobility [3]. The average concentration of Cr and Cu in sediment in the rainy season is higher than dry season which is probably due to run off and industrial outlets.

According to analysis of variance by statistical Analysis System (SAS) and Duncan's multiple tests, there are not significant differences (α level=0.05) concentration of metals in sediment in two seasons. This indicates that the metals have strong bound with the crystal structure of minerals that are in sediment; thus dilution due to rain cannot largely affect metals concentrations in sediment. From table 2 above, the average concentration of heavy metals is lower in control station than other stations in the study area because the control station was selected far from source of pollution (14km far from costal water area). 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 Weng et al., [16]–[17] 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.

Assessing environmental and geochemical condition of metals in sediment by comparison with SQGs from the several SQGs (Table II) show that Pb, Cd, Hg and Cr elements are moderately polluted, Zn, Ni and Cu elements are unpolluted and As element is heavily polluted in this study area. The New York Sediment Criteria and Provincial Sediment Quality Guidelines for metals are divided into effect range low (ISQG-L) and effect range high (ISQG-H).ISQG-L level indicates the sediment contaminants do not have adverse effects on aquatic organisms in sediment. ISQG-H level indicates that the sediment contaminant certainly have adverse effects on organisms that live in sediment. Also the level of sediment contaminant that is between ISOG-L and ISQG-H shows that the contaminants probably have adverse effects.

According to these guidelines above, Zn is below ISQG-L level and Cu, Pb, Cd, Ni, Hg and Cr are lower than ISQG-H and higher than ISQG-L level which indicates these elements probably have adverse effects on organisms that live in sediment.

Parizanganeh et al., [19] have stated that "even though the surface sediment was still generally well below the ISQG-H concentration where substantial adverse effects on benthic biota could be expected".

Arsenic value is higher than ISQG-H level, which indicates that a high percentage of the concentration is likely to have adverse effects on sediment organisms.

Comparison of heavy metals concentration in West port with other studies in Malaysia is discussed below. In Sungai Juru, it demonstrated low levels of metal contamination (33 µg/g for Pb, 35 µg/g for Zn, 11.7 µg/g for Cu and 0.58 µg/g for Cd). In Sungai Malacca, most of metals concentration are above ISQG-L but below ISQG-H level, except of the cupper (158 µg/g for Pb,125 µg/g for Zn,262 µg/g for Cu and 1.21 µg/g for Cd), in Sungai Sepang Cu and Cd are above ISQG-H, Zn is above ISQG-L and Pb is lower ISQG-L (7.4µg/g for Pb,167µg/g for Zn,11.0.9 µg/g for Cu and 0.90µg/g for Cd [20]. These above mentioned results indicate moderate contamination in these areas. In comparison with Port Jackson estuary (Sydney, Australia), it shows much higher range of metals contamination (800 for Cu, 900µg/g for Pb and 1,000µg/g for Zn) in several strongly contaminated inshore areas.

The results of these researches emphasize the importance of proactive measurements to manage and control pollution in costal water [19]–[21]. 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 SQGs, the heavy metals pollution in the surface sediment of West port is moderate but the concentration of Arsenic is higher ISQG-H which may be considered as a serious threat for aquatic organism and human being health.

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