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Heavy Metal Concentration in the Surface Sediment of Tanjung Lumpur Mangrove Forest, Kuantan, Malaysia

(Kepekatan Logam Berat di Sedimen Dasar Hutan Paya Bakau Tanjung Lumpur, Kuantan, Malaysia)

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ABSTRACT

Surface sediment samples from 2 transects (20 sampling points) of Tanjung Lumpur mangrove forest were analyzed for the concentrations of Pb, Cu, Co and Mn. In this study, the average concentrations of Pb, Cu, Co and Mn were 44.41 μg/g dry weight, 32.79 μg/g dry weight, 5.79 μg/g dry weight and 117.73 μg/g dry weight, respectively. The calculated enrichment factors (EF) obtained for Co and Mn can be considered to have the terigeneous in sources while Pb and Cu are considered to have anthropogenic input.

Keywords: Co; Cu; enrichment factors; Mn; Pb; Tanjung Lumpur

ABSTRAK

Sampel sedimen permukaan daripada 2 transek (20 sampel) dari hutan paya bakau Tanjung Lumpur diukur kepekatan Pb, Cu, Zn dan Co. Dalam kajian ini, purata kepekatan Pb, Cu, Co and Mn adalah masing-masing 44.41 μg/g berat kering, 32.79 μg/g berat kering, 5.79 μg/g berat kering dan 117.73 μg/g berat kering. Nilai faktor pengayaan (EF) yang diperolehi bagi Co dan Mn boleh dianggap terhasil daripada sumber terigenus semula jadi manakala logam Pb dan Cu didapati mempunyai sumber input antropogenik.

Kata kunci: Co; Cu; faktor pengayaan; Mn; Pb; Tanjung Lumpur

INTRODUCTION

Mangroves are an integral part of the tropical vegetation and it is a common feature along sheltered coastline where there are constant freshwater discharges. Malaysia which is located in the tropical belt is blessed with plentiful of this forest. In Peninsular Malaysia, the bulk of mangrove forests is found in the west coast of Peninsular Malaysia of Perak and Johor (State Forestry Department of Pahang 2006). Mangrove forests are among naturally fertile and productive area as it serves as nesting and feeding ground for biodiversity of life.

Besides acting as a pollutant trap, mangrove sediments have the capability to trap and retain the heavy metals from indirectly enters to the other ecosystems (Tam & Wong 1995). Some scientists (MacFarlane 2002; Preda & Cox 2002; Tam & Wong 2000) affirm that many mangrove forests all over the world located near to urban area. Hence, this ecosystem faces long lasting effects from industrial waste. Metal enrichment contributed from urban waste and runoff, industrial effluents, boating activities, domestic garbage dumps, agricultural runoff, mining activities and sewage treatment plant. The most concern metals are copper, lead and zinc because they accumulated in aquatic organism consumed by humans (Luoma 1990; MacFarlane & Burchett 2000). Heavy metals are regarded as severe pollutants due to their toxicity, persistent and bioaccumulation problem (Tam & Wong 2000). They are not chemically or biologically degraded; thus the pollutant stay for longer period in the environment.

The main objective of this work is to study the concentration of heavy metals as well as their distribution pattern in sediment of Tanjung Lumpur mangrove areas. In Malaysia, studies concerning the geochemistry of the mangrove forest have received little attention and only limited studies have been done regarding their role in the process of sedimentation (Kamaruzzaman et al. 2001).

MATERIALS AND METHODS

SAMPLING SITES

Tanjung Lumpur mangrove forest is located in the Kuantan town, the capital state of Pahang (Figure 1). The study area was mostly influenced by semidiurnal tides and lies in the wet tropics where high rainfall is recorded in the monsoon season in the month of November up to January. In this study, two transect lines (TL 1 and TL 2) were set up with 20 sampling points fixed along each transect. The transect lines with no physical signs of active bioturbation were selected, thus avoiding the complication of biological disturbance. TL 1 was set up near the Kuantan river mouth while TL 2 was set up near the upstream. Surface sediments for trace metals and physical characteristics were collected at all sampling points by gently scraping the sediment surface.

ANALYTICAL METHOD FOR METALS

The sediment samples were digested according to the methods (Kamaruzzaman 1999; Noriki et al. 1980; Sen Gupta & Bertrand 1995) with some modifications. An inductively-coupled plasma mass spectrometer (ICP-MS) was used for the quick and precise determinations of Mn, Cu, Zn, Pb and Th in the digested marine sediment. Briefly, the digestion method involved the heating of 50 mg of a less than 63 μm size sample in a sealed teflon vessel with mixed concentrated acids of HF, HNO_3 and HCl in the ratio of 2.5:3.5:3.5. The teflon vessels were kept at 150°C for 3 to 5 h. After cooling, a mixed solution of boric acid and EDTA was added, and the vessel was again heated at 150°C for at least 5 h. After cooling to room temperature, the content of the vessel was thoroughly transferred into a 10 mL polypropylene test tube and was diluted to 10 mL with deionized water. A clear solution with no residue was obtained at this stage. The precision assessed by replicate analyses was within 3%. The accuracy was also examined by analyzing, in duplicate a Canadian Certified Reference Materials Project standard (DL-1a) and the results coincided with the certified values with a difference of ± 3%.

RESULTS AND DISCUSSION

Horizontal distribution of Pb, Cu, Co and Mn for TL 1 and TL 2 are given in the bar graph (Figure 2). The concentrations of Pb for both transects generally increase with the distance from the riverside. However, statistically, the concentration of metals at both transects does not vary significantly ($p<0.05$). It only shows some relatively higher concentration values of metals at transect 1.

Pb concentration ranged from 0.85 μg/g dry weight to 85.12 μg/g dry weight and averaged 44.41 μg/dry weight. Cu concentrations ranged from 14.63 μg/g dry weight to 53.29 μg/g dry weight and averaged 32.79 μg/g dry weight. However, the mean value was lower when compared with their average shales. Meanwhile, concentrations of Co were observed to be almost constant and ranged from 0.56 μg/g dry weight to 23.61 μg/dry weight. Their average concentration of 5.79 μg/g dry weight is close to the values of the average shales and the mean crustal material. Mn has a similar trend with Co where their metal concentration was almost constant. The average concentration of Mn was 117.73 μg/g dry weight, and ranged from 45.41 μg/g dry weight to 200.24 μg/g dry weights. Marchand et al. (2006) support that river flowing through urban areas may bring the pollutants to the downstream estuarine sediments, where they are incorporated in mud bank cycle. This process may result in the downstream (TL 1) having higher concentration of heavy metals compared to transect at upstream (TL 1). The relatively high values at some stations probably are the result of a combination of

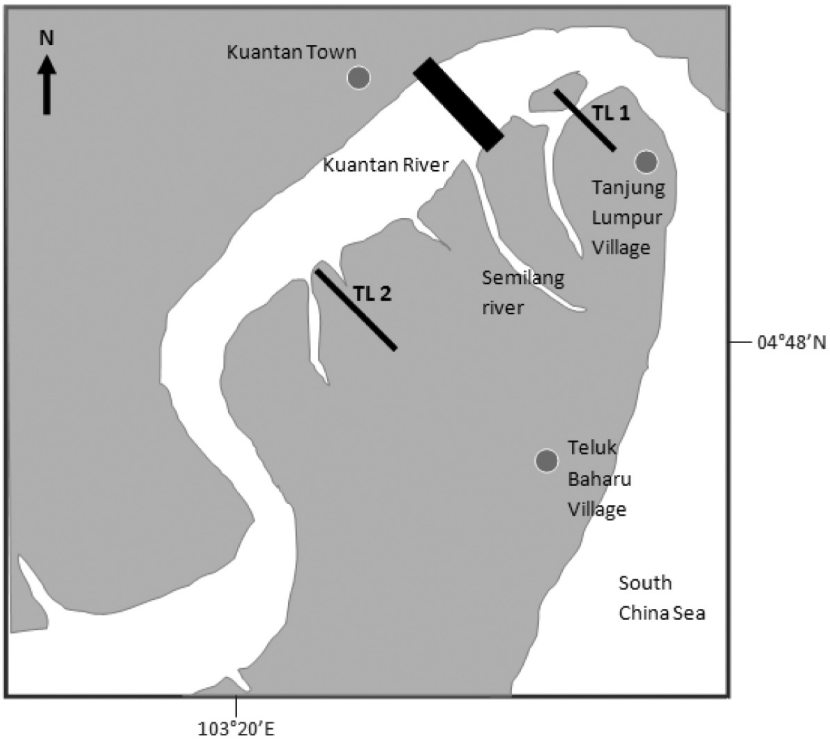

FIGURE 1. Map of the Tanjung Lumpur Mangrove Forest, Kuantan, Pahang, Malaysia

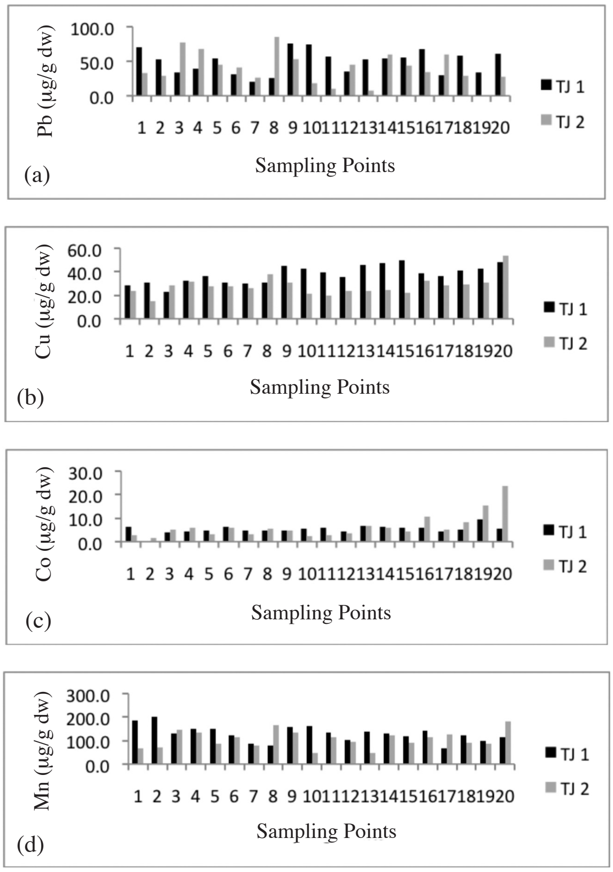

FIGURE 2. Concentration of the (a)Pb, (b)Cu, (c)Co and (d)Mn in the sediments for both transects

factors including industrial discharges to the river, inputs from weathering and the effects of local activities nearby such as fishing and industrial activities.

Salomons and Forstner (1984) asserted that sediment chemical composition and diagenesis could contribute to metal accumulation in sediment. Meanwhile, other major factors controlling the metal behavior are oxidation and reduction horizons, bioturbation and water fluctuations (Clark et al. 1998). Bioturbation is caused by burrowing organisms like polychaete and affected the surface sediments. Field observation revealed that these mangrove swamp received sewage discharge from domestic premises, restaurants, fish pond and boating. Boat fuel is the main source of lead. The major contributions of copper are from urban runoff, industrial effluents and wastewater. While manganese is donated from dry cell batteries, scrap metals and steel slag. Besides, manganese nodules were widely scattered on the ocean floor and this could be the reason the concentration is higher than other metals. The geographical factor of Tanjung Lumpur gives the distinction of heavy metal concentration in the area. The sources flowed through the Kuantan River and transferred slowly for decades through dynamic equilibrium process (erosion and accretion). During the process, river flow carried with them the heavy metal content to downstream. For a better estimation of anthropogenic input, an enrichment factor was calculated for each metal by dividing its ratio to the normalizing element by the same ratio found in the chosen baseline. Table 1 shows the calculated EFs of the analyzed elements with respect to those determined in the crustal abundance (Kamaruzzaman et al. 2002), employing the equation:

$$EF = (E/Al)_{sed}/(E/Al)_{crust},$$

where $(E/Al)_{sed}$ and $(E/Al)_{crust}$ are the relative concentrations of the respective elements E and Al in the sediment and in the crustal material, respectively (Kremling & Streu 1993; Molinari et al. 1993). An enrichment factor close to 1 would indicate a crustal origin, while those with factors greater than 10 are considered to have non-crustal sources. It is clear from Table 1 that only Co and Mn have EF values close to unity and may therefore be considered to be predominantly terrigenous in origin. On the contrary, the higher EF values found for Pb and Cu indicate that these metals can be considered to be predominantly anthropogenic in origin.

CONCLUSION

By comparing between the two transects, downstream transect (TL 1) shows the higher value because the position of the cape. The water flow through the river, and the contaminant is deposited on the cape and settled down for decades. This also strengthens the view that mangrove acts as sink for the pollutant so that the foreign and hazardous substance do not directly enter the sea. Action and cooperation must be taken between the locals and state government to reduce the pollution level in this mangrove area which was indicated by enrichment value of lead.

TABLE 1. Calculated average values of enrichment factor (EF) for Pb, Cu, Co and Mn in the study area for both transects

Element	EF values	Contamination Categories
Pb	13.84	Significant Contamination
Cu	3.44	Moderate Contamination
Co	1.27	Deficiency to minimal Contamination
Mn	0.37	Deficiency to minimal Contamination

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