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Distribution of Some Geochemical Elements in the Surface Sediment of Kerteh Mangrove Forest, Terengganu, Malaysia

(Taburan Beberapa Elemen Geokimia dalam Sedimen Permukaan di Hutan Paya Bakau Kerteh, Terengganu, Malaysia)

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ABSTRACT

Surface sediments collected from two transects (30 sampling points) in the Kerteh mangrove forest had been analyzed for Co, Cu, Pb, Zn and Cr concentrations with the Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The average concentration of Co was 8.91±1.89 µg/g dry weight, Cu was 29.0±12.8 µg/g dry weight, Pb was 11.7±6.85 µg/g dry weight, Zn was 22.3±13.7 µg/g dry weight and Cr was 13.2±9.07 µg/g dry weight. Their concentrations were significantly higher near the front mangrove and declined as the sampling points of each transect near the back mangrove area. The calculated enrichment factors (EF) obtained for Zn and Cr can be considered to have the terigeneous in sources while Co, Cu and Pb, which had slightly higher value, were probably influenced by anthropogenic input.

Keywords : Enrichment factor; mangrove forest; surface sediment

ABSTRAK

Sedimen permukaan yang dikutip dari dua transet (30 sampel permukaan) di kawasan hutan paya bakau Kerteh telah diukur bagi logam Co, Cu, Pb, Zn dan Cr dengan menggunakan peralatan Inductively Coupled Plasma-Mass Spectrometry *(ICP-MS). Purata kepekatan Co adalah 8.91±1.89 µg/g berat kering, Cu adalah 29.0±12.8 µg/g berat kering, Pb adalah 11.7±6.85 µg/g berat kering, Zn adalah 22.3±13.7 µg/g berat kering dan Cr adalah 13.2±9.07 µg/g berat kering. Secara signifikannya, kepekatan kesemua logam adalah tinggi di kawasan hadapan hutan paya bakau dan menjadi berkurangan pada transek di kawasan belakang hutan paya bakau. Faktor pengkayaan (EF) yang dikira bagi Zn dan Cr adalah didapati menghampiri 1 dan boleh dianggap terhasil daripada sumber semula jadi, manakala Co, Cu dan Pb mempunyai nilai EF yang lebih tinggi memberikan gambaran bahawa sumber Mn mempunyai sedikit pengaruh daripada antropogenik.*

Kata kunci: Faktor pengkayaan; hutan paya bakau; sedimen permukaan

INTRODUCTION

The mangrove areas of Terengganu are mostly small and fragmented and are mainly found in the protected waters of estuaries and lagoons. As such, the total mangrove area of Terengganu is small (approximately 2400 ha) and amounting to only 0.14% of the total mangrove area of Malaysia. The most extensive mangrove areas are those of the Kemaman Permanent Forest Reserve with a total area of 938 ha. The continual development of industrial activities, urban run off and human activities have given rise to a number of environmental problems. Heavy metal contamination in the aquatic environment such as river systems and mangrove areas is of critical concern, due to the toxicity of metals and their accumulation in aquatic habitats. Heavy metals, in contrast to most pollutants, are not biodegradable, and they undergo a global ecological cycle in which natural waters are the main pathways. Salt marshes, particularly those located near or along estuaries such as mangrove forests, are often polluted by river–borne and marine–derived particles and pollutants. Therefore, mangrove sediments can act either as sources or sinks of heavy metals (Harbison 1986; Silva et al. 1990).

Mangrove sediments are anaerobic and reducing, rich in sulphide and organic matter content, thus favoring the retention of the water–borne heavy metals (Silva et al. 1990). Elevated metal concentration related with long–term pollution caused by human activities has been recorded in mangrove sediment. Similarly, several studies have shown that mangrove sediments have a high capacity to retain heavy metals from tidal water and water runoff, and therefore they often act as sinks for heavy metal (Tam & Yao 1998; Kamaruzzaman et al. 2004)

METHODS

EXPERIMENTAL METHOD

The Kerteh mangrove forest is located in the Kemaman district and can be considered as one of the most extensive mangrove areas on the east coast of Peninsular Malaysia. Two transect lines (KR 1 and KR 2) were set up inside the mangrove forest, where 25 sampling station points were fixed. The transect lines with no physical signs of active bioturbation were selected, thus avoiding the complication of biological disturbance. KR 1 was set up near the estuary while KR 2 was near the upstream (Figure 1). Surface sediments for heavy metal analysis at all sampling points along each transect were collected by gently scraping the sediment surface.

ANALYTICAL METHOD

The sediment samples were digested and analyzed for total Pb and Cu following published methodologies with some modifications (Noriki et al. 1980; Kamaruzzaman 1999). An inductively–coupled plasma mass spectrometer (ICP–MS) was used for the quick and precise determination of Pb and Cu in the digested sediment. The digestion method involved heating of 50 mg of a finely powdered sample in a sealed Teflon vessel in a mixture with a mixed acid solution (1.5 mL) of concentrated HF, HNO_3 and HCl. The Teflon vessel was kept at 150ºC for 5 hours. After cooling, a mixed solution of boric acid and EDTA (3 mL) was added, and the vessel was again heated at 150ºC for 5 hours. After cooling to room temperature, the content of the vessel was 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 the last stage. The precision assessed by the replicate analyses was less than 3%. The accuracy was also examined by analyzing a Canadian Certified Reference Materials Project standard and the result coincided with the certified values within ±3%.

RESULTS AND DISCUSSION

Horizontal distribution of Co, Cu, Pb, Zn and Cr for two transects are given in line graphs in Figure 2. The concentration of Co was generally constant ranging 5.62 to 14.2 µg/g dry weight, with the average concentration value of 8.91 µg/g dry weight. Higher concentration of Co occurred at the riverside and decreased toward the back mangrove. The average concentration of Cu was 25.4 µg/g dry weight, ranged from 12.1 to 47.8 µg/g dry weight. Similar as Co, the concentration of Cu showed relatively high values at the riverside area. On the other hand, the concentration of Pb was not constant for both transects. The lowest concentration of Pb was also observed at the back mangrove (2.56 µg/g dry weight), while the highest was observed near the riverside (28.2 µg/g dry weight) with the average concentration value of 10.8 µg/g dry weight. For Zn, the average concentration was 22.4 µg/g dry weight ranging from 5.26 to 68.2 µg/g dry weight. The riverside had the higher Zn concentration compared with the back mangrove for both the transects. The concentrations of Cr also had similar trend as the other metals with the concentration at the back mangrove being lower compared with the front mangrove. The highest Cr concentration was 26.3 µg/g dry weight, while the lowest was 3.54 µg/g dry weight, and the averange was 9.92 µg/g dry weight.

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

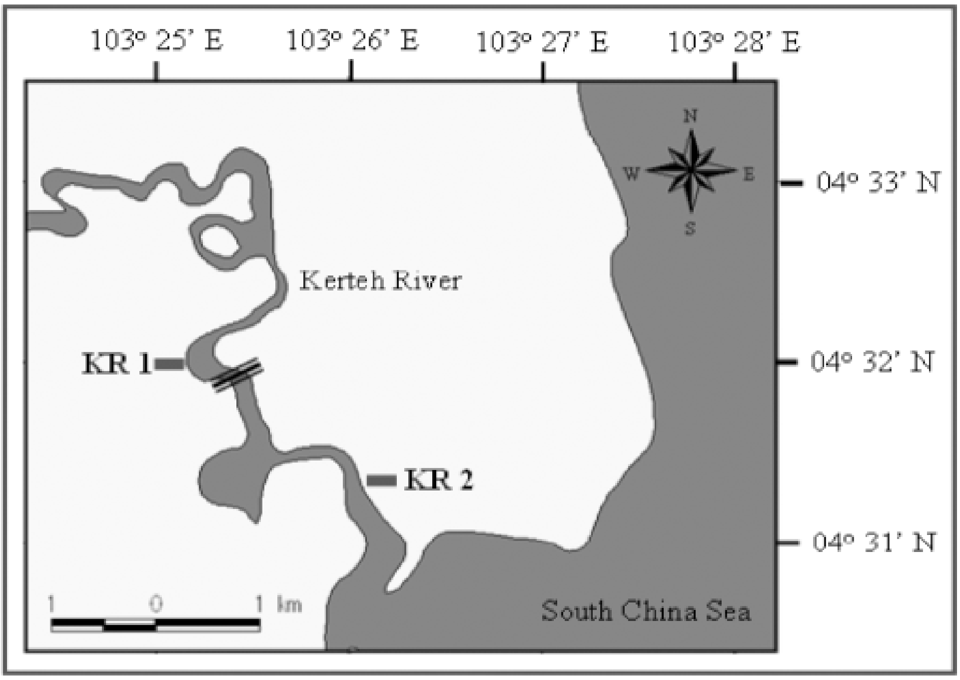

FIGURE 1. Location of the sampling sites (KR1 and KR2) along Kerteh Mangrove forest, Terengganu, Malaysia

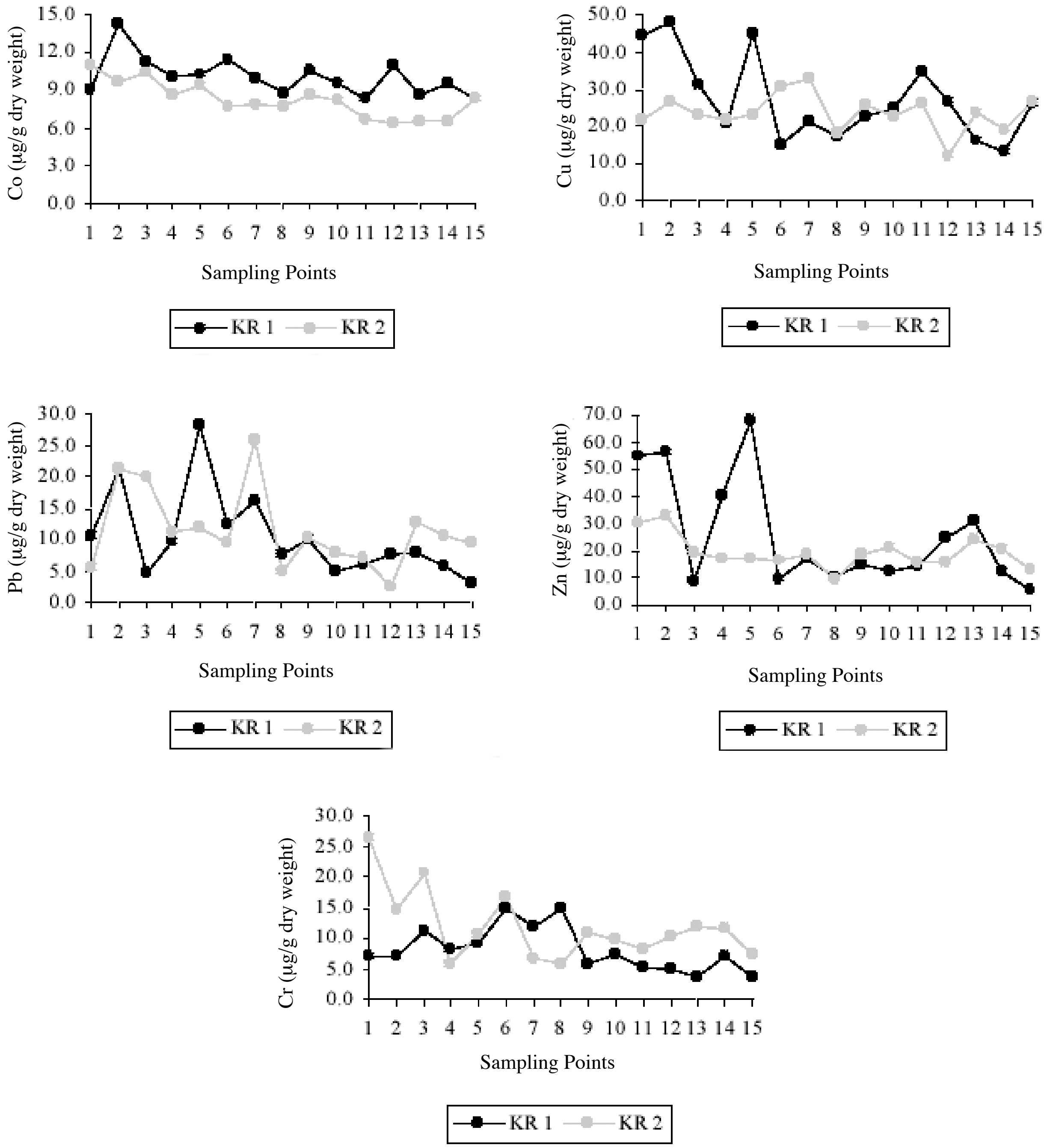

FIGURE 2. Horizontal distribution of Co, Cu, Pb, Zn and Cr at Kerteh Mangrove Forest, Terengganu

TABLE 1. EF value with respect to crustal ratios based on mean concentration determined in surface sediment in Kerteh mangrove

Element	EF value	Contamination Category
Co	1.90±0.53	Deficiency to minimal enrichment
Cu	2.23±0.76	Moderately enrichment
Pb	2.28±1.57	Moderately enrichment
Zn	0.92±0.54	Deficiency to minimal enrichment
Cr	0.03±0.02	Deficiency to minimal enrichment

in the chosen baseline. Table 1 shows the calculated EFs of the analyzed elements with respect to those determined in the crustal abundance (Taylor 1964), 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 element E and Al in the sediment and in the crustal material, respectively (Kremling & Streu 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 Zn and Cr has EF values close to unity and may therefore be considered to be predominantly terrigenous in origin. On the contrary, the higher EF values found in Co, Cu and Pb indicated that these metals can be considered to be predominantly anthropogenic in origin.

CONCLUSION

From the EF calculation, it is clear that concentrations of the selected elements were not greatly caused by anthropogenic activities, but occured somewhat naturally. Anthropogenic sources such as fishing activities and industrial estate may be the main sources contributing to the insignificant heavy metal in the mangrove sediment. In brief, can be concluded that there is no serious heavy metal contamination in Kerteh mangrove forest.

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