*Malaysian Journal of Science* **28** (2): 217– 222 (2009)

# Geochemical Studies of Setiu Lagoon, Terengganu, Malaysia

**Ong, M.C.[1,*], Kamaruzzaman, B.Y.[2] and Joseph, B.[3]**

[1]Deparment of Marine Sciences, Faculty of Maritime Studies and Marine Science, University Malaysia Terengganu, 21030 Kuala Terengganu *ong@umt.edu.my **(***Corresponding author)*
[2]Institute of Oceanography and Maritime Studies, International Islamic University Malaysia, Bandar Indera Mahkota, 25200 Kuantan, Pahang
[3]Institute of Oceanography, University Malaysia Terengganu, 21030 Kuala Terengganu
Received in 15th September 2008, accepted in revised form 14th December 2008.

**ABSTRACT** 26 surfical sediment of Setiu lagoon were collected in order to analyze the heavy metals concentrations using the sensitive Inductively Coupled Plasma Mass Spectrometer (ICP-MS). Results from this study revealed that the average sediment concentration of lead (Pb), cobalt (Co) and copper (Cu) were 23.26 μg/g dry weight, 22.29 μg/g dry weight and 47.25 μg/g dry weight, respectively. The calculated enrichment factors (EF) for Pb, Co and Cu close to 1 can be considered to have terigeneous in sources. Generally, the concentration of Pb, Co and Cu at present is not widespread enough as to have much influence on pollution of that area.

**ABSTRAK** 26 sedimen permukaan yang diperoleh dari lagun Setiu telah dianalisis bagi menentukan taburan kepekatan Pb, Co dan Cu dengan menggunakan Inductively Coupled Plasma Mass Spectrometer (ICP-MS). Purata kepekatan Pb, Co dan Cu di dalam sediment adalah masing-masing 23.26 μg/g berat kering, 22.29 μg/g berat kering and 47.25 μg/g berat kering. Dalam kajian ini, nilai EF yang didapati menghampiri 1 dan boleh dianggap sebagai berasal dari sumber terigenus yang dominan. Secara keseluruhannya, kawasan kajian tidak tercemar dengan kepekatan Pb, Co dan Cu.

**(Keywords:** lagun Setiu, Pb, Co, Cu, EF)

## INTRODUCTION

Heavy metals are present in streams as a result of chemical leaching of bedrocks, water drainage and runoff from the banks and discharge of urban and industrial wastewaters [1]. Due to their strong affinity for sedimentary particle surfaces, scavenging by suspended particulate matter and subsequent sedimentation exacerbates the environmental impact of these pollutants and sustains the environmental deterioration of estuaries and neighboring coastal zone [2].

Setiu lagoon is a well known estuary in the northern part of Terengganu and is unique as it covers many ecosystems such as lagoon, rivers, sea, mangrove forest and small islands. The lagoon's ecosystem is semi-enclosed with limited and poor tidal flushings and has a total water surface area of about 880 ha. This study area is of primary oceanographic interest since it is one of the largest estuaries of the Terengganu coast into which two river systems flow, the Setiu river and Chalok river. These areas are an area of diverse ecosystem, with utilizable natural resources, a vast array of biological diversity and coastal and riverine fishing activities [3, 4].

For the comprehensive conservation and management plan of Setiu Lagoon, it is vital to determine the heavy metal concentration and organic carbon content in sediment as well as water parameters of Setiu Lagoon. Furthermore, there are limited information regarding to the geochemical profile of estuarine system in Malaysia and only some initial research had been done [5, 6].

## METHODOLOGY

### Site description and sampling

Samples were collected from the Setiu Lagoon of Terengganu from 26 stations along the estuary (Figure 1). The bottom sediment samples were collected by using a Ponar Grab. All samples will be dried in oven at 60$^{o}$C until constant weight and ground to a fine powder with a porcelain mortal and pestle. Precautions to prevent contamination are given a priority. Digestion and analytical procedures for all chemical elements will be analyzed using the published methods.

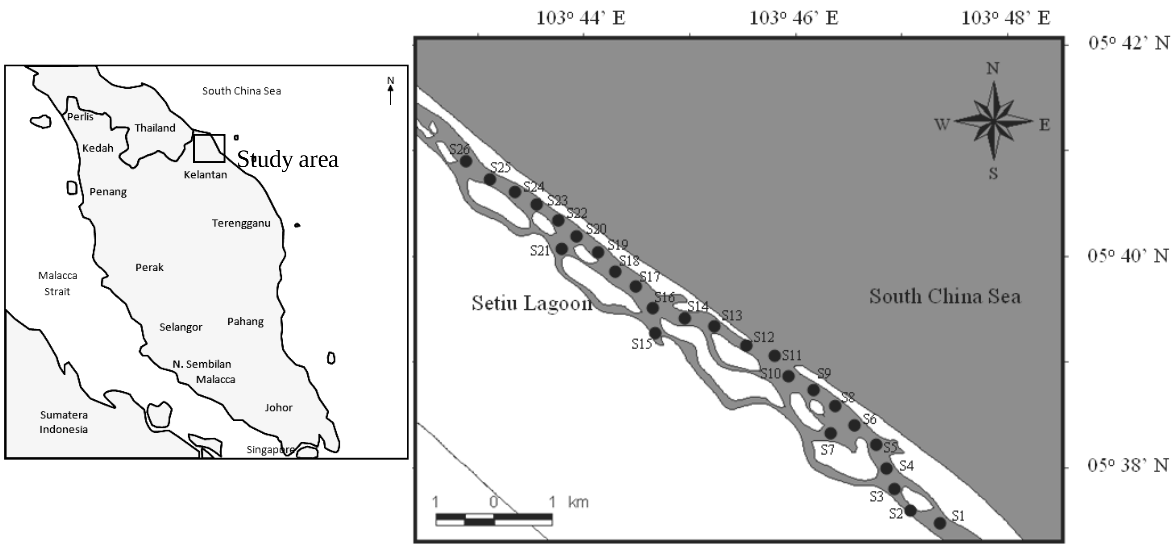


**Figure 1**. Location of study area showing the sampling site along Setiu Lagoon, Terengganu, Malaysia

### Heavy metal analysis

The sediment samples were digested according to the published methods with some modifications [7, 8, 9]. An inductively-coupled plasma mass spectrometer (ICP-MS) was used for the quick and precise determinations of Pb, Cu, Mn and Zn in the digested marine sediment. Briefly, the digestion method involved the heating of 50 mg of a < 63 µm size sample in a sealed teflon vessel with a 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 $^{0}$C for 5 hours. After cooling, a mixed solution of boric acid and EDTA was added, and the vessel was again heated at 150 $^{0}$C for 5 hours. 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 5% $HNO_3$. A clear solution with no residue should be 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 within a difference of ± 3%.

## RESULTS AND DISCUSSIONS

The distributions of Pb, Co and Cu concentration at Setiu Lagoon are given in the bar graph (Figure 2). Generally, the results indicate that the concentration of Pb, Co and Cu were higher than the average concentrations estimated for shales and mean crustal materials [10, 11]. For Pb concentration, the average concentration was 23.36 µg/g dry weights, ranged from 10.58 µg/g dry weight to 45.22 µg/g dry weights. The concentrations of Co with sampling points was varied from 8.54 µg/g dry weight to 32.29 µg/g dry weight, average at 22.29 µg/g dry weight. The average concentration of Cu ranged from 9.12 µg/g dry weights to 94.40 µg/g dry weight, average at 47.25 µg/g dry weights. The contribution of these metals in the study area would likely be due to the anthropogenic activities such as boating, sand mining [5], and sea dumping activities. Furthermore, the elevation of river discharge resulted from a combination of factors including industrial discharges to the river, inputs from weathering and the effects of local activities nearby are likely contributes to Pb, Co and Cu concentration throughout the study area.

**Table 1**. Pb, Co and Cu (μg/g dry weights) distribution at Setiu Lagoon, Terengganu

| Station | Pb (μg/g dry weights) | Co (μg/g dry weights) | Cu (μg/g dry weights) |
|---|---|---|---|
| S1 | 13.80 | 13.99 | 46.78 |
| S2 | 14.69 | 25.02 | 38.77 |
| S3 | 19.21 | 25.83 | 34.51 |
| S4 | 10.68 | 28.87 | 39.72 |
| S5 | 14.90 | 8.54 | 20.43 |
| S6 | 19.34 | 8.77 | 94.40 |
| S7 | 14.90 | 18.28 | 36.76 |
| S8 | 15.89 | 26.65 | 29.87 |
| S9 | 16.58 | 27.24 | 45.79 |
| S10 | 22.94 | 13.10 | 31.45 |
| S11 | 27.50 | 27.44 | 19.89 |
| S12 | 19.24 | 17.74 | 62.27 |
| S13 | 29.40 | 27.45 | 66.41 |
| S14 | 30.34 | 31.57 | 59.81 |
| S15 | 45.22 | 29.46 | 21.63 |
| S16 | 27.82 | 15.41 | 47.81 |
| S17 | 11.98 | 11.95 | 89.28 |
| S18 | 23.62 | 29.04 | 72.55 |
| S19 | 30.72 | 32.29 | 61.08 |
| S20 | 23.38 | 30.32 | 63.66 |
| S21 | 30.26 | 22.24 | 9.12 |
| S22 | 32.16 | 14.62 | 60.57 |
| S23 | 25.03 | 29.15 | 66.25 |
| S24 | 35.16 | 32.08 | 55.88 |
| S25 | 28.32 | 13.89 | 22.08 |
| S26 | 22.25 | 18.72 | 31.77 |
| **Average** | **23.28** | **22.29** | **47.25** |
| **Mean crustal materials** | **20** | **19** | **45** |

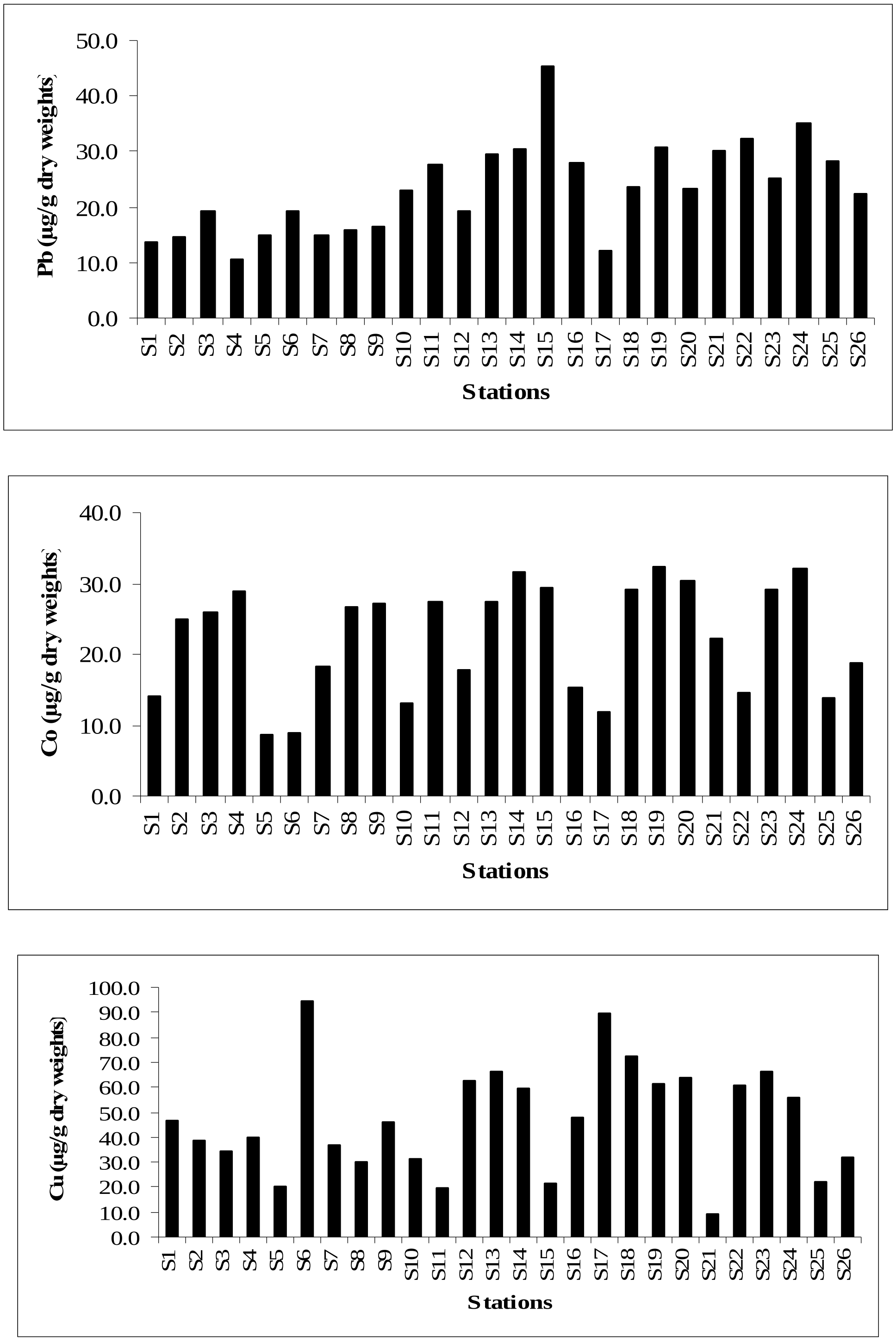


**Figure 2**. Pb, Co and Cu (µg/g dry weights) distribution at Setiu Lagoon, Terengganu

Anthropogenic activities had caused important transformation in coastal environments during the last 150 years. Heavy metals were among the most widespread of the various pollutants originating from anthropogenic activities, particularly from mining and smelting waste sites [12, 13]. The approach most often used to determine the sources of the pollutant is through the normalization of geochemical data to reference metal. The reference metal must therefore be an important constituent of one or more of the major fine-grained trace metal carriers reflect their granular variability in the sediment. The most often used reference metal is Al, which represents a chemical tracer of Al-silicates, particularly the clay minerals [14, 15, 16]. For a better estimation of anthropogenic input, an enrichment factor was calculated for each metal by dividing its ration to the normalizing element by the same ration found in the chosen baseline. EF values are applied to evaluate the dominant source of the sediments and as indicators for pollution [17] and describe as:

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

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 [10, 11, 18, 19]. 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. From the average calculated value for Pb, Co and Cu was 0.91 (0.70-1.12), 0.91 (0.64-1.04) and 0.89 (0.52-1.08), respectively, it is clear that all elements has EF values close to unity and may therefore be considered to be predominantly terrigenous in origin.

## CONCLUSION

Generally metals concentrations in the sediment were much influenced by the natural processes and show some relative enrichment near the estuary compared to upstream. The calculated EF for all elements indicates their occurrence in both lithogenous and non-lithogenous fractions. In conclusion, even though the Setiu estuary and nearby areas are rapidly developing, the activities at present are not widespread enough as to have much influence on pollution of the area.

## ACKNOWLEDGEMENTS

This research was conducted with joint funding from the Malaysia Ministry of Science Technology and Innovation under the Intensified Research for Priority Areas (IRPA). The authors wish to express their gratitude to Oceanography Laboratory and INOCEM team for their invaluable assistance and hospitality throughout the sampling period.

## REFERENCES

1. Soares H.M.V., Boaventura R., Machado A.A.S.C. and Silva J.C.G. (1999). Sediments as Monitors of Heavy Metal Contamination in the Ave river basin (Portugal): Multivariate Analysis of Data. *Environment Pollution* **105**: 311 – 323.
2. Gerritse R.G., Wallbrink P.J. and Murria A.S. (1998). Accumulation of Phosphorus and Heavy Metals in the Swan-Canning Estuary, Western Australia. *Estuaries, Coastal, Shelf Science* **47**: 165 – 170.
3. Ong, M.C. (2006). Geochemistry of Sediment and heavy Metals in the Major Estuarine Mangrove Forest of Terengganu, Malaysia. *Master of Science Thesis*. Submitted to Kolej Universiti Sains & Teknologi Malaysia. 225p.
4. Kamaruzzaman B.Y., Effendy A.W.M., Ahmad Shamsuddin A. and Nor Afandy B.H. (2005). Vertical and Horizontal Variability of Organic Carbon in Setiu Mangrove Forests, Malaysia. *Chemical Research Communication* **18**: 33 – 37.
5. Kamaruzzaman B.Y., Husain M.L., Shazili N.A.M., Sulong, I. and Rashid, K.A. (2002). Study on the Distribution of Some Heavy Metals and Pollution Status of a Tropical Microtidal River: The Chukai-Kemaman River, Terengganu, Malaysia, *Dimensions of Pollution* **1**: 115 – 130.
6. Noor Azhar M.S., Kamaruzzaman B.Y., Rosnan Y. and Nor Antonina A. (2003) Speciation of Cu, Pb and Zn in Sediments of Ibai Estuary, Kuala Terengganu, Malaysia. *Dimensions of Pollution* **2**: 43 – 52.
7. Noriki, S.K., Nakanishi, T., Fukawa, M., Uematsu, T., Uchida and S. Tsunogai (1980). Use of a Teflon Vessel for the Decomposition Followed by the Determination of Chemical

Contituents of Various Marine Samples. *Bull. Fac. Fish, Hokkaido Univ.,* **31**: 354 - 465.

8. Sen Gupta J.G. and Bertrand N.B. (1995). Direct ICP-MS determination of trace and ultratrace elements in geological materials after decomposition in a microwave oven, Quantitation of Y, Th, U and lanthanides. *Talanta*, **42**: 1595-1607.
9. Kamaruzzaman B.Y. (1999). Geochemistry or the Marine Sediments. Its Paleoceanographic Significance. *Ph.D Thesis.* Submitted to Hokkaido University. 143p.
10. Turekian K.K. and Wadepohl D.H. (1961). Distribution of the Elements in Some Major Units of the Earth's Crust. *Bull. Geol. Soc. Amer*. **72**: 175 – 192.
11. Wadepohl K.H. (1995). The Composition of the Continental Crust. *Geochim. Cosmo. Acta* 95: 1217 – 1232.
12. Solomons W. (1995). Environmental impact of metals derived from mining activities: Processes predictions, prevention. *Journal of Geochemical Exploration* **52**: 5-23.
13. Hochella Jr., M.F., Moor J.N., Golla U. and Putnis A. (1999). A TEM study of samples from acid mine drainage systems: Metal-mineral association with implication for transport. *Geochimica at Cosmochimica Acta* **19–20**: 3395–3406.
14. Din Z.B. (1992). Use of aluminium to normalize heavy metal data from estuarine and coastal sediments of Straits of Melaka. *Marine Pollution Bulletin* **24**: 484–491.
15. Weijden V.C.H. (2002). Pitfalls of normalization of marine geochemical data using a common divisor. *Marine Geology* **184**: 167–187.
16. Loring D.H. and Rantala R.T.T. (1992). Manual for the geochemical analyses of marine sediments and suspended particulate matter. *Earth Sciences Review* **32**: 235–283.
17. Taylor S.R. (1964). Abundance of chemical elements in the continental crust: a new table. *Geochimica et Cosmochimica Acta* **28**: 1273 – 1285.
18. Molinari E., Guerzoni S. and Rampazzo G. (1993). Contribution of Saharan Dust to the Central Mediterranean Basin. *Geological Society of America, special paper* **284**: 303 – 312.
19. Kremling K. and Streu P. (1993). Saharan dust influence trace element fluxes in deep North Atlantic subtropical waters. *Deep Sea Research* **40**: 1155 – 1168.