SURFACE SEDIMENT ANALYSIS ON HEAVY METALS IN COASTAL AREA OF UMS – TUARAN, SABAH

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ABSTRACT. *Heavy metal concentrations (Cd, Cr, Cu, Pb and Zn) were investigated in surface sediments from Universiti Malaysia Sabah (UMS) - Tuaran coastal area, Sabah. Samples were collected using Ponar grab sampler in ten different stations at the site area. The heavy metals were analyzed using Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) after the surface sediments were digested with aqua regia (HNO_3: HCl) solution. The overall mean and range of heavy metal concentrations in the surface sediments were: Cd (0.55, 0.27 - 1.06 mg/kg), Cr (4.93, 1.97 - 10.30 mg/kg), Cu (7.40, 0 – 18.57 mg/kg), Pb (3.88, 0 – 14.4 mg/kg) and Zn (31.84, 11.60 - 67.1 mg/kg) respectively. Overall, the heavy metal concentrations in surface sediments were not exceeded the Interim Sediment Quality Guidelines (ISQG) limit except for Cd which a bit higher than 0.7 mg kg^{-1} indicating considered slightly pollute.*

KEYWORDS. Heavy metals, ICP-OES, *aqua-regia* solution, surface sediments

INTRODUCTION

Sediments are categorized as heterogeneous mixture, in which it involves solids particles of relatively large size, suspended and distributed in liquids (Mudroch & Azecue, 1995). The particle size of sediment affects the depth and ease for some organism to burrow in sediment. This also depends on the acceptability of organism towards the chemical environment of the sediment and its associated pore water. In seawater, the sediment could act as a source of metal whenever there is a change in physical or chemical conditions in sediment-seawater interface (Lerman, 1978). Since sediment becomes a sink for some other pollutant, at some time the pollutants can be released back to the water phase by the process which is known as re-suspension. When this happens, the compound or pollutant that is trapped in the sediment will be remobilized (Lick, 2009).

Heavy metals are incorporate of the many dangerous pollutants can also be found in sediments. It tends to underlying sediments and is good indicators of metal contamination levels (Wendy, 2005). According to Phillips (1977), metal concentration tends to be higher in sediments level as compared with water and is much easier to analyze and accurate. The alteration of results due to sample contamination is less likely where sediments may integrate environmental fluctuations of heavy metal levels, and allowing for better consistency in readings/result. Metals tend to be assimilated in sediment with organic matter, Fe/Mn oxides, sulfide and clay thus forming several reactive components which are harmful to the environment (Wan, 2012).

The aim of this study is to determine the distribution of Cd, Cr, Cu, Pb and Zn in surface sediment of coastal area from Universiti Malaysia Sabah (UMS) to Tuaran and then the collected data were compared with Interim Sediment Quality Guidelines (ISQGs). The study focused on this area due to the interest to know whether the areas that polluted or not because many residents living nearby are depend on it for food. Along the coastal or nearby are the villages, industries and other development activities such as Sepanggar Water Village, Numbak Water Village, Kibagu Village, UMS Port, Sepanggar Bay Oil Terminal, Major Naval Base for the Royal Malaysian Navy, Kota Kinabalu Industrial Park, Nexus Resort Karambunai, Mimpian Jadi Resort, Rasa Ria Resort, Salut Village, Gayang Water Village, Trayung Water Village, Mengkabong Water Village and entrance of Simpangan River, Dalit River, Mengkabong River, Salut River and Tuaran River. Those potential areas will discharge effluents, sewage, wastes and pollutants directly to coastal or from the river to coastal which will increase the existing concentration of particular heavy metal.

MATERIALS & METHODS

This study was conducted in October 2012. A total of 10 surface sediment samples (0-1 cm) were collected using Ponar grab sampler from ten stations around coastal area (5 to 7 meter above the sea) from Universiti Malaysia Sabah (UMS) to Tuaran as shown in Figure 1. The exact sampling locations were recorded by the Global Positioning System (GPS) device (Table 1). Analysis of the top (1-2 cm) surface layer provides baseline data for present-day pollution (AI-Abdali *et al*., 1996; Michel *et al.*, 1993). About 1g of dried surface sediment samples were digested (110°C for 90 min) with 14 ml *aqua-regia* solution (HNO_3:HCl). After cooled, 14 ml *aqua-regia* were added and heated again at 110°C for 30 min. The digested samples were filtered through a 0.45 μm membrane and analyzed heavy metals concentration using Perkin Elmer Optima 5300DV Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES). Quality Control Standard 21 (Perkin Elmer Pure) was used as standard reference material (SRM) for instrument recovery.

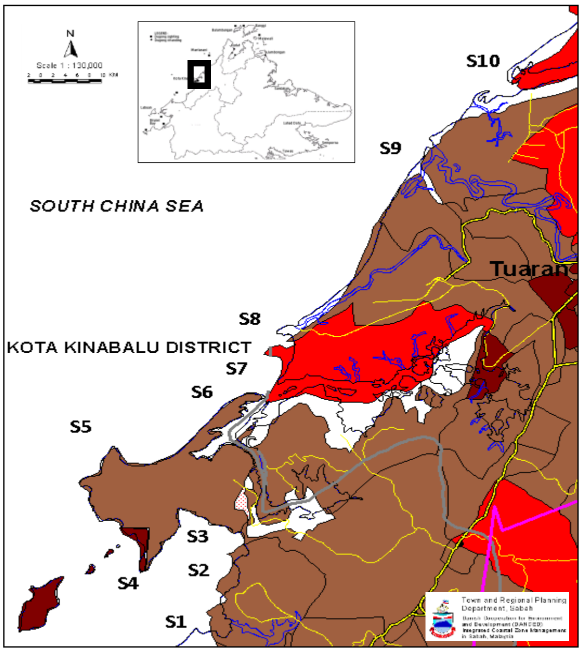

Table 1. The coordinate of sampling stations

Stations	Latitude	Longitude
1	N $06^0$02.151’	E $116^0$06.263’
2	N $06^0$02.545’	E $116^0$06.432’
3	N $06^0$03.880’	E $116^0$06.753’
4	N $06^0$07.181’	E $116^0$06.309’
5	N $06^0$08.533’	E 116^{007} 964’
6	N $06^0$08.274’	E $116^0$08.234’
7	N $06^0$08.485’	E $116^0$08.924’
8	N $06^0$09.882’	E $116^0$08.626’
9	N $06^0$13.934’	E $116^0$10.756’
10	N $06^0$14.641’	E $116^0$12 819’

Figure 1. Study area and sampling stations.

RESULTS & DISCUSSION

The overall mean concentration of heavy metals (mg/kg) are listed in Table 2. The range of heavy metals concentrations are Cd (0.27 - 1.06 mg/kg), Cr (1.97 - 10.30 mg/kg), Cu (0 – 18.57 mg/kg), Pb (0 – 14.4 mg/kg) and Zn (11.60 - 67.1 mg/kg) respectively. The concentration of metals in surface sediment with ascending order was Cd < Pb < Cr < Cu < Zn. The concentration of Zn in surface sediment is higher compared to other metals with overall mean 31.84 mg/kg. The Zn content in soil depends on the nature of parent rocks, texture, organic matter and pH and ranges from 10 to 300 mg kg^{-1} (Muller, 1999) with an estimated global average of 64 mg kg^{-1} (Kabata-Pendias & Mukherjee, 2007).

Table 2. Mean concentration of heavy metals (mg/kg).

Stations	Heavy metals concentration (mg/kg)				
	Cd	Cr	Cu	Pb	Zn
1	0.51	**10.30**	10.10	**14.40**	66.60
2	0.34	3.09	0.00	1.50	18.80
3	**1.06**	9.48	14.80	12.60	**67.10**
4	0.78	4.12	3.25	0.00	28.60
5	0.73	2.57	4.65	0.55	21.40
6	0.61	1.97	0.29	0.00	13.52
7	0.43	1.99	1.58	0.00	13.00
8	0.50	2.17	11.02	0.00	11.60
9	0.28	8.60	**18.57**	8.20	43.46
10	0.27	4.97	9.78	1.56	34.29
Mean	**0.55**	**4.93**	**7.40**	**3.88**	**31.84**

Cd concentration exceeded the lowest effect level recommended in Interim Sediment Quality Guidelines (ISQGs) (Table 3) in S3, S4 & S5 which indicates the level of contamination probably have adverse effects on benthic biota that live in sediment (Tavakoly *et al.*, 2011). The highest reading of Cd may be due to human waste and industrial activities along the coastal areas. The major factors governing cadmium speciation, adsorption and distribution in sediments are pH, organic matter content, hydrous metal oxide content, clay content and type, presence of organic and inorganic ligands and the competition from other metal ions (OECD, 1994). In Europe, the primary reason for the increase in the Cd content was the use of Cd-containing fertilizers and sewage sludge (Jensen & Bro-Rasmussen, 1992).

Table 3. Interim marine sediment quality guidelines (ISQGs) (CCME, 1999).

Heavy metal	Interim marine sediment quality guidelines (ISQGs) ($mgkg^{-1}$)
Cd	0.7
Cr	52.3
Cu	18.7
Pb	30.2
Zn	124.0

The highest concentration of Cr and Pb were found in Station 1 with 10.30±0.0020 mg/kg and 14.40±0.0010 mg/kg, respectively. Station 1 is located at UMS Port. The sources of Pb could be connected with leaded petrol/diesel from vehicles and specially boats at the port. Besides, the UMS Port is near with Kota Kinabalu City and Kota Kinabalu Port which will contribute to the presence of Cr and Pb in sediments through migration and also brought by the water current. Cr and Pb might also discharge from industrial effluent and residential sewage such Kota Kinabalu Industrial Park (KKIP), Kibagu Village and Numbak Water Village.

Station 3 which located at Sepanggar Bay has always among the highest concentration of the selected heavy metals (Cd = 1.06±0.0009 mg/kg, Cr = 9.48±0.0015 mg/kg, Cu = 14.80±0.0004 mg/kg, Pb = 12.60±0.0010 mg/kg and Zn = 67.10±0.0103 mg/kg). It may be because the station were collected near the coastal villages and surrounds by many industrial areas such as Sepanggar Bay Oil Terminal, Major Naval Base for the Royal Malaysian Navy, Kota Kinabalu Industrial Park (KKIP) and main campus for UMS, UITM and Polytechnic Kota Kinabalu. The human and industrial wastes discharge may increase the availability of heavy metals in the seawater and sediment itself.

The highest concentration of Cu (18.57±0.0004 mg/kg) was found in Station 9 which located at estuary of Tuaran River. Mimpian Jadi Resort is near the estuary and fertilisers that containing Cu might apply to the grass on the golf club of the Resort. Excessive Cu will release to the seawater and trapped in the sediment. Other contributions were from the anthropogenic activity such as agriculture and domestic wastes from the nearby villages such as Penambawan Village and Tambalugu Village.

CONCLUSION

The distributions of Cd, Cr, Cu, Pb and Zn in surface sediment of Universiti Malaysia Sabah (UMS) – Tuaran coastal area were determined in this study. Heavy metals accumulated were different in each station but follow the sequence of Zn > Cu > Cr > Pb > Cd. The heavy metal concentrations in surface sediment do not exceed the Interim Sediment Quality Guidelines (ISQGs) limit except for Cd which was considered slightly polluted.

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REFERENCES

AI-Abdali, F., Massoud, M. S. & A1-Ghadban, A. N. 1996. Bottom sediments of the Arabian Gulf; IIL Trace metal contents as indicators of pollution and implications for the effect and fate of Kuwait oil slick. *Environmental Pollution*, **93(3)**: 285-301.

CCME. 1999. *Canadian sediment quality guidelines for the protection of aquatic life: Summary tables.* In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers for the Environment, Winnipeg.

Jensen, A. & Bro-Rasmussen, F. 1992. Environmental Contamination in Europe. *Reviews of Environmental Contamination and Toxicology*, **125**: 101-181.

Kabata- Pendias, A. & Mukherjee, A.B. 2007. *Trace Elements From Soil To Human.* Springer, New York.

Lerman, A. 1978. Chemical exchange across sediment-water interface. *Annual Review of Earth and Planetary Sciences,* **6**: 281-303

Lick, W. 2009. *Sediment and contaminant transport in surface water*. CRC Press. America.

Michel, J., Hayes, M. O., Keenan, R. S., Sauer, T. C., Jensen, J. R. & Narumalani, S. 1993. Contamination of nearshore subtidal sediments of Saudi Arabia from the Gulf War oil spill. *Marine Pollution Bulletin*, **27**: 109-116.

Mudroch, A. & Azecue, J. M. 1995. *Manual of aquatic sediment sampling*. Lewis Publishers, USA.

Muller, A. 1999. Distribution of Heavy Metals in Recent Sediments in the Archipelago Sea of Southwestern Finland. *Boreal Environment*, **4**: 319-330.

Organisation for Economic Co-operation and Development (OECD). 1994. Risk Reduction Monograph No. 5: Cadmium OECD Environment Directorate, Paris, France.

Philips, D. J. H. 1977. The use of biological indicator organisms to monitor trace metal Pollution in marine and estuarine environments – A review. *Environmental Pollution,* **13**: 281-317.

Tavakoly, S.B., Sulaiman, A.H, Monazami, G.H. & Salleh, A. 2011. Assessment of Sediment Quality According To Heavy Metal Status in the West Port of Malaysia. *World Academy of Science, Engineering and Technology,* **50**: 633-637.

Wan, Y. L., Ahmad, Z. A. & Mohammad, P. Z. 2012. Spatial variability of metals in surface water and sediment in the Langat River and geochemical factors that influence their water-sediment interactions. *The Scientific World Journal,* Vol 2012. ID:652150.

Wendy, N. 2005. Spatial distribution of heavy metals in sediments from the gulf of Paria, Trinidad. *Institute of Marine Affairs*, **53**: 33-40.