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PRELIMINARY STUDIES ON SEDIMENT CHARACTERISTICS AND METALS CONTAMINANTS OF TEMENGGOR LAKE, MALAYSIA

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Abstract: Seven sampling stations surrounding Banding Island, Temenggor Lake were chosen to evaluate the status of Temenggor Lake's sediment quality. A total set of sediment samples from each station were collected during December 2010. An experimental technique was involved to analyze the sediment particle size (sand, silt and clay), pH, conductivity, total organic carbon, total organic matter, total hydrocarbon and some selected metals**.** The texture analysis study revealed that the sandy type sediment was the predominant fractions in Temenggor Lake. In this study, chemical characteristic of the sediment in Temenggor Lake has shown total organic carbon (0.07 – 0.62%), organic matter (0.20 – 1.83%) and hydrocarbon (0.01 – 0.39%). Metals concentrations in lake sediment were found to be in the following order Fe > Mn > Pb > Cr > Zn > Cu > Cd. All metal studied in Temenggor Lake were generally low and in the range of natural concentration when compared with Interim Sediment Quality Guidelines (ISQG). It was also noted that the Mohd Shah Resort Station is a predominant potential to be polluted compared to other sampling locations.

KEYWORDS: Sediment characteristics, organic carbon, organic matter, hydrocarbon, metals

Introduction

Temenggor Lake is the second largest manmade lake in Peninsular Malaysia. It is located at approximately 45 km from Gerik district of Perak State. The catchment area is approximately 152 km^2, formed as a result of hydroelectric dam established in 1974 and it was completed in 1977. Banding which is originally the highest peak in the Temenggor basin has been transformed into an island (Perak Info, 2010), with an area approximately 127.28 km^2. The major land use for this area is forestry which constitutes about 66.26 percent of the entire study area with a projected human population of 616 by 2015 (Gerik Web Portal, 2011).

Other land uses in the Banding Island are roads and drainage (21.64%), agriculture in which is mainly rubber plantation (10.9%), commercial area (0.03%) and idle land cover up 1.17% (Gerik Web Portal, 2011). Banding area receives effluents discharges from the local communities, resort, boating and daily activities. Although there were many human activities and development in the vicinity of Banding Island, no proper study on the sediment quality of this lake was performed. Thus this study was initiated to assess the sediment quality in terms of its particle size distributions and some selected chemical characteristics of Temenggor Lake. The principle objective of this study is to carry out metal analysis concentrations in order to provide baseline information for future references. The location of seven stations at Temenggor Lake was selected for the present study and is summarized below.

Materials and Methods

The sediment samples collected for this study were from seven selected stations around Banding Island during the month of December 2010. All sampling stations were selected to represent different localities with varying anthropogenic discharge and influences in the vicinity of Banding Island. Sediments were

Table 1: Description of sampling location.

Station		Latitude	Longitude	Lake Depth (m)
1A	Banding Fisheries Centre	05° 33.138 N	101° 21.180 E	10.32
2A	Banding Island Public Jetty	05° 33.097 N	101° 20.887 E	7.80
3A	Mohd Shah Resort	05° 32.928 N	101° 21.190 E	21.20
4A	Banding Island Southern Region	05° 31.748 N	101° 20.845 E	13.00
5A	Banding Island Resort	05° 33.522 N	101° 20.481 E	11.05
6A	Banding Island Resort (discharge)	05° 32.559 N	101° 20.404 E	4.30
7A	Banding Island Northern Region	05° 33.591 N	101° 20.103 E	11.00

collected using Eckman grab sampler, and three replicates were taken from each station. The sediment samples were collected using anti rust scoop, wrapped in aluminum foil (hydrocarbon) and stored in a labeled polythene bags prior to laboratory analysis. Samples were stored at 4°C in an ice cool box and carefully transferred to the laboratory.

The pH value and electrical conductivity of lake sediment were measured by mixing 50 gram sediment with distilled water in 1:1 ratios. After 30 min, the pH and conductivity readings were taken by inserting their respective electrodes in the sediment solution (Ezekiel *et al.*, 2011). The moisture content of sediment was measured by loss of weight at 105 °C and sediment fractions grain size was determined by using laboratory dry sieving technique analysis. The sediment fractions were determined based on the guidelines set by the International Soil Science Society (ISSS) Schemes: sand (<200 µm), silt (<20 µm) and clay (<2 µm).

The total organic carbon and total organic matter of lake sediment were determined using the Walkey - Black method (Schulte and Hoskins, 2009). This method basically involves the oxidation of the organic material in the sediment sample with potassium dichromate solution ($K_2Cr_2O_7$) and sulfuric acid (H_2SO_4). The excess of $K_2Cr_2O_7$ solution was titrated with Ferrous Ammonium Sulphate solution and a few drops of ferroin solution. The total organic carbon was calculated using the following equation:

$$\text{Organic Carbon (\%)} = \frac{[B - A] \times 0.195 \text{ (factor) of blank of sample}}{\text{Weight of soil sample (g)}}$$

Where B is the to total volume (mL) of Fe^{2+} solution used to titrate the blank while A is the total volume (mL) of Fe^{2+} solution used to titrate the sample. The estimation of total organic matter was calculated based on the following equation:

$$\text{Organic Matter (\%)} = \frac{\text{\% total organic carbon x 1.72}}{0.58}$$

The total hydrocarbon was determined using EPA 1664 method, following procedure the previously reported in Mahadi and Ross (1994). This method involved extracting hydrocarbons using petroleum ether and gravimetric analysis. Further treatment with silica gel was conducted to remove polar content. Meanwhile some selected metals which consist of seven elements (Cu, Cd, Cr, Fe, Mn, Pb, and Zn) were measured in the sediment samples. The metal analysis was carried out by sequential extraction method following the procedure previously reported in Ahmad *et al*. (2009).

The final heavy metals concentration was analyzed using inductively coupled plasma-mass spectrometry (ICP-MS) model Perkin Elmer. Standard and blank were analyzed in every 10 samples. The metal concentrations in reference soil material (SRM 2711) were determined using the same analytical procedures and values obtained were within 10% range of the reference values.

Analysis of variance (ANOVA) and Pearson correlation coefficient were used to analyze the data using SPSS statistical software package version 17. Correlation analyses (Pearson) were applied to test the relationship between metal

Table 2: Spatial variations of physical sediment characteristic in Temenggor Lake.

Station		Sand (%)	Silt (%)	Clay (%)
1A	Banding Fisheries Centre	26.72	11.81	50.01
2A	Banding Island Public Jetty	54.91	7.25	31.50
3A	Mohd Shah Resort	38.91	8.67	42.42
4A	Banding Island Southern Region	65.24	6.85	13.30
5A	Banding Island Resort	54.60	5.97	22.30
6A	Banding Island Resort (discharge)	21.44	10.17	58.02
7A	Banding Island Northern Region	38.06	11.90	31.92

Table 3: Spatial variations of chemical sediment characteristic in Temenggor Lake.

Station	pH	EC (μScm^{1})	TOC (%)	TOM (%)	THC (%)
1A Banding Fisheries Centre	6.32	40	0.54	1.60	0.12
2A Banding Island Public Jetty	6.54	38	0.54	1.60	0.01
3A Mohd Shah Resort	6.24	86	0.62	1.83	0.07
4A Banding Island Southern Region	6.49	39	0.14	0.45	0.38
5A Banding Island Resort	6.48	40	0.54	1.60	0.05
6A Banding Island Resort (discharge)	6.62	36	0.07	0.20	0.04
7A Banding Island Northern Region	6.79	35	0.44	1.31	0.06

concentrations in the sediment and also between sediment characteristics and sediment size fractions.

Results and Discussion

The percentage of sediment particle size for sandy type were ranged from approximately 21.44 to 54.91%, while for clay type size were approximately 13.30 to 58.02%. There were only 5.97 to 11.90% for silt type size in Temenggor Lake's sediment. The texture study revealed that clay was the predominant fractions size at the three stations namely Banding Island Fisheries Centre (1A), Mohd Shah Resort (3A), and Banding Island Resort discharge (6A).

Other stations such as Banding Island Public Jetty (2A), Banding Island Southern Region (4A), Banding Island Resort (5A) and Banding Island Northern Region (7A) were clearly predominated by sandy type size. No station was predominant by silt type size in which the highest percentage approximately 11.90% was recorded at station 7A.

The moisture content of lake sediment varied between 43 to 60.83%. Generally, sandy type of sediments showed lower water content as compared with those of clay type of sediment. Spatial variations of physical sediment characteristic for the present study are summarized in Table 2.

The sediments sample of Temenggor Lake were slightly acidic (pH around 6). The low pH of the sediments in Temenggor Lake might be attributed to high organic matter and carbon content. The lowest pH value was obtained at Mohd Shah Resort (3A) with pH of 6.42. The findings of this study has shown that the mean pH value in lake sediment are better than those previously reported for Chini Lake, Malaysia with pH of 4.8 to 5.5 (Ebrahimpour and Mushifah, 2008).

The high EC value (86 µScm^{-1}) was measured at Station Mohd Shah Resort (3A) and low EC value (35 µScm^{-1}) at the northern region of Banding Island (Station 7A). The low levels of electrical conductivity especially at northern region maybe due to receiving anthropogenic from Royal Belum Temenggor input as most of the discharges probably have high amount of organic matter (dissolved and suspended). Since the dissolved organic matter in water probably is not an electrolyte and hence the highest content does not conduct electricity (Sayok *et al*., 2009). The spatial variations of chemical sediment characteristic in Temenggor Lake are summarized in Table 3.

Total organic carbon (TOC) content was recorded in range of 0.07 to 0.62%. There are indications that highest TOC levels in sediments at station Mohd Shah Resort (3A) are a significant impact of fish farming operations at the study sites. Most common environmental impact of cage based aquaculture is the organic loading through from deposition of organic-rich particulate matter (from feces or uneaten food pellets) into the bottom of lake (Caroll *et al*., 2003). It might be attributed to the raw human feces as built conventional septic tank of sanitary system and improper domestic wastes treatment from resort as well.

According to Kumary *et al*. (2001) in those areas where organic pollutant is high, organic carbon level often exceeds 5%. Recent percentage of organic carbon in Temenggor Lake can be considered low since highest concentrations at station 3A still behind low of excess limit. The distribution of total organic carbon was found to be closely related to the distribution of high percentage clay content. Statistical analysis showed that there were significant difference (ANOVA, $p<0.05$) for TOC in lake sediment between sampling stations.

Total organic matter (TOM) content was recorded in the ranged of 0.20 to 1.83%. The highest concentration was recorded at Mohd Shah Resort (3A). High level of organic matter recorded at station 3A indicated that this area have experienced receiving much effluent discharge either from septic system or fish farming operations. Statistical analysis showed that there were significant differences (ANOVA, $p<0.05$) for organic matter in sediment between sampling stations.

Total hydrocarbon (THC) content was recorded in the ranged of 0.01 to 0.38%. The low hydrocarbon concentrations in this study could indicate that it came from natural sources and to a very less extent from the refined petroleum from the numerous boat traffics (Davies and Abowei, 2009). According to Ezekiel *et al.* (2009) the major attribution either increases or decreases in hydrocarbon concentrations had come out from oil spillage rather than climatic conditions. Statistical analysis showed that there were no significant differences (ANOVA, $p>0.05$) in the total hydrocarbon content between sampling stations.

The metal concentrations in the Temenggor Lake's sediment were compared with the Canadian Environmental Quality Guidelines for freshwater sediment based on the Interim Sediment Quality Guideline (ISQG) and Probable Effect Level, PEL (CCME, 1999). Generally, all metals concentrations studied in Temenggor Lake's sediment can be considered as low level and within the natural concentration which is below probable effect level.

The metals concentrations in lake sediment were found in the following order Fe > Mn > Pb > Cr > Zn > Cu > Cd. All metals in sediments were expressed as µg g^{-1} except for iron, where it is expressed as mg g^{-1} due to its high concentrations in the sediments. The mean of heavy metals concentration are summarized in Table 4.

Iron appears in the lake sediments as the most abundance and major element for all sampling station in the Temenggor Lake. This is probably due to soil composition of Peninsular Malaysia which mainly consists of laterite which is iron and aluminium-riched content reported by Aleva (1994) and cited by Shuhaimi-Othman *et al*.,(2009).

Table 4: Mean of heavy metals concentration (µg g^{-1} dry wt) in sediment of Temenggor Lakes.

	Cd	Cr	Cu	Fe*	Mn	Pb	Zn
Min	0.04	4.40	3.60	5.41	44.02	9.01	1.83
Max	0.34	15.60	6.80	16.03	55.80	26.80	32.40
Mean	0.20	14.01	5.02	9.87	51.20	15.40	10.61
Std Deviation	0.15	12.95	1.20	3.62	4.60	0.75	10.05
CCME (1999)	0.60	37	35.7	-	-	35	123
PEL	3.5	90	197	-	-	91.30	315

*concentration in mg/g dry wt., PEL – Probable Effect Level

The source of Cd and Pb in sediments could be attributed to spills of leaded petrol from boating activities which are the main mode of transport in Temenggor Lake. In addition, dust which holds a huge amount of lead from the combustion of petrol in automobile cars enhanced the increase of content (Saeed and Shaker, 2008) especially closely related to traffic road on Banding Island Bridge. In fact, the findings in this study for Pb concentrations still can be considered low as compared to those reported by Lau *et al*. (2006) for Logan Bunut Lake, one of the natural lakes in Malaysia 20 – 28 $mgkg^{-1}$.

The concentration of zinc in sediment samples of Temenggor Lake was probably due to considerable amounts of zinc leached from protection plates of boats containing the active zinc (Shuhaimi-Othman *et al*., 2009) especially at station Banding Island Public Jetty and Mohd Shah Resort. Moreover, this element is well known as essential metal probably come out from discharge area as waste material likewise has shown at Banding Island Resort (6A).

Nevertheless the zinc metal concentrations were still considered low in this present study, their adsorption in bottom sediment were also considered as potential toxicant (Srivastava *et al*., 2009). Thus, the present status of Temenggor Lake's sediment was reflected as clean and good quality in terms of low accumulation of zinc concentrations.

The major contaminants of Cr, Cu and Cd were found to have significant correlations among them suggesting the same source of metal pollution abundant in Temenggor Lake. The highest concentrations for those three metals were recorded at station Banding Island Southern Region (4A) while the lowest concentrations were recorded at station Banding Island Resort (5A). The high concentrations of copper at station 7A indicated that the sediment characterized by sandy clay predominant type sediments (sand and clay combined) tend to accumulate copper rather than sandy and clay sediments dominant individually (Kaki *et al*., 2011).

The capacity of adsorption of metals is in increasing order, sand<silt<clay, due to the increase in the superficial area or to the content of minerals and organic matter (Barroso *et al*., 2010). The statistical analysis showed that there were significant differences (ANOVA, $p<0.05$) only for copper concentrations in sediment between sampling stations. Correlation coefficient between iron and manganese concentrations has been observed ($r=0.588$). This moderate correlation probably indicates that association of Fe and Mn were the strength of main compositions of clays (Masoud *et al*., 2011).

Iron and manganese showed a similar distribution profiles which suggests that both metals were derived from the same source. This phenomenon was reflected to similarity of highest concentrations recorded for both metals at station Banding Island Public Jetty (2A). Furthermore, the source of pollution for both metals probably come off from meteorological influences through airborne particulate matter (Ali *et al*., 2005) since station 2A was located near Banding Bridge.

The correlation coefficient between manganese and copper concentrations has been observed (r=0.752). An abundance of Mn concentrations as oxide or hydroxide formed in the lake sediment as part of the suspended matter, suggesting that Mn could play an important role in the distribution dynamic of total manganese concentrations (Abdo and El-Nasharty, 2010) especially into Temenggor Lake's ecosystems.

The correlation coefficient between chromium and sand sediment fractions has been observed at r=0.575. The correlation coefficient between lead and zinc with respect to clay type sediment fractions has been observed too (r=0.532, r=0.873 respectively). According to Tijani et al. (2005), metal element such as Pb and Zn are mostly related to geogenic inputs through meteorological influence such as precipitation, erosion or run off from catchment area into aquatic lake ecosystems.

Conclusion

Temenggor Lake can be considered as major aquatic resource in northern part of Peninsular Malaysia. Temenggor Lake's sediment size fraction analysis has shown it was predominant by sandy type size. In the present study, sediments were not polluted by heavy metals, and they seem to represent the background concentrations in this study area. The findings of sediment characteristic study clearly showed that several metals are potentials to be associated with sediment fractions and local community activities. One of the popular human activities, fish farming operations has shown negative impact on sediment lake quality especially in terms of accumulation organic carbon content. It was also identified that Mohd Shah Resort station has higher potential to be polluted area among the other sampling locations based on its high measurement on conductivity, organic carbon, organic matter and lead for metals.

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