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Preliminary study on Copper, Zinc and Iron concentration in soils from waste dumping site in Tanah Merah, Kelantan, Malaysia

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Abstract

Soil is a complex matrix and a major reservoir of contamination. It can bind many potential toxic elements such as heavy metals, and they can exist in various forms. The main objective was to characterize the soil sample in relation to heavy metal concentrations in the Tanah Merah waste dumping site. Soil samples were taken from three different locations around the waste dumping site and determined by Atomic Absorption Spectrophotometry (AAS) for Cu, Fe and Zn determination. High concentrations of Fe (9.18 mg/L) as compared to Cu (0.53 mg/L), and Zn (0.49 mg/L) were found in the soil samples but were lower than previous studies. However, early precautionary actions need to be implemented since a higher volume of waste disposal in the future might cause changes in heavy metals intensity at the waste dumping site.

1. INTRODUCTION

A dumping site is a site for disposal of waste materials by burial and is the oldest form of waste treatment. However, dumping sites are still considered to be the most popular solid waste disposal method until now. This is because waste disposal into dumping sites is one of the simplest and easiest approach practiced in managing solid waste (Tchobanoglous *et al.*, 1993). Municipal solid waste is disposed by dumping on land on most Malaysia region. It has been reported that in 2011, Malaysians produced more than 19,000 tonnes of municipal solid waste daily (Chin, 2011). It was anticipated that the amount would increase to 31,000 tonnes in 2020 per day (Anwar *et al.*, 2012). Limited availability of land for dumping encourages the uncontrolled dumping of waste, on the outskirts of city that take a large space of land. The ever-increasing waste generation shortens the span of a dumping site that more new areas are converted into disposal sites. The location of dumping sites and the methods of disposing of solid waste at a site can create serious environmental problems (Ali *et al.*, 2017). With less than 10% disposal sites being non-sanitary, heavy metal pollution has become an issue of concern. The site selection process for disposal site is considered to be one of the most complex tasks related to solid waste management systems because many factors must be taken into consideration. Examples of such factors include government and municipal funding, government regulation, social and environmental factors, concerns for public health, growing environmental awareness, decreased in land availability and increasing political and social opposition to the establishment of landfill (Erkut and Moran, 1991).

The increasing rate of population growth, improving standards of living, industrial growth and increasing commercial activities are major factors behind the increase in the quantity of waste produced around the world (El-Fadel *et al.*, 1997; Hart, 2013; Scott *et al.*, 2005). About 95% of solid waste that is generated in the world is disposed in landfills (Hart, 2013; Scott *et al.*, 2005). In Malaysia, almost all landfill areas (93%) are open dumps and only 7% are sanitary landfills (Malek & Shaaban, 2008). Different kinds of industrial, household and sometimes toxic wastes were mixed together in the same area (Scott *et al.*, 2005; Stanton and Schrader, 2001). The negative impacts of municipal solid waste to the environment cause a wide range of concern; it includes risk of explosion, odour problem, leachate seeping into surface and groundwater system, as well as, soil contamination due to heavy metal sourced from disposed waste (Avery *et al.*, 1987; Fauziah and Agamuthu, 2005). The heavy metals usage in industrial and technologies causes a lot of

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environmental issues (Tchounwou *et al.*, 2012) that could potentially post a serious risk to the human and ecosystem health. Besides, the contamination of soil by heavy metal can cause adverse effects on human health, animals and soil productivity (Smith *et al.*, 1996). Contaminated soil remediation is reported as one of the most expensive technology in environmental management. Nowadays, due to human activities, animals such as long-tailed macaques are keen to feed on food wastes in garbage bins and dumpsites area where they may easily be exposed to heavy metal elements; this habit will affect their health (Nurul Ashikin Hassim *et al.*, 2018).

The aim of this research was to assess water quality for drinking and irrigation purposes of Otukpo Local Government Area. This will involve determination of physical, biological, and chemical parameters of surface and groundwater in the research area.

2. MATERIALS AND METHODS

2.1. Study area

In this study, the sampling area was focused at Tanah Merah dumping site, Kelantan (Figure 1). The dumping site is located next to the East-West highway connecting Jeli-Machang, where it is under the jurisdiction of Majlis Daerah Tanah Merah (MDTM). It is about 7.8 km from Tanah Merah town.

Figure 1: Map of sampling locations at Tanah Merah dumping site indicated by yellow pin-points for location 1 (coordinates: 5º 47' 5.90'' N, 102º 6' 35.83'' E), location 2 (coordinates: 5º 47' 5.46'' N, 102º 6' 34.20'' E) and location 3 (coordinates: 5º 47' 7.20'' N, 102º 6' 30.78'' E) (Source: Google Earth, 2020).

2.2. Sample collection

The soil samples were collected at three different locations around the dumping site. Each of the soil samples was collected from the cores using a stainless-steel spatula, kept in a clean self-locking polybag, and labelled clearly. For soil samples, three replicates for each sample were collected at three different sub-locations. All samples were transported to the laboratory on the same day. Samples were prepared and analysed at the Faculty of Earth Science, Universiti Malaysia Kelantan's laboratory.

2.2.1 Soil preparation and analysis

The soil samples were dried based on the Tanner *et al.*, (2000) method. The samples were air-dried by drying in an air-circulating oven at 60°C for 72 hours. The dried samples were crushed in a porcelain mortar and sieved through a 2 mm wire mesh. Then, each soil sample was weighed into 5.0 g by using a digital analytical balance and placed into Erlenmeyer flask. 20 mL of extracting solution (0.05N HCl + 0.025N H_2HSO_4) was added and placed in a mechanical shaker for 15 minutes. After 15 minutes of shaking, the sample was filtered by using filter paper and diluted with extracting solution to 50 ml.

2.2.2 Cu, Zn and Fe determination

All digested soils and leachate samples were analyzed for the concentration of Cu, Zn and Fe using Perkin Elmer Atomic Absorption Spectrophotometer in the flame mode. Analysis of three metals was carried out with appropriate lamps that emit light with element-specific

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wavelength. Calibration of the instrument was performed on the basis of linear calibration curves with R^2 values between 0.999 and 1.000 for each element. All glassware used for the experiment were pre-cleaned by soaking in 10% (v/v) nitric acid solution. A blank was employed for each metal during the metal analysis to ensure that the samples and chemicals used were free from metal contaminants. The quality of the applied analytical procedures was checked with a Certified Reference Material (CRM) for soil (PACS-2) with satisfactory recoveries for Cu (106.45%), Zn (120.55%) and Fe (101.20%). According to Tokalioglu *et al.*, (2000), the recovery values for extraction/direct digestion based on the Cu, and Zn were 90.0%, 140.0% respectively.

2.2.3 Statistical analysis

Data are presented as mean ± SD (standard deviation). Paired T-test was used to test for significant differences between metal concentrations while the differences of each metal concentration between the three different locations and sub-locations were analysed by using One Way ANOVA (Tukey's Post Hoc Test). All statistical analyses were performed using SPSS version 21.

3. RESULT AND DISCUSSION

Results of the Cu, Zn and Fe concentration in soil samples were presented in Table 1. From the results, Fe concentrations were found highest (9.19 ± 4.20 mg/L) as compared to Cu (0.53 ± 0.52 mg/L) and Zn (0.48 ± 0.28 mg/L). The metal concentration for each metal studied (Fe, Cu and Zn) did not vary significantly between the three main locations but differed significantly (P<0.05) within the sub-locations (Table 1). This was probably due to soil heterogeneity resulting from variability in resources such as water, plants and physical factors such as soil particle size (Wei *et al.*, 2016).

High loading of Fe in the soil samples showed that the soils collected from the dumping site were enriched with Fe elements. This shows that Fe concentration was likely due to the waste dumping activities, which may be linked to the past disposal of foundry waste from local iron and steel industries (Akoto *et al.*, 2016). In comparison with other studies conducted by Rashidi *et al.*, (2016), the Fe levels (0.154 – 0.770 mg/L) at waste disposal areas in Malaysia were lower than in the present study. Based on Rashidi *et al.*, (2016), there are other factors that influence the accumulation of Fe, such as years of operation, tone collection of waste, and area (acre). However, the presence of high Fe could cause a serious health hazard to human such as choroiditis.

Copper (Cu) is an essential element in human metabolism and is considered to be non-toxic at 1.0 mg/L concentration (MOH, 2004; WHO, 2003). Cu is one of the heavy metals that could potentially be toxic if contained in soil with excess concentration. In this study, the Cu concentration in soils at the three locations were below 1.0 mg/L and posed no harmful effects to the environments, yet to the living organisms. Zn is an element that can be found easily in paint pigments, steel products, metal, automotive parts, roofing, packaging materials, cleaning and food products. The presence of Zn can be attributed to the disposal of batteries, fluorescent lamps (Moturi *et al.*, 2004), food wastes and burning tyres at the site (Adeolu *et al.*, 2011). According to Aucott, (2006), Zn was mostly found in the form of scrap metals but could also exist in association with fine particles. From the result obtained in this study as presented in Table 1, the concentration of Zn in the soil ranged between 0.287 mg/L to 0.593 mg/L and was the lowest as compared to Fe and Cu. Factors affecting the Zn adsorption in the soil are pH, clay mineral, organic matter, Cation Exchange Capacity (CEC) and soil type. In calcareous and alkaline soil, Zn was rarely found due to the carbonate precipitation, zinc hydroxide or carbonate and insoluble calcium zincate (Udomporn *et al.*, 2008). Basically, Zn will provide an astringent taste to water if it is exceedingly more than 3 mg/L while the stipulated limit for drinking water was below 0.1 mg/L (Oyem *et al.*, 2015). Hence, we can conclude that the Zn concentration for these 3 locations was still in a safer zone.

Table 1: Concentration of Cu, Zn and Fe (mg/L ± S.D) in the soil sample.

Location	Sub-location	Cu	Zn	Fe
1	1	30.9	26.72	3.274
	2	7.31	6.39	0.666
	3	0.901	0.35	0.309
	average	312	89.01	71.675
2	1	236.1	112.27	55.811
	2	3	0.92	1.113
	3	521.1	327.32	96.069
	average	150	81.16	30.54
3	1	9.82	7.6	1.595
	2	39.67	31.79	4.333
	3	4.21	1.88	1.111
	average	4.049	0.8	0.958
Overall	average	61.51	48.69	12.959*

Remarks: Post-Hoc: Mean metal concentrations of different sub-locations sharing a common letter for a particular metal represents no significant differences (P>0.05). Paired T-test: Asterisk (*) indicates significant differences (P<0.05) between Cu and Fe, Zn and Fe, respectively.

4. CONCLUSION

This study primarily determined the Fe, Cu and Zn element in soil from Tanah Merah Dumping site, located at Kelantan, Malaysia. Following the sample analysis, the concentration of most heavy metals considered in this study was lower as compared to other

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studies. Hence, it was concluded that the concentration of Fe, Cu and Zn measured posed no harmful effects on the environment and human. However, continuous monitoring and regular assessment of heavy metals accumulation should be conducted and expanded to the surrounding locations of the dumping site. This is to improve the field estimates of heavy metals accumulation from dumping site for public and ecosystem health. Additionally, this study also suggests the need to study geochemical fractions of metals in soils for better understanding towards the speciation, spatial distribution and risk assessment, which could provide critical information for proper management of dumping sites.

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