e-ISSN: 2289-6589

ASSESSING THE SELECTED HEAVY METALS CONCENTRATION ON PALM OIL SOIL AND FRUIT FARM SOIL

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Submission date: 30 Sept 2018 *Accepted date: 30 Dec 2018* *Published date: 30 Jan 2019*

Abstract

This study was conducted at Felda Jengka 8, Pahang in Malaysia to find out the contents of heavy metals in palm oil soil and fruit farm soil adjacent to estimate the pollution level. Four types of selected heavy metals namely Cu, Zn, Pb and Ni in different soil sampling point were collected in triplicates and analysed by Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES) after wet digestion. Contamination factor (CF) and geo-accumulation index (Igeo) were used to estimate the degree of contamination heavy metal in soil. Heavy metal concentration range were as follow; 0.910 – 2.000 mg/kg for Cu, 0.460 – 2.060 mg/kg for Zn, 0.080 – 0.220 mg/kg for Pb and 0.020 – 0.100 mg/kg for Ni. Cu and Zn concentration was found to be higher than other metal concentrations. The continuous application of chemical fertilizers possibly related to accumulation of heavy metals in soil. Results showed CF values were between moderate to considerable contaminant especially in palm oil soil. While, for Igeo values were indicated uncontaminated to fairly contaminated for the study sites. This recommends the utilization of chemical fertilizer is still in the monitoring. However, more physicochemical analyses are needed for metal analysis and determination of other heavy metal elements such as Cd, As, Se and Cr for further research.

Keywords: Chemical Fertilizer, Contamination Factor, Geo-accumulation Index, Heavy Metal

1.0 INTRODUCTION

Heavy metal may occur naturally in soil but the exposure of heavy metals from anthropogenic sources such as mining and industrial activities can enhance the concentrations of heavy metal in soil. Availability of heavy metal in soil indirectly influenced the growth of plant and activities of soil microorganisms. Thus, it will decrease the organic matter content in soil (Chibuike & Obiora, 2014). Generally, copper (Cu) and lead (Pb) are mainly generated by anthropogenic activities while nickel (Ni) and zinc (Zn) are influenced by parent material in the soils (Chen et al., 2005).

Improper use of chemical fertilizers caused the soil concentrated with heavy metal. It is because, industrial used raw materials that consist of cadmium (Cd) and chromium (Cr) for producing chemical fertilizers (Nacke, Goncalves & Coelho, 2014). This utilization leads to the accumulation of heavy metals like cadmium (Cd) and arsenic (As) (Atafar et al., 2010). The utilization of phosphate fertilizer in agricultural activities can enhance the level of Cd, As, Cr, and Pb in soil.

The exposure of heavy metal in higher concentration can influence human health and other animals, and unidentified medical treatment to outcome these health effects (Huang et al., 2007). It is important to assess the concentration of the metal uptake in soil. Numerous studies have been carried out to determine the effects of heavy metals (Atafar et al., 2010; Sulaiman, Mustaffa & Khazaai, 2016). However, most of the previous studies have been carried out at city areas and industrial areas. Thus, this study is carried out in a palm oil plantation area and fruit farm area in Felda Jengka 8, Pahang, Malaysia. This area is chosen because mostly people live in this area are entirely involved in the agricultural practices mainly related to rubber plants and palm oil (Manan, Sulaiman, Alias & Laiman, 2017).

2.0 METHODOLOGY

2.1 Study Site

The sampling sites are located in Felda Jengka 8, Pahang, Malaysia (Figure 1). Several types of pesticides and chemical fertilizers have been extensively used for agricultural activities in this area. Fertilizers upgrade the quality of agricultural products as well as increase the productivity. The types of fertilizers that generally used in agricultural activities comprise of organic and inorganic fertilizer.

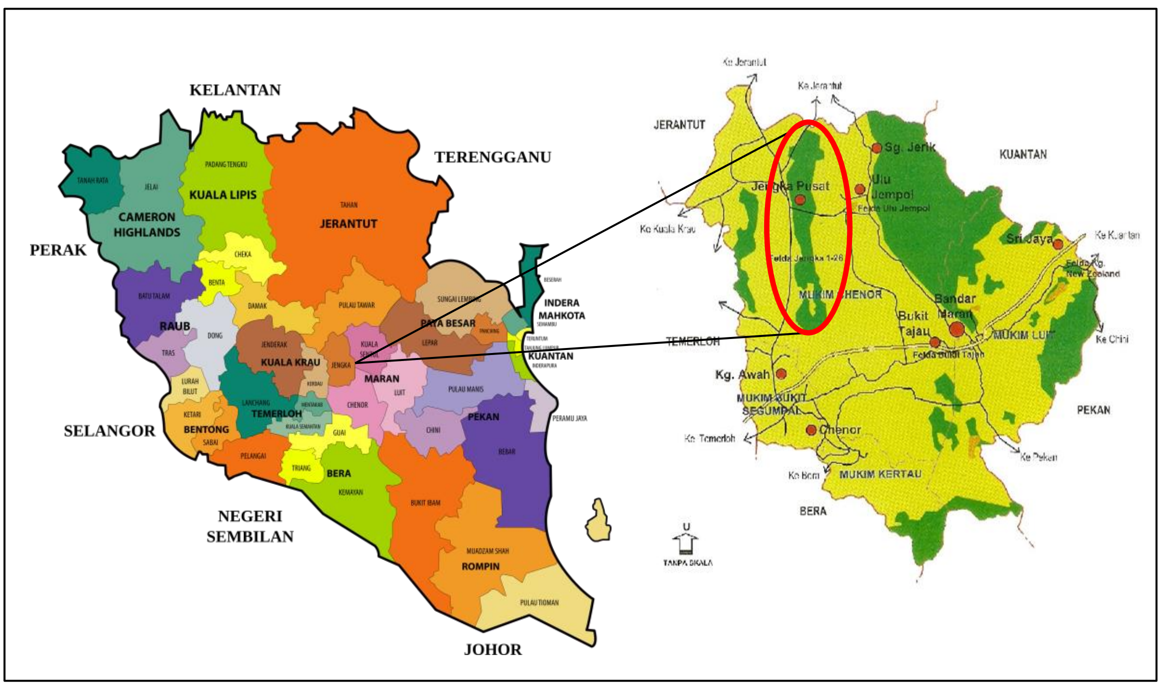

Figure 1 Location map of study site in Jengka, Pahang, Malaysia

2.2 Sample Collection and Preparation

Soil samples were collected around oil palm plantation and fruit farm area. The soil texture varied from loam to sandy loam texture. The soil samples were collected as triplicates to a depth of range 0 - 40 cm using a hand auger (Manan et al., 2017). Soil samples were collected after application of chemical fertilizers and during sunny day in late September 2016 and early October 2016 due to the accumulation of major nutrients on the surface soil. The type of chemical fertilizers applied was determined by asking the workers at the plantations. The soil samples were stored in polyethylene bags and brought back to laboratory for further analysis. Control soil sample was collected as a background value of the metal for this study and was chosen from uninterrupted area and not involved in any agricultural and fertilizer applications (Manan et al., 2017).

The leaves, roots and stone were removed from the soil samples before sieved with 2 mm sieve (Odat, 2015). The collected soil samples were air dried in room temperature for 7 days. The samples were ground using a mechanical grinder to reduce particle size. By using wet digestion technique, 1g of soil samples with 6 ml HNO_3 (65%) and 2 ml H_2O_2 (30%) were mixed in the beaker and heated on the hot plate (Altundag & Tuzen, 2011; Zhai, Kampunzu & Modisi, 2003). During heating, the samples were covered with transparent lid at constant temperature 120°C for 2 hours to allow the samples completely solubilization (Marin, Lacrimioara & Cecilia, 2011).

Then, the soil samples were filtered through qualitative filter paper, Whatman 42 into a 50 ml volumetric flask. The samples then were diluted with deionized water to the mark in the volumetric flask. Nitric acid (HNO_3) was used to acidify the soil samples to pH less than 2 and the temperature of refrigerator was set at 4°C for preservation to avoid or to minimize biological, chemical or physical variations that can happen between period of collection and analysis (Manan et al., 2017).

2.3 Heavy Metal Analysis

Metal content in the soils sample was determined by Inductively Coupled Plasma-Optical Emission Spectrometer (Agilent Technologies 5100 ICP-OES). The calibration standards solution was prepared by diluting the stock multi-elemental standard solution 100 mg/L to detect the presence of selected heavy metals (Cu, Zn, Pb and Ni). The standard solution was prepared from 100 ppm diluted into 0.5, 1.50, 2.50, 3.50 and 4.50 ppm respectively. The same method also applied for control soil. Quality assurance and quality control (QA/QC) is necessary to produce reliable and descriptive data (Praveena & Aris, 2012; Sulaiman et al., 2016). Each sample was conducted by three replications. Metal contents in the standard reference materials were determined as suggested by the World Health Organization (WHO) for QA/QC to verify the accuracy and precision of the digestion procedure and subsequent analyses.

3.0 RESULT AND DISCUSSION

3.1 Metal Concentration

Four metals (Cu, Zn, Pb and Ni) were selected for determination purposes in this study. Table 1 shows the concentration of heavy metal in soil samples in mg/kg. The concentration of Zn at fruit farm soil had the highest value for each point of soil samples as expected. In palm oil soil, the heavy metal concentration range for the studied metals were observed as follows, 0.910 – 2.000 mg/kg for Cu, 0.020 – 0.050 mg/kg for Ni, 0.460 – 1.580 mg/kg for Zn and 0.080 – 0.220 for Pb. For the fruit farm soil, the heavy metal concentrations were as follows, 0.027 – 0.100 mg/kg for Ni and 1.246 – 2.060 mg/kg for Zn. Both Cu and Pb metals were not detected in the fruit farm area.

According to (Rahman & Zaim, 2015), the widespread of Cu and Zn on the crops due to the application of large amount of pesticides and organic and inorganic fertilizers in intensively farmed areas. This suggests that agricultural activities can spread heavy metal to the environment and cause the accumulation of metals in certain tissue in the human body and will become toxic even in low doses. Even though toxic level of Cu can occur naturally in some soils, but the anthropogenic activities through mining, smelting, agriculture and waste disposal technologies may enhance the level of concentrations (Lima, Cardoso, Guerreiro & Pimental, 2006).

Long term application of organic fertilizers also can give side effect in soil. The accumulation of salt, nutrient and heavy metal in agricultural soils would influence the plant growth, soil organisms, water quality, animal and human health (Chen, 2006). The concentration of nutrient also can affect the plant growth where top soils need to contain enough nutrients like phosphorus (P), potassium (K) and iron (Fe) to ensure plant growth. The fertilizer was used to the plant to give sufficiency nutrient but it was one of the sources of the heavy metal in term of anthropogenic (Su, Jiang & Zhang, 2014). The level of nitrogen, phosphorus, calcium, and magnesium became lower due to high acidity of soil.

Table 1 Concentration of Selected Heavy Metals in Soil Samples in Mg/Kg (Mean±SD)

Metals	Range concentration (mg/kg)		
	Palm oil soil	*Fruit farm soil*	*Control soil*
Cu	0.910 – 2.000 ± 0.970	NA	0.760 ± 0.340
Ni	0.020 – 0.050 ± 0.023	0.027-0.100 ± 0.042	0.030 ± 0.010
Zn	0.460 – 1.580 ± 0.680	1.246-2.060 ± 1.102	0.850 ± 0.290
Pb	0.080 – 0.220 ± 0.100	NA	0.070 ± 0.040

***NA= not available, SD = standard deviation**

3.2 Contamination Factor (CF) and Geo-accumulation Index (Igeo)

The contamination factor is applied to quantification and indicates the level of contamination in the soil samples (Omotoso & Ojo, 2015). The CF is the ratio between concentration of element in soil and concentration of background value that applied in this study. If CF below than one ($CF < 1$), it classed as lower contamination; moderate contamination if CF was equal to one or below than three ($1 \leq CF < 3$). The soil was indicated as considerable contaminant when CF value was equal to three or six and above ($3 \leq CF \leq 6$) and very high ($CF > 6$). The CF of metal in soil can be calculated using equation (1) as follows (Mmolawa, Likuku & Gaboutloeloe, 2011):

$$CF = Cm/Bm \qquad (1)$$

It can be measured by the ratio of concentration of element in the sample (Cm) divided by local background value of that metal (Bm). Table 2 shows the CF values for soil samples in the study sites. CF in the study area ranges between 2.63 – 5.44 for palm oil soil and 1.73 – 1.83 for fruit farm soil. The CF value for Zn shows the highest value among the other metals which is 5.44. This indicates considerable contaminant by Zn concentration for palm oil soil. Meanwhile, the CF values for fruit farm soil indicated moderate contamination for Ni and Zn concentration.

The pollution index of heavy metals in agricultural soils were identified by using Igeo introduced by (Bassey, Ama, Esien & Alex, 2015; Omotoso & Ojo, 2015; Shafie et al., 2013). Geo-accumulation was used to compare the concentration of contaminant by trace metal in sample with the background concentration purely (Omotoso & Ojo, 2015). The values geochemical background of the metals in soil was derived from Department of Environment (DOE) (Ibarahim, 2009). The Igeo of metal in soil can be calculated using equation (2) (Bassey, Ama, Esien & Alex, 2015; Omotoso & Ojo, 2015; Shafie et al., 2013):

$$\text{Igeo} = \log_2(C_x/1.5\text{Bn}) \quad (2)$$

Where;

Igeo = geo-accumulation index of quantitative measure
C_x = Measured concentration of heavy metal in
Bn = Geochemical background value of element metal
1.5 = variations of the background data

According to (Bassey, Ama, Esien & Alex, 2015; Omotoso & Ojo, 2015; Salmanighabeshi et al., 2015; Shafie et al., 2013), Igeo value suggests the degree of heavy metals contamination as uncontaminated (Igeo ≤ 0), uncontaminated to fairly contaminated ($0 \leq$ Igeo ≤ 1), fairly contaminated ($1 \leq$ Igeo ≤ 2), fairly to high contaminated ($2 \leq$ Igeo ≤ 3), highly contaminated ($3 \leq$ Igeo ≤ 4), highly to very highly contaminated ($4 \leq$ Igeo ≤ 5), and very highly contaminated (Igeo > 6).

Table 2 indicates the Igeo values for soil samples in the study locations. Results showed that the Igeo value was less than two, with values less than zero of minimal Igeo. The Igeo value for palm oil soil indicates fairly contaminated by Zn, Ni, Cu and Pb were classified as uncontaminated to fairly contaminated. Meanwhile, at fruit farm soil the Igeo value indicates uncontaminated with value less than zero were for Ni and Zn. Mamat, Yimit, Ji & Eziz (2014) stated that the different value of heavy metal compare to geochemical background value was influenced by combination of natural geologic background and human activity.

Table 2 Contamination Factor (CF) And Geo-Accumulation Index (Igeo) for Selected Metals

Soil samples	Ni	Zn	Cu	Pb
Contamination factor (CF)				
Palm oil soil	5.00	5.44	2.63	3.14
Fruit farm soil	1.73	1.83	NA	NA
Geo accumulation index (Igeo)				
Palm oil soil	1.00	1.09	0.53	0.63
Fruit farm soil	-7.379	-4.401	NA	NA

4.0 CONCLUSION AND FUTURE WORKS

From this study, the palm oil soil was dominated by Cu concentration while the highest concentration in fruit farm soil was Zn and perhaps related to the application of chemical fertilizer. However, the concentration of heavy metals in both types of soil samples does not exceed the WHO permissible limit. The CF value for soil samples in this study was less than 6 which signifies that soil around oil palm plantation and fruit farm area are not highly contaminated by selected metals. The palm oil plantation soil and fruit farm soil do not indicate serious pollution and toxicity problem.

The quantity of chemical fertilizers that used to the study sites should be controlled to avoid soil toxicity. Future study should consider the more variety of agricultural soil available and evaluate more toxic heavy metals for example Cd, As, Se and Cr in order to determine the potential contaminated to soil.

Acknowledgement

The corresponding author wishes to acknowledge UiTM for financially sponsors this work through a research grant (iRAGS) 600- RMI/iRAGS 5/3 (16/2015).

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