Determination of Heavy Metals Deposition from Palm Oil Mill

Noor Azimah Darus
Salwa Adam

ABSTRACT

Palm oil mills nowadays will affect the environment as it will produce smoke and fumes in its operation by using palm waste materials like fiber and shell as fuel energy was the main factor contributing to the emission of ash. This ash will fly together with the smoke and known as fly ash. Four radius areas recovered which were north, south, west and east of palm oil mill with five different distances. The objective of this study was to determine the concentration of heavy metal in airborne deposited and soil located at four areas of study (north, south, east and west) of the palm oil mill at FELCRA Nasaruddin Bota Perak which focuses on deposited airborne and soil sampling. The samples were analyzed using the X-Ray Fluorescence (ED-XRF).Overall, the pattern of variation in concentration (mg/kg) of airborne deposited elements in all distance at all direction showed that the highest concentration (mg/kg) were manganese (Mn), zinc (Zn) and iron (Fe). Meanwhile, the lowest concentration (mg/kg) were mercury (Hg) and cobalt (Co). In the soil sample, the pattern of variation in concentration (mg/kg) of elements at all distance in all direction showed that the highest concentration (mg/kg) were manganese (Mn), zinc (Zn), vanadium (V) and iron (Fe). Meanwhile, the lowest concentration (mg/kg) were mercury (Hg) and cobalt (Co). The elements concentration in soil accumulation is depended on the fertilizer application, water runoff and soil structure.

Keywords: *Fiber, Shell, Heavy metal, Palm oil mill, Fly ash*

Introduction

The palm oil industry in Malaysia was a success story and one of stationary source. Unfortunately, absence of proper control resulted in excessive smoke and particles emission. So, from this situation, this study was conducted to evaluate the level of heavy metal that was deposited from the palm oil mill and its effects to the oil palm planting surrounding the mill because as know, palm oil is the main production of Malaysia and the implementation of Roundtable on Sustainable Palm Oil (RSPO) to increase the yield of oil palm. However, there was limited research and data about heavy metal deposition especially from palm oil mill. It is difficult to survey air quality status of smoke emission from palm oil mill to four radius study area because of wind speed and direction, temperature, rainfall and humidity

Heavy metals such as cadmium, lead and mercury are common air pollutants and are emitted mainly into the air as a result of diverse industrial and human activities. Nowadays, heavy metal is causing concern due to the potential effects on human health and the possible of long-term sustainability of food production in impure areas (Zarcinas *et al.*, 2004).

According to Mohd Yaccob *et al.* (1989), a large number of palm oil mills will affect the environment as it will provide smoke and fumes in its operation of extracting oil. Smoke and fumes released by such palm oil mills are usually visible from a far. So, it will affect the soil, oil palm planting and workers. The utilization of palm waste materials like fiber and shell as fuel energy is the main factor contributing to the emission of pollutants because it will provide ash. This ash will fly together with the smoke and known as fly ash. According to Subramaniam *et al.* (2008), the potential impact of fly ash is contributed to under eco – toxicity impact. It contains minerals and also traces of metals such as Al, Mg, Cr and Fe which are emitted to the soil when the ash is administered to the ground. Mohd Yaccob *et al.* (1989) stated that, in order to obtain atmospheric emission level contributed by the palm oil mills, observation and awareness should be carried out by the Department of Environment Malaysia (DOE) and Malaysia Oil Palm Growers Council (MOPGC) to palm oil mill.

The objectives of this research are to determine the concentration of heavy metal in airborne deposited and soil located at four area study (north, south, east and west) of palm oil mill and to analyze the elemental composition present in the palm oil mill fly ash.

Materias and Method

This study was conducted in the field and also in the soil and environment laboratory. Different number of distance were considered for four radius areas of plantation area which were 0.1 km, 0.5 km, 1 km, 2 km and 3 km distance from the palm oil mill. Data collection carried out depends on the parameters of the study. The parameters were as follow:

A. Fly ash sampling

Data collected at four different stages location downstream of the palm oil mill boiler. The samples were named M1, M2, M3 and M4. M1 was a first stage in multidust cyclone followed up by M2 and M3. M4 was the final stage of fly ash retained in the multidust cyclone before emitted to the atmosphere. Oil palm fiber and shell were also collected as samples to determine the concentration of elements.

B. Airborne deposited sampling

Airborne deposited that accumulated at the oil palm tree over three years period simultaneously were studied. The airborne was collected at every point of distance. The debris was collected between oil palm frond and trunk.

C. Soil sampling

Soil was taken using auger 15cm. The soil sampling collected at every point of distance in each direction.

In the laboratory study, 10 elements of heavy metal were observed (Arsenic (As), Nikel (Ni), Zinc (Zn), Iron (Fe), Vanadium (V), Potassium (K), Manganese (Mn), Cobalt (Co), Copper (Cu) and Mercury (Hg)). The samples from the field study were dried in the drying oven at 60°C for 24 hours to ensure that no water exist in the airborne and soil samples. Drying was carried out before XRF procedure. The XRF is used to analyze heavy metals deposition in the airborne deposited that accumulate at the oil palm tree and soil sample. The media being sampled may be placed in either an 8-ounce glass container or a clean, unused zip-closure plastic bag. Before XRF takes place, the sample must be in pellet size. One sample (one pellet) of one element took about 100 seconds to analyze.

Results

A. Elements concentration content in oil palm shell and oil palm fiber

Figure 1 showed, among all the elements concentration, potassium (K) showed the highest concentration (12850 mg/kg) while mercury (Hg) and cobalt (Co) showed the least concentration (0.02 mg/kg and 0.19 mg/kg). Figure 2 showed the percentage of elements concentration in oil palm fiber. Potassium (K) recorded the highest concentration (61400 mg/kg) while cobalt (Co) and mercury (Hg) showed the lowest percentages concentration (0.39 mg/kg and 0.03 mg/kg)

B. Concentration (mg/kg) of ash in multidust cyclone

Figure 3 showed the total concentration (mg/kg) of all elements in four stages of multidust cyclone. Iron (Fe) showed the highest concentration (mg/kg) in ash (1294.15 mg/kg) while mercury (hg) showed the lowest concentration (0.02 mg/kg).

C. Airborne sampling: Overall performance of 10 elements.

The trend of change in concentration (mg/kg) of elements in all distances (0.1 km, 0.5 km,.1 km, 2 km and 3 km) at all directions (north, south, east and west) showed that the highest elements concentration (mg/kg) were manganese (Mn), zinc (Zn) and iron (Fe). Meanwhile the lowest concentration (mg/kg) were mercury (Hg) and cobalt (Co). Mostly all elements in airborne deposited that accumulate at oil palm tree was 0.1 km from the palm oil mill as showed in Appendix 1.

D. Soil sampling: Overall performance of 10 elements.

Appendix 2 showed the overall pattern of variation in concentration (mg/kg) of elements at all distances (0.1 km, 0.5 km,.1 km, 2 km and 3 km) in all directions (north, south, east and west) showed that the highest concentration (mg/kg) were manganese (Mn), zinc (Zn), vanadium (V) and iron (Fe). Meanwhile the lowest concentration (mg/kg) were mercury (Hg) and cobalt (Co). The elements concentration in soil accumulated was dependent on the fertilizer application, water runoff and soil structure and also airborne deposited on the soil.

Discussion

In this study potassium (K) shows the highest percentages of concentration (mg/kg) which contributes to the 98% of elements in oil palm fiber. High concentration (mg/kg) of K elements in the fiber is due to the application of fertilizer and herbicides in the field. Fertilizer is applied to the area in a large amount because of the soil structure. The soil in FELCRA Nasaruddin Belia, Bota, Perak was mostly of the peat soil. So, a large amount of fertilizer is needed to fertilize the soil.

In FELCRA Nasaruddin palm oil mill, multidust cyclone in the boiler was used to control particulate matter produce from the fiber and shell burning process. Fiber and shell were used to supply energy for mill operation that contributed to ash being produced in the palm oil mill operation. Result showed the highest concentration (mg/kg) of iron (Fe) 1294.15 mg/kg or 0.25%, while mercury (hg) showed the lowest concentration 0.02 mg/kg. According to the study of Rashid *et al.* (1987), several elements were found to be much higher in concentration in the ash sample. The result on iron (Fe) was 1.46% and arsenic (As) 17.9%. This result is different from the FELCRA Nasaruddin palm oil mill study because the use of multidust cyclone in FELCRA Nasaruddin palm oil mill boiler is much better and efficient than in the Rashid *et al.* (1987) study. The high concentration of Fe, Zn, K, Mn and Cu in the ash could infer that these elements were in the submicron sized particles.

A study conducted by Nugteren *et al.* (1999) showed the chemical composition of the used fly ash that was produced from the refinery plant. This data recorded that the concentration of As was at 27.7 ppm, Co (66.1 ppm), Cu (214 ppm), Ni (138 ppm), V (320 ppm) and Zn (217 ppm). Compared to the FELCRA Nasaruddin Bota, Perak palm oil mill, chemical compositions of the total fly ash for four stages produced from the mill were As (7.13 mg/kg), Cu (223 mg/kg), Ni (15.83 mg/kg), Co (0.49 mg/kg), V (31.81 mg/kg) and Zn (249.01 mg/kg). It shows a different concentration especially in As, Co, Ni and V. The change may occur because of the uptake of fertilizer and pesticide of fruit bunches.
In this study it showed that potassium (K) has the lowest concentration (-1189 mg/kg). Compared to the Soil test done by White (2010), potassium elements in the soil at FELCRA Nasaruddin Belia is very low. This is because the structure of soil in FELCRA Nasaruddin Belia is influenced by the amount of K fertilizer. The soil at FELCRA Nasaruddin Belia is of peat soil. The characteristic of peat soil are poor storage qualities, water table is always high and occurs at or near the surface and nutrient deficiency. Peat soil has poor nutrient retention capacity characteristic especially for potassium (K). This is because, acidity from peat soil contributes to the leaching of elements. High acidity will contribute to the high leaching that causes higher concentration of elements being leached out. A lot of fertilizer applications are needed to increase amount of K.

In soil sampling, the highest number of concentration (mg/kg) of Fe was recorded. Fe is the fourth most abundant elements in the earth crust. Besides, Shamsuddin (2006) stated that peat soil at low pH has a high amount of Fe and this element exists in a strong complex form with organic matter line humic and fulvic acids. This means that Fe element was already present in peat soil.

The fluctuation of elements at every distance (0.1 km, 0.5 km, 1 km, 2 km and 3 km) in each direction depended on the particle size of the elements, age of tree that airborne deposited accumulate, wind speed, rainfall and wind direction. Heavy rainfall may result in the runoff of airborne, dust and fertilizer trapped at the oil palm tree. Meanwhile, increase in the age of the oil palm tree will increase the airborne deposited that accumulate at the tree.

Conclusion

Zinc (Zn), manganese (Mn), iron (Fe) and vanadium (V) showed the highest result of concentration (mg/kg) at all levels of distance (0.1 km, 0.5 km, 1 km, 2 km and 3 km) of airborne deposited and soil sampling. This is because the adsorption strength of humic substances in peat soil for elements ions were Fe > Zn > Mn. Fluctuation of concentration in every level of distance is influenced by the wind speed and particle size of the elements. Mercury (Hg) concentration in soil and airborne was still below the recommended value.

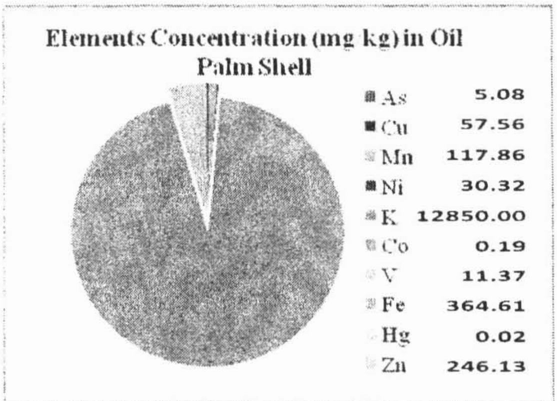

Figure 1 : Elements concentration (mg/kg) in oil palm shell

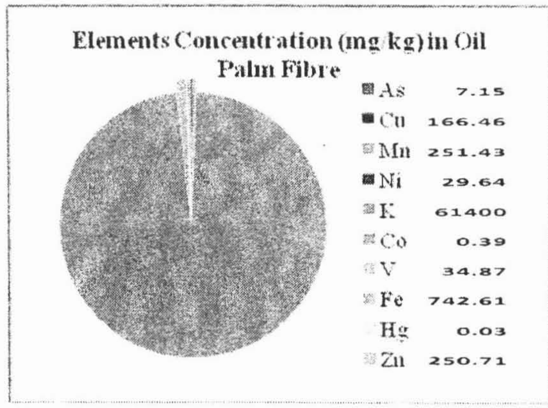

Figure 2 : Elements concentration (mg/kg) in oil palm fiber

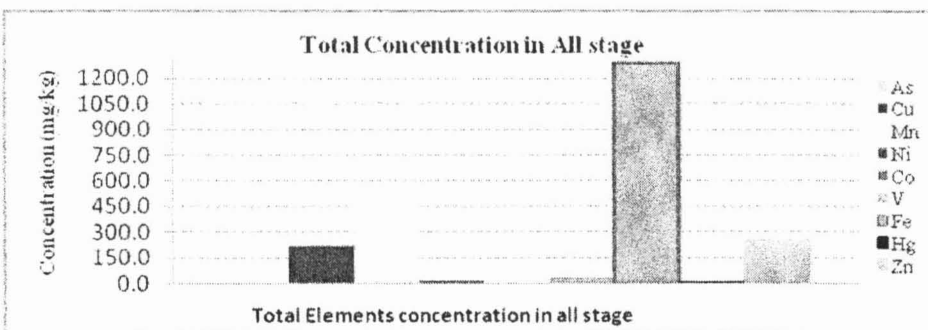

Figure 3 : Total Concentration (mg/kg) of four stages of ash in multidust cyclone

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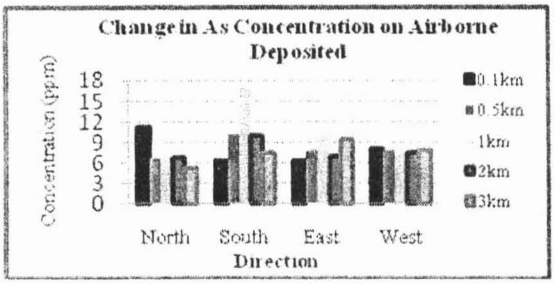
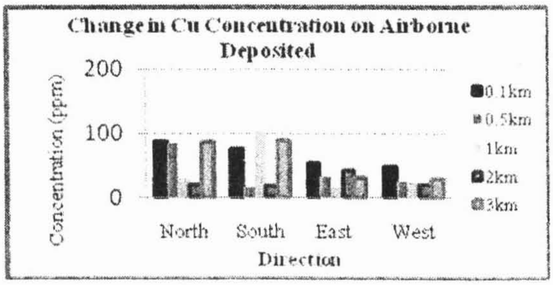
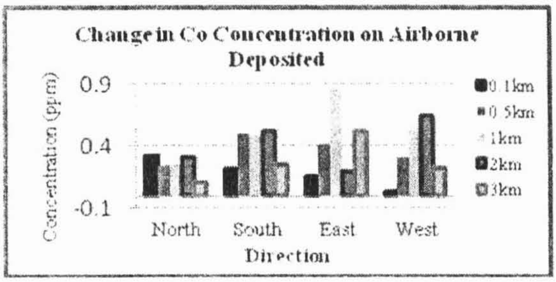
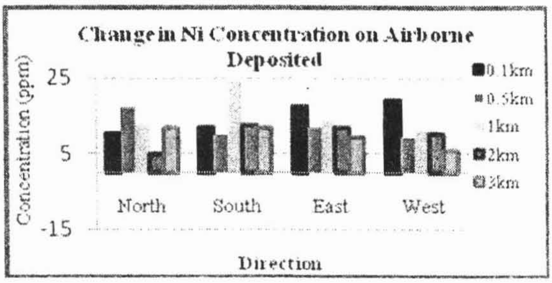
NOOR AZIMAH DARUS, SALWA ADAM. Universiti Teknologi MARA Pahang.

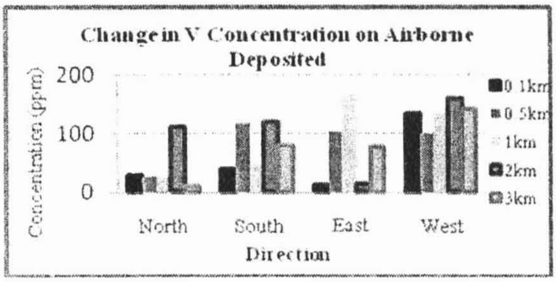
APPENDIX 1 Airborne sampling: Overall performance of 10 elements.

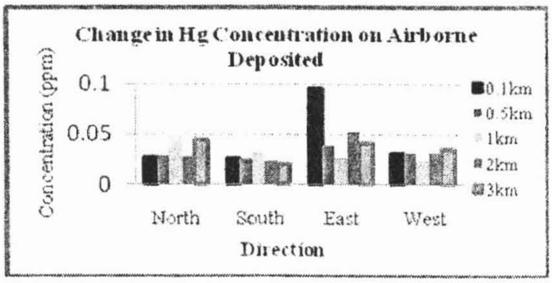


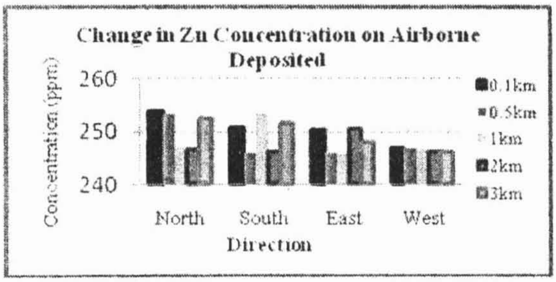


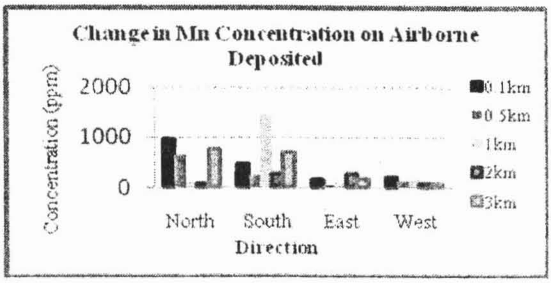


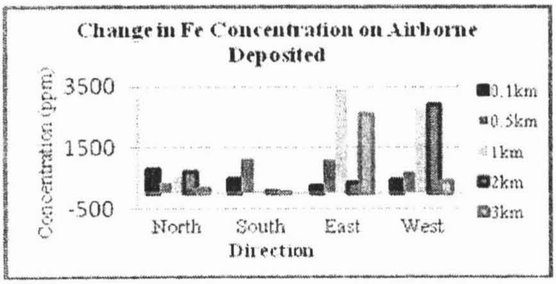


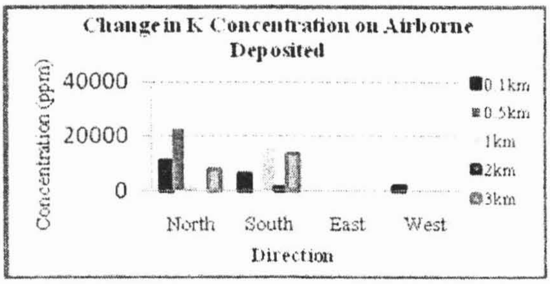












APPENDIX 2 Soil sampling: Overall performance of 10elements.