THE CONCENTRATION OF HEAVY METAL CONTENT AT DIFFERENT OPERATIONAL ZONE ON PEAT SOIL AT FELCRA SRI MENDAPAT

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MOHAMAD NAZMI BIN MOHAMAD SHARIF

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LIST OF ABBREVIATION

Cu	Copper
Zn	Zinc
B	Boron
pH	Potential of hydrogen
Pb	Lead
Cd	Cadmium
MAC	Maximum Allowable Concentration
MPOB	Malaysian Palm Oil Board
WHO	World Health Organization
UiTM	Universiti Teknologi Mara
ICP- OES	Inductively Couple Plasma- Optical Emission Spectrometry
HCL	Hydrochloric acid
HNO_3	Nitrate acid
mm	Millimeter
cm	Centimeter
H_2O	Water
^oC	Degree Celcious

ABSTRACT

THE CONCENTRATION OF HEAVY METAL CONTENT AT DIFFERENT OPERATIONAL ZONE ON PEAT SOIL AT FELCRA SRI MENDAPAT

Heavy metals are bioaccumulation and non-degradable elements in the soil. The contamination by heavy metals in soil is one of the important issues and requires attention because heavy metals above the maximum allowable concentration will threatened to both plants and living things. I was therefore of interest to conduct a study regarding the concentration of heavy metals on peat soil at FELCRA Sri Mendapat. The soil was also analyzed for its properties such as pH and moisture. Besides that, the soil samples were collected at different operational zones such as pesticide area, frond heap, weeded circle and harvesting path. Heavy metals for which these samples were analyzed were zinc, copper, lead and chromium. Results showed that concentration of copper, lead and chromium were recorded as exceeded the maximum allowable concentration (MAC) set by World Health Organization (WHO) while zinc was recorded below the MAC. The pH of all soil samples were recorded in acid condition and a range within 3-5. Meanwhile the soil moisture for all samples was recorded in a range within 150-260 mBar. The moisture of the soil is considered dry above than 230 mBar. Most of the operational zones are under normal moisture except the harvesting path zone which is above than 230 mBar. The relationship between soil pH and soil moisture have significant difference toward heavy metal concentration.

ABSTRAK

KANDUNGAN KONSENTRASI LOGAM BERAT DI ZON OPERASI YANG BERBEZA DALAM TANAH GAMBUT DI FELCRA SRI MENDAPAT

Logam berat adalah bioakumulasi dan merupakan unsur yang tidak terurai dalam tanah. Pencemaran oleh logam berat dalam tanah adalah salah satu isu yang penting dan memerlukan perhatian sekiranya ia berada di atas kepekatan maksimum yang dibenarkan akan mengancam kepada tumbuhan dan hidupan semuladi. Oleh itu saya berminat untuk menjalankan kajian mengenai kepekatan logam berat di dalam tanah gambut di Felcra Sri Mendapat. Tanah tersebut perlu dianalisis untuk mendapatkan nilai pH dan kelembapan sebenar. Di samping itu, sampel tanah telah diambil mengikut zon operasi yang berbeza seperti kawasan racun perosak, timbunan pelepah, bulatan merumpai dan laluan menuai. Logam berat yang telah dianalisis adalah zink, tembaga, plumbum dan kromium. Hasil kajian menunjukkan bahawa kepekatan kuprum, plumbum dan kromium telah direkodkan melebihi kepekatan maksimum yang dibenarkan dan ditetapkan oleh Pertubuhan Kesihatan Sedunia (WHO) manakala zink dicatatkan di bawah kepekatan yang dibenarkan. PH semua sampel tanah telah direkodkan dalam keadaan asid dan mempunyai nilai pH 3-5. Sementara itu kelembapan tanah untuk semua sampel dicatatkan antara 150-260 mBar. Kelembapan tanah dianggap kering atas dari 230 mBar. Kebanyakan zon operasi adalah di bawah kelembapan normal kecuali zon jalan penuaian. Hubungan antara pH dan kelembapan tanah boleh mempengaruhi konsentrasi logam berat.

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Peat soil is an important ecosystem that provides a significance contribution to the agriculture sector in Malaysia. Peat soils are considered as a soil which provides little economic benefit apart from being used for agricultural activities. The total world coverage of peat soil is about thirty million hectares with Canada and Russia having the largest distribution of peat (Zainorabidin, 2010) as cited by Rashidah et al., (2012). More than sixty percent of the world's tropical peat land is found in South-East Asia (Lette, 2006) as cited by Rashidah et al., (2012). Peat is brownish-black in colour and is formed by decomposed organic matter that have accumulated over thousands of years. The characteristics of peat soil which is lack of oxygen and under waterlogged condition. Peat soil is generally very acid and deficient in nutrients particularly cu, Zn, Fe and B (Bolan et al., 2014). Under natural conditions, it is flooded and requires drainage before crop cultivation. Unfortunately, uncontrolled and excessive drainage of peat will cause the subsidence and irreversible shrinkage of the peat soil (Abu Bakar et al., 2011).

However, there are some problems on peat soil such as accumulation of heavy metal content. The high concentration of heavy metal content is known to be toxic to soil organisms as well as plant growth (Bolan et al., 2014).

The accumulation of metal element by plants are affected by several soil factors such as pH, clay content, organic matter content, concentration of trace element in soil, cation exchange capacity, soil moisture and temperature (Marina & Alexandra, 2009). The process of liming is considered for reducing the transport of heavy metals into the food chain since it is low cost practices. There are two effects of liming including increase in soil pH and contribute to calcium element. The solubility and toxicity of heavy metals such as Cadmium, Chromium, Iron, Lead, Nickel, Mercury and Zinc decrease as soil pH increases (McLaughlin, 2002) as cited by Marina & Alexandra, 2009) . The increase of negative charge on variable charge in the surface of soil makes this situation happen (Bolan et al. 2014).

High concentration of heavy metal in the soil does not necessarily imply their availability to the plants (Vodyanitskii et al., 2010). The mobility and bioavailability of heavy metals depend heavily on their physical and chemical form. The increasing of heavy metal content will give negative effects toward the soil's microorganism population, thus have significant effect on soil fertility (Asta et al., 2014).

Besides that, the contamination of heavy metal will result the environmental pressure that can reduce the biodiversity of microorganisms and affect the ecological balance. It is important to understand the relationships between acidity and heavy metal (cadmium, copper, lead and zinc) concentration in peat soil since soil acidity has an effect on the mobilization of heavy metal in the environment. The increases in the ratio of cadmium and zinc in the top soil is seen with a decrease in the soil pH and soil acidity. This shows that, soils are more acidic and sensitive to the heavy metal concentration. It can be concluded, mobilization of the heavy metal is under acid condition. Results for the copper are similar but the relationship is weaker. However the leads, the ratio tend to decrease with decrease in pH and lead remains in the soil rather than being mobilized into the stream. This reflects the association between soil lead concentration and soil organic matter content which tend to be greater in peat soil (Smeija et al., 2010).

1.2 Problem statement

Increased of peat soil remediation with heavy metals content due to various human and natural activities has led to a growing need to address environmental contamination (Bolan et al., 2014). Besides that, the discarding of domestic and industrial may contain toxic material such as Pb, Cu, Cd and Zn from insecticides and herbicides for agricultural activities. Heavy metals are very harmful because of their non-biodegradable nature and their potential to accumulate in the environment. Excessive accumulation of heavy metals in agriculture soils through waste water irrigation may also affect the food quality and safety. Besides that, increase of heavy metal content give negative effects to soil microbial population which may have direct negative effect on soil fertility (Asta et al., 2014). Furthermore, heavy metal concentration has an effect on the soil acidity. The increasing of heavy metal concentration in the peat soil is seen with a decrease in the pH value and the soils are under acid condition (Smeija et al., 2010).

Moreover, the concentration of heavy metal content has different volume at different operational zone in peat soil (Vodyanitskii et al., 2012). This is due to the process of manuring and herbicide activities. Therefore this study is purposes to determine the heavy metal content on different zone in peat soil.

1.3 Objectives

The objectives of this study as follows:

1. To determine the concentration of heavy metal content at different operational zone in peat soil.
2. To compare the concentration of heavy metal content on the peat soil to the maximum allowable concentration (MAC).
3. To determine the factors affect the concentration of heavy metal in peat soil.

1.4 Hypothesis

1.4.1 Determination of heavy metal content on different operational zone in peat soil

H^{o}: There is no significant difference on the concentration of heavy metal content at different operational zone in peat soil.

H_{i}: There is a significant difference on the concentration of heavy metal content at different operational zone in peat soil.

1.4.2 Comparison of heavy metal content on peat soils toward maximum allowable concentration

$H^{o:}$ The concentration of heavy metal content on peat soil does not exceed the maximum allowable concentration (MAC).

$H_{i:}$ The concentration of heavy metal content on peat soil does not exceed the maximum allowable concentration (MAC).

1.4.3 Determination of the factors that affect the concentration of heavy metal in peat soil

$H^{o:}$ The factors do not affect the concentration of heavy metal in peat soil.

$H_{i:}$ The factors do not affect the concentration of heavy metal in peat soil.

1.5 Significance of study

This research study could provide information on the presence of heavy metal content on different operational zone in peat soil. Besides that, purpose of this study is to identify the causes of heavy metal element that presence on different zone in peat soil. Furthermore, it can be beneficial information to Malaysian Palm Oil Board (MPOB) to being aware toward the factors that can contribute to the accumulation of heavy metal in peat soil. Moreover, there are important to know whether the heavy metal content exceeds the maximum allowable concentration (MAC) or not because it will determine the toxicity in the soil as well as on food chain. Last but not least, this would increase the awareness of planters to ensure there are no excessive of herbicides and insecticides usage.

CHAPTER 2

LITERATURE REVIEW

2.1 Peat Soil

Peat soil cover an estimated area about 400 million hectares which is 3% of earth's land area (Paramananthan, 2013). The cultivation of oil palm on peat soil is a solution to establish the rural development and also contribute to global attention particularly on a climate change perspective. However, there are two major issues related to the yield economics of oil palm cultivation on peat soil which are depth and drainability consideration. The depth of the peat soils are shallow (0 – 100 cm), moderate deep (>100 – 300 cm) and deep (<300 cm) (Paramananthan, 2013). While drainability regarding to sustainable drainage structure or condition where it is in relation to the depth of mineral subsoil level relatively than the present ground surface to the river water levels.

2.2 Distribution of Peat Soil in Malaysia

Peat is an accumulation of partially decomposed of plant sustain under condition of incomplete aeration and high water content. Peat covers widely in the tropics area, which is near the coastal plains and mostly formed in natural environments that do not allow for the quick decay of materials. Peat also form of soft soil with high organic content and difficult to sample (Rashidah, 2012).

There are several factors that contribute to the stabilization of peat soil such as water content, physical, chemical and mineralogical properties, amount of organic matter and pH of pore water (Dettmann et al., 2014). Peat sediment occurs in both highland and lowland, but highland organic soils are not cover a wide area. Meanwhile, the lowland peat covers most area in low-lying, poorly drained condition in the coastal areas.

In Peninsular Malaysia, peat soils are found in the coastal area of the east and west coasts (Huang et al., 2009). Mostly the depth of peat soil is shallower particularly near the coast and topically almost more than 20 m. Peat land at the coastal area generally elevated well above adjacent river courses (Huang et al, 2009).

2.3 Heavy Metal Content in Peat Soil

Many researches have been recorded to assess the characteristic of heavy metals in naturally contaminated soils and sediments (Dettmann et al., 2014). Organic and inorganic matter from waste deposits has a potential risk to the environment in long term through the accumulation of heavy metals (Marina & Alexandra, 2009). There are very little original heavy metals within the first decades after disposal because most of them are insoluble in the anaerobic phase of degradation of organic matter and become retained in the solid form (McCormack, 1999).

The accumulation of metal element by plants are affected by several soil factors such as pH, clay content, organic matter content, concentration of trace element in soil, cation exchange capacity, soil moisture and temperature. The process of liming is considered for reducing the transport of heavy metals into the food chain since it is low cost practices. There are two effects of liming including increase in soil pH and contribute to calcium element. The solubility and toxicity of heavy metals such as Cadmium, Chromium, Iron, Lead, Nickel, Mercury and Zinc decrease as soil pH increases (Liu, 2013). The increase of negative charge on variable charge in the surface of soil makes this situation happen (Bolan et al., 2014).

Moreover, soil environment in industrial areas are often polluted by heavy metal with various xenobiotic such as polycyclic aromatic hydrocarbons especially in the agriculture areas which surrounding with these facilities (Asta et al., 2014). The increasing of heavy metal content will give negative effects toward the soil's microorganism population, thus have significant effect on soil fertility (McCormack et al., 1999). Besides that, the contamination of heavy metal will result the environmental pressure that can reduce the biodiversity of microorganisms and affect the ecological balance.

2.4 Oil Palm Management

2.4.1 Soil and climatic requirement

The oil palm can be adapted to several of soil types because it can be tolerates the low of soil pH. However, it does not thrive at very high pH which is greater than 7.5. The soil must be well drainage because it not suitable for waterlogging condition. For climatic requirement, it requires low altitude which is less than 500 m above the sea level. Besides that, the range of rainfall must be 1800 to 2000 mm per year, but it also will tolerate the rainfall up to 5000 mm per year if the soil is properly drained. The yield will be reduced if there are less than 100 mm of rainfall per month which is more than 3 consecutive months.

2.4.2 Maintenance activities

Weeding should be carried out by hand weeding only for bag weeding either pre-nursery or main nursery. For interrow weeding, only hand weeding is allowed in pre- nursery because the row within the bags is near to each other. However, the knapsack sprayer with 5/64'' Fan- Jet nozzle can be used for spraying and the shield must be attached to the nozzle for prevention of drifts. Besides that, the spraying operator should know the correct height for spraying herbicides and avoid spraying at windy time.

Pest and disease control by using insecticide or fungicide is not recommended if nursery practices are good and seedlings are vigorous. Though, the preventive control should be taken when weather is in favour of diseases and pest development. The seedlings that are obviously undersize should be removed from nursery because the seedlings are prone to be host of disease.

The fertilizer requirement for double stage nursery should be applied based on the fertilizer schedule below:

Table 2.1 *Fertilizer Schedule*

Age of seedlings	Fertilizer applications
Bag filling	Mix soil medium with 20 gm RP/ bag
2nd month	Weekly drench with CPD 15:15:6:4 or equivalent at 15 gm in 5 litres of water for 100 seedlings.
3rd month	Weekly drench with CPD 15:15:6:4 at 15 gm in 5 litres of water for 25 seedlings.
4th month	Mix 100 gm RP/bag in soil medium for large bags. After transplanting no solid fertilizer for three weeks. Continue weekly CPD drench as per 3rd month.
5th month	10 gm CPD 12:12:17:2+TE continue weekly CPD drench if seedlings are chlorotic
6th month	10 gm CPD 15:15:6:4
7th month	15 gm CPD 15:15:6:4 + 5 gm Kieserite
8th month	20 gm CPD 12:12:17:2+TE
9th month	20 gm CPD 12:12:17:2+TE
10th month	30 gm CPD 44 or equivalent
11th month	35 gm CPD 44 or equivalent
12th month	35 gm CPD 44 or equivalent
12th month and above	35 gm CPD 44 or equivalent

2.4.3 Harvesting

The harvesting process must be followed the minimum ripeness standard:

For 8 years of palm, three loose fruits on the ground, meanwhile the older palms, and one to three loose fruits on the ground depending on the harvesting interval. All ripe bunches and all loose fruits must be harvested, collected and delivered to the mill. No palm debris is to be collected. Besides that, harvesting interval for young palms which are less than 6 years is 8-10 days. Meanwhile older palms which are more than 6 years, the harvesting interval are 10-12 days. Bunch stalk must be cut as close to the palm trunk as possible. Furthermore, the stalk must no longer than 5 cm and will be cut into a 'V' shape.

CHAPTER 3

METHODOLOGY

3.1 Location of Study

This study was conducted at UiTM Jasin, Melaka. This location is suitable to be chosen because the laboratory there equipped with sufficient equipment and tools to conduct the study such as Inductively Couple Plasma (ICP) or Optical Emission Spectrometry (OES) machine.

3.2 Preliminary Study

Preliminary study was conducted to ensure there are presences of heavy metal content on the peat soil at the estate of Felcra Sri Mendapat. Soil sample which is peat soil was taken to test the presence of heavy metal content by using ICP/OES machine and to compare with the maximum allowable concentration (MAC). The leaves of oil palm there also were taken to determine the availability of heavy metal content.

3.3 Soil Sampling

Peat soil was collected at the estate of Felcra Sri Mendapat since most of the soil there are peat soil. Besides that, the site is located nearer to the location of the study and it can make the transportation of the material become much easier.

Composite sampling is the most suitable method to conduct this research. By way of clarification, a 'sample' in this entry refers to a physical object to be measured, whether an individual or a composite, and not a collection of observations in the statistical sense.

3.4 Apparatus and Equipment

In this study, there are some apparatus and equipment for soil sampling, determination of heavy metal content, determination of soil pH and determination of soil moisture.

3.4.1 Soil sampling

To conduct for soil sampling method, the suitable equipment needs were used such as auger and plastic containers. Soil auger is the most desirable tool to be used for collecting soil samples and also it can be subdivided into a different depth of increments. While the plastic container used to store the collected soil samples.

3.4.2 Determination of heavy metal content

In order to determine the presence of heavy metal content, there are some apparatus and equipment to be used such as ICP/OES machine, grinder, pestle and mortar, oven, hot plate and analytical balance.

3.4.3 Determination of soil pH

To determine the soil pH, the equipment needed such as orbital shaker, pH meter with appropriate electrode, sample bottle 50ml with cap and pH buffer solution.

3.4.4 Determination of soil moisture

To determine the soil moisture, the equipment is soil moisture meter. This electronic device can give instant result by attached the equipment in peat soil.

3.5 Laboratory Experiment

The heavy metal content on the peat soil was tested by using ICP- OES machine. For the first step, the soil samples were digested through wet digestion method (Henryk Matusiewicz, n.d).

3.5.1 Wet digestion method

Procedures

1. 10g of soil sample was weighted and place into aluminium foil.
2. The soil samples were dried in oven at 105 °c for 24 hours.
3. Grinder was used to grind the samples and pass through 150μm sieve.
4. 0.5g of samples will weighted and put into conical flask (100cm^3). Each of samples were added with 10 ml of HNO3 and 10 ml of HCl and 10 ml deionized water. The samples need to cover with parafilm.

5. The samples were using a hotplate. During process of heating orange gases (NO^2) were revealed. The heating process will be end until there is no more gas produced.
6. After heating the samples need to be cooled. The cooled sample mixture then was filtered using funnel and filter paper.
7. The samples need to be transferred into $50cm^3$ volumetric flasks and then the samples were added with deionized water to make up $50cm^3$.
8. All the samples were be transferred into plastic bottle and kept in a chiller at 4- 6 °c.
9. Finally all the samples were analyzed by using Inductively Couple Plasma (ICP/OES).

3.5.2 Determination of soil pH

Procedures

1. 10g of a representative sample of the air- dried soil (fraction < 2mm).
2. The test sample was placed in the bottle and added two and half times its volume of calcium chloride solution (CaCl2) or water (H2O).
3. The suspension was shaken vigorously, for 30 minutes, using the mechanical shaker or mixer.
4. The suspension was stand about 30 minutes
5. The electrode was immersed into clear supernatant and the pH value will be recorded once the reading is constant.
6. The pH was calibrated – meter as prescribed in the manufacturer's manual using the buffer solutions.

7. Finally, after done using the pH meter, the electrode was immersed in distilled water to let it wet.

3.5.3 Determination of soil moisture

Procedure

1. The probe was refilled with the water until full.
2. The probe was inserted vertically into the soil half way.
3. The meter reading was varies as the probe move downward while pushing into the soil.

3.5.4 Soil Sampling

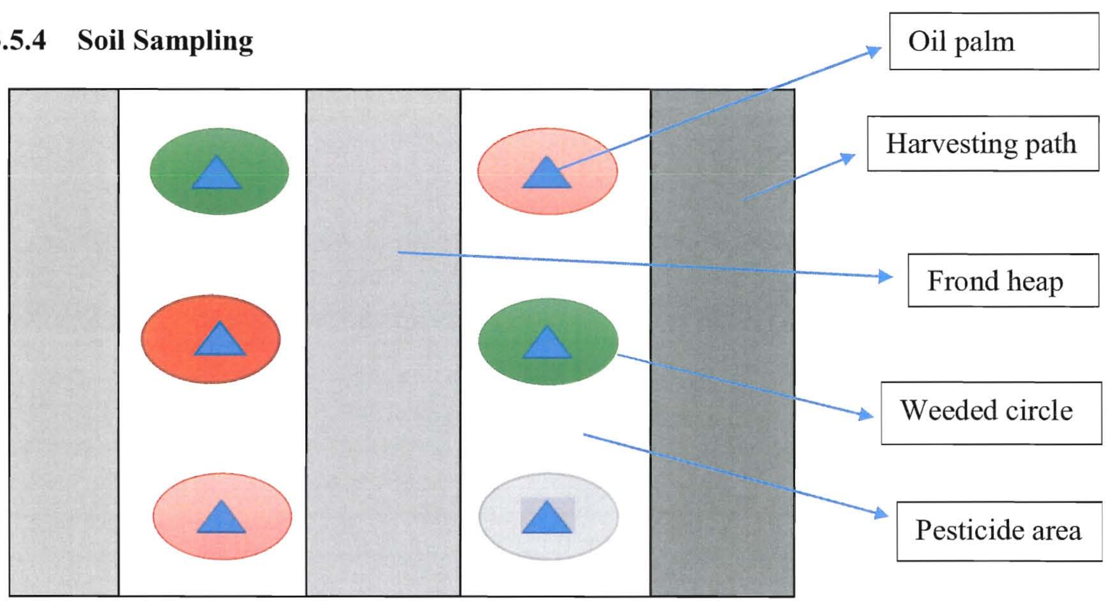

Figure 3.1 Soil sampling

3.6 Parameter

The parameter in this study consists of pH value and heavy metal content in peat soil. The heavy metal element that was focused in this study such as Cu, Zn, Cr, and Pb on the peat soil samples. Besides that, this study also focused on the factors that contribute to the availability of heavy metal such as soil pH and soil moisture.

3.7 Data Analysis

The data was analyzed by using MINITAB 16. Analysis of variance (ANOVA) was used to determine the significant of heavy metal concentration at different operational zone of peat soil which is ($p>0.05$). The data was including the content of trace element compared to the maximum allowable concentration (MAC) and the pH value for each sample. Correlation and regression also was conducted to identify the relationship between the pH value and the heavy metal content and also soil moisture and the heavy metal.

Table 3.1 *Planning Schedule*

Year	2014			2015					
Month	Oct	Nov	Dec	Jan	Feb	Mac	Apr	Jun	Jul
ACTIVITIES									
PROPOSAL									
Title									
Introduction									
Literature review									
Research Methodology									
Expected output									
Power Point Presentation									
Submission of proposal									
THESIS									
Preparation of site									
soil sampling									
Labaratory experiment and field experiment									
Data Collection									
Data Compilation									
Analysis and Discussion									
Report Writing									
Presentation									
Submission of Thesis									

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Analysis of the concentration of heavy metal content, soil pH and soil moisture at different operational zone in oil palm plantation

The concentration of heavy metal has been analyzed by using Inductively Couple Plasma (ICP) according to the type of operational zones with four replications. The element of heavy metal that have been analyzed are zinc, copper, lead and chromium. Besides that, the result for heavy metal concentrations were represent in mg/kg or ppm. Furthermore, the soil pH has been tested by using pH meter for each operational zone with four replications. Most of the soil pH gained from the different operational zones were acidic. Last but not least, the soil moisture for each zone gained at the site.

4.1.1 Concentration of heavy metal for zinc (Zn) for each operational zone

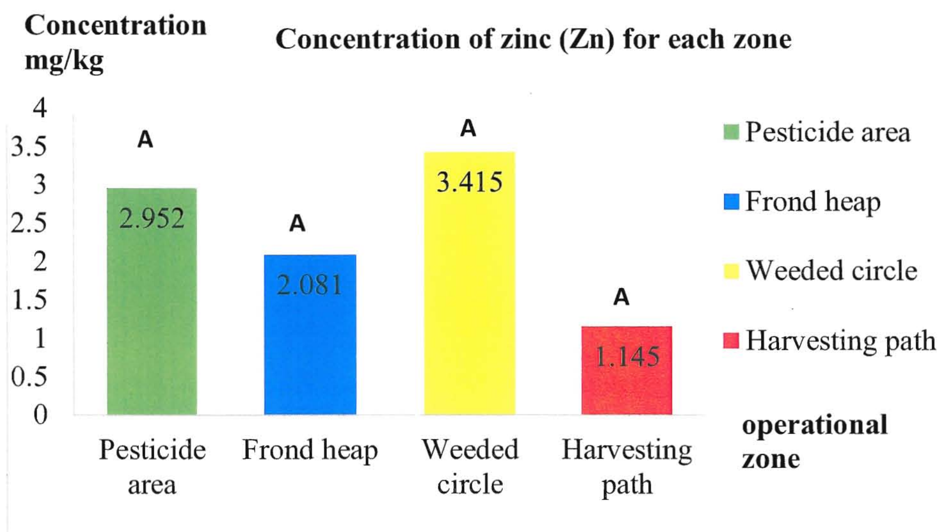

Figure 4.1 Zinc Concentration

Based on Figure 4.1 the concentrations of zinc were varies for different operational zones. The concentration of zinc element was high at weeded circle zone. It was 3.415 mg/kg or ppm which is the highest concentration of zinc compared to the other zone. Meanwhile the lowest concentration of zinc was recorded at harvesting path zone which 1.145 mg/kg or ppm. The P-Value for zinc concentration was 0.157 and greater than 0.05. Therefore, there were no significant among the operational zone. The pesticide area does not significant with the frond heap, weeded circle and harvesting path. Moreover, the graph patterns shown from the result above are not consistent.

The concentration of zinc was high at weeded circle zone because it comes from the manuring activities. Zinc is required for proper growth and development of oil palm. It was also essential in auxin metabolism (Jude & Bassy, 2012).

However if the concentration of zinc at lower rate, it can be corrected with application of zinc sulphate (Marina, 2009).

4.1.2 Concentration of heavy metal for copper (Cu) for each operational zone

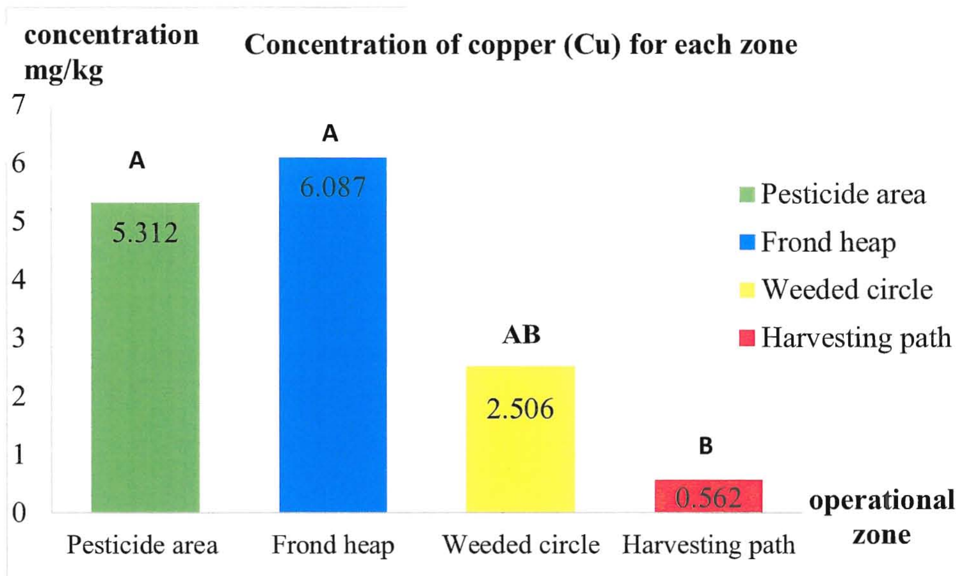

Figure 4.2 Copper Concentration

Based on Figure 4.2 the concentration of heavy metal for copper was recorded for different operational zones. The concentration of copper element was high at frond heap zone. It was 6.087 mg/kg or ppm which is the highest concentration of zinc compared to the other zone. Meanwhile the lowest concentration of copper was recorded at harvesting path zone about 0.562 mg/kg or ppm. The P-Value for zinc concentration was 0.005 which is lower than 0.05. Therefore, there was a significant difference among the operational zone. However, the pesticide area has no significant with the frond heap and weeded circle except for harvesting path.

However, weeded circle has no significant with the harvesting path. The concentration of copper in soil might be contributed by copper fertilizer, fungicide and livestock manure (Ruqia, 2015). Moreover, the abundant of organic matter with soluble organic acid lead to pronounced metalloid especially copper released from fertilizer – amended soil (Bolan, 2014).

4.1.3 Concentration of heavy metal for lead (Pb) for each operational zone

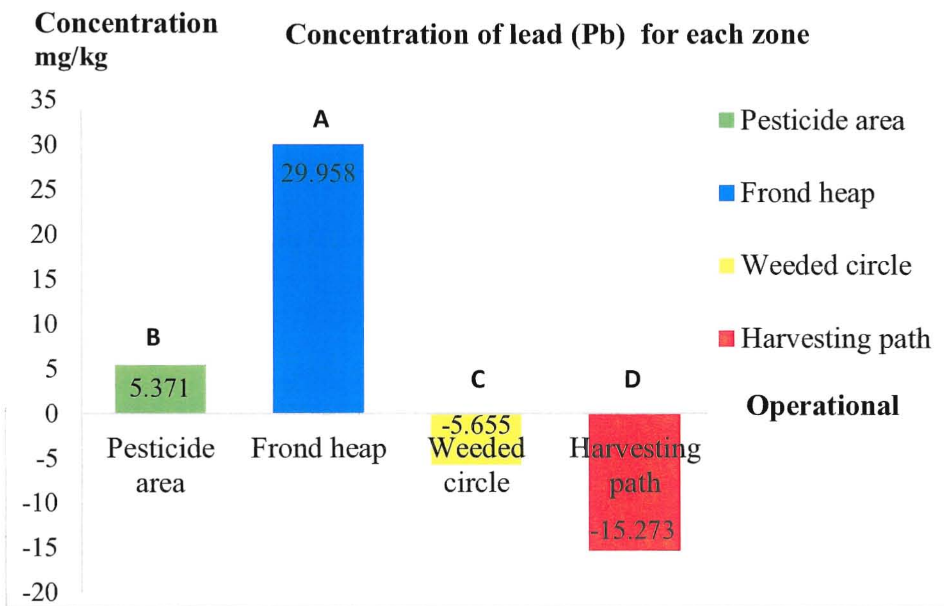

Figure 4.3 Lead Concentration

Based on Figure 4.3 the concentration of heavy metal for lead was recorded for different operational zones. The concentration of lead element was high at frond heap zone. It was 29.958 mg/kg or ppm which is the highest concentration of lead compared to the other zones. Meanwhile the lowest concentration of copper was recorded at harvesting path zone about -15.273 mg/kg or ppm. The P-Value for lead concentration was 0.000 which is lower than 0.05. Therefore there was a significant difference among the operational zone. From the Tukey test showed each of operational zone have significant differences. The major contribution of lead in soil is the weathering, chipping, lead arsenate and pesticide (Ruqia, 2015). However, lead are not essential for plant growth, they are readily taken up and accumulated by plant toxic form (Bolan, 2014).

4.1.4 Concentration of heavy metal for chromium (Cr)

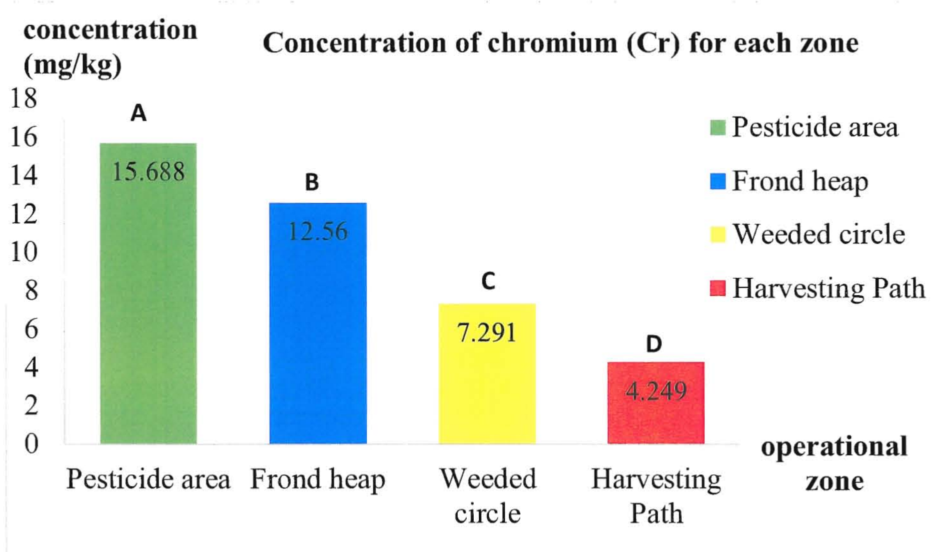

Figure 4.4 Chromium Concentration

Based on Figure 4.4 the concentration of heavy metal for chromium was recorded for different operational zones. The concentration of chromium element was high at pesticide area zone. It was 15.688 mg/kg or ppm which is the highest concentration of lead compared to the other zones. Meanwhile the lowest concentration of copper was recorded at harvesting path zone about 4.249 mg/kg or ppm. The P-Value for lead concentration was 0.000 which is lower than 0.05. Therefore, there was a significant difference among the operational zone. The pesticide area has a significant with the frond heap, weeded circle and harvesting path. In contrast, the presence of chromium is comes from naturally occurring element that exist in rocks, animals, plants and soils. In addition, the element of chromium is commonly used as a pesticide (Smieja, 2010).

4.2 The comparison of heavy metal content to the Maximum Allowable Concentration

Table 4.1 *Maximum Allowable Concentration for Some Heavy Metals*

Element	Maximum Allowable Concentration (mg/kg or ppm)
Zinc (Zn)	15.00
Copper (Cu)	1.5
Lead (Pb)	0.1
Chromium (Cr)	0.05

Source: World Health Organization (2015)

Table 4.1 shows the World Health permissible limits for some heavy metals in ppm. The standard permissible limits are used to compare with the concentration of heavy metals for different zones in order to measure the level of soil contamination. The concentration of heavy metal in soil supposed to be below than the maximum allowable concentration. Otherwise, the soil become contaminated with heavy metal and harmful to the soil microorganism since it has non-biodegradable characteristic and increase the toxicity in soil.

4.2.1 Operational Zone: Pesticide area

Table 4.2 *Heavy Metals at Pesticide Area*

Zn	MAC	Cu	MAC	Pb	MAC	Cr	MAC
2.952	15	5.312	1.5	5.371	0.1	15.688	0.05

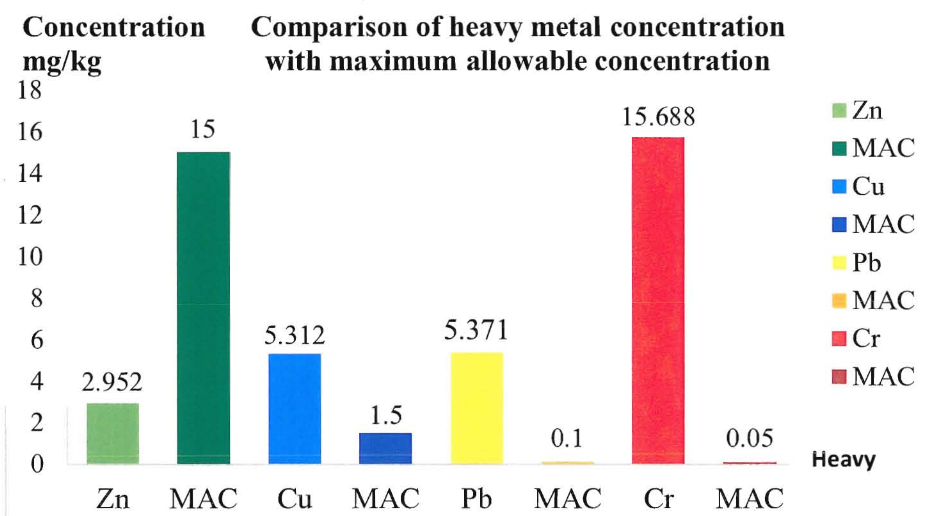

Figure 4.5 Comparison of Heavy Metals with MAC at Pesticide Area

Figure 4.5 shows the result from comparison of heavy metal concentration with maximum allowable concentration at pesticide area. Based on the result above, most of the heavy metal elements at pesticide area were exceeding the MAC except the concentration of zinc. The concentration of chromium was recorded as the highest one compared to the other elements of heavy metal at pesticide area. It was 15.688 mg/kg or ppm of chromium concentration which exceeded obviously from the standard permissible limit. Meanwhile the lowest concentration is zinc and it was recorded about 2.952 mg/kg or ppm which is not exceeding the MAC. The concentration of chromium become was high at pesticide area because it was contributed by pesticide and fertilizer application (Pallerin & Booker, 2000). The concentration of zinc was low at pesticide area because it commonly present in zinc sulphate which is used in fertizer (Jude & Bassy, 2012).

4.2.2 Operational zone: Frond heap

Table 4.3 *Heavy Metals at Frond Heap*

Zn	MAC	Cu	MAC	Pb	MAC	Cr	MAC
2.081	15	6.087	1.5	29.958	0.1	12.56	0.05

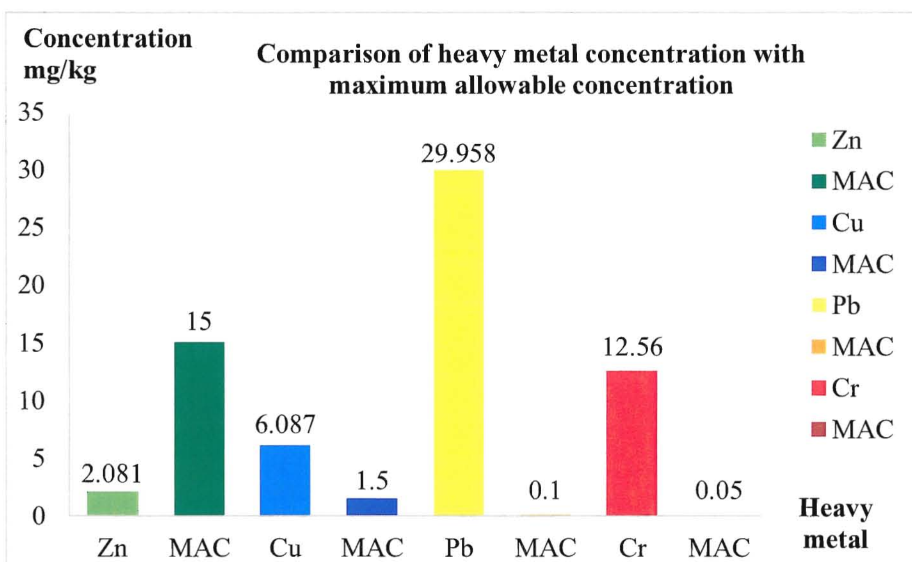

Figure 4.6 Comparison of Heavy Metals with MAC at Frond Heap

Figure 4.6 shows the result from comparison of heavy metal concentration with maximum allowable concentration at frond heap zone. Based on the result above, most of the heavy metal elements at frond heap were exceeding the MAC except for the concentration of zinc. The concentration of lead was recorded as the highest one compared to the other elements of heavy metal. It was 29.958 mg/kg or ppm of lead concentration which exceeded tremendously from the standard permissible limit. Meanwhile the lowest concentration is zinc and it was recorded about 2.081 mg/kg or ppm which is not exceeding the MAC. The concentration of lead was increased tremendously because the major contributions of lead in soil are the weathering, chipping, lead arsenate and pesticides (Ruqia, 2015).

4.2.3 Operational zone: Weeded circle

Table 4.4 *Heavy Metals at Weeded Circle*

Zn	MAC	Cu	MAC	Pb	MAC	Cr	MAC
3.415	15	2.506	1.5	-5.655	0.1	7.291	0.05

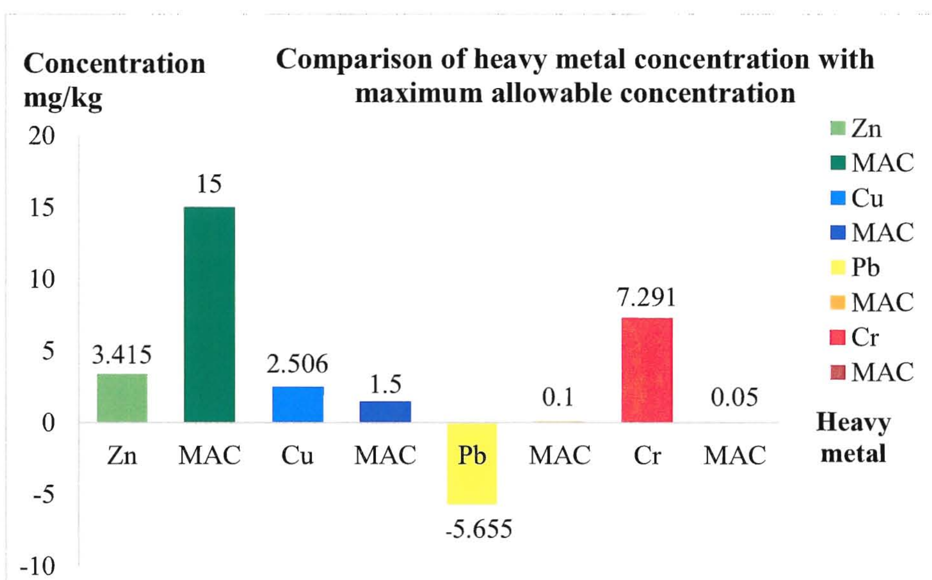

Figure 4.7 Comparison of heavy metal with MAC at Weeded Circle

Figure 4.7 shows the result from comparison of heavy metal concentration with maximum allowable concentration at frond weeded circle zone. Based on the result above, some of the heavy metal elements at weeded circle were exceeding the MAC except the concentration of zinc and lead. The concentration of chromium was recorded as the highest one compared to the other elements of heavy metal. It was 7.291 mg/kg or ppm of chromium concentration which exceeded from the standard permissible limit. Meanwhile the lowest concentration is lead and it was recorded about -5.655 mg/kg or ppm which is not exceeding the MAC. The presence of lead was very low at weeded circle because it is not essential for plant growth, they are readily taken up and accumulated by plant toxic form (Bolan, 2014). The zinc content was higher at weeded circle zone compared to other zone because zinc is required for proper growth and development oil oil palm (Jude & Bassy, 2012). However, the concentration of chromium was highest at weeded circle because instead of pesticides it also present in fertilizers.

4.2.4 Operational zone: Harvesting path

Table 4.5 *Heavy metals at Harvesting Path*

Zn	MAC	Cu	MAC	Pb	MAC	Cr	MAC
1.145	15	0.562	1.5	-15.273	0.1	4.249	0.05

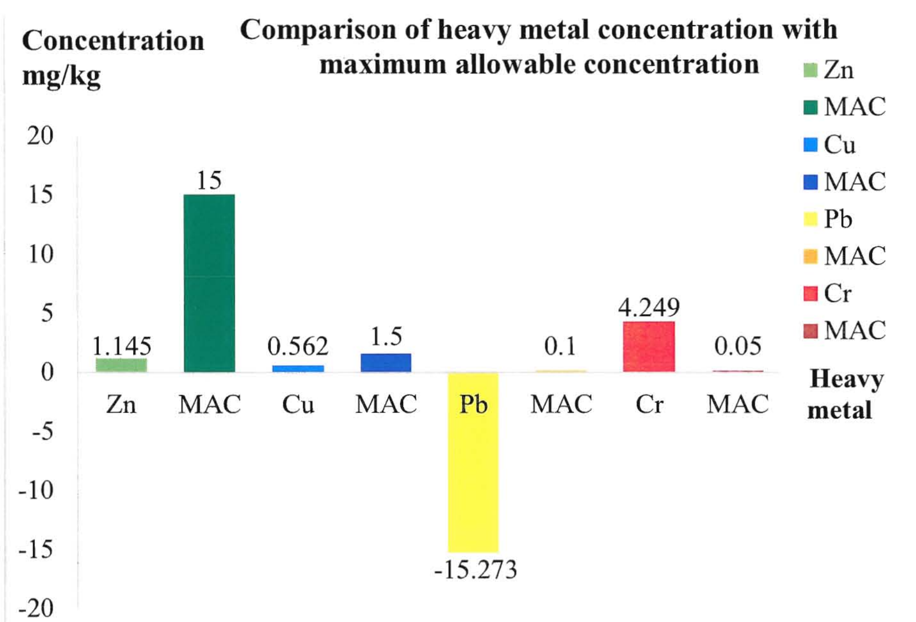

Figure 4.8 Comparison of Heavy Metal with MAC at Harvesting Path

Figure 4.8 shows the result from comparison of heavy metal concentration with maximum allowable concentration at harvesting path zone. Based on the result above, most of the heavy metal elements at pesticide area were not exceeding the MAC except the concentration of chromium. The concentration of chromium was recorded as the highest one compared to the other elements of heavy metal. It was 4.249 mg/kg or ppm of chromium concentration which exceeded only a small portion from the standard permissible limit. Meanwhile the lowest concentration is lead and it was recorded about

-15.273 mg/kg or ppm and below than the MAC. All the heavy metals element were low at harvesting path except chromium because it is exist in rocks, animals, plants and soils (Vodyanitskii, 2009).

4.3 Determination of factors that affect the availability of heavy metal

There were two factors that had been analyzed which are soil pH and soil moisture to identify the availability of heavy metal.

4.3.1 To determine the relationship between availability of heavy metal and soil pH

Table 4.6 *Heavy Metals versus soil pH*

Elements	**Pearson correlation**	**P-Value**	**R-square**
Zinc (Zn)	-0.556	0.025	30.9 %
Copper (Cu)	-0.558	0.025	31.1 %
Lead (Pb)	-0.369	0.159	-
Chromium (Cr)	-0.697	0.003	48.6 %

From the result of correlation between soil pH and the concentration of heavy metal above, there were only three elements which have significant toward the soil pH. It was showed that, all the heavy metal concentration have correlation with soil pH except for lead (Pb).

4.3.1.1 Soil pH against Zn at all operational zones

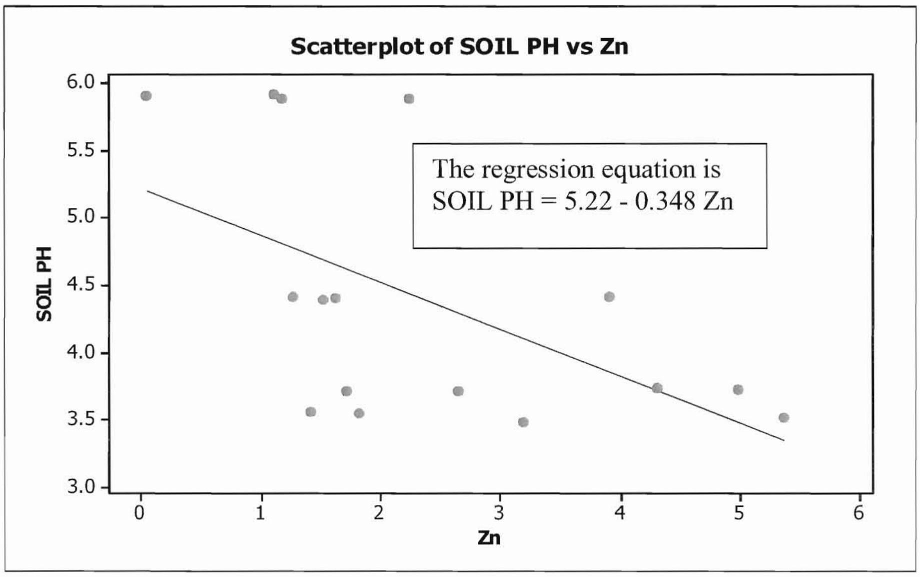

Figure 4.9 Scatterplot of pH versus Zn

Figure 4.9 shows the scatterplot of soil pH against concentration of Zn for all operational zones. Based on the graph above, the result indicates that when the soil pH is higher, the concentration of Zn become lower. However, when the soil pH is lower, the concentration of pH become vice versa. The result shown that the concentration of Zn is depends on the soil pH.

4.3.1.2 Soil pH against Cu at different operational zones

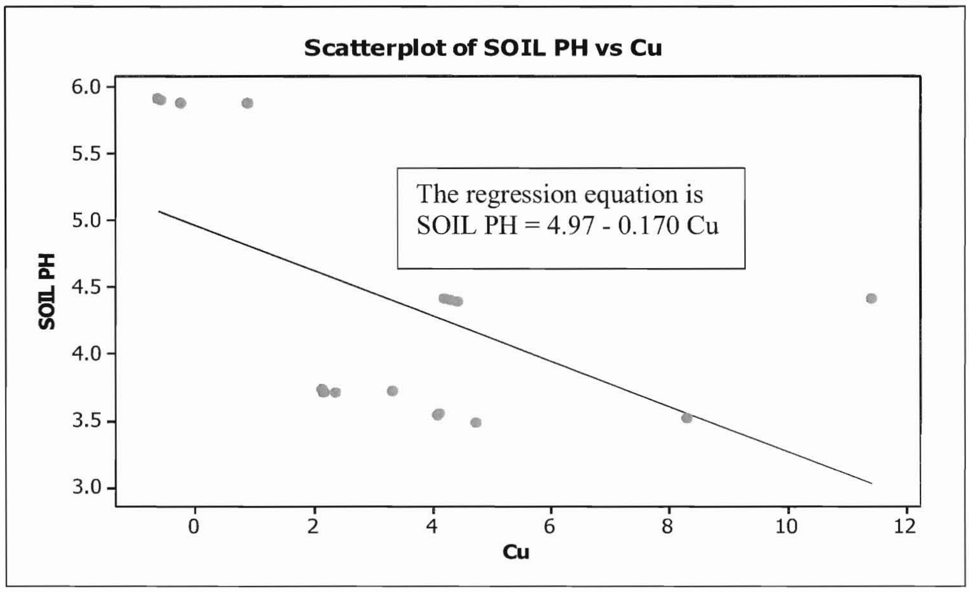

Figure 4.10 Scatterplot of pH versus Cu

Figure 4.10 shows the scatterplot of soil pH against concentration of Cu for all operational zones. Based on the graph above, the result indicates that when the soil pH is increased the concentration of Cu becomes decreased. However, when the soil pH is decreased, the concentration of Cu become vice versa. The result shown that the concentration of Cu is depends on the soil pH.

4.3.1.3 Soil pH against Cr at different operational zones

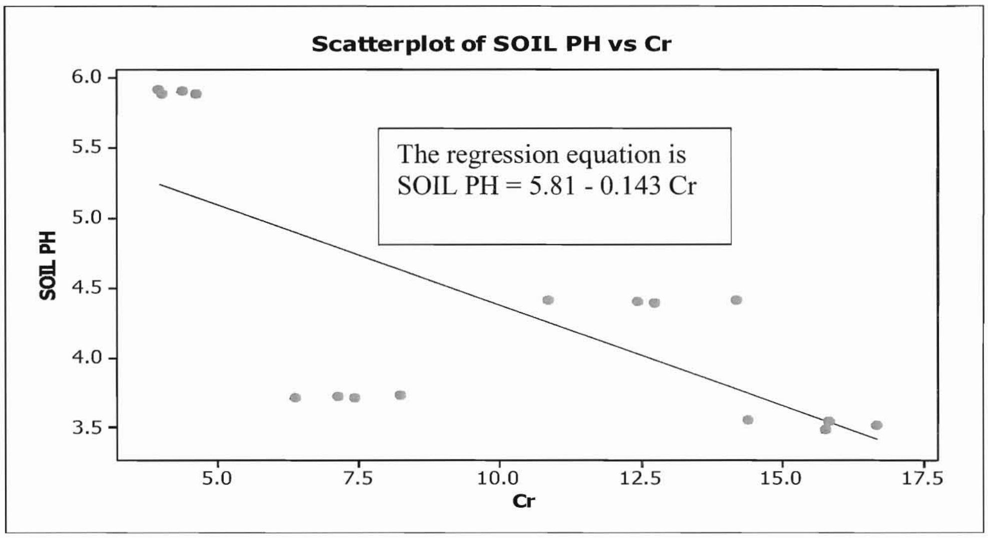

Figure 4.11 Scatterplot of pH versus Cr

Figure 4.11 shows the scatterplot of soil pH against concentration of Cr for all operational zones. Based on the graph above, the result indicates that when the soil pH is increased the concentration of Cr becomes decreased. However, when the soil pH is decreased, the concentration of Cr become vice versa. The result shown that the concentration of Cr is depends on the soil pH.

Soil pH, correlated negatively with metals in soils and it played an important role in governing metal uptake by plants. It can be expected that the concentrations of Cr, Cu, Pb and Zn increase with depth, possibly due to leaching from the surface under acidic conditions ($pH < 4$). The higher soil pH impacted on heavy metals availability decrement, but decrement effect differed among analysed heavy metals considering initial soil acidity (Asta Kazlauskaite, 2014).

4.3.2 Relationship between availability of heavy metal and soil moisture

Table 4.7 *Heavy Metals versus Soil Moisture*

Elements	**Pearson correlation**	**P-Value**	**R-square**
Zinc (Zn)	-0.268	0.316	-
Copper (Cu)	-0.519	0.040	26.9 %
Lead (Pb)	-0.714	0.002	51.0 %
Chromium (Cr)	-0.388	0.138	-

From the result of correlation between soil moisture and the concentration of heavy metal above, there were some of elements which have significant toward the soil moisture. It was noticed that, copper (Cu) and lead (Pb) concentrations have correlation with soil moisture whereas zinc (Zn) and chromium (Cr) does not show any correlation with soil moisture.

4.3.2.1 Soil moisture against Cu at different operational zones

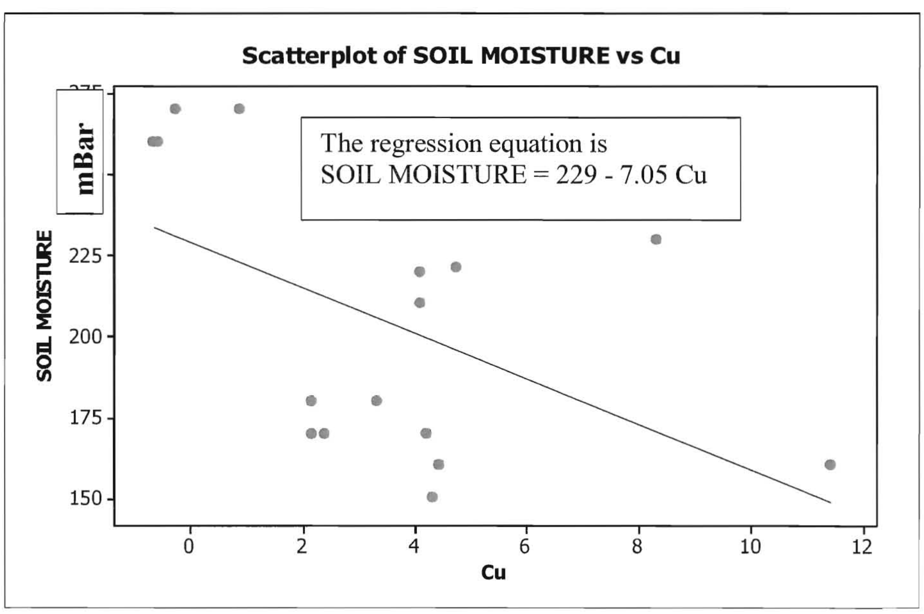

Figure 4.12 Scatterplot of Soil Moisture versus Cu

Figure 4.12 shows the scatterplot of soil moisture against concentration of Cu for different operational zones. Based on the graph above, the result indicates that when the soil moisture is high, the concentration of Cu becomes low. However, when the soil moisture is low, the concentration of Cu become vice versa. The result shown that the soil moisture can be affects the concentration of Cu in soil.

4.3.2.2 Soil moisture against Pb at different operational zones

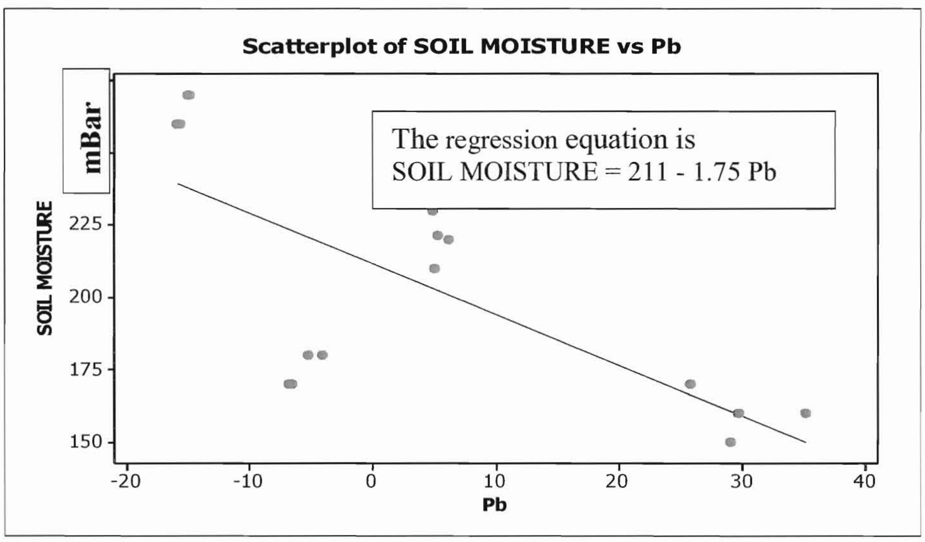

Figure 4.13 Scatterplot of Soil Moisture versus Pb

Figure 4.13 shows the scatterplot of soil moisture against concentration of Pb for all operational zones. Based on the graph above, the result indicates that when the soil moisture is low, the concentration of Pb also becomes low. However, when the soil moisture is high, the concentration of Pb becomes high. The result shown that the soil moisture might be affects the concentration of Pb in soil.

The results revealed that the concentration of heavy metal decreased considerably when the soil contained higher moisture content, but the moisture content effect on heavy metal contaminant migration and removal appeared to be minimal (Krishna, 2002).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The main goals of this research work was to determine the concentration of heavy metal content and also factors such as soil pH and soil moisture that affect the availability of heavy metal content. A total number of 16 samples were collected and were analyzed for two parameters (soil pH and soil moisture) and emphasized on four elements of heavy metal (Zn, Cu, Pb and Cr). The soil samples were collected at four different operational zones such as pesticide area, frond heap, weeded circle and harvesting path with four replications. The result shows that, pH of all soil samples were in acidic condition. Whereas, the values of soil moisture of all soil samples in a range within 150 - 270mBar.

Besides that, the comparison between heavy metal content and Maximum Allowable Concentration (MAC) also was carried out to determine whether the concentration of heavy metal element exceeding the MAC or not. Some of the heavy metal elements exceeded the MAC such as Cu, Pb and Cr at pesticide area and concentration of Cr was obviously high compared to the other heavy metals. Besides that, the Cr also exceeded the MAC for four different operational zones. Meanwhile, the concentration of Pb had shown a highest concentration at frond heap. However, it was decreasing and below than zero at weeded circle and harvesting path. The concentration of Zn was not exceeded the MAC for all operational zones with a small portion which less than 4.0 mg/kg or ppm. Soil pH was negatively correlated with metal in soils and played an important role in governing metal uptake by plants. Soil moisture also was negatively correlated with the metal in soil which is similar to the soil pH.

From the research finding, the concentration of heavy metal in peat soil is not high enough. However, there were exceed the MAC for some heavy metals such as Cu, Pb and Cr except for Zn. The concentration of heavy metal in peat soils can be improved by applying liming to the soil in order to increase the soil pH. This is because when the soil pH increases, the concentrations of heavy metal become decrease.

The limitation occur in this research were regards to determination of cation exchange capacity (CEC) is unable to carry out due to the lack of equipment and tools such as leaching tubes.

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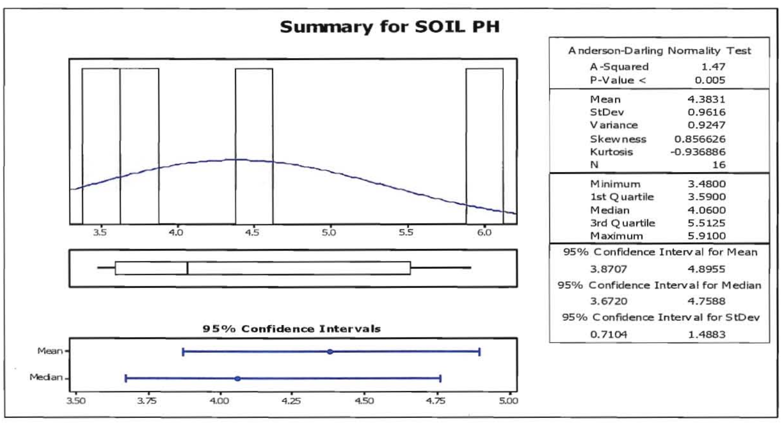
APPENDICES

A) Normality Test

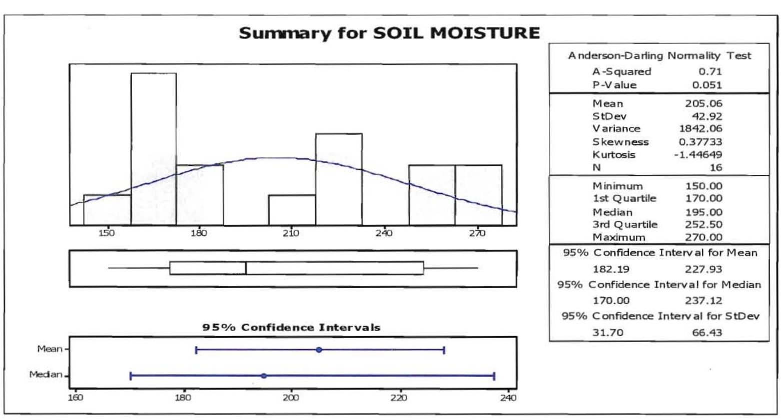
Normality test is the degree to which the distribution of the data information relates to a normal distribution. It is the most basic assumption in multivariate analysis. After we run the test, if the P-Value is greater than 0.05, the data is typical appropriate.



I. Soil pH

P-Value = 0.005

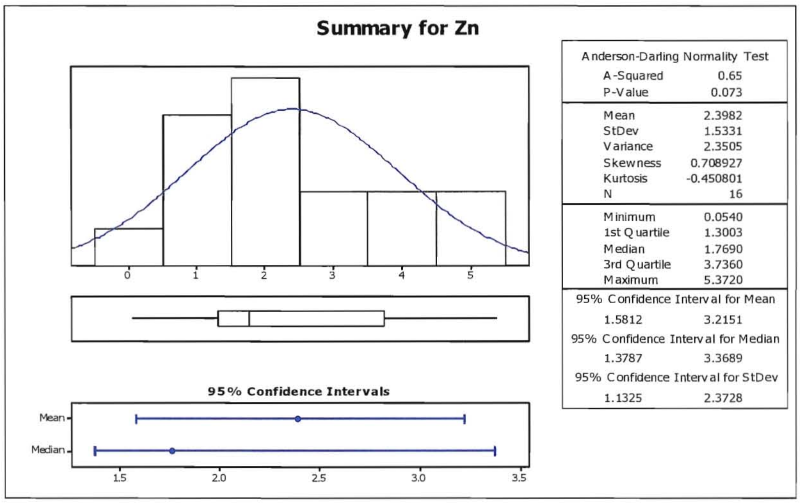
The data for soil pH is not normal because P-Value is lower than 0.05.



II. Soil moisture

P-Value = 0.051

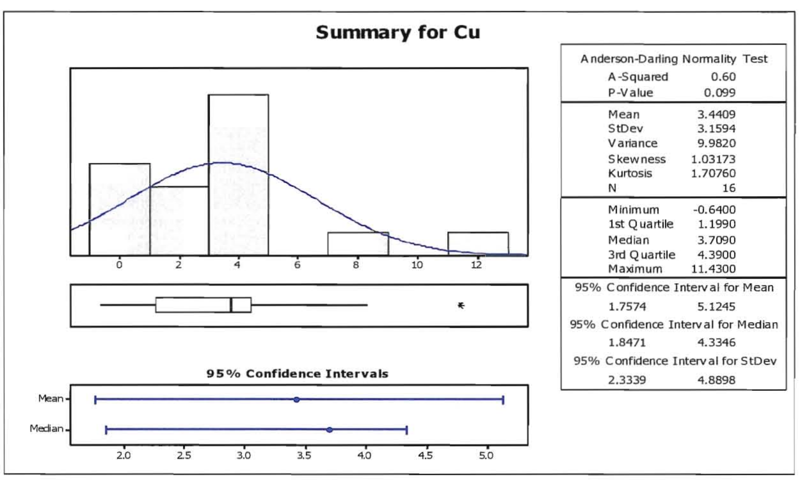
The data of soil moisture is normal because P-Value is greater than 0.05.



III. Concentration of zinc (Zn)

P-Value = 0.073

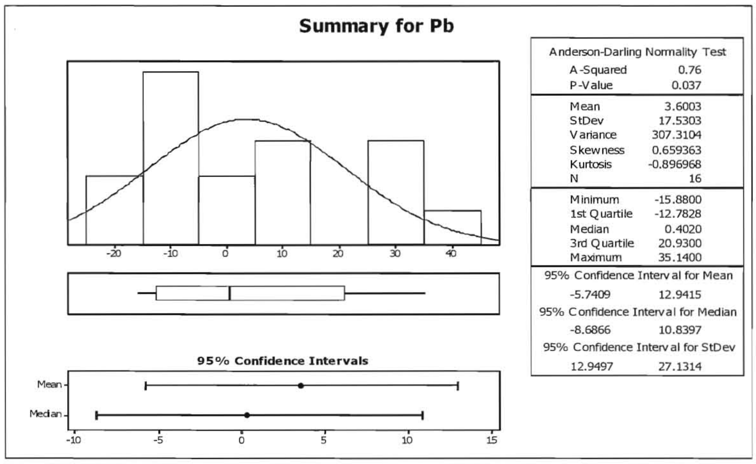
The data of zinc concentration is normal because P-Value is greater than 0.05.



IV. Concentration of copper (Cu)

P-value = 0.099

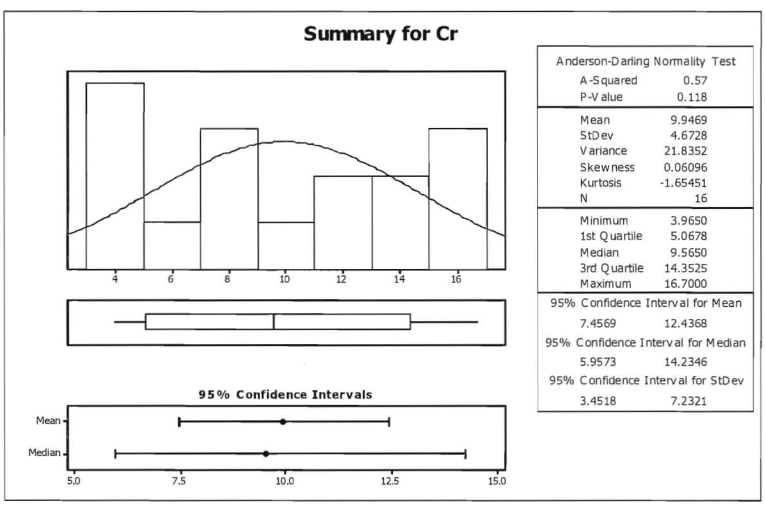
The data of copper concentration is normal because P-Value is greater than 0.05.



V. Concentration of lead (Pb)

P-Value = 0.037

The data of lead concentration is not normal because P-Value is lower than 0.05.



VI. Concentration of chromium (Cr)

P-Value = 0.118

The data of chromium concentration is normal because P-Value is greater than 0.05.

B) Regression Analysis for Soil pH

I. Regression Analysis: SOIL pH versus Zn

```
The regression equation is
SOIL PH = 5.22 - 0.348 Zn


Predictor      Coef  SE Coef      T      P
Constant     5.2187   0.3931  13.27  0.000
Zn          -0.3484   0.1394  -2.50  0.025


S = 0.827662   R-Sq = 30.9%   R-Sq(adj) = 25.9%


Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   4.2804  4.2804  6.25  0.025
Residual Error  14   9.5903  0.6850
Total           15  13.8707
```

II. Regression Analysis: SOIL pH versus Cu

```
The regression equation is
SOIL PH = 4.97 - 0.170 Cu

Predictor       Coef  SE Coef      T      P
Constant      4.9674   0.3108  15.98  0.000
Cu          -0.16980  0.06751  -2.52  0.025


S = 0.826079   R-Sq = 31.1%   R-Sq(adj) = 26.2%


Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   4.3170  4.3170  6.33  0.025
Residual Error  14   9.5537  0.6824
Total           15  13.8707
```

III. Regression Analysis: SOIL pH versus Pb

```
The regression equation is
SOIL PH = 4.46 - 0.0202 Pb


Predictor       Coef  SE Coef      T      P
Constant      4.4560   0.2364  18.85  0.000
Pb          -0.02025  0.01363  -1.49  0.159


S = 0.925084   R-Sq = 13.6%   R-Sq(adj) = 7.5%


Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   1.8898  1.8898  2.21  0.159
Residual Error  14  11.9809  0.8558
Total           15  13.8707
```

IV. Regression Analysis: SOIL pH versus Cr

```
The regression equation is
SOIL PH = 5.81 - 0.143 Cr


Predictor       Coef  SE Coef      T      P
Constant      5.8101   0.4309  13.48  0.000
Cr          -0.14346  0.03943  -3.64  0.003


S = 0.713657   R-Sq = 48.6%   R-Sq(adj) = 44.9%


Analysis of Variance

Source          DF       SS      MS      F      P
Regression       1   6.7405  6.7405  13.23  0.003
Residual Error  14   7.1303  0.5093
Total           15  13.8707
```

C) Regression Analysis for Soil Moisture

I. Regression Analysis: SOIL MOISTURE versus Zn

The regression equation is
SOIL MOISTURE = 223 - 7.49 Zn

Predictor	Coef	SE Coef	T	P
Constant	223.02	20.33	10.97	0.000
Zn	-7.489	7.209	-1.04	0.316

S = 42.8064   R-Sq = 7.2%   R-Sq(adj) = 0.5%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1978	1978	1.08	0.316
Residual Error	14	25653	1832		
Total	15	27631			

II. Regression Analysis: SOIL MOISTURE versus Cu

The regression equation is
SOIL MOISTURE = 229 - 7.05 Cu

Predictor	Coef	SE Coef	T	P
Constant	229.31	14.29	16.04	0.000
Cu	-7.046	3.104	-2.27	0.040

S = 37.9830   R-Sq = 26.9%   R-Sq(adj) = 21.7%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	7433	7433	5.15	0.040
Residual Error	14	20198	1443		
Total	15	27631			

III. Regression Analysis: SOIL MOISTURE versus Pb

The regression equation is
SOIL MOISTURE = 211 - 1.75 Pb

Predictor	Coef	SE Coef	T	P
Constant	211.358	7.946	26.60	0.000
Pb	-1.7487	0.4580	-3.82	0.002

S = 31.0937   R-Sq = 51.0%   R-Sq(adj) = 47.5%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	14096	14096	14.58	0.002
Residual Error	14	13535	967		
Total	15	27631			

IV. Regression Analysis: SOIL MOISTURE versus Cr

The regression equation is
SOIL MOISTURE = 240 - 3.56 Cr

Predictor	Coef	SE Coef	T	P
Constant	240.49	24.73	9.73	0.000
Cr	-3.562	2.263	-1.57	0.138

S = 40.9490   R-Sq = 15.0%   R-Sq(adj) = 9.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	4155	4155	2.48	0.138
Residual Error	14	23476	1677		
Total	15	27631			

CURRICULUM VITAE

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2. EDUCATION BACKGROUND

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Universiti Teknologi MARA, Kuala Pilah, Negeri Sembilan	Diploma In Planting Industry Management	2012
S.M.K. Seri Jempol, Negeri Sembilan	Sijil Pelajaran Malaysia (SPM)	2008
MRSM Kuala Klawang, Negeri Sembilan	Penilaian Menengah Rendah (PMR)	2006
S.K. Serting Tiga Felda, Negeri Sembilan	Ujian Penilaian Sekolah Rendah (UPSR)	2003

3. WORKING EXPERIENCE (IF ANY)

1. Laboratory assistant at UiTM Negeri Sembilan. From June 2012 to September 2012

Signature: ______________________ ______________________