Heavy Metal Loadings in Residential Yards in Tronoh, Perak.

by

Nik Mohd Irfan Nik Adnan

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Engineering (Hons)
(Chemical Engineering)

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Chemical Engineering Programme
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Approved by,

(Dr Nurlidia Mansor)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
June 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NIK MOHD IRFAN NIK ADNAN

ABSTRACT

Heavy metals occur naturally in earth and they are essential to the human body in trace amount. In high doses, they exert the toxic effect and will be harmful to human health. The excess concentration of heavy metals can eventually lead to poisoning and can be fatal. There are various sources of heavy metals and they can be transported to residential yards in many ways. One of them is through the atmosphere. Heavy metal will deposit eventually be into the soil and may accumulate. Soil pollution can sometimes enriched trace metal contents in airborne particles originate from soils and the polluted air will be inhaled by human. Most people do not realize that air contains lots of heavy metals due to human activities, vehicle emissions and other sources. These heavy metals can harm human being by entering human body via inhalation, ingestion and skin absorption. However, the level of awareness among the general public regarding soil pollution with heavy metal is still low. This report reflects the research done and also the basic understanding of the topic which is: **Heavy Metal Loadings in Residential Yards in Tronoh, Perak.** The main objective of this research is to measure the concentration of Pb, Zn and Cd in residential estates within Tronoh and to compare the level of heavy metal in the residential estates with the rural area. The rural area with low volume of traffic and negligible industry that has been chosen for this project is Bota which is located next to Tronoh. In this study, three residential yards were chosen as the sampling locations. Two sampling locations are within Tronoh and one is in Bota. For each sampling location, two random points been chosen and two samples from each point were taken at different depth; the top soil (0-8cm) and the bottom soil (9-16cm). The samples were sent to the laboratory for the analysis using Atomic Absorption Spectroscopy (AAS). From the findings, heavy metal concentration is consider low and is still in acceptable range. The highest metal concentration is Pb in Taman Universiti with the concentration of 512.01 mg/kg and the lowest is Cd in Bota with the concentration of 5.2 mg/kg. Cd concentration is very low for all sampling locations since the locations are away from any industry activities.

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ABBREVIATION AND NOMENCLATURES

AAS	Atomic Absorption Spectroscopy
Pb	Lead
Zn	Zinc
Cd	Cadmium
Cu	Copper
Cr	Chromium
Hg	Mercury
Ni	Nickel
As	Arsenic
Mn	Manganese
Al	Aluminium
Fe	Iron
HNO_3	Nitric Acid
HCl	Hydrochloric Acid
UV	Ultraviolet
ppm	Part per Million

CHAPTER 1

INTRODUCTION

1.1. Background of Study

Heavy metals represent special members of metals that are hazardous to the environment and health even when discharged in small quantities. They are one of the harmful elements that originate from various sources.

Anthropogenic activities such as mining and other industrial activities emit dusts and small particles that contain heavy metals. These metals are transported to the nearby area mainly through the atmosphere. The contaminants will then enter the soil through atmospheric deposition. Vehicle emission containing heavy metal such as Pb is also one of the factors that contribute to pollution in soil. The concentration of the heavy metals in the soil can be accumulated and increase in concentration after a long period of deposition time.

There are three main factors that influence the levels of heavy metals in soils which are traffic, industry and weathered materials, particularly house and street dust. Surface soil in urban areas is the indicator of heavy metal contamination from atmospheric deposition.

It is often assumed that urban areas are more contaminated than rural areas due to the high number of these potential sources. However, rural soils may also contain high concentration of metals due to the natural geologic sources, high amount usage of pesticide, localized industrial facilities and atmospheric deposition.

1.2. Problem Statement

Some heavy metals are naturally found in earth. They normally occur at low concentrations and are known as trace metals. These heavy metals are essential to human health in trace concentration. In high doses, they may be toxic to the body and tend to accumulate or increase in concentration in a biological organism over time.

Most people do not realize that air contains lots of heavy metals due to human activities, vehicle emissions and other sources. These heavy metals can harm human being by entering human body via inhalation, ingestion and skin absorption.

1.3. Research Significant

The awareness level of the heavy metal hazards among the general public is still low. This research is very essential in order to raise the level of awareness among people living in residential areas which are close to anthropogenic sources that may emit lots of hazardous heavy metals. These heavy metals may disperse through the atmosphere to the nearby area and they will be deposited into the soil thus will be contaminated.

The deposited heavy metal may be harmful to the residents as they can enter the food chain through leaching into groundwater or plant absorption. Therefore, the residents who continuously consume the crops planted in their garden which the soil is contaminated will have a probability to get poisoned due to the accumulation of heavy metals in body.

Soil pollution may threaten human health not only through its effect on the hygiene quality of food and drinking water, but also through its effect on air quality. Soil pollution can sometimes enriched trace metal contents in airborne particles originate from soils (Chen et al., 1996).

Furthermore, there is a need to study heavy metal contamination within populated areas as such studies are limited in Malaysia.

1.4. Objectives and Scope of Study

The objectives of the research are:

- To study heavy metal loadings in residential yards around Tronoh, Perak
- To investigate the concentration of Pb, Zn and Cd in the soil of residential yards
- To compare levels of heavy metal in yards of housing estates and rural residential areas

The scope of study for the research is residential yards within Tronoh. The research is to include the study on the heavy metals loadings in the selected residential yards by measuring their concentration in the soil. It is a need to know the concentration of the heavy metals in the residential yards since the effects it has to human are very significant.

CHAPTER 2

LITERATURE REVIEW

2.1. Definition of Heavy Metals

Heavy metals represent special members of metals even when discharged in small quantities are hazardous to the environment and human health (Nagwan et al., 2006). According to B.J Alloway (1995), the term 'heavy metal' is known as a large group of elements with an atomic density greater than 6 g/cm^3.

Environmental contamination is one of the most important factors destroying the biosphere. Heavy metals play the main part in this destruction (Darunas et al., 2004). Some of the metals are essential for many biological systems including humans at certain concentrations. However, they can exert toxic effects at high concentration (Hussain et al., 2005).

Heavy metal poisoning could result from drinking-water contamination, high ambient air concentrations near emission sources or intake via the food chain. The examples of heavy metals are Pb, Zn, Cu, Cd, Cr, Hg and Ni. These heavy metals occur as natural constituents of the earth crust and are determined as environmental contaminants since they cannot be degraded or destroyed (Duruibe et al., 2007).

More importantly, heavy metals can enter the food chain through leaching into groundwater or plant absorption. Therefore, they can threaten human health and sometimes cause chronic health conditions (X. Hang et al., 2008).

2.2. Soil Pollution in Residential Yards

Soil is an essential non-renewable resource and not only a part of ecosystem, but also occupies a basic role for humans (Loredana & Angela, 2008). It is a complex heterogeneous medium comprising mineral and organic solids, aqueous and gaseous components. Soils normally contain low natural levels of heavy metals and they are necessary for agriculture production but become hazardous when they occur in excess in soil (Sangi & Sasi, 2001).

Soil is not only a medium for plants to grow or a pool to dispose of undesirable materials, but also a transmitter of many pollutants to surface water, groundwater, atmosphere and food (Chen et al., 1996). Surface soil is a relevant exposure route for a variety of metals (Davis et al., 2009). Therefore, accumulated pollutants in surface soils can be transported to different environmental components such as deep soil, water, plant, and dust particles (Chen et al., 1996).

Dietary intake of heavy metals also poses risk to human health. Heavy metals such as Pb and Cd have been shown to have carcinogenic effects (Sharma et al., 2008). These heavy metals can enter human body by the food chain. Some of the residents might plant vegetables in their residential yards and then consume them without knowing the heavy metals level in the soil of the yards.

Soil pollution may threaten human health not only through its effect on the hygiene quality of food and drinking water, but also through its effect on air quality. For example, soil pollution can sometimes enriched trace metal contents in airborne particles originate from soils. Although not much attention has been paid to soil compared with food, water and atmospheric pollution, soil pollution has been emphasized increasingly by many environmental protection agencies and communities (Chen et al., 1996).

The high concentration of heavy metals in soils has posed adverse effect on human health because it can be easily transferred into human bodies from suspended dust or by direct contact (Sun et al., 2009).

2.3. Heavy Metals Source and Dispersal

Heavy metals may come from many different sources. Main anthropogenic sources of heavy metals are from various industrial such as current and former mining activities, foundries, smelters and diffuse sources, traffic, industrial and human activities (Omar, 2004). The usage of insect sprays, pesticides and fertilizers also contribute to the emission of heavy metals to the environment. These heavy metals that are being emitted can be transported through several mediums such as water and atmosphere.

Three main factors known to influence the levels of heavy metals in soils which have been reported are traffic, industry and weathered materials, particularly house and street dust. The increasing anthropogenic activities intensify the emission of various pollutants into the environment and introduce different types of harmful substances into the atmosphere. (Al-Khlaifat, 2007).

One of the important heavy metals source is the vehicle emission (Omar, 2004). High Pb concentration in air and soil in urban areas has been attributed due to the increasing number of automobiles, especially leaded petrol (Heinze et al., 1998). It has been noted that the location close to the roads are severally polluted by heavy metals such as Pb, Zn, Cu, Cd, etc. from traffic (Omar, 2004).

Many of the studies concerning Pb availability from soil have been carried out on soils polluted by mining activities or by Pb smelters (Mercier, 2001). However, there are other sources of Pb pollution such as the spreading of sewage sludge and gas emissions from cars (Mercier et al., 2001).

Pb is a common heavy metal whose dispersion into the environment from various sources has led to its widespread occurrence in soil, water and air. Anthropogenic dispersion of this metal is derived from mining activities, its use as a fuel additive for nearly 70 years, its use as a paint additive for nearly 50 years and its use in pesticides and other industrial chemicals (Elless, 2007).

Worldwide, the Pb concentration of soils receiving atmospheric deposition ranges from 10 to 84 mg/kg (Elless, 2007). Due to the severe health effects, particularly in children, the Secretary of Health and Human Services in 1991 called Pb "the number one environmental threat to the health of children in the United States" (http://www.epa.gov/iaq/lead.html, verified on 28-10-09).

Another most important factor of heavy metals pollutions is mining activities. The activities cause a great destruction to the environment. Mining sites emit large quantities of waste which must be deposited on land or in aquatic systems (Edeltrauda, 1999). They can affect relatively small areas but can have large local impact on the environment. Release of metals from mining sites occurs primarily through erosion of waste dumps, air emission and deposition (Salomon, 1994).

Active mining sites as well as abandoned mining sites can contaminate the surrounding and ecosystem by the release of heavy metals and dust into the air through wind blow dust particles (Alla et al., 2006). According to the Abandon Mine Site Characterization and Cleanup Handbook, (2000), during mining and mineral processing, dusts that contain gaseous and particle are emitted. The impacts caused by gaseous and particle emission usually focused on the contaminated soils associated with the downwind deposition.

The heavy metals emitted into the atmosphere as dusts will be unequally dispersed around the point sources (Mariana et al., 2006). The dispersal depends on the wind direction, geographical area and local meteorological factors such as fog, rains and thermal inversions. A low speed of the wind of 2.2 m/s will lead to a weak ventilation of the area and the dusts from the air will deposit into the soil on the short distances from the point source (Mariana et al., 2006).

In the northeastern United States, regional studies of heavy metal contamination in forest soils showed a significant relationship between Pb concentrations and proximity to major urban areas, whereas variations in the amounts of Zn, Cu, Ni, and Cd did not appear to be related to atmospheric patterns of deposition except near the point sources of pollution (Yesilonis, 2008).

2.4. Effects of Heavy Metals to Humans

Heavy metals commonly found in the modern environment in air, soil, food and drinking water. Heavy metals accumulation in soil and plant is the increasing concern because of the potential human health risks. They affect human health because the body cannot break it down upon ingestion or inhalation. Thus, they can lead to poisoning (Khan et al., 2007).

A common poisonous metal is Pb. At high levels of human exposure, there is damage to almost all organs and organ systems. The most important to be damaged is the central nervous system, kidneys and blood, culminating in death at excessive levels. Pb exposure can come from many sources including soil, air, drinking water, food, paint and house dust. Pb remains in the body and disturbs the enzyme system and the formation of hemoglobin. Hemoglobin carries oxygen through bloodstream to organs and tissues. When high levels of Pb are present, the entire body is affected especially the nervous system and kidneys. It is particularly dangerous for children because of their immature neurological system (Tong et al., 2000).

Direct oral ingestion of contaminated soils and dust by children is the principal cause of Pb absorption. Pb present in soils and dust at concentrations of 500–1000 mg/kg can affect children's health (Mercier, 2001).

Developing fetuses will be affected the most by heavy metals because their brains are growing much faster than an older child or adult. In addition, the brain stores the toxins because of the body's survival instinct. The heavy metals stored in the brain cells might be used as the essential minerals for the body and this will lead to disabilities, decreased growth, impaired hearing and brain damage.

Most heavy metals in high concentrations have an adverse effect on human health, especially on the health of young children, who have a higher rate of absorption of heavy metals because of their active digestion systems and sensitivity to hemoglobin (Li et al., 2004).

Table 2.1 listed the uses of several heavy metals and its health effect on human (Azila, 2008). The characteristics of heavy metals are described as:

1. Toxicity that can last for a long time in nature.
2. Transformation of low toxic heavy metals to more toxic form in a certain environment, such as Hg.
3. Bioaccumulation of heavy metals by food chain that could damage normal physiological activity and endanger human life.
4. Heavy metals cannot be degraded including biotreatment.
5. Heavy metals are very toxic even at low concentration (1.0-10 mg/L). Metal ions such as Cd and Hg have been reported very toxic even in lower concentration range from 0.001 to 0.1 mg/L (Azila, 2008).

Table 2.1: Heavy metals uses and health effects to human (Azila, 2008)

Heavy Metals	Uses/Sources	Health Effects
Arsenic (As)	Metal processing plants, burning of fossil fuels, mining of arsenic containing ores and use of arsenical pesticides	Internal cancer, skin lesions and death
Cadmium (Cd)	Electroplating, fertilizers, mineral processing and battery manufacturing	Cancer, lung insufficiency, disturbances in cardiovascular system, liver and kidney damage
Copper (Cu)	Copper and brass plating, mining, metal industries and copper-ammonium rayon industries	Normocytic, hypochromic, anemia, leucopenia and osteoporosis; copper deficiency
Chromium (Cr)	Metal plating, leather, mining, galvanometry, dye production	Ulcer, skin irritation, liver and kidney damage
Lead (Pb)	Metal plating, textile, battery manufacturer, automotive and petroleum industries	Spontaneous abortion, damage nervous system, kidney and brain damage
Zinc (Zn)	Pesticides, fertilizers, chemical manufacturing and metal finishing	Loss of appetite, decreased sense of taste and smell, slow wounding healing and skin sores

2.5. Comparisons of Heavy Metal Concentration between Different Locations

Table 2.2 shows the results from a study to determine the heavy metals contents in the soils from nurseries. The study has been conducted in Dungun, Terengganu. Soil samples from different general land usage backgrounds were chosen.

The first group of sampling location is the industrial area with a high density of petroleum chemical industry, power plant and main road with heavy traffic load. The second group of sampling site is the town with the heavily frequented urban traffic routes. The third group of sampling is a village at the edge of urban with low traffic and negligible industries.

Table 2.2: Heavy metals content and soil parameters in town, industrial and village soil samples (Norhayati et al., 2007)

Location	Cu (µg/g)	Mn (µg/g)	Cd (µg/g)	Pb (µg/g)	Fe (µg/g)	Al (µg/g)	Zn (µg/g)
Industrial							
Range	1.3-15	28-89	ND-2.88	ND-88	0.08-2.7	1.3-7.6	2.3-32
Mean	5.9	59	2.0	58	0.69	2.9	17
Median	4.3	59	1.9	69	0.25	2.0	16
Town							
Range	0.5-20	48-124	ND-4.7	ND-74	0.1-1.5	0.5-5.8	9.8-130
Mean	7.4	92	2.5	59	0.66	1.8	56
Median	4.1	91	2.4	58	0.51	1.1	60
Village							
Range	16-47	23-338	0.54-3.2	26-67	1.5-7.6	4.8-11	13-74
Mean	30	246	1.9	36	4.5	7	52
Median	23	307	1.6	32	3.8	6	59
Overall							
Mean	13	121	1.5	47	1.7	3.5	41
Median	7	79	1.4	51	0.62	2.2	28

Basically, most of the metals contents except Pb, Zn and Cd in town and industrial areas are lower compared to soils on the village areas. Pb and Cd are anthropogenic metals and they are normally not abundant in upper layer soils. The level of these metals in the soils of three areas with the exception of Zn from industrial area are within similar range suggesting they might be derived from common input since all the sampling areas were near busy roadside (Norhayati et al., 2007).

The variation of heavy metals concentration between the study areas could generally be attributed to differences in population densities and the degree of the industrial activities in the respective area.

CHAPTER 3

METHODOLOGY

3.1. Sampling Site

The study was conducted in the district of Tronoh, a town located in Perak, Malaysia. In this study, three residential yards were chosen as the sampling locations. The first sampling site is Taman Tasek Putra which is located near a mining area and also next to a medium frequented traffic route. The second sampling site is Taman Universiti, located approximately 5km from the first sampling site. The third sampling site is Bota which is a rural area next to Tronoh with a low volume of traffic and has no significant industry activity or negligible industrial area.

3.2. Soil Sampling

1. For each sampling site, soils from two random points were chosen.

Figure 3.1: Two sampling locations for each residential yard chosen

2. Two soil samples for each point were taken at different depth; the upper part (0-8cm) and the lower part (9-16cm).

Figure 3.2: (a) 0-8cm (b) 9-16cm

3. The samples placed into sampling bags and sent to the laboratory for the analysis.

Figure 3.3: Soil Sampling

Table 3.1: Soil sampling details

Sampling Site	Samples	Sampling Coordinate	Sample Labeling	
Taman Universiti	Point 1	N04° 21.403' E100° 59.612'	A1	0-8cm
			A2	9-16cm
	Point 2	N04° 21.639' E100° 59.283'	B1	0-8cm
			B2	9-16cm
Taman Tasek Putra	Point 1	N04° 23.938' E100° 58.870'	C1	0-8cm
			C2	9-16cm
	Point 2	N04° 23.928' E100° 58.890'	D1	0-8cm
			D2	9-16cm
Bota (Rural)	Point 1	N04° 20.349' E100° 53.164'	E1	0-8cm
			E2	9-16cm
	Point 2	N04° 20.482' E100° 53.219'	F1	0-8cm
			F2	9-16cm

3.3. Soil Analysis

1. The weight of the soil sample was recorded. The sample was then air-dried for five days and the weight was measured once again to find the moisture content of the soil.

2. The soil sample was heated in an oven at 120°C for 24 hours to remove the organic matter such as dry leaves, humus and decaying plants and other living organisms from the soil. Besides, it was also done to completely remove the moisture content.

3. For heavy metal analysis, the sample was crushed lightly and sieved to pass through 2-mm mesh.

Figure 3.4: Oven-Drying

Figure 3.5: Soil Crushing Process

4. About 1.0 g of sieved soil sample was mixed with 10 mL of concentrated HNO_3 (65%) in a beaker and being covered with a watch glass or vapor recovery device. The sample was then placed on a hot plate to be heated at 95°C and refluxed for approximately 10 to 15 minutes without boiling.

Figure 3.6: The sample covered with a watch glass

Figure 3.7: Heating the sample on a hot plate

5. After the sample was cooled, 5 mL of concentrated HNO_3 was added and the reflux process was repeated for approximately 30 minutes.

6. If the brown fumes were generated, step 5 was repeated until no brown fumes were generated.

7. After the sample was cooled, 10 mL of concentrated HCl (37%) was added and the beaker was covered with the watch glass or the vapor recovery device.

8. The sample was then heated at 95°C and refluxed for 15 minutes.

9. The watch glass or the vapor recovery device was then removed and the heating process continued until the volume of the content was reduced to approximately 5 mL.

10. The content was cooled to the room temperature, filtered through filter paper and diluted with distilled water into a 100 mL volumetric flask.

Figure 3.8: Filter the sample

11. The content of the flask was brought to the required volume with distilled water.

12. The samples were ready to be analyzed by the AAS for Pb, Zn and Cd.

3.4. Atomic Absorption Spectroscopy (AAS)

3.4.1. Introduction

AAS is a device that is being used to determine the existence and the concentrations of heavy metals such as Pb, Zn, Cu, Fe, Al, Ca, Cd and others in a sample.

It uses the absorption of light to measure the concentration of a gas-phase atom. UV light will be absorbed by the metals when they are heated and being in the excited state. Each metal has its own characteristic wavelength that will be absorbed. The AAS instrument looks for a particular metal by focusing a beam of UV light at a specific wavelength through a flame and into a detector. The sample of interest is aspirated into the flame. If that metal is present in the sample, it will absorb some of the light thus its intensity is reduced. The instrument measures the change in intensity. A computer data system converts the change in the intensity into an absorbance.

As the concentration goes up, absorbance goes up. The researcher can construct a calibration curve by running standards of various concentrations on the AAS and observing the absorbance. In the lab, the computer data system will draw the curve for the researchers. Then, samples can be tested and measured against this curve.

Figure 3.9: Atomic Absorption Spectroscopy

3.4.2. Theory

The atomic absorption spectroscopy uses the principles of Beer-Lambert law. The Beer-Lambert law is a linear relationship between absorbance and concentration of an absorber of electromagnetic radiation. The general Beer-Lambert law is usually written as:

$$A = a_\lambda \times b \times c$$

where A is the measured absorbance, a_λ is a wavelength-dependent absorptivity coefficient, b is the path length of the sample, and c is the concentration of compound in the solution.

Experimental measurements are usually made in terms of transmittance (T), which is defined as:

$$T = \frac{I}{I_0}$$

where I is the intensity of light after it passes through the sample and I_0 is the initial light intensity. The relation between A and T is:

$$A = -\log(T) = -\log\left(\frac{P}{P_0}\right)$$

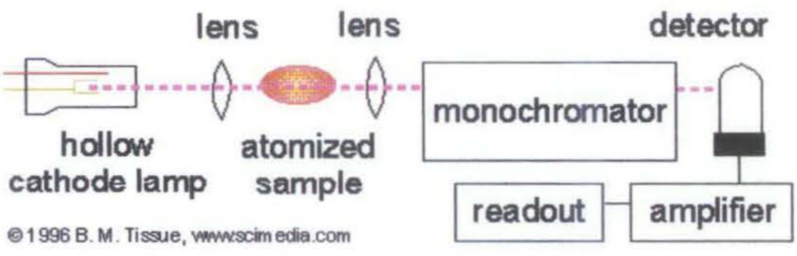

Figure 3.10: Simplified Diagram of AAS Equipment

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Moisture Content in Soil Samples

Soil moisture content indicates the amount of water present in the soil. It is not constant with time and may vary. The amount of moisture found in soil varies greatly with the type of soil, climate and the amount of humus in the soil. It is commonly expressed as the amount of water (in mm of water depth) present in a depth of one meter of soil.

In this research, the moisture content is reported as the percentage on a weight basis. Soil samples were dried in an oven and the weight of the soil after drying is compared to the weight before drying.

Below is the formula that is used to calculate the percentage of moisture in the soil sample. The example of the moisture content for sample A1 is calculated.

$$Moisture\,(\%) = \frac{Wet\ Weight - Dry\ Weight}{Wet\ Weight} \times 100$$

$$Moisture(\%) = \frac{676.95 - 623.83}{676.95} \times 100 = 7.85\%$$

Table 4.1: Moisture Content in Soil Samples

Sampling Location	Depth	Sample	Weight (g)		Moisture Content (g)	Moisture Content (%)
Taman Universiti 1	0-8cm	A1	Wet	676.95	53.12	7.85%
			Dry	623.83		
	9-16cm	A2	Wet	607.89	18.90	3.11%
			Dry	588.99		
Taman Universiti 2	0-8cm	B1	Wet	487.34	82.44	16.92%
			Dry	404.90		
	9-16cm	B2	Wet	572.80	68.86	12.02%
			Dry	503.94		
Taman Tasek Putra 1	0-8cm	C1	Wet	384.17	18.54	4.83%
			Dry	365.63		
	9-16cm	C2	Wet	830.69	36.49	4.39%
			Dry	794.20		
Taman Tasek Putra 2	0-8cm	D1	Wet	947.39	32.17	3.40%
			Dry	915.22		
	9-16cm	D2	Wet	746.48	16.20	2.17%
			Dry	730.28		
Bota 1	0-8cm	E1	Wet	296.31	77.23	26.06%
			Dry	219.08		
	9-16cm	E2	Wet	290.68	68.86	23.69%
			Dry	221.82		
Bota 2	0-8cm	F1	Wet	170.31	42.00	24.66%
			Dry	128.31		
	9-16cm	F2	Wet	206.74	49.83	24.10%
			Dry	156.91		

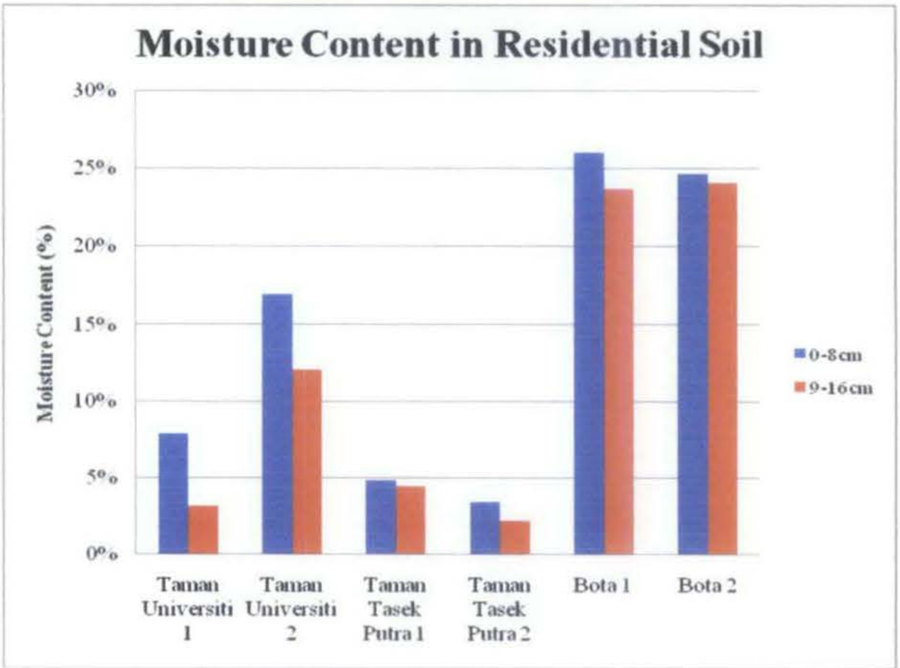

Figure 4.1: Moisture Content in Residential Soil

Based on the results above, the top soil contains more moisture compared to the bottom soil because the top soils are normally fine and less porous. Hence, they can contain more water.

Besides that, the moisture content varies based on the location. There are several factors that influence the moisture content in soil which are the type of soil and the sampling time. For example, if the samples are taken during the rainy season, the moisture content will be higher.

4.2. Heavy Metal Content in Residential Soil

The readings that are retrieved from the AAS are in the unit of ppm (mg/L). The unit needs to be converted into mg/kg. Therefore, the conversion formula as follows is used:

$$Concentration\left(\frac{mg}{kg}\right) = \frac{Concentration\left(\frac{mg}{L}\right) \times Vol\ of\ Extraction(L) \times Dilution\ Factor}{Weight\ of\ Sample(kg)}$$

For example, the average concentration of the top soil from Taman Universiti 1 is 2.7186 mg/L.

$$Concentration\left(\frac{mg}{kg}\right) = \frac{2.7186\frac{mg}{L} \times 0.1L \times 1}{0.001kg} = 271.86\frac{mg}{kg}$$

After the conversion, the concentration of the heavy metal is 271.86 mg/kg. It indicates that every kilogram of soil contains 271.86 mg of Pb.

Table 4.2: Pb Content in Residential Soil

Sampling Location	Depth	Sample Label	Reading	Concentration from AAS (mg/L)	Concentration (mg/kg)
Taman Universiti 1	0-8cm	A1	Reading 1	2.5753	257.53
			Reading 2	2.8262	282.62
			Average	**2.7186**	**271.86**
	9-16cm	A2	Reading 1	5.2634	526.34
			Reading 2	4.9767	497.67
			Average	**5.1201**	**512.01**
Taman Universiti 2	0-8cm	B1	Reading 1	2.1093	210.93
			Reading 2	2.0376	203.76
			Average	**2.0735**	**207.35**
	9-16cm	B2	Reading 1	2.7545	275.45
			Reading 2	2.6828	268.28
			Average	**2.7186**	**271.86**
Taman Tasek Putra 1	0-8cm	C1	Reading 1	2.5753	257.53
			Reading 2	2.5394	253.94
			Average	**2.5753**	**257.53**
	9-16cm	C2	Reading 1	1.8226	182.26
			Reading 2	1.7867	178.67
			Average	**1.7867**	**178.67**
Taman Tasek Putra 2	0-8cm	D1	Reading 1	1.6222	162.22
			Reading 2	1.5801	158.01
			Average	**1.6012**	**160.12**
	9-16cm	D2	Reading 1	1.4115	141.15
			Reading 2	1.3904	139.04
			Average	**1.3904**	**139.04**
Bota 1	0-8cm	E1	Reading 1	1.6222	162.22
			Reading 2	1.4326	143.26
			Average	**1.5169**	**151.69**
	9-16cm	E2	Reading 1	1.7065	170.65
			Reading 2	1.6855	168.55
			Average	**1.6855**	**168.55**
Bota 2	0-8cm	F1	Reading 1	1.6222	162.22
			Reading 2	1.7065	170.65
			Average	**1.6644**	**166.44**
	9-16cm	F2	Reading 1	1.5801	158.01
			Reading 2	1.4958	149.58
			Average	**1.5379**	**153.79**

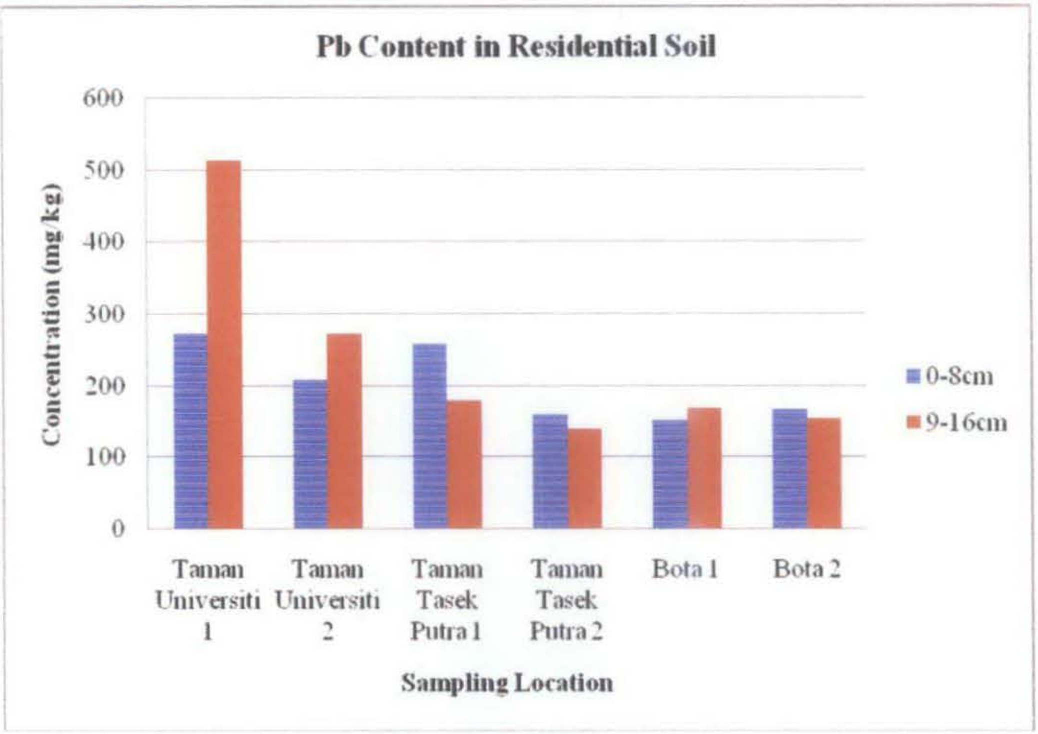

Figure 4.2: Pb Content in Residential Soil

For the top soil, the highest Pb concentration is 276.86 mg/kg which is Taman Universiti 1. The lowest value is in Bota 1 with the value of 151.69 mg/kg.

For the bottom soil, Taman Universiti 1 give highest reading of 512.01 mg/kg and the lowest reading is 139.04 mg/kg which is the soil from Taman Tasek Putra 2.

Basically, the Pb content in the top soil of Taman Universiti and Taman Tasek Putra is higher compared to the Bota residential area. It is proven that the location of the sampling site is the main factor that contributes to the concentration of Pb.

Taman Universiti and Taman Tasek Putra are located near to the main road with heavy traffic compared to the Bota residential which can be considered as rural area with low traffic.

Table 4.3: Zn Content in Residential Soil

Sampling Location	Depth	Sample Label	Reading	Concentration from AAS (mg/L)	Concentration (mg/kg)
Taman Universiti 1	0-8cm	A1	Reading 1	0.2977	29.77
			Reading 2	0.2873	28.73
			Average	**0.2918**	**29.18**
	9-16cm	A2	Reading 1	0.2560	25.60
			Reading 2	0.2322	23.22
			Average	**0.2441**	**24.41**
Taman Universiti 2	0-8cm	B1	Reading 1	0.5910	59.10
			Reading 2	0.6088	60.88
			Average	**0.5999**	**59.99**
	9-16cm	B2	Reading 1	0.3126	31.26
			Reading 2	0.3201	32.01
			Average	**0.3156**	**31.56**
Taman Tasek Putra 1	0-8cm	C1	Reading 1	0.4778	47.78
			Reading 2	0.4972	49.72
			Average	**0.4883**	**48.83**
	9-16cm	C2	Reading 1	0.4615	46.15
			Reading 2	0.4734	47.34
			Average	**0.4674**	**46.74**
Taman Tasek Putra 2	0-8cm	D1	Reading 1	0.6192	61.92
			Reading 2	0.647	64.70
			Average	**0.6331**	**63.31**
	9-16cm	D2	Reading 1	0.4845	48.45
			Reading 2	0.5013	50.13
			Average	**0.4924**	**49.24**
Bota 1	0-8cm	E1	Reading 1	1.9301	193.01
			Reading 2	1.9906	199.06
			Average	**1.9608**	**196.08**
	9-16cm	E2	Reading 1	1.0701	107.01
			Reading 2	1.073	107.30
			Average	**1.0711**	**107.11**
Bota 2	0-8cm	F1	Reading 1	0.9492	94.92
			Reading 2	0.9779	97.79
			Average	**0.9641**	**96.41**
	9-16cm	F2	Reading 1	0.9432	94.32
			Reading 2	0.9779	97.79
			Average	**0.9601**	**96.01**

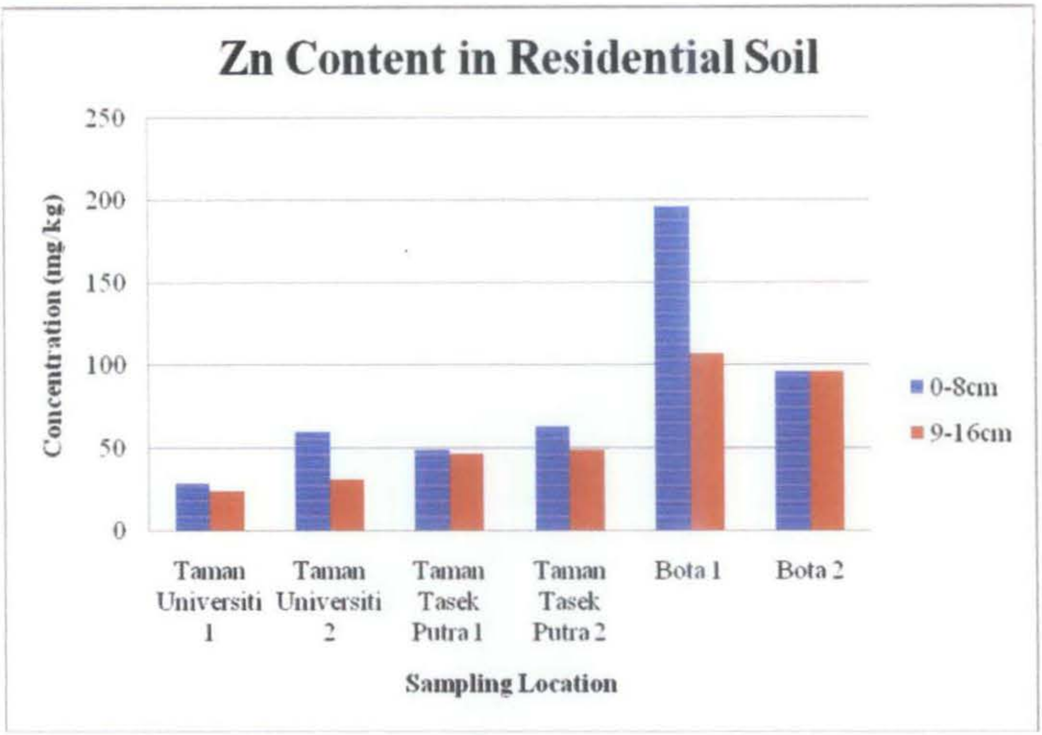

Figure 4.3: Zn Content in Residential Soil

The highest Zn concentration is in Bota 1 residential soil with the concentration of 196.08 mg/kg for the top soil. While the lowest Zn concentration is 29.18 mg/kg which is from the top soil of Taman Universiti 1.

For the bottom soil, the highest concentration is 107.11 mg/kg, also from Bota 1 and the lowest is from Taman Universiti 1 with the concentration of 24.41 mg/kg.

Zn concentration in Bota residential area is higher than Taman Tasek Putra and Taman Universiti. It is assumed that main causes are not from the atmosphere deposition, but from other activities that may have occurred in Bota such as dumping activities or past activities. Besides that, it can also be assumed that the usage of the pesticides or fertilizers may contribute to the high Zn levels.

Table 4.4: Cd Content in Residential Soil

Sampling Location	Depth	Sample Label	Reading	Concentration from AAS (mg/L)	Concentration (mg/kg)
Taman Universiti 1	0-8cm	A1	Reading 1	0.0613	6.13
			Reading 2	0.0590	5.90
			Average	**0.0598**	**5.98**
	9-16cm	A2	Reading 1	0.0605	6.05
			Reading 2	0.0652	6.52
			Average	**0.0629**	**6.29**
Taman Universiti 2	0-8cm	B1	Reading 1	0.0675	6.75
			Reading 2	0.0621	6.21
			Average	**0.0644**	**6.44**
	9-16cm	B2	Reading 1	0.0590	5.90
			Reading 2	0.0559	5.59
			Average	**0.0574**	**5.74**
Taman Tasek Putra 1	0-8cm	C1	Reading 1	0.0776	7.76
			Reading 2	0.0768	7.68
			Average	**0.0768**	**7.68**
	9-16cm	C2	Reading 1	0.0590	5.90
			Reading 2	0.0582	5.82
			Average	**0.0582**	**5.82**
Taman Tasek Putra 2	0-8cm	D1	Reading 1	0.0699	6.99
			Reading 2	0.0660	6.60
			Average	**0.0675**	**6.75**
	9-16cm	D2	Reading 1	0.0691	6.91
			Reading 2	0.0636	6.36
			Average	**0.0660**	**6.60**
Bota 1	0-8cm	E1	Reading 1	0.0761	7.61
			Reading 2	0.0714	7.14
			Average	**0.0737**	**7.37**
	9-16cm	E2	Reading 1	0.0706	7.06
			Reading 2	0.0629	6.29
			Average	**0.0668**	**6.68**
Bota 2	0-8cm	F1	Reading 1	0.0551	5.51
			Reading 2	0.0497	4.97
			Average	**0.0520**	**5.20**
	9-16cm	F2	Reading 1	0.0551	5.51
			Reading 2	0.0551	5.51
			Average	**0.0551**	**5.51**

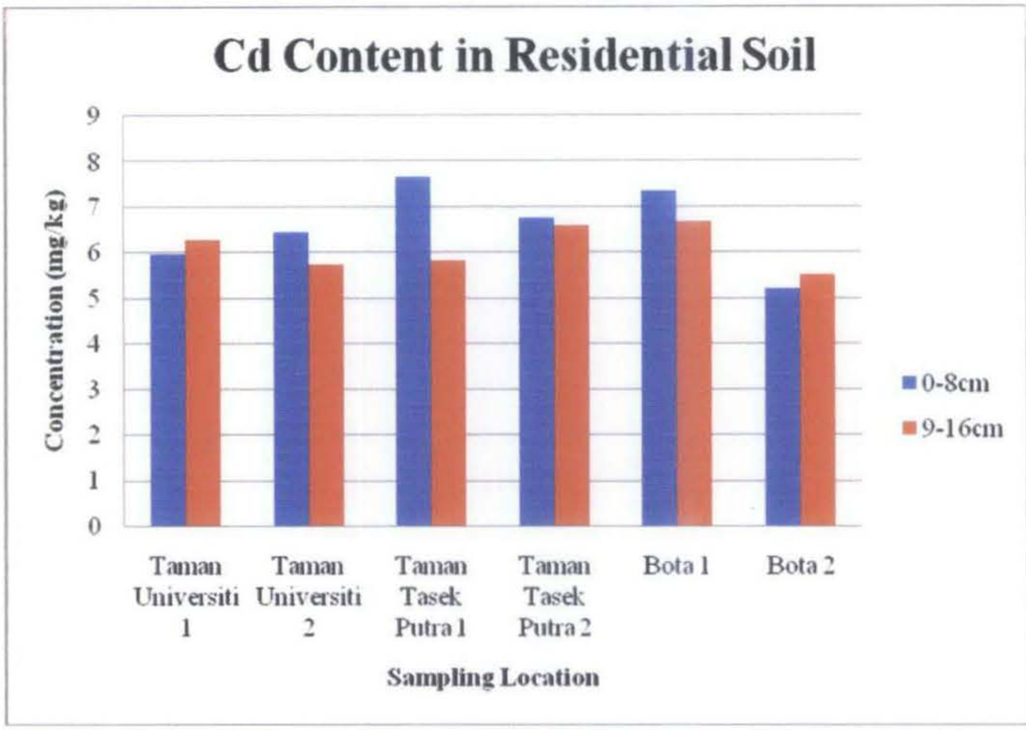

Figure 4.4: Cd Content in Residential Soil

For the top soil, the highest Cd concentration is 7.68 mg/kg which is Taman Tasek Putra 1. The lowest value is in Bota 2 with the value of 5.2 mg/kg.

For the bottom soil, Bota 1 give highest reading of 6.68 mg/kg and the lowest reading is 5.51 mg/kg which is the soil from Bota 2.

Cd concentration is very low for all sampling sites. This could be due to the sampling locations are away from any industry activities. Cd is normally found in soil close to industrial area and it is a common indicator of industrial influence.

4.3. Overall Heavy Metal Content in Residential Soil

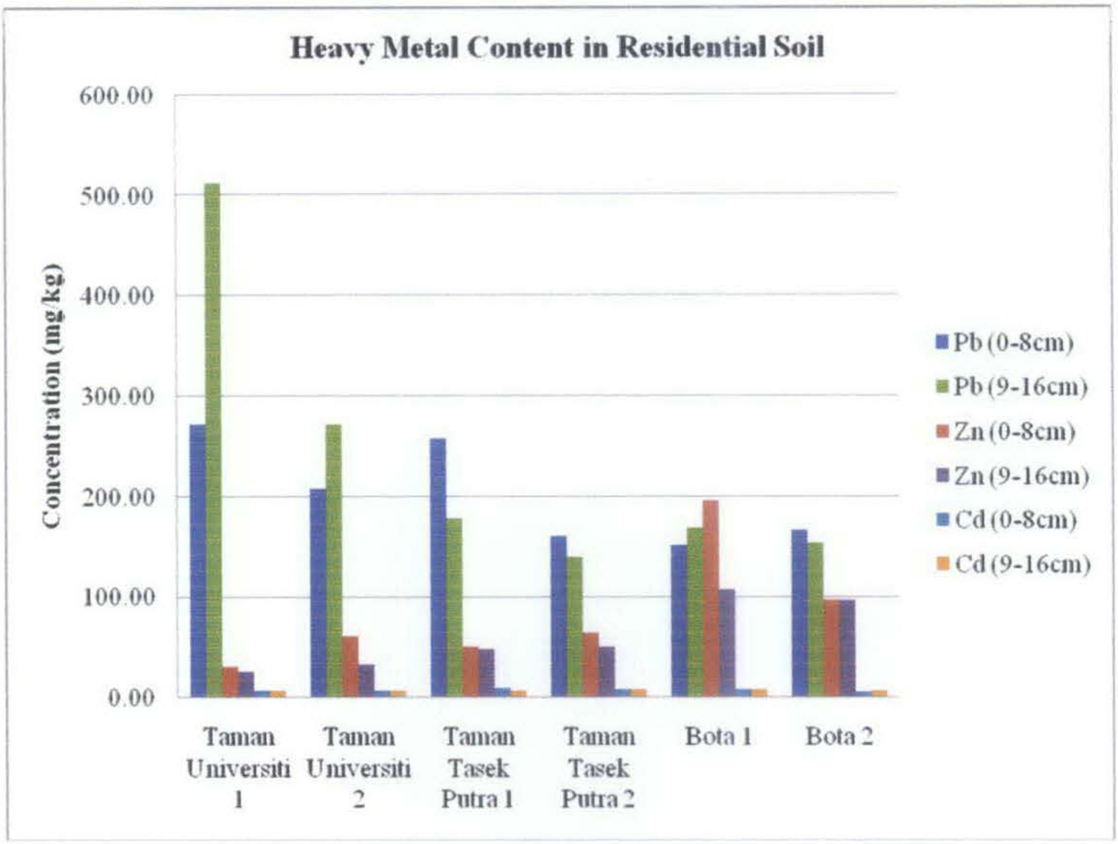

Figure 4.5: Overall Heavy Metal Content in Residential Soil

Based on the results above, the concentration of heavy metal in the top soil (0-8cm) seems to be higher compared to the concentration of the bottom soil (9-16cm). This is due to the deposition of heavy metal from the atmosphere. The top soil indicates recent deposition and the bottom soil has older concentration.

For the case where the bottom soil is higher than the top soil, it is possible that the soil originates from other places where the content of Pb is high. Some of the soil may have been brought in by the developer from other sources to the location for the purpose of building the foundation for the residential area. Furthermore, it may also indicate deposition from past activities.

From the overall results, Pb was found to be the highest heavy metal found in residential soil followed by Zn and Cd.

Table 4.5 gives the comparison between heavy metal contents obtained in Tronoh and Bota soil with those reported in literature. It shows the average of the heavy metal concentration for every location.

Table 4.5: Comparison with Other Study

Average Heavy Metals Content (mg/kg)	Residential Estate		Rural	Norhayati et al., 2007		
	Taman Universiti	Taman Tasik Putra	Bota	Town	Village	Industrial
Pb	316	184	160	59	36	58
Zn	36	52	124	56	52	17
Cd	6	7	6	3	2	15

From the comparison with the study that has been done by Norhayati, the trend is quite similar for Pb and Cd. Pb found in town is higher compared to the concentration in village. The same trend can be observed in this study where the concentration of Pb in residential estate seems to be higher than the rural area. As for Cd, the concentration in industrial area is higher compared to the concentration in town and village.

Table 4.6: Summary of Dutch Standards (http://www.economicexpert.com/a/Dutch:standards.htm)

Heavy Metal	Soil (mg/kg dry matter)				
	Reference Value	Intervention Value	Taman Universiti	Taman Tasik Putra	Bota
Pb	85.0	530	316	184	160
Zn	140	720	36	52	124
Cd	0.8	12	6	7	6

The comparison has also been done with the Dutch Standards to clarify either the concentration of heavy metal in soil is still within the allowable limit. From the comparison, the concentration that has been measured is not exceeding the intervention value. Therefore, the heavy metal concentration in Tronoh is considered as within the acceptable range.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

As the conclusion, the heavy metal especially Pb is higher in residential estates compared to the rural residential areas. It is also can be concluded that the heavy metal concentration is affected by the distance from the point sources. The concentrations decrease as the distance from these point sources increase.

Top soil or surface soil is the best indicator of heavy metal contamination from recent atmospheric deposition.

From the study, the level of heavy metal in residential yards in Tronoh, Perak is acceptable and within the allowed range of concentration.

5.2. Recommendation

The followings are the recommendations that could be made to control or reduce heavy metal loadings in residential yards:

- Environmental planning is considered not to be luxury. Therefore, before starting any project, a study to evaluate the environmental impacts has to be conducted as part of other feasibility studies.

- Monitoring heavy metals build up in the environment is a need as it is a recommended practice all over the world.

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APPENDIX A

Gantt Chart for Final Year Project 1 (FYP 1)

No.	Action Items	Week														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Release of FYP Topics for Selection (with no supervisor's name)			UTP Closed due to H1N1							Hari Raya Break / Mid-Semester Break					
2	Briefing to students on "Final Year Research Project Background"															
3	Submission of FYP Topics Selection (Form 02)															
4	Release of FYP Topics Assigned (with students and supervisor's name)															
5	Submission of FYP Proposal															
6	Preliminary Research Work															
7	Submission of Preliminary Report															
8	Briefing to students on "Library Facilities & How to access Journals"															
9	Project Work continues															
10	Submission of Form 03 for Chemical Requisition															
11	Progress Reporting															
12	Submission of Progress Report (Draft of Interim Report)															
13	Seminar with Internal Examiner															
14	AAS Training															
15	Briefing to student on "Risk Assessment/Lab Safety/Rules & Regulations															
16	Project Work Continues															
17	Submission of Final Interim Report															
18	Final Oral Presentation															
19	Debriefing on Final Oral Presentation & Interim Report by Supervisors															

Gantt Chart for Final Year Project 2 (FYP 2)

No.	Action Items	Week 1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continues								Mid-Semester Break							
2	Submission of Progress Report 1															
3	Project Work Continues															
4	Submission of Progress Report 2															
5	Seminar (Compulsary)															
6	Project Work Continues															
7	Poster Exhibition															
8	Submission of Dissertation (soft bound)															
9	Oral Presentation															
10	Submission of Project Dissertation (hard bound)															

APPENDIX B

Dutch Standard for Heavy Metals

Heavy Metals	Soil (mg/kg dry matter)		Groundwater (µg/L)	
	Reference Value	Intervention Value	Reference Value	Intervention Value
Cd	0.8	12	0.4	6
Cr	100.0	380	1	30
Cu	36.0	190	15	75
Ni	35.0	210	15	75
Pb	85.0	530	15	75
Zn	140.0	720	65	800
Hg	0.3	10	0.05	0.3
As	29.0	55	10	60
Ba	160	625	50	625
Co	9.0	240	20	100
Mo	3.0	200	5	300
Sb	3.0	15	0.15	10
Be	1.1	30	0.05	15
Ag	-	15	-	40
Se	0.7	100	0.07	160
Te	-	600	-	70
Th	1.0	15	2	7
Sn	-	900	2.2	50
V	42.0	250	1.2	70