CHARACTERIZATION AND IDENTIFICATION OF HEAVY METAL ELEMENTS (PM_{10}) SAMPLED FROM URBAN AND RURAL SCHOOLS IN KELANTAN

By

NUR DALILA BINTI CHE OMAR

A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Sustainable Science) with Honors

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2017

DECLARATION

I declare that this thesis entitled "Characterization and Identification of Heavy Metal Elements In Particulate Matter Sampled From Urban And Rural Schools In Kelantan"is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

ACKNOWLEDGEMENT

First of all, Alhamdulillah and thank you to the most merciful and gracious god, Allah S.W.T, for giving me the opportunity to finally completed my final year project. I would like to express my gratitude to my former supervisor Madam Siti Hajar bt Yaa'cob and my current supervisor Dr. Norrimi Rosaida Binti Awang who have guided me in the preparation of my final year project. They have guided me patiently for the whole project writing and willing to spend their precious time having discussion regarding my final year project. They have always been enthusiastic in assisting me in solving various problems, offering numerous suggestions for improvement of my work and checking my work for accuracy. I really appreciate for their patient guidance, advices and giving me a golden opportunity to gain more knowledge.

Furthermore, I would like thank to headmasters of Sekolah Kebangsaan Batu Melintang and Sekolah Menengah Kebangsaan Kubang Kerian 1 for giving me the opportunity to carry out my final year project experiment in their schools area. I am very grateful for their help in assisting me and giving me the approval to carry out my experiment in their schools area. Special thanks to staffs from at calibration laboratory and analytical laboratory of Universiti Sains Malaysia Kubang Kerian and also not forgotten staffs at Environmental laboratory of Universiti Malaysia Kelantan who had helped me a lot on my data analysis for my experiment.

Besides that, millions of thank to Universiti Malaysia Kelantan especially Faculty of Earth Science for offering this final year project as a requirement for all Bachelor Degree students. This enables the students to learn a lot more for completing final year project. Last but not least, special thanks to my family and friends for their help, support and understanding. Their support has given me a great motivation for my final year project.

TABLE OF CONTENT

PAGE

PAGE

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATION

AAS	Atomic Absorption Spectrometry
ATSDR	Agency for Toxic Substances and Disease Registry
Cd	Cadmium
Cr	Chromium
FR	flow rate
Hg	Mercury
LVS	Low volume sampler
Mn	Manganese
Ni	Nickel
Pb	Lead
PM_{10}	Particulate matter with aerodynamic diameter < 10 micrometer
PM	Particulate matter
SERAS	Scientific Engineering Response and Analytical Services
SPSS	Statistical Package for Social Sciences
T	Sampling duration in min
USEPA	United State Environmental Protection Agency
WHO	World Health Organization
Zn	Zinc

Characterization and Identification of Heavy Metal Elements In Particulate Matter Sampled From Urban And Rural Schools In Kelantan

ABSTRACT

Air pollution is define as the presence of any pollutant in the air that are potential to cause health effect or cause harm to the environment. A study was conducted to investigate the exposure of air pollutants in school environment at two different area. Location of the sampling involves two different selected schools, Sekolah Kebangsaan Batu Melintang located in rural area and Sekolah Menengah Kebangsaan Kubang Kerian 1, located in urban area. The method used in this study includes sampling of 15 air pollutant samples in each location from April to June 2016 using Lower Volume sampler (LVS). Atomic Absorption Spectrophotometer (AAS) was used to determine the amount of heavy metal elements (Zinc, Lead and Cadmium) in outdoor air dust. The highest mass concentration of recorded at school in rural area was 86.051 $\mu g/m^3$ whereas at the school in urban area was 99.550 $\mu g/m^3$.The mean mass concentration of at Sekolah Menengah Kebangsaan Kubang Kerian 1 (52.527 $\mu g/m^3$) was higher than Sekolah Kebangsaan Batu Melintang (39.760 $\mu g/m^3$).The mass concentration of is still below the permissible limits (150 $\mu g/m^3$) set up by Malaysia Department of Environment. The heavy metal at rural area was found to follow the order Pb > Zn > Cd while in urban area Zn > Cd with absent of Pb. High concentration of and heavy metals due to the high traffic density, high population movement, and the anthropogenic activities surrounding. Therefore, this study will will help to provide the quantitative measurements of and heavy metal elements which will help to assess the air quality in Malaysia.

Pencirian dan mengenal pasti unsur-unsur logam berat dam zarah terampai sampel dari sekolah Bandar dan luar Bandar di Kelantan

ABSTRAK

Pencemaran udara ditakrifkan sebagai kewujudan bahan pencemar di dalam udara yang boleh mendatangkan masalah kesihatan atau menyebabkan bahaya pada alam sekitar. Satu kajian telah dijalankan bagi mengkaji tentang pendedahan bahan pencemar udara di persekitaran sekolah di dua kawasan yang berbeza. Lokasi kajian melibatkan dua sekolah, iaitu Sekolah Kebangsaan Batu Melintang yang terletak di kawasan luar bandar dan Sekolah Menengah Kebangsaan Kubang Kerian 1 yang terletak di kawasan bandar. Kaedah yang digunakan dalam kajian ini melibatkan pengumpulan 15 sampel udara di setiap lokasi dari bulan April hingga bulan Jun 2016 menggunakan sampler isipadu rendah (LVS). Spektofotometer Serapan Atom (AAS) digunakan untuk menentukan jumlah elemen logam berat (Zink, Plumbum, Kadmium) dalam zarahan terampai dalam debu udara luaran. Kepekatan tertinggi jisim di sekolah luar bandar direkodkan sebanyak 86.051 $\mu g/m^3$ sedangkan di sekolah bandar adalah sebanyak 99.550 $\mu g/m^3$. Purata kepekatan jisim di Sekolah Menengah Kebangsaan Kubang Kerian 1 (52.527 $\mu g/m^3$) lebih tinggi berbanding di Sekolah Kebangsaan Batu Melintang (39.760 $\mu g/m^3$). Kepekatan jisim masih di bawah had yang digariskan (150 $\mu g/m^3$) yang ditubuhkan oleh Jabatan Alam Sekitar Malaysia. Logam berat dikenal pasti di kawasan luar bandar mengikut turutan tersebut iaitu Pb > Zn > Cd sementara di kawasan bandar Zn > Cd tanpa kehadiran Pb. Kepekatan jisim yang tinggi dan kehadiran logam berat adalah kerana ketumpatan trafik yang tinggi, pergerakan penduduk yang tinggi dan aktiviti antropogenik sekitar kawasan persampelan. Oleh itu, kajian ini akan membantu untuk menilai kualiti udara di Malaysia.

CHAPTER 1

INTRODUCTION

1.1 Background of Study

As rapid development of the economy and booming population growth, high amount of resources such as energy, water, and food is needed in our society to sustain our daily activities. As a consequence, various kinds of pollution have been developed and introduced to the environment. Among the enormous pollution problems, air pollution has caused major concern over the world due to its widespread nature, capable in destructing the environment and potential health risk to humans, vegetation and water (Leung & Drakaki, 2015). Air pollution are emission of any substances from an anthropogenic, biogenic, or geogenic source, that is either not part of the natural atmosphere or is present in higher concentrations than the natural atmosphere, and may cause a short-term or long-term adverse effect to environment and human health (Daly & Zannetti, 2007). Thus, air pollution has become a public concerned problem in modern capital cities or urban areas

Air pollution produced from the contamination of indoor and outdoor environment by any chemical, physical or biological agent that alter the natural characteristics of the atmosphere (Olade, 1987a). Anthropogenic sources of air pollution include fossil fuel and coal combustion, industrial effluents, solid waste disposal, fertilizers, mining and metal processing (Olade, 1987a). At present, the impact of these air pollutants is confined mostly to the urban centre with large populations, high traffic density and consumer-oriented industries (Olade, 1987a). Furthermore, natural sources of pollution include weathering of mineral deposits, brush burning and dusts, transportation related with activities on the road. According to the World Health Organization (WHO), 48% of deaths occurring annually in the world are related to air pollution associated with anthropogenic activities (Melaku *et al.*, 2008)

1.2 Problem Statement

Air pollution is a major health environmental health problem affecting everyone in both rural and urban area. Rural area usually outside the towns and cities with small sizes population and slow development activity while urban have high human population and vast human built infrastructures cause by active development activity. The topographic between urban and rural area also different. The prime sources of employment in urban area is related on industrial-based while for rural area is agricultural-based. Moreover, accessibility for transportation and other services probably different between these two areas (Pateman, 2010). Among the differences stated, development activities may elevated the higher risk of air pollution at urban area rather than rural area (Jimoda, 2012). Literature search revealed that research before only focusing in big and popular cities which contain high industrial activities rather than medium industrial due to possibility of higher pollutants emission. Thus, less information of air quality from rural areas. Thus, this research will provide data to show the current state of air quality for rural citizen especially in important area such as school area.

Most of the children spent their time six to seven hours in their schools throughout their growth period (Ismail & Suroto, 2014). From this situation, probability for children to be exposed to air pollutants is high. Children are known as sensitive group of human being to air pollution due to the fact that their metabolic rate per kilogram of body weight is much higher than of an adult (Ismail & Suroto, 2014). Infant or child is extremely vulnerable to environmental interference because their organs are developing rapidly at early stage of development, making them more susceptible to functional damage or disorders (Mohamed Darus *et al.,* 2011). These groups are also vulnerable to heavy metal poisoning since this is the period for maximal brain growth and differentiation (Mohamed Darus *et al.,* 2011). Besides, the rate of absorption of heavy metals from the digestion system and the haemoglobin sensitivity to these metals in children is much higher than in adults. Thus, through this research, students, school employees, families, and community members will recognize environmental health threats that may be present in schools area caused by air pollutants and create awareness of this air pollution issues among society.

1.3 Objectives

The main objectives of this study are:

i. To determine the concentration of particulate matter (PM_{10}) at school in rural an urban area of Kelantan.

ii. To compare the concentration particulate matter (PM_{10}) between schools at rural area and urban area of Kelantan.

iii. To characterize the types of heavy metals in particulate matter (PM_{10}) found in school at rural and urban area of Kelantan

1.4 Significance of Study

Children spend their waking time longer at school rather than at their house. Thus, air quality assessment at school is very important. Mostly, the air quality in school at urban area more polluted than school at rural area because of higher number of air pollutant sources such as mobile sources which are cars, buses, trucks and stationary sources like industrial facilities and factories. From this research, the concentration of particulate matter in school areas can be measure. Thus, from collection of particulate matter can determine and compare concentration of heavy metals in research area. The data collection of particulate matter and heavy metals concentration will encourage the community to aware of the air pollution risks in school areas by taking health precaution step as contaminated environment can cause or exacerbate health problems to their children. A healthy school environment can directly improve children's health and effective learning and thereby contribute to the development of healthy adults as skilled and productive members of society (Swaleha, 2012).

CHAPTER 2

LITERATURE REVIEW

2.1 Air Pollution

Air pollution by heavy metals is a worldwide problem because these heavy metals are indestructible and mostly have toxic effects on living organisms when allowable concentration levels are exceeded (Oluwole *et al*., 2013). Air quality level in any area is detected based on the presence of particulate matter, carbon oxide, nitrogen oxide and sulphur oxide (Bolong *et al*., 2008). Particulate matter (PM) defined as term for complex mixture of extremely small particles found in the air, including dust, dirt, smoke, soot and liquid droplets. According to U.S. Environmental Protection Agency (2004), some particles are large or dark enough to be seen as soot or smoke while others are so small that thus, can only be detected with an electron microscope. These particles are directly emitted to the air. Other particles may be formed in the air from the chemical change of gases. They are indirectly formed when gases from burning fuels react with sunlight and water vapour (Seinfeld & Pandis, 2006). Environmental Protection Agency (EPA) is concerned about particles that are 10 aerodynamic micrometers in diameter or smaller because those are the particles that generally pass through the throat and nose and enter the lungs. Once inhaled, these particles can affect the heart and lungs and cause serious health effects. The size of particles is directly linked to their potential for causing health problems.

2.2 Definition of rural and urban area

Rural area is defined as areas with population less than 10,000 people having agriculture and natural resources in which its population either clustered, linear or scattered. The definition of urban areas defined as gazetted areas with their adjoining built-up areas that have a combined population of 10,000 or more (Yaakob *et al*,. 2012). As stated in official website of Tanah Merah District Council, the total population until 2010 based on local authority area for Kubang kerian is 12,563 people and Batu Melintang have 2,383 people respectively. Thus, Kubang Kerian can be considered as urban area while Batu Melintang can be considered as rural area.

2.3 Sources of Heavy Metals In Atmosphere

The major sources of air pollution in urban areas are anthropogenic, while contamination from natural sources predominate in the rural areas (Olade, 1987a). The main sources of air pollution are mostly from industrial establishment and motor vehicles which are significantly lower in rural areas. Another sources of heavy metals are from agriculture occur during the process of farming including undue use of chemical fertilizer, pesticide and chemical-based fast methods to grow crop faster than its normal time. In addition, heavy metals and particulate matter in the rural areas also emitted from coal and wood burning, fertilizers use in farming, agricultural activity, road construction activity and the dust from long range transport along with naturally occurring re-suspended dust (Tyagi *et al.*, 2012). Among the listed sources, wood burning was identified as most significant source of elevated concentrations in rural areas.

Intensive anthropogenic activities are also from high population density, where population will yield abundance of heavy metal sources that have considerable influence on human health (Mohamed *et al.*, 2014). According to Leung and Drakaki (2015), these pollutants are predominantly emitted from on-road and off- road transports in urban areas. Other sources are from power plants, industrial boilers, incinerators, petrochemical plants, aircrafts, ships and soon, depending on the locations and transported pollutant due to prevailing winds. Despite that, urban air quality is highly affected by city design. Compactly distributed and deep street canyons (buildings with large building height to road width ratios) can block and weaken the wind and reducing its air scattering capability. On the other hand, good urban design can reduce air pollutants and can lessen the problems of air pollutant accumulation.

2.4 Types of Heavy Metals in The Atmosphere

Heavy metals are defines as any metallic chemical element that has a relatively high density (superior to 5 g/cm^3). Heavy metals are formed in the fine and light compounds and suspended in the air at atmosphere (Heidari-Farsani *et al.*, 2013). Even at low concentrations, most of heavy metals are carcinogenic or toxic. The composition of the air pollutants can be inorganic, organic or complex mixtures of both. Among the many inorganic pollutants emitted by anthropogenic activities, heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni), manganese (Mn) and lead (Pb) are of a major concern due to their toxic and potentially carcinogenic characteristics (Vosniakos *et al*., 2011). Generic sources of heavy metals include mining and industrial production such as foundries, smelters, oil refineries, petrochemical plants and chemical industry, untreated sewage sludge, disperse sources such as metal piping, traffic and combustion by-production from coal burning power plants (Vosniakos *et al.*, 2011). In particular, these three heavy metals (Hg, Pb and Cd) are of great concern to human health and to the environment, mostly due to their ability to travel long distances in the atmosphere before deposition (Vosniakos *et al.*, 2011).

Lead is a heavy, low melting, bluish-gray metal that occurs naturally in the Earth's crust (ATSDR, 2007). However, it is rarely found naturally as a metal. It is usually found combined with two or more other elements to form lead compounds. Lead is a very soft metal and over decades has been used in many different applications: building materials, pigments for glazing ceramics and pipes for transporting water. The largest use for Pb is in storage batteries in cars and other vehicles (ATSDR, 2007). Most Pb used by industry comes from mined ores (primary) or from recycled scrap metal or batteries (secondary)(ATSDR, 2007). Today most of the 25 millions of tons of Pb produced every year is used in batteries. Lead is ranked as number two in Agency for Toxic Substances and Disease Registry top 20 list (ATSDR, 2015). During the last century, the Pb content in fuels was a main source of pollution to the environment and particularly the release of lead to the atmosphere was especially hazardous to children (ATSDR, 2015). Lead can enter the environment through releases from mining lead and other metals, and from factories that make or use Pb, Pb alloys, or Pb compounds. Lead is released into the air during burning coal, oil, or waste (ATSDR, 2007). Once Pb gets into the atmosphere, it may travel long distances if the lead particles are very small. Lead is removed from the air by rain and by particles falling to land or into surface water (ATSDR, 2007).

Pure Cadmium is a soft, silver-white metal (ATSDR, 2012) which is ranked as the seven in ATSDR's top 20 list (ATSDR, 2015). It is widely used in batteries and in paint pigments. Cadmium is also a by-product of the mining and smelting of Pb and Zn. It is a common component of commercial fertilizers used in agriculture for insecticides and fungicides and is frequently found in agricultural soils. Non-ferrous metal mining and refining, manufacture and application of phosphate fertilizers, fossil fuel combustion, and waste incineration and disposal are the main anthropogenic sources of cadmium in the environment (ATSDR, 2012). Cigarettes also contain cadmium (U.S Department of Health and Human, 2012). Smoking greatly increases exposure to cadmium, as tobacco leaves naturally accumulate high amounts of cadmium (ATSDR, 2012). Cadmium in forms oxide, chloride, and sulfate will exist in air as particles or vapors from high temperature processes). It can be transported long distances in the atmosphere, where it will deposit in wet or dry forms onto soils and water surfaces.

Zinc is one of the most common elements in the Earth's crust. Zinc is found in the air, soil, and water and is present in all foods (ATSDR, 2005). In its pure elemental form, zinc is a bluish-white, shiny metal (ATSDR, 2005). Zinc enters the air, water, and soil as a result of both natural processes and human activities (ATSDR, 2005). A common use for zinc is to coat steel and iron as wellas other metals to prevent rust and corrosion (ATSDR, 2005). Most Zn enters the environment as the result of mining, purifying of zinc, lead, and cadmium ores, steel production, coal burning, and burning of wastes (ATSDR, 2005). These activities can increase Zn levels in the atmosphere.In air, Zn is present mostly as fine dust particles (ATSDR, 2005). This dust eventually settles over land and water. Rain and snow aid in removing zinc from air. Zinc is also an essential element needed by human body in small amounts. Human are exposed to zinc compounds in food as well as in most of drinking water. Drinking water or other beverages may contain high levels of zinc due to usage of metal containers to stored the water through Zn coated to resist rust.

2.5 Health Effects of Particulate Matter

Particulate matter exposure has been linked in a number of different health outcomes including lung inflammatory reactions, reduction in lung function and also effects on cardiovascular system (Praznikar & Praznikar, 2012). Health effect cause by particulate matter can lead visitation to the hospital emergency, hospital admission and death (Praznikar & Praznikar, 2012). Furthermore, literature search revealed PM_{10} exposure is associated with increased of heart disease among elderly and with higher risk of myocardial infraction (Rai, 2015). Increase of dust particulates concentration in the air contribute human health hazards including acute respiratory disorders such as bronchitis, sinusitis, allergy and asthma and damage to the defensive functions of alveolar macrophages leading to increase respiratory infections (Rai, 2015).

2.6 Health Effects of Heavy Metals Exposure

Air pollution has many effects on the health of both adults and children. Even healthy teenagers, young adults, and strong athletes can suffer negative effects from high pollution levels, especially when exercising outdoors. Individual reactions to air pollutants depend on the type of exposed pollutant, the degree of exposure, the individual's health status and also genetics (USEPA, 2015a). Air pollution can affect human health in many ways with both short-term and long-term effects. Different groups of individuals are affected by air pollution in different ways. Infants and young children are at risk because their lungs are not fully developed and faster breathing speed. The elderly are at risk because their bodies are no longer as effective at dealing with environmental stress. In addition, children also spend more time outdoor than adults. The average adult, except for those who work mostly outdoors, spends most of their time indoors in home, work, or even at the gym (Kleinman, 2000). Children have higher risk expose to outdoor especially during haze episode (Kleinman, 2000).

Some examples of short-term effects including eyes irritation, nose and throat, and upper respiratory infections such as pneumonia and bronchitis (USEPA, 2015a). More symptoms can include nausea, headaches, and allergic (USEPA, 2015a). Short-term air pollution can disturb the medical conditions of individuals with asthma and emphysema (USEPA, 2015b). Meanwhile, long-term health effects encompass chronic respiratory disease, heart disease, lung cancer, and even brain, nerves, liver, or kidneys damage (USEPA, 2015a). Continuous exposure to air pollution affects the lungs of children and may bother or complicate medical conditions in the elderly (USEPA, 2015a).

Air pollution is a significant risk factor for a number of health conditions including respiratory infections, heart disease, stroke and lung cancer. The health effects caused by air pollution may include difficulty in breathing, wheezing, coughing, asthma and worsening of existing respiratory and cardiac conditions (USEPA, 2015a). These effects can result in increased medication use, increased doctor or emergency room visits, more hospital admissions and premature death (USEPA, 2015a). The human health effects of low air quality are far reaching, but basically affect the body's cardiovascular system and the respiratory system (USEPA, 2015a).

Further detail of health effects of for lead are the same whether it enters the body through breathing or swallowing. The main target for lead toxicity is the nervous system, both in adults and children (ATSDR, 2007). Children are more vulnerable to lead poisoning than adults. Children are exposed to lead all through their lives. Children can be exposed to lead in the womb if their mothers have lead in their bodies. Babies can swallow lead when they breast feed, or eat other foods, and drink water that contains lead (ATSDR, 2007). Babies and children can swallow and breathe lead in dirt, dust, or sand while they playing on the floor or ground. These activities make it easier for children to be exposed to lead than adults (ATSDR, 2007). The dirt or dust on hands, toys, and other items may have lead particles in it.

Cadmium has been detected in human blood, urine, breast milk, liver, kidney, and other tissues, both in occupationally exposed individuals and in the general population (ATSDR, 2012).The sensitive targets of cadmium toxicity are the kidney and bone following oral exposure and kidney and lung following inhalation exposure (ATSDR, 2012). Other effects that have been observed in humans and/or animals include reproductive toxicity, hepatic effects, hematological effects, and immunological effects (ATSDR, 2012). Prolonged inhalation or ingestion exposure of humans to cadmium at levels causing renal dysfunction can lead to painful and debilitating bone disease in individuals with risk factors such as poor nutrition. The health effects seen in children from exposure to toxic levels of cadmium are expected to be similar to the effects seen in adults such kidney and lung damage. Children can be exposed to cadmium through parents who work in cadmium-emitting industries

(ATSDR, 2012). Some studies indicate that maternal cadmium exposure may cause decreased birth weight in humans, but most of these studies are of limited use because of weaknesses in the study design and lack of control for confounding factors (ATSDR, 2012).

Inhaling large amounts of zinc as zinc dust or fumes from smelting or welding can cause a specific short-term disease called metal fume fever, which is generally reversible once exposureto zinc ceases. However, very little is known about the long-term effects of breathing zinc dust or fumes (ATSDR, 2005). As for young children, Zinc is essential for proper growth and development. Mothers who did not eat enough zinc during pregnancy had a higher frequency of birth defects and gave birth to smaller children than mothers whose zinc levels were sufficient (ATSDR, 2005). A child who accidentally drank a large amount of a caustic zinc solution was found to have damage to his mouth and stomach, and later to his pancreas, but similar effects have been seen in adults who accidentally drank the same solution (ATSDR, 2005). Furthermore, children living near waste sites containing zinc are likely to be exposed to higher environmental levels of zinc through breathing, drinking contaminated drinking water, touching soil, and eating contaminated soil (ATSDR, 2005).

CHAPTER 3

METHODOLOGY

3.1 Site Description

3.1.1 Sampling place

This research was conducted at two schools in Kelantan urban and rural area. In order to assess differences in air pollutants exposure, two secondary schools were chosen. One school was located at rural area in Batu Melintang while the other one was in urban area at Kubang Kerian. The schools were Sekolah Kebangsaan Batu Melintang located in a rural area (Figure 3.1 (a)) and Sekolah Menengah Kebangsaan Kubang Kerian 1 (Figure 3.1 (b)) located in Kubang Kerian. This research was conducted between April to June 2016.

Figure 3.1: Location of Sekolah Kebangsaan Batu Melintang

Figure 3.2: Location of Sekolah Menengah Kebangsaan Kubang Kerian 1

3.1.2 Sampling point

Lower volume air sampler (LVS) were placed at guardhouse of each school. Outdoor measurement were carried at the guardhouse because it was not frequently visited by the students hence for security purposes. Installation of air sampler 1.5 m – 2 m above the ground is preferable when considers the effect of air pollution on the human body and the area in which people are most active (Japan Environmental Overseas Cooperation Center, 2000).

3.2 Collection of Particulate Matter Samples

3.2.1 Sampling Procedures

The sampling frequency for each school are 15 times. Five samples from Sekolah Kebangsaan Batu Melintang and five samples from Sekolah Menengah

Kebangsaan Kubang Kerian 1 were collected every month for three months starting April until June 2016. The fiberglass filter papers 8 x 10 inch (20 x 25 cm) were pre-treated with heat at 500°C for 3 hours in a furnace to remove any deposited organic compounds.

These type of filter paper were chosen because they were suitable for measuring the particles weight. The filter papers were wrapped with aluminium foil and equilibrated in a desiccator for at least 24 hours before and after sampling to reduce moisture effect and are weighed using electronic microbalance. The filter papers were kept in sealed plastic bag during sampling.

Air contaminants were collected using LV-20P low volume air sampler on a fiberglass filter, passing air through the filter for 24 hours. The exposed filter media were kept in a sealed plastic bag and brought back to the laboratory. Figure 3.3(a) was shown the sampling process of particulate matter at Sekolah Kebangsaan Batu Melintang while figure 3.3(b) was at Sekolah Menengah Kebangsaan Kubang Kerian 1. After sampling, the filter medium were detached from the sampler and analysed gravimetrically to determine concentrations. After gravimetrical analysis, the filter paper were packed in aluminium foils and stored at −20 °C until the digestion and chemical analysis (Hassanvand *et al.*, 2015).

Figure 3.3: Sampling point at Sekolah Kebangsaan Batu Melintang

Figure 3.4: Sampling point at Sekolah Menengah Kebangsaan Kubang Kerian 1

The storage method for filter paper that has been used for collection differs depending on the analysis objectives. Heavy metal components can be stored at room temperature after being placed in a plastic bag or suchlike to avoid contamination from within the room (Japan Environmental Overseas Cooperation Center, 2000). Furthermore, there are some substances whose concentration certainly decreases under light at room temperature. Thus, it is better to store samples that are used to analyze a number of components in a dark and frozen state (Japan Environmental Overseas Cooperation Center, 2000). The gravimetric mass was calculated as the subtraction of the weight of the filter after sampling from that of the prior sampling. As for further precaution, particulate matter concentration at each measurement point changes in accordance with the existence of local pollution sources, the peripheral natural environment and the existence of manmade structures such as buildings and roads, and the height of the measurement point. The filter mass obtained was recorded and PM_{10} was calculated using the equation 3.1 below (Breysse *et al*,. 2006):

PM_{10} mass concentration in mg/L

$$= \frac{mass\ of\ sampled\ particulate\ matter\ (\mathrm{PM10})}{Flow\ rate^{1}/_{min} \times Elapsed\ time\ (min)}$$

$$= \left[\frac{M_1 - M_2 \times 10^6}{FR \times T}\right] \qquad Equation\ 3.1$$

Where

M_1 = Weight of filter paper before sampling (g)

M_2 = Weight of filter paper after sampling (g)

FR = Average flow rate (1/min or m^3/min)

T = Sampling duration in minutes

3.3 Laboratory Analysis of Particulate Matter

3.3.1 Sample Digestion and Dilution

Heavy metals from samples were extracted by using digestion method. Digestion method is referred based on Modified NIOSH 7300 Method (SERAS). The filter papers were cut into small pieces and transferred into a clean 50-mL beaker. 5 mL concentrated nitric acid (HNO_3) was added to the beaker, covered with a watchglass, and let stand 30-minutes at room temperature. All digestions must be performed under a working fume hood. The hotplate (120°C) was heated until approximately 0.5 mL of sample remained. 2 mL of HNO_3 was added and heated until approximately 0.5 mL of sample remained. This heating process was repeated until the solution was clear. Then, removed watch glass and rinsed into the beaker with deionized water. The temperature was increased to 150°C and heated until approximately 0.5 mL of sample remains. The solution was filtered by using Whatman filter paper and transferred into 25 mL volumetric flask (NIOSH 7300, 2003). The transferred solution in the 25 mL volumetric flask was then diluted until the mark of 25 mL volumetric flask with dilution acid (4% Nitric Acid) (NIOSH 7300, 2003).

3.2 Heavy Metals Analysis

Samples were analysed by using Atomic Absorption Spectrometry (AAS) model Aanalyst 800 produced by Perkin Elmer to measure the concentration of Pb, Zn, Cd.

3.4 Quality Control of Atomic Absorption Spectrometry

3.4.1 Preparation of Standard solution corresponding to 10 mg/l of each heavy metal

Each of 10 mL of Cadmium, Lead, and Zinc stock solution were pipette into each 1000 mL volumetric flask. 20 mL of diluted nitric acid (25% concentrated nitric acid) and were filled to the mark of each volumetric flask with deionized water and mixed well.

3.4.2 Calibration Curve

Quantitative measurements in atomic absorption are based on Beer's Law, which states that concentration is proportional to absorbance ($C = kA$) where C is concentration, k is constant values and A is absorbance. Five different concentrations of 0.0, 0.5, 1.0, 1.5, and 2.0 mL were needed to obtain calibration curve for quantitative analysis. Thus, serial dilution is required to obtain absorbance reading within the working range for each heavy metal. This process was applied for standard solution and sample solution. A calibration curve and the equation for the line used to determine unknown concentration based on its absorbance. Standard was run at least after every five samples to check the spectrometry calibration.

3.5 Statistical Analysis

The tool used to collect data is Microsoft Excel and *Statistical Package for Social Sciences* (SPSS) version 20.0. The tests used was inferential analysis. The types of inferential analysis were single Independent t-Test. T-Test is used to compare two different set of values. It is generally performed on a small set of data. T-Test is generally applied to normal distribution which has a small set of values. This test compares the mean of two samples. T-Test used means and standard deviations of two samples to make a comparison. The formula for t-Test is given below:

$$\frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}} \qquad Equation\ 3.2$$

Where,

$\bar{X}_1$ = Mean of first set concentration

$\bar{X}_2$ = Mean of second set concentration

S_1 = Standard deviation of first set of concentrations

S_2 = Standard deviation of second set of concentration

n_1 = Total number of values in first set of samples

n_2 = Total number of values in second set of samples.

The formula for standard deviation is given by:

$$\sqrt{\frac{\Sigma(x-\overline{X})^{2}}{n-1}} \qquad Equation\ 3.3$$

Where,

x = Values of concentration

$\overline{X}$ = Mean concentration

n = Total number of population

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Variation of PM_{10} concentration in urban and rural area

Total of 15 samples were collected at two different schools between rural and urban area in Kelantan, which are Sekolah Kebangsaan Batu Melintang and Sekolah Menengah Kebangsaan Kubang Kerian 1 respectively during the month of April, May and June 2016. The gravimetric mass concentration of PM_{10} within the school ranged between 18.008 ($\mu g/m^3$) to 86.051 ($\mu g/m^3$) for Sekolah Kebangsaan Batu Melintang. The concentration of all samples in April at rural area on average between 30 to 40 $\mu g/m^3$. For data samples in May, all data samples concentration was in average 29 to 76 $\mu g/m^3$ while on June, all data samples concentration was in average 19 to 86 $\mu g/m^3$. Range concentration of PM_{10} for Sekolah Menengah Kebangsaan Kubang Kerian 1 is between 24.861 ($\mu g/m^3$) to 99.550 ($\mu g/m^3$). The concentration of all samples in April at urban area is on average 51 to 99 ($\mu g/m^3$). For data samples in May, the particulate matter concentration is between 37 to 56 ($\mu g/m^3$) while on June, all data samples concentration was in average 24 to 37 ($\mu g/m^3$). Figure 4.1 and 4.2 shows there is no sample data that exceed the maximum concentration value (150 $\mu g/m^3$) from Recommended Malaysia Air Quality Guideline (RMAAQG) set by Department of Environment for PM_{10} in ambient air (24 hours average).

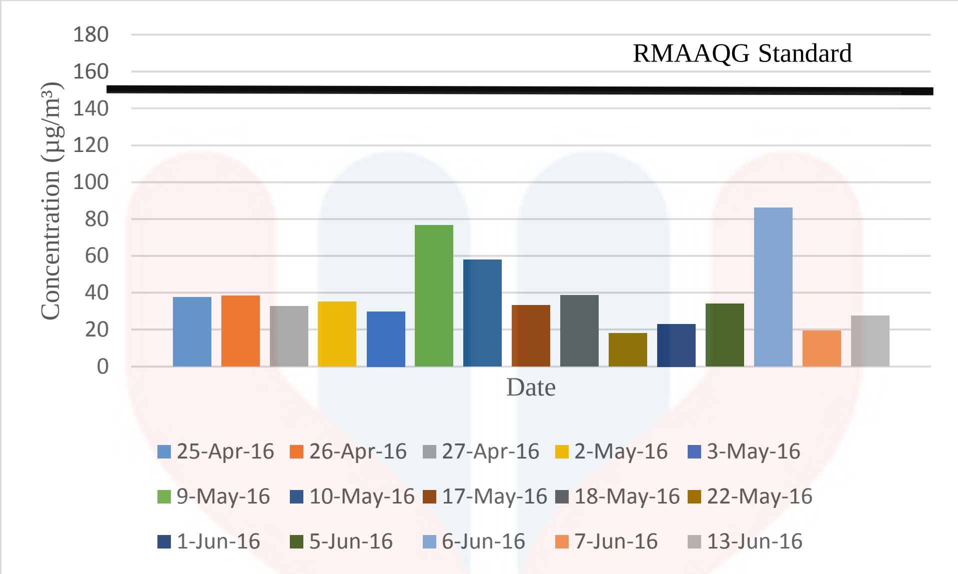

Figure 4.1 : Trend of 24 hours concentration of PM10 in Sekolah Kebangsaan Batu Melintang

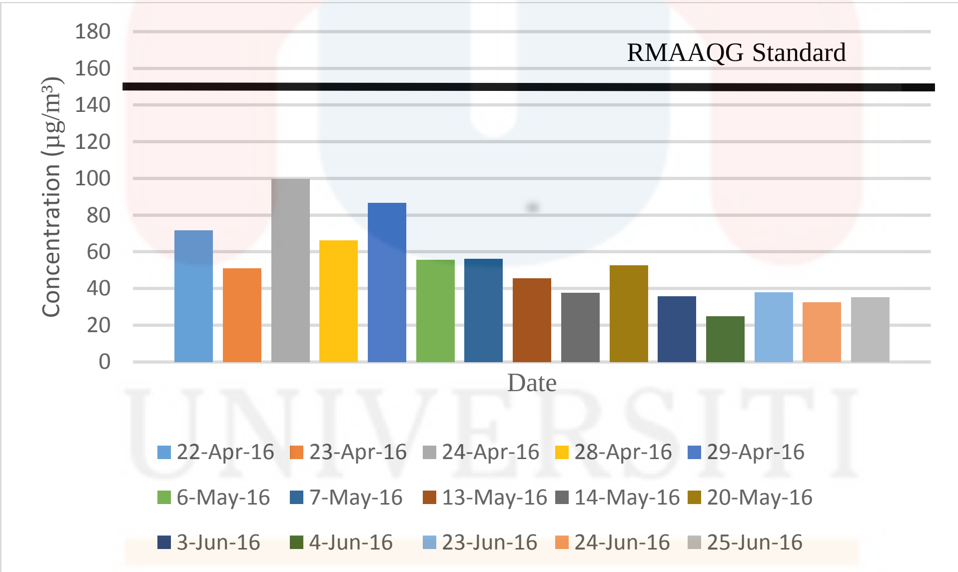

Figure 4.2: Trend of 24 hours concentration of in Sekolah Menengah Kebangsaan Kubang Kerian 1

From Figure 4.3, the distribution gap between maximum and minimum at urban and rural area is huge. The differences between upper quartile and lower quartile at urban area is more than at rural area. The median at urban area also higher than rural area. Although PM_{10} concentration in urban area is higher than rural area, the differences between these two areas is not much. Thus from the outliers, data extreme not found in both area. Meaning that results is not significantly difference.

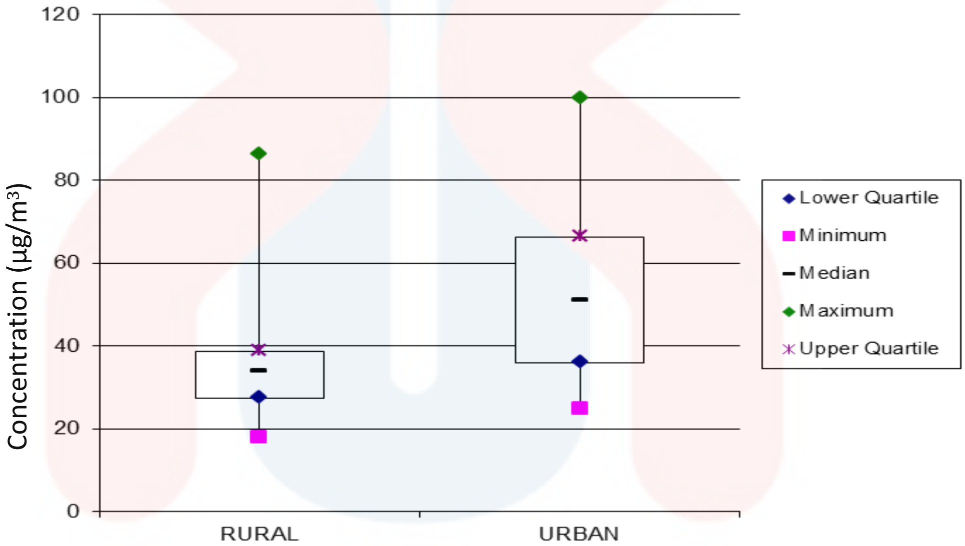

Figure 4.3: Box and whisker plot of the PM1**0** concentration between rural and urban area

4.2. Influence of Meteorology on Mass Concentration

The highest PM_{10} concentration in rural area was on 06 June 2016 that was 86.051 µg/m^3 and the second highest is on 09 May 2016 that was 76.632 µg/m^3. As for the concentration of of all samples at urban area, the sample datas have most different fluctuation in increase of concentration values. The highest concentration was on 24 April 2016 that was 99.550 µg/m^3 and the second highest is on 29 April 2016 that was 86.528 µg/m^3.

As we know, on April until May, Malaysia is having inter-monsoon season. Mostly the highest concentration data is not having a rainfall, only hot and sunny day. It is interpreted that reasons for the higher levels of the particulate matter mass in the dry season are due to temperature inversion and absence of rain wash-down (Mkoma & Mjemah, 2011). The less amounts of rain fall contribute to the higher concentration of particulate matter in the air (Alias *et al.*, 2007). Data from at the end of May until June mostly show low concentration of particulate matter because present of rain. The rain can reduce the amount of particulate matter collected because most of it will be carried way by rain water (Alias *et al.*, 2007). The observed particulate matter levels are also affected by the variations in sources strenghts and in meteorological conditions such as mixing heights, precipitation, relative humidity, wind speed and direction as supported by air mass trajectories (Mkoma & Mjemah, 2011).

The average temperature during sampling day at rural area was 25.4 $\mu g/m^3$ to 30.1 $\mu g/m^3$ and urban area is around 27 $\mu g/m^3$ to 30.4 $\mu g/m^3$. Mostly, the higher concentration, stated as 29 $\mu g/m^3$ to 30.4 $\mu g/m^3$ might be caused by more intense information of secondary aerosols (Mkoma & Mjemah, 2011). The wind speed is less clear than any of other meteorological parameter. The wind speed at rural area was around 0.7 m/s until 1.5 m/s while in urban area the wind speed was around 1.7 m/s to 3.0 m/s. Low wind speeds inhibit dilution whereas large wind speeds lead to increased soil dust mobilization. It seems that the effects of decreased dilution and increased dust were roughly of equal importance (Mkoma & Mjemah, 2011).

4.2.1 The Comparison of Mass Concentration of PM_{10} between Schools in rural and urban area.

The mean concentration of PM_{10} of rural and urban area was analyzed using Independent Sample t-Test. Based on the tabel 4.1 below, the mean concentration of PM_{10} in rural area was 39.209 µg/m^3 while in urban area was 52.569 µg/m^3. The Independent t-Test applied to this data set allowed to infer that urban area showed statistically not significant difference of the increasing in data concentration with rural area. Meaning that, eventhough there have a difference concentration of particulate matter, similar trend with literature but there are not significantly difference between data of these two areas.

Table 4.1: Independent Sample t-Test result

School location		N	Mean	Std. Deviation	Std. Error Mean
PM_{10} Concentration	Jeli	15	39.209	19.641	5.071
	Kota Bharu	15	52.569	21.022	5.428

4.3 Heavy metals analysis using Atomic Absorption Spectrometry

Figure 4.4 showed the variable weight distribution of heavy metals at school in urban area while figure 4.5 showed the weight distribution of heavy metals at school in rural area. We examined the three heavy metals which includes; Pb, Cd and Zn. The analysis of the samples was made in triplicate and the average value was used in calculation.

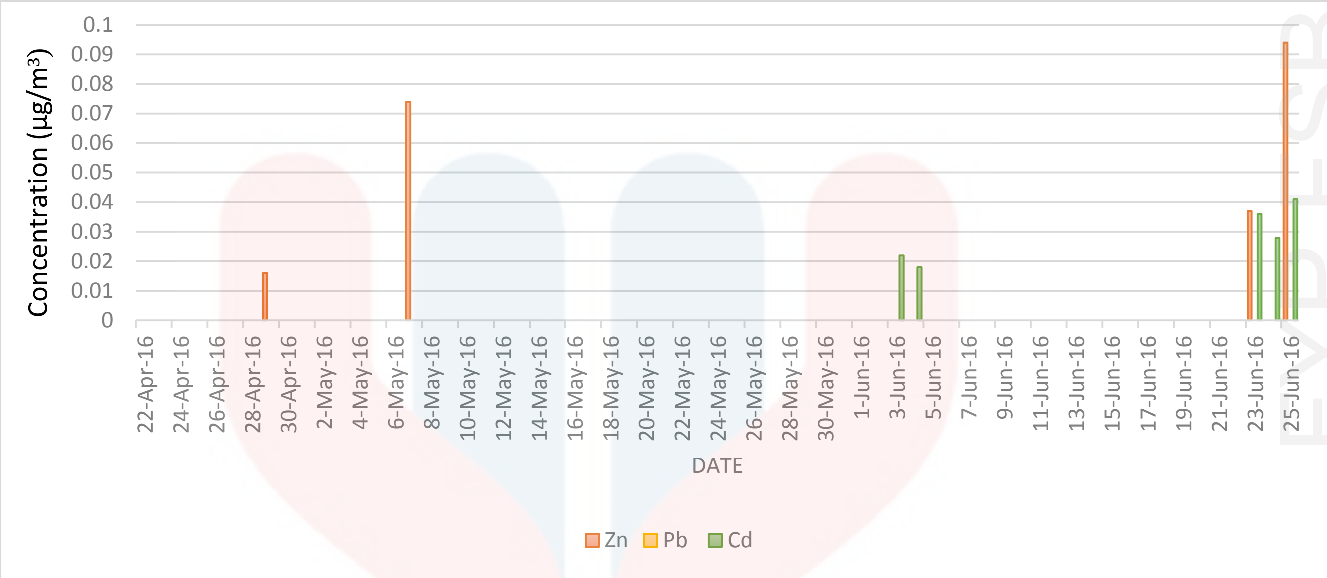

Figure 4.4: Concentration of heavy metals at school in urban area

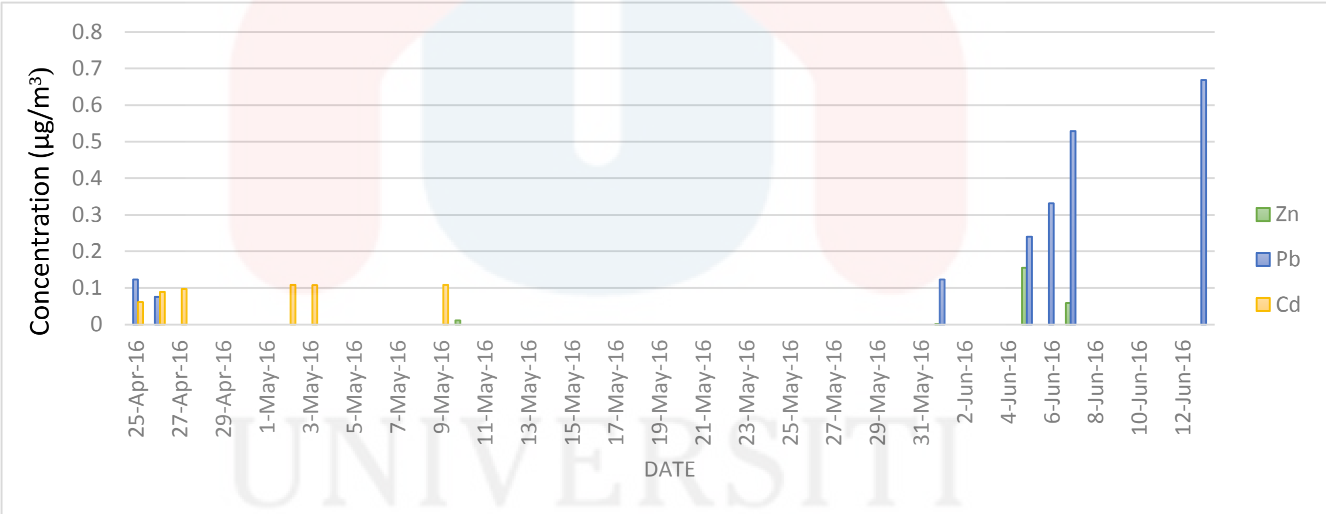

Figure 4.5: Concentration of heavy metals at school in rural area

The concentration of Pb, Zn, Cd found in PM_{10} at urban and rural area illustrated in Figure 4.6, Figure 4.7 and Figure 4.8. The results indicate that all the determined heavy metals were within the permissible limit directed by the world health organization (WHO, 2011). Based on the graph below, we can see the detection Pb element present in samples ranged from 0.076 μg/m^3 to 0.669 μg/m^3 and only can be found at rural area. The detection of Zn present in both rural and urban samples ranged from 0.001 μg/m^3 to 0.155 μg/m^3 and the highest value is found in sample in rural area. Other than that, the detection of Cd element both present in rural and urban sample ranged from 0.018 μg/m^3 to 0.108 μg/m^3 with the highest value is from sample in rural area.

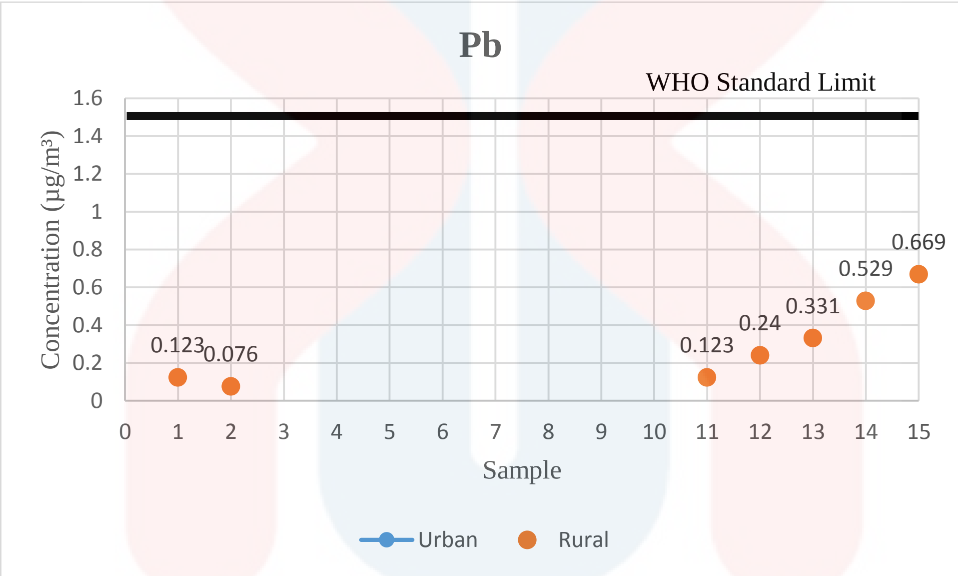

Figure 4.6: Concentration Lead elements detected in urban and rural area

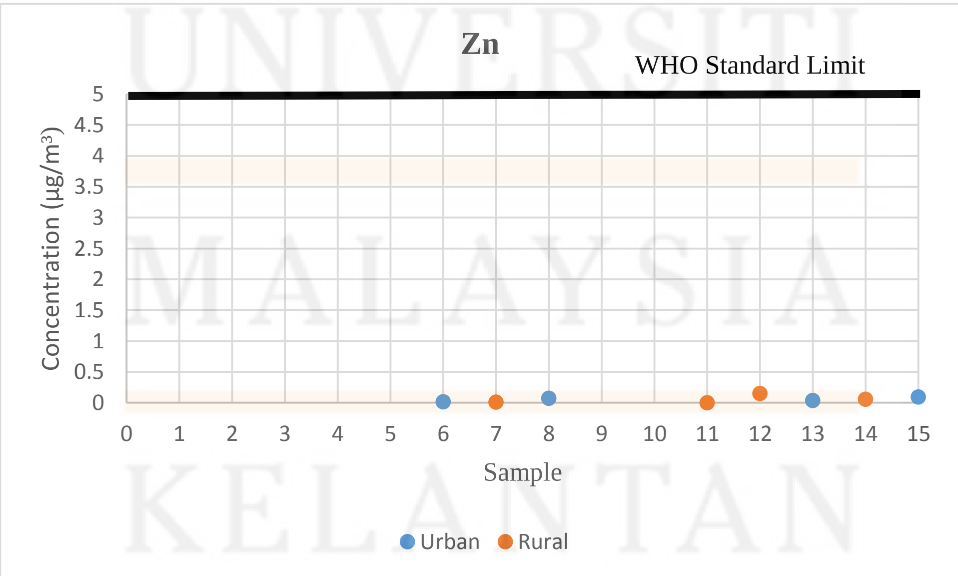

Figure 4.7: Concentration of Zinc elements detected in urban and rural area

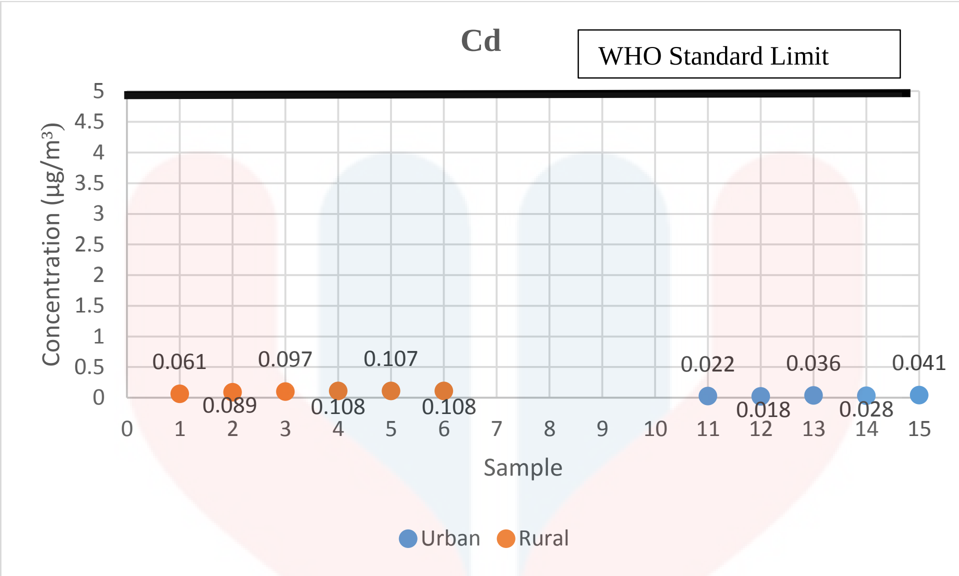

Figure 4.8: Concentration of Cadmium elements detected in urban and rural area

Sekolah Kebangsaan Batu Melintang dominating in the concentration of Pb as there is no detection of Pb at Sekolah Menengah Kebangsaan Kubang Kerian 1. The present of Pb in sample majorly due to automobile emission and also the deposition near the road (Darus *et al.*, 2012). High concentrations of Pb in this study may be a consequence of the number of vehicles passing through the area near sampling location. As the location of sampling instruments are at the guardhouse, the absence of Pb in urban area is because of less number of vehicles passing through the schools.It is because the sampling schedule at urban area mostly at weekend. Thus, less human activity happened at urban area and less mobile emission. Vehicles that use the leaded gasoline might contributed toward the emission of Pb in the atmosphere however, the less Pb present in air also maybe because air lead levels have decreased considerably with the phase-down of lead in gasoline (Geiger & Cooper, 2010).

Both rural and urban area had detected Zn element. Zn also related to automobile emission (Darus *et al.*, 2012). The sources of Zn in dust may have its origin from automotive sources such as from wear and tear of vulcanized rubber tyres, lubricating oils and corrosion of galvanized vehicular parts (Darus *et al.*, 2012). It may also comes from human activities like mining, steel production, coal burning, and burning of waste (Geiger & Cooper, 2010). Cd element only present on

April and early of May at rural while on June at urban area. The present of Cd in rural and urban samples may from burning fossil fuels, from incineration of municipal waste materials, and from zinc, lead, and copper smelters. Smoking cigarettes is another source of airborne cadmium (Geiger & Cooper, 2010). The present of Pb, Zn, and Cd in rural area also may because of the school in rural area is a community centre. In the afternoon, community people will gather and doing their activity such as playing football or organize special events.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The study revealed the mean gravimetric mass concentration of in outdoor air in selected school located at rural and urban area of Kelantan. The mean gravimetric mass concentration of at urban area (52.527 $\mu g/m^3$) higher than rural area (39.760 $\mu g/m^3$) but still not exceed the maximum concentration value (150 $\mu g/m^3$) from Malaysia Air Quality Guideline set by Department of Environment for in ambient air (24 hours average). The concentration at rural and urban area is most likely due to meteorological factor, number of vehicles going through the school gate, high population movement and more anthropogenic activity happened in surrounding. As for heavy metal detection, the highest number of heavy metal present at rural area is Pb elements while in urban area is Cd elements. The possible sources of heavy metals might be coming from vehicles and also anthropogenic activities by the surrounding area. Based on previous study, the number of heavy metals present in urban area less than rural area thus, it does not meet the expectation. It may because the researched conducted at urban area mostly in weekends while rural area is in the weekdays. In conclusion, the results showed that there are not significantly differences between concentration among these two areas.

5.2 Recommendation

From this research, some recommendations are made in order to improve future research for better understanding air quality in Kelantan. Since this research only got 15 samples for each area thus, only some information can be extracted from this air quality assessment Therefore, it is recommended that the sample size should be increased in order to get more comprehensive and exact results of the study area. Further study also can be made in two different monsoon season so the results can be differentiate between wet and dry season and not in inter-monsoon season. During inter-monsoon season, the wind speed is light,wind direction is variable and also unpredictable rain. Beside that, for sampling date, the sampling of particulate matter at two different area should be made at the same day. Sampling date should also be decided between weekends or weekdays. Thus, the data collected can be can be differentiate with meteorological factor, anthropogenic activity and number of vehicles more accurately, Other than that, the spatial variation and geographic variation data by using geographical mapping should be further analyzed, interview or observation should be taken, so that the results collected can be relate with activity and development in surrounding and will provided more information for future study of particulate matter in Malaysia.

REFERENCES

Alias, M., Hamzah, Z., & Kenn, L. S. (2007). PM10 and Total suspended particulates (TSP) measurements in various power stations. *The Malaysian Journal of Analytical Sciences*, *11*(1), 255-261.

Analysis of Metals In Air With A Modified NIOSH 7300 Method. (2001),(1813), (Icv), (March),1–23.

ATSDR. (2005). Toxicological Profile For Zinc. *Journal of Public Health*, (August).

ATSDR. (2007). Toxicological Profile For Lead. *Journal of Public Health*, (August).

ATSDR. (2012). Toxicological Profile For Cadmium. *Journal of Public Health*, (September).

ATSDR. (2015). Summary Data for 2015 Priority List Of Hazardous Substances. *Journal of Toxicology and Human Health Sciences*, *1*(1), 1–2.

Bolong, N., Said, F. M., Halim, F., Omar, H., Engineering, N., & Kinabalu, K. (2008). Particulate Matter Determination From Transportation and Construction Area. *Journal of Nano Engineering and Material*, *1*(February), 1.

Daly, A., & Zannetti, P. (2007). An introduction to air pollution–Definitions, classifications, and history. *Ambient air pollution. P. Zannetti, D. Al-Ajmi and S. Al-Rashied, The Arab School for Science and Technology and The EnviroComp Institute*, 1-14.

Darus, F. M., Nasir, R. A., Sumari, S. M., Ismail, Z. S., & Omar, N. A. (2012). Heavy metals composition of indoor dust in nursery schools building. *Procedia-Social and Behavioral Sciences*, *38*, 169-175.

Hassanvand, M. S., Naddafi, K., Faridi, S., Nabizadeh, R., Sowlat, M. H., Momeniha, F., & Niazi, S. (2015). Characterization of PAHs and metals in indoor/outdoor PM 10/PM 2.5/PM 1 in a retirement home and a school dormitory. *Science of the Total Environment*, *527*, 100-110.

Heidari-Farsani, M., Shirmardi, M., Goudarzi, G., Alavi-Bakhtiarivand, N., Ahmadi-Ankali, K., Zallaghi, E., ... & Hashemzadeh, B. (2014). The evaluation of heavy metals concentration related to PM10 in ambient air of Ahvaz city, Iran. *Journal of Advances in Environmental Health Research*, *1*(2), 120-128.

Ismail, M., & Suroto, A. (2014). Influence of different microenvironment on respirable particulate matter in pre-school of Kuala Terengganu, Malaysia. *Journal of Sustainability Science and Management*, *9*(1), 141-149.

Japan Environmental Overseas Cooperation Center. (2000). Text Book for Sampling for Environmental Monitoring, (March), 39–45.

Jimoda, L. A. (2012). Effects of particulate matter on human health, the ecosystem, climate and materials: a review. *Facta universitatis-series: Working and Living Enviromental Protection*, *9*(1), 27-44.

Geiger, A., & Cooper, J. (2010). Overview of Airborne Metals Regulations, Exposure Limits, Health Effects, and Contemporary Research. *US Environmental Protection Agency. Accessed Accessed on August*, *25*, 2015.

Leung, D. Y. (2015). Outdoor-indoor air pollution in urban environment: challenges and opportunity. *Frontiers in Environmental Science*, *2*, 69.

Melaku, S., Morris, V., Raghavan, D., & Hosten, C. (2008). Seasonal variation of heavy metals in ambient air and precipitation at a single site in Washington, DC. *Environmental Pollution*, *155*(1), 88-98.

Michael T. Kleinman. (2000). The Health Effects of Air Pollution On Children. *Journal of Community and Environmental Medicine*, *1*(Fall), 3.

Mkoma, S. L., & Mjemah, I. C. (2011). Influence of meteorology on ambient air quality in morogoro, Tanzania. *International Journal of Environmental Sciences*, *1*(6), 1107.

Mohamed, R., Saphira, R. M., Aziz, C., Hanim, F., Kassim, M., & Hashim, A. (2014). An assessment of selected heavy metal concentrations (Pb, Cu, Cr, Cd, Ni, Zn) in university campus located in industrial area. *ARPN Journal of Engineering and Applied Sciences*, *9*(12), 2724-2730.

Muhamad-Darus, F., Nasir, R. A., Sumari, S. M., Ismail, Z. S., & Omar, N. A. (2011). Nursery schools: Characterization of heavy metal content in indoor dust. *Asian J. of Environment-Behaviour Studies*, *2*(6), 53-60.

Olade, M. A. (1987a). Heavy Metal Pollution and the Need for Monitoring: Illustratedfor Developing Countries in West Africa.

Olade, M. A. (1987b). Dispersion of cadmium, lead and zinc in soils and sediments of a humid tropical ecosystem in Nigeria. *Lead, mercury, cadmium and arsenic in the environment: New York, John Wiley & Sons*, 303-313.

Oluwole, S. O., Makinde, S. C. O., Yusuf, K. A., Fajana, O. O., & Odumosu, A. O. (2013). Determination of heavy metal contaminants in leafy vegetables cultivated by the road side. *International Journal of Engineering Research and Development*, *7*(3), 01-05.

Seinfeld, J. H., & Pandis, S. N. (2016). *Atmospheric chemistry and physics: from air pollution to climate change*. John Wiley & Sons.

Patrick N. Breysse, Peter S.J. Lees, J. H. (2006). Air Sampling for Particulate Matter, 6–9.

Pražnikar, Z., & Pražnikar, J. (2012). The effects of particulate matter air pollution on respiratory health and on the cardiovascular system. *Slovenian Journal of Public Health*, *51*(3), 190-199.

Rai, P. K. (2015). Multifaceted health impacts of Particulate Matter (PM) and its management: An overview. *Environmental Skeptics and Critics*, *4*(1), 1.

Swaleha S. (2012). *Education An Agency for Creating Safe School Environment : A Sustainable Development Approach*. Vadodara.

Tyagi, V., Gurjar, B. R., Joshi, N., & Kumar, P. (2011). PM 10 and Heavy Metals in Suburban and Rural Atmospheric Environments of Northern India. *Journal of Hazardous, Toxic, and Radioactive Waste*, *16*(2), 175-182.

U.S Department of Health and Human. (2012). Toxicological Profile for Cadmium. *Journal Public Health*, (September), 1–487.

USEPA. (2004). Air Quality Criteria for Particulate Matter October 2004, Volume 2. *Air Quality Criteria for Particulate Matter*, *II*(October), 100.

USEPA. (2015a). Health Effects of Air Pollution. *Journal of Environmental and Workplace Health*, 1–8. \

USEPA. (2015b). Health Effects of Air Pollution. *Journal of Mecklenburg County Air Quality*, 28202.

Vosniakos, F., Vasile, G., Albanis, T., Petre, J., Stanescu, E., Cruceru, L., Vasilikiotis, G. (2011). Environmental Heavy Metal Pollution and Effects on Child Mental Development. *NATO Science for Peace and Security Series C: Environmental Security*, *1*(October), 257–286.

Yaakob, U., Masron, T., & Masami, F. (2010). Ninety years of urbanization in Malaysia: a geographical investigation of its trends and characteristics. *J Ritsumeikan Soc Sci Humanit*, *4*, 79-101.