Particulate Matter Pollutant Monitoring and Analyzing

By

Zuhaidah Binti Shafudin

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

January 2009

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CERTIFICATION OF APPROVAL

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January 2009

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.

ZUHAIDAH BINTI SHAFUDIN

ABSTRACT

Particulate matter is one of the pollutants that have adverse effect to human health such as respiratory and cardiopulmonary illness. Based on the studies, transportation has been identified as one of the major source of particulate matter emission. The objective of this project is to measure the particulate matter concentration level around the university campus. There are 5 selected sampling points which are at the main gate, student village area, student room, lecture hall and administration department. The device used to measure the particulate matter concentration is MiniVol 1100 Low Flow-rate Air Sampler. The average flow rate used for the device is 3 L/min. Duration for the sampling is for 24 hours. The result indicates that the highest particulate matter in at the main gate area this is due to the active transportation activities. The major sources of the particulate matters in the campus area are from vehicles and also from windblown dust, road dust and construction activities. Outdoor air quality has been measured to be poorer than the indoor air quality.

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CHAPTER 1
INTRODUCTION

1.1 Background

Air pollution is the presence of undesirable material in air, in quantities large enough to produce harmful effects. The undesirable materials may damage human health, vegetation, human property, or the global environment, as well as create aesthetic insults in the form of brown or hazy air or unpleasant smells (Nevers, 2000). This pollutions can occurs inside homes, schools, and offices; in cities; across continents; and even globally. It causes breathing problems and promotes cancer and it harms plants, animals, and the ecosystems in which they live. Some air pollutants return to earth in the form of acid rain and snow which can corrode statues and buildings, damage crops and forests, and make lakes danger for fish and other plant and animal life (Hart, 2008).

Pollution is changing Earth's atmosphere so that it lets in more harmful radiation from the Sun. At the same time, our polluted atmosphere is becoming a better insulator, preventing heat from escaping back into space and leading to a rise in global average temperatures (Hart, 2008). Most air pollution comes from human activity: burning fossil fuels which are natural gas, coal, and oil to power industrial processes and motor vehicles. Among the harmful chemical compounds this burning puts into the atmosphere are carbon dioxide, carbon monoxide, nitrogen oxides, sulfur dioxide, and tiny solid particles including lead from gasoline additives called particulates (Hart, 2008).

In Malaysia, air pollution has been recognized as one of the major concerns that have high potential for deleterious effects on health (Jamal *et al.*, 1994; Jamal *et al.*, 1998; Zailina, 1996; Zailina *et al.*, 1997; Juliana, 1998;). Increased urbanization, human activities and changing urban setting in the country as a result of development have resulted in elevated air pollution and the occurrence of urban heat islands. The sources of air pollutants are both localized and transboundary. Localized sources are both mobile and stationary. Mobile sources are from private and public motor vehicles (Jamal *et al.*, 2004)

1.2 Problem Statement

Pollution has become one of the major problems faced by the world today. Human activities release substances into the air, some of which can cause harm or discomfort to human and other living organisms. These human activities also can cause air pollution to the environment. One of the pollutant than have adverse effect on human health related to respiratory and cardiopulmonary illnesses is particulate matter. Particulate matter typically consists of a mixture of solids and liquid droplets in the air; particles that are small enough can get into the lungs and give rise to or worsen respiratory and other illnesses, sometimes even with just short exposure. Due to this fact it is important to ensure that the air quality level around us save to be breath especially around the campus area.

1.3 Objective of Study

The purpose of this study is to:-

1. To measure and monitor the particulate matter level around the university campus.
2. To observe the particulate matter level with respect to human activity such as the presence of people and transportation activity.
3. To determine the impact of this particulate matter.
4. To give awareness to people about the adverse effect of this particulate matter pollutant.

1.4 Scope of Study

To achieve to the objective of this project, several work have to be done;

1. Selection of the sampling points. The factors that have to be considered are population involved, environmental condition and also human activities at that point.
2. Conducting the measurement and monitoring at the selected area.
3. Calculate the particulate matter concentration based on the weight of the filter.
4. Observed the relation between the particulate matter concentration and the human activities at the sampling area.

CHAPTER 2
LITERATURE REVIEW

2.1 Air Pollution History

The predominant air pollution problem in the nineteenth century after the industrial revolution was smoke and ash from the burning of coal or oil for steam generation in the boiler furnaces of stationary power plants, locomotives and marine vessels, and in home heating fireplaces and furnaces. Great Britain took the lead in addressing this pollution problem. As the nineteenth century drew to a close, the severity of the pollution has risen to a peak; as the cities and factories grew in size and rapid changes in technology such as the replacement of steam engine to electric motor that rapidly increase the number of automobile from almost none to millions by 1925 (Boubel *et al.,* 1994).

New technologies have been invented and proposed as to control and protect air quality, such as the substitute of the soft coal used in heating homes with smokeless fuel or electric heating for heating fireplace which result in decreasing in smoke concentration measured by the blackness of paper filter through which British air was passed from 175 $\mu g/m^3$ in 1958 to 75 $\mu g/m^3$ in 1968. The air pollution research expanded tremendously in United States between 1955 and 1980 under the responsibility of the United States Environmental Protection Agency (EPA). Air pollution meteorology came of age and, by 1980, mathematical models of the pollution of the atmosphere were being energetically developed. Air quality monitoring systems becomes operational throughout the world with wide variety of measuring instrument available (Boubel *et al.,* 1994).

All around the world, the advent of the internal combustion engine-powered vehicles compounded air pollution, adding particulate and gaseous contaminate to the air people breath. In 1987, scientists discovered a hole in the ozone layer and recognized a serious threat to the layer that protects the earth from the sun's ultraviolet radiation. The Montréal Protocol, drafted in 1987, addressed the damage caused to the ozone layer by a chemical group known as CFCs, which were common in aerosol spray containers and air conditioners. The Montréal Protocol set as a goal the elimination of CFCs in consumer and industrial products. The global climate change accord signed in Rio de Janeiro, Brazil, in 1992 addressed the so-called "green-house gases," gases which trap heat in the atmosphere and lead to a global warming trend. Late, the Rio Accord, and the Kyoto Protocol (1997) call for a reduction in greenhouse gases. The air pollution problem of the future ore predicted on the used of more and more fossil and nuclear fuel as the population of the world increases (Boubel *et al.*, 1994).

2.2 Malaysia Air Pollution

Malaysia's air quality is fairly good except during the periods of haze between April and November 1997. Between April and November of 1997, a widespread series of forest fires in Indonesia threw a blanket of thick, smoky haze over a large portion of Southeast Asia. The smoke covered Indonesia, Malaysia, Singapore, and Brunei, as well as southern Thailand and the Philippines, and continued for several months. This smoke from the forest fires represented a major environmental disaster. It destroyed a large amount of rainforest, contributed to a significant release of greenhouse gases, and resulted in the loss of habitat for threatened or endangered species of plants and animals. The smoke traveled across the Southeast Asian region, reaching all the way to southern parts of Thailand and the Philippines but with the most severe effects being felt in Singapore, Malaysia, and Brunei.

The smoky haze reduced the visibility to as low as one kilometer (half a mile) covered Malaysia's main city, Kuala Lumpur and other 32 towns. During the peak period of haze in September 1997, the ambient air pollution concentrations in Kuching, Sarawak, Malaysia, reached 930 micrograms per cubic meter (μg/m3), an astonishingly high level more than 10-times higher than normal (WHO, 1998;

Brauer and Hisham-Hashim, 1998). In many other cities in the region, air pollution indexes repeatedly reached unsafe level. During periods of severe air pollution, schools, factories, and offices were closed and people especially children, the elderly, the sick, and the infirm were advised to stay indoors and restrict their activities. The atmospheric pollutant that most consistently increases with this smoke is suspended micro-particulate matter. These small solid combustion particles comprise of organic matter, black elemental carbon (soot particles), and inorganic materials such as potassium carbonate and silica (Andreae, 1990).

Figure 2.1 shows the annual average concentration levels of ambient PM_{10} from 1998 to 2004. It shows that the concentration were generally within the Malaysian Ambient Air Quality Guideline (RMG) for PM_{10}. During the year 1997, the concentration exceeds the RMG limit due to this severe haze problem cause from the forest fires (CSR, 2006). Figure 2.2 shows more specific level of PM_{10} concentration for Kuala Lumpur for year 1996 to 1997

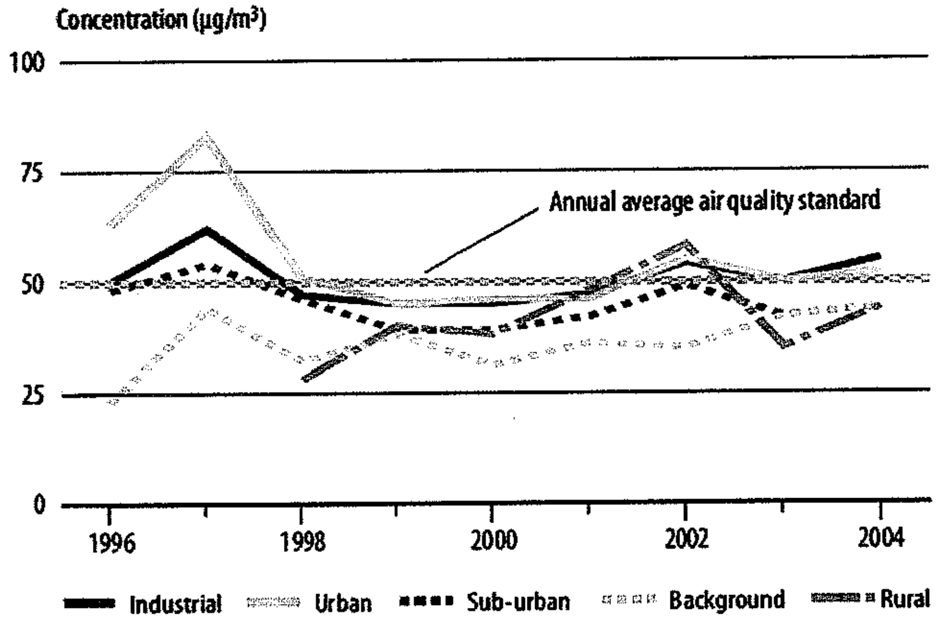


Figure 2.1: Annual Average Concentration of Particulate Matter (PM_{10}), 1996-2004.
Source: Country Synthesis Report on Urban Air Quality Management.

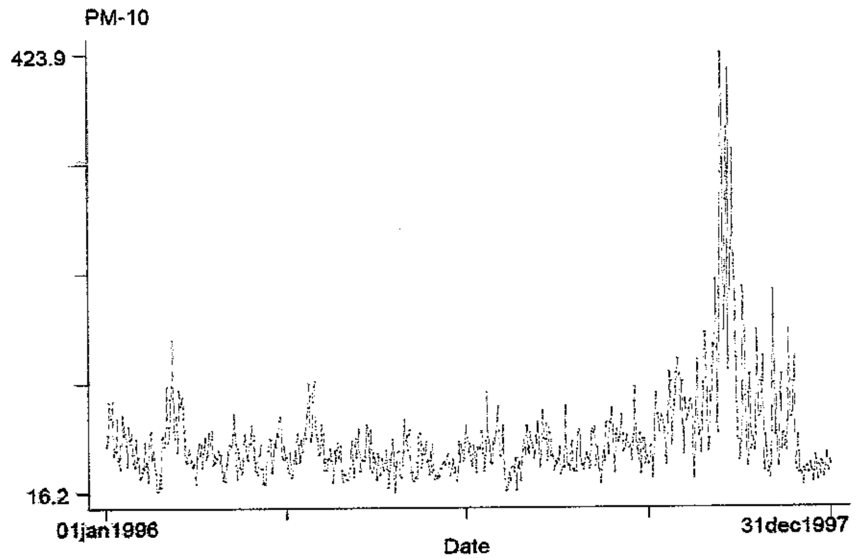


Figure 2.2: PM_{10} Concentration for Kuala Lumpur, Malaysia, 1996-1997

2.2.1 Malaysia Air Quality Management

The Environment Quality Act (EQA) is the basic framework for environmental management in Malaysia, was enacted in 1974. The Act was officially endorsed by the Government of Malaysia in its Third Malaysia Plan (1981-1985). The main environmental regulatory agency in Malaysia at the federal level is DoE, which is currently part of the Ministry of Natural Resources and the Environment. It was established to administer and enforce EQA of 1974 (Heng 2002).

2.2.2 Air Quality Monitoring

Malaysia's air quality monitoring network is operated and maintained by a private company, Alam Sekitar Malaysia Sdn Bhd (ASMA). ASMA operates, manages, and maintains 51 continuous air quality monitoring (CAQM) stations and 19 manual air quality monitoring (MAQM) stations nationwide (ASMA 2006). In 1995, DoE awarded a 20-year concession to ASMA, which included the establishment and management of the National Environmental Data Center (EDC), as well as the collection, processing, interpretation, analysis, and dissemination of environmental data (ASMA 2006).

The air quality monitoring network has 51 monitoring stations that are linked via public telephone lines to EDC as shown in Figure 2.3. The network has become one of the most successful air quality monitoring programs in the developing world. The $6 million system includes 51 CAQM stations, of which 44 are designed to measure CO, SO_2, NO_X, PM10, and O_3 and 7 are designed to measure PM_{10} only. In addition, there are 25 MAQM stations for measuring total suspended particulates (TSP), PM_{10}, and heavy metals, which are checked every 6 days. The stations are also equipped with meteorological parameters like wind speed and direction, temperature and relative humidity (CSR, 2006)

The continuous monitors provide real-time updates every hour. The average data capture rate has been more than 95%, and the project passed an audit by the United States Environmental Protection Agency (Hight and Kirkpatrick 2006). EDC is equipped with a sophisticated computer system that automatically dials up the 51 CAQM stations every hour for an immediate update of air quality data collected at the stations. The system has a QA/QC in place to ensure collection of good quality data (ASMA 2006).

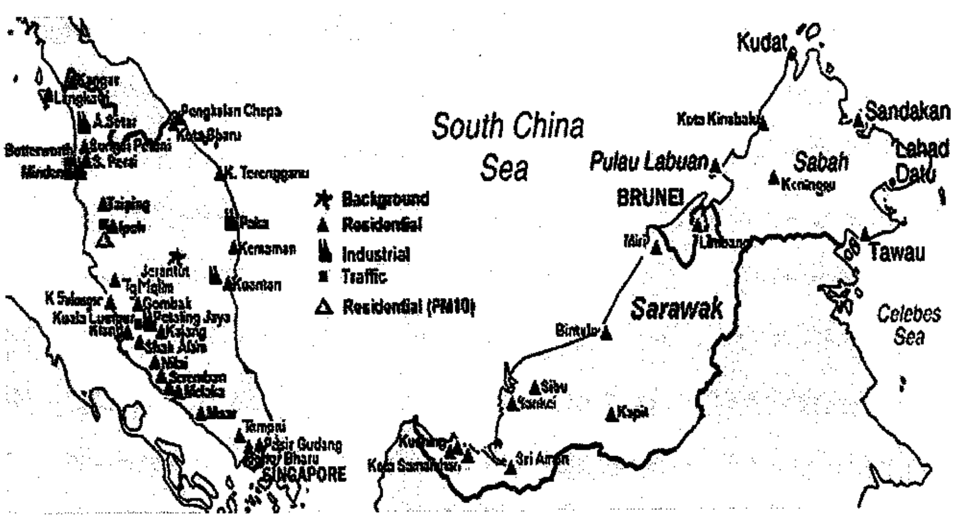


Figure 2.3: Location of CAQM Stations

Source: Alam Sekitar Malaysia

2.2.3 Ambient Air Quality Standard

In 1988, DoE formulated a set of air quality guidelines called the Recommended Malaysia Air Quality Guidelines (RMG) (CSR, 2006). Table 2.1 shows the Recommended Malaysia Air Quality Guidelines (RMG). Pollutant addressed in the guidelines include ozone, carbon dioxide, nitrogen dioxide, sulfur dioxide, total suspended particles, particulate matter under 10 microns, lead and dust fall.

Table 2.1: Malaysia and WHO Ambient Air Quality Guidelines

Pollutant	Averaging Time	Malaysian Air Quality Guidelines		WHO (2005)
		ppm	µg/m3	
Sulfur Dioxide ($S0_2$)	1 hr	0.13	350	
	24 hrs	0.04	105	20
PM_{10}	24 hrs		150	50
	1 year		50	20
TSP	24 hrs		260	-
Nitrogen Dioxide (NO_2)	1 hr	0.17	320	200
	24 hrs			-
	1 year	0.04	90	40
Carbon Monoxide (CO)	1 hr	30	35 mg/m_3	
	8 hrs	9	10 mg/m_3	
Ozone (O_3)	1 hr	0.1	200	-
	8 hrs	0.06	120	100
Lead (Pb)	3 months	1.5		1.5

Note: The limits given are the basis for assessing atmospheric load in Malaysia. The figure all in all correspond to international guidelines for assessment

Source: Department of Environment (1989)

2.2.4 Air Pollution Index

The air quality status for Malaysia is determined and disseminated according to the Air Pollution Index (API). The API level is based on the level of 5 atmospheric pollutants, namely sulfur dioxide (SO_2), nitrogen dioxide (NO_2), suspended particulates (PM_{10}), carbon monoxide (CO), and ozone (O_3) measured at the monitoring stations throughout each city.

Table 2.2: API Status Indicator

API	STATUS
0-50	Good
51-100	Moderate
101-200	Unhealthy
201-300	Very Unhealthy
301-500	Hazardous
Above 500	Emergency

Source: Yahaya *et al.* (2006)

Table 2.3: Comparison of API values with level of pollution and health measures

API	Air Pollution Level	Health Problems	Action Plan
0 – 25	Low	Not expected	No response needed
26 – 50	Medium	Not expected for the general population	
51 – 100	High	Acute health effects are not expected, but chronic effects may be observed if one is persistently exposed to such levels of air pollution	No immediate response needed; detrimental effects may be seen in the long run

100 – 200	Very High	People with existing heart or respiratory illnesses may notice mild aggravation of their health conditions Generally healthy individuals may also notice some discomfort	Population with medical condition is advised to refrain from physical activities; general population is advised to refrain from forceful physical activities
201 – 500	Very High	People with existing heart or respiratory illnesses may experience significant aggravation of their symptoms. There may be widespread symptoms in the healthy population like • eye irritation • wheezing • coughing • phlegm • sore throats	General population should refrain from physical actives and population with medical condition(s) should take extra care/

Source: Yahaya *et al.* (2006)

2.3 Particulate Matter

The primary air pollutants found in most urban areas are carbon monoxide, CFCs, nitrogen oxides, sulfur dioxide and particulates. These types of pollutants are dispersed throughout the world's atmosphere in concentrations high enough to gradually cause serious health problems. Particulate matter (PM) is defined as material suspended in the air in the form of minute solid particles or liquid droplets, especially when considered as an atmospheric pollutant. It is also defined as small discrete mass of solid or liquid matter that remains individually dispersed in gas or liquid emission. Particulate matter includes a wide range of particles size and many different chemical constituents. Traditionally, the environmental sciences have divided particles into two main groups and these two groups are different in many ways. PM_{10} is particles between 2.5 and 10 microns (micrometers) in diameter (a human hair is about 60 micron in diameter). $PM_{2.5}$ is particles smaller than 2.5 microns (Dylos, 2007).

They can be characterized by their physical attributes, which influence their transport and deposition, and their chemical composition, which influences their effect on health (Nicholas. 2002). PM_{10} is the concentration of particles that are less than or equal to 10 μm in diameter. Particles of this size range are also called "thoracic particles", with the fact that it can be inhaled into the tracheobranchial and alveolar (thoracic) regions of the respiratory system. Similarly $PM_{2.5}$ describes the concentration of particles that are less or equal to 2.5 μm in diameter (Nor Roslina *et al.*, 2006). The acid components of particulate matter, and most of its mutagenic activity, are generally contained in the fine particles. Particles interact with various substances in the air to form organic or inorganic chemical compound, the most common combinations of fine particles are those with sulfates (Nicholas.2002).

The respiratory system is the major route of entry for airborne particulates. The deposition of particulates in different parts of the human respiratory system depends on particle size, shape, density, and individual breathing patterns (mouth or nose breathing). The effect on the human organism is also influenced by the chemical composition of particles, the duration of expose, and individual susceptibility. While all particles smaller than 10 μm in diameter can reach human lungs, the retention rate is largest for the finer particles (Nicholas.2002).

Epidemiological studies suggest that exposure to particles with an aerodynamic diameter less that 10 μm (PM10) induces adverse health effects. Elderly people with cardiopulmonary illness, exposed to particulate matter may lead to increased mortality and hospitalization rates (Chapman *et al.*, 1997). Braun-Fahrlander *et al.* (1997) reported that symptom rates of chronic cough, nocturnal dry cough, and bronchitis were positively associated with PM 10 in the study that covers the impact of long-term exposure to air pollution on respiratory and allergic and illness to the schoolchildren in Switzerland.

2.4 Source of Particulate Matter

Particle pollution can be produced in a great number of ways and it can be classified into either mechanical or chemical processes. The mechanical process of particle pollution involves the breaking down of bigger matter into smaller particles without the material changing, only becoming smaller. Agriculture, coal and oil combustions, dust storms and construction are some activities that produce many of the larger or coarse particles. The chemical process of particle formation can be from sources that burn fuel and emit gases. The pollutant vaporizes and then condenses to become a particle of the same chemical compound. The small particles can further react or combine with other compounds in the atmosphere. A major source for particles formed this way is the burning of fossil fuels in industry, transportation, agriculture, etc (Dylos, 2007)

Some particulates come from natural sources such as evaporated sea spray, windborne pollen, dust, and volcanic or other geothermal eruptions. Particulates from natural sources tend to be coarse. Almost all fine particulates are generated as a result of combustion process, including the burning of fossil fuels for steam generation, heating and household cooking, agricultural field burning, diesel-fueled engine combustion, and various industrial processes. Emissions from these anthropogenic sources tend to be in fine fractions. However, some industrial and other processes that produce large amounts of dust tend to generate particles larger than 1 μm and mostly larger than 2.5 μm. Traffic-related emissions may make a substantial contribution to the concentration of suspended particulates in area close to traffic (Nicholas.2002).

Figure 2.4 show the sources for PM_{10} emission in Malaysia for year 2005 until 2006. It shows that power station is the major source of PM_{10} emission (44%0 followed by industries (25%), other (23%) and motor vehicles (8%). Based on Figure 2.5, the emission load from motor vehicle mostly comes from vans and lorries (67.78%) followed by buses (31.45%), passenger cars (0,04%) and taxis (0.37%)

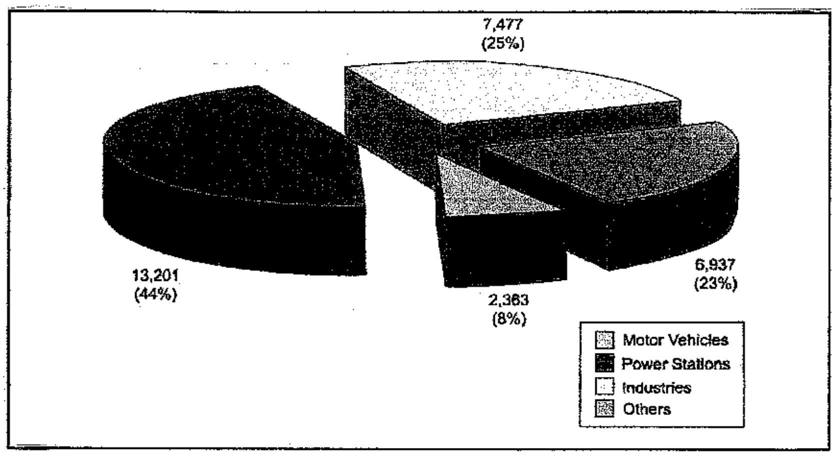


Figure 2.4: PM_{10} Emission by Sources (Metric Tonnes), 2005-2006.

Source: Department of Environment

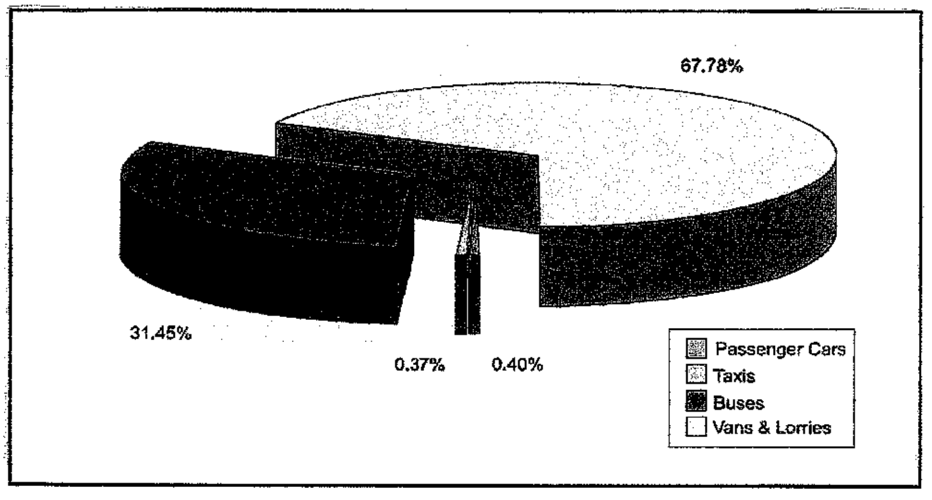


Figure 2.5: Distribution of PM_{10} Emission Load from Motor Vehicles, 2005-2006.

Source: Department of Environment

2.5 Metrological effect on Particulate Matter Concentration

Meteorological condition such as wind speed, wind direction and temperature can have gives several effects on the particulate matter concentration profile. According to Jones and Harrison (2004), aerosol concentration is affected by the relative humidity of the surrounding air, wind speed and radiation upon the surface of a material in which the particulate is being lifted off. Maximum wind speeds have to exceed a threshold speed in order to remove particulate material from a surface by either blow off or movement of the surface.

Pollutant concentrations are reduced by atmospheric mixing, which depends on temperature, wind speed, amount of sunlight, and the movement of high and low pressure systems and their interaction with the local topography, for example, mountains and valleys. Normally, temperature decreases with altitude. But when a colder layer of air settles under a warm layer, producing a temperature, or thermal, inversion, atmospheric mixing is retarded and pollutants may accumulate near the ground. Poor atmospheric mixing can lead to heavy concentrations of hazardous materials in high-pollution areas and, under severe conditions, can result in illness and even death (Funk and Wagnalls, 2006).

2.6 Effect of Particulate Matter on Human Health

The health effect due to particulate matter (PM) air pollution (PM_{10} and $PM_{2.5}$) has become one of the biggest environmental health concerns around the world. The effects related to short-term exposure include: inflammatory reactions in the lung, respiratory systems, adverse effects on the cardiovascular system and increases in medication use, hospital admissions and mortality (WHO, 2005). The long-term effects clearly have greater significance to public health than the short-term effects

During the inhalation, the air breath along with any particles that are in the air. This breath of air, along with the particles, travel into the respiratory system, and along the way the particles can stick to the sides of the airway or travel much deeper into the lungs. Lungs produce mucous to trap particles and there are also tiny hairs (called cilia) that move the mucous and particles out of the lungs. $PM_{2.5}$ can get down into the deepest (alveolar) portions of the lungs when gas exchange occurs between the air and your blood stream. These are the most dangerous particles because the alveolar portion of the lungs has no efficient means of removing them and if the particles are water soluble, they can pass into the blood stream within minutes. If they are not water soluble, they remain in the alveolar portion of the lungs for a long time (Dylos, 2007).

However, when the small particles go deeply into the lungs and become trapped this can result in lung disease, emphysema and/or lung cancer in some cases. Exercise and physical activity cause people to breather faster and more deeply and to take more particles into their lungs. The United States Environmental Protection Agency reported "studies suggested small particles can leave the lung and travel through the blood to other organs, including the heart".The main effects associated with exposure to particulate matter may include: premature mortality, aggravation of respiratory and cardiovascular disease (indicated by increased hospital admissions and emergency room visits, school absences, loss of work days, and restricted activity days) aggravated asthma, acute respiratory symptoms, chronic bronchitis, decreased lung function and increased myocardial infarction. Epidemiologic studies suggest that exposure to particulate matter may result in tens of thousands of excess deaths per year, and many more cases of illness among the US population (Dylos, 2007).

CHAPTER 3

METHODOLOGY

There are two different approaches that can be used to detect the presence of air pollution, source sampling which obtains the pollutant count of a particular source, where as ambient sampling deals with the pollutant within the total air mass surrounding the earth. These two methods have been discussed by World Health Organization (WHO, 1979) and US Environmental Protection Agency (EPA 1982, EPA, 1996). The approach used for this project is the ambient sampling method.

3.1 Sampling Procedure/Analysis

There are several factors that have to be considered before starts the sampling in order obtain accurate data, which are site selection, duration of the sampling and sampling device. The flow diagram (Figure 3.1) below shows the sampling procedure provided by Canadian Chemical Producer's Association (CCPA, 2001)

3.1.1 Site Selection

The sampling area was located at one of the university campus in Perak state. There are five selected sampling locations. The sampling location is shown in Figure 3.2 below.

3.1.2 Sampling Duration

The sampling duration for this project was conducted for 24 hours/day. The monitoring is done for weekdays and weekends at the main gate point to observe the trend of the particulate matters emission. As for the student village area, it is done at different height to observe the particulate matter concentration level with respect to height. The major sources of the particulate matters in the campus area are from vehicles and also from windblown dust, road dust and construction activities

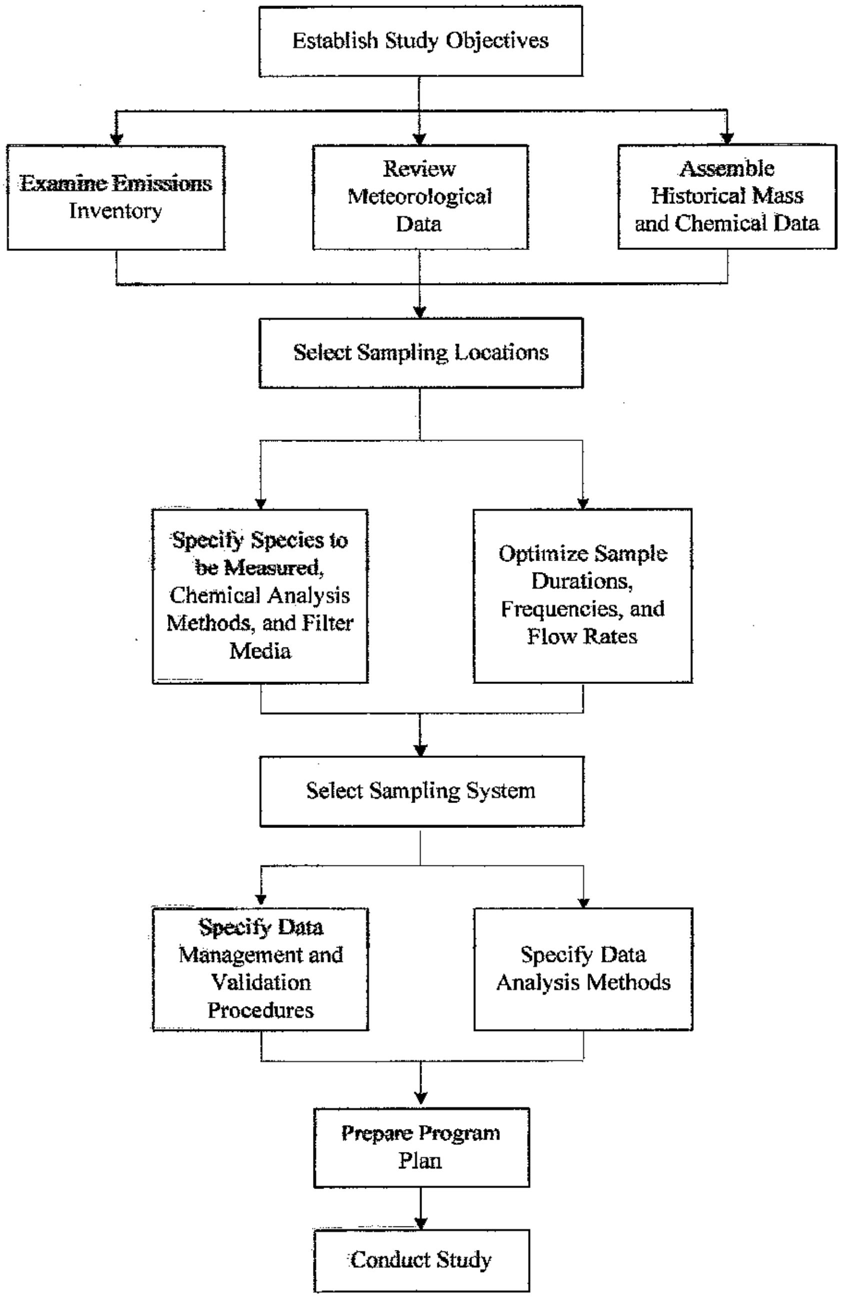


Figure 3.1: Flow Diagram of PM Study

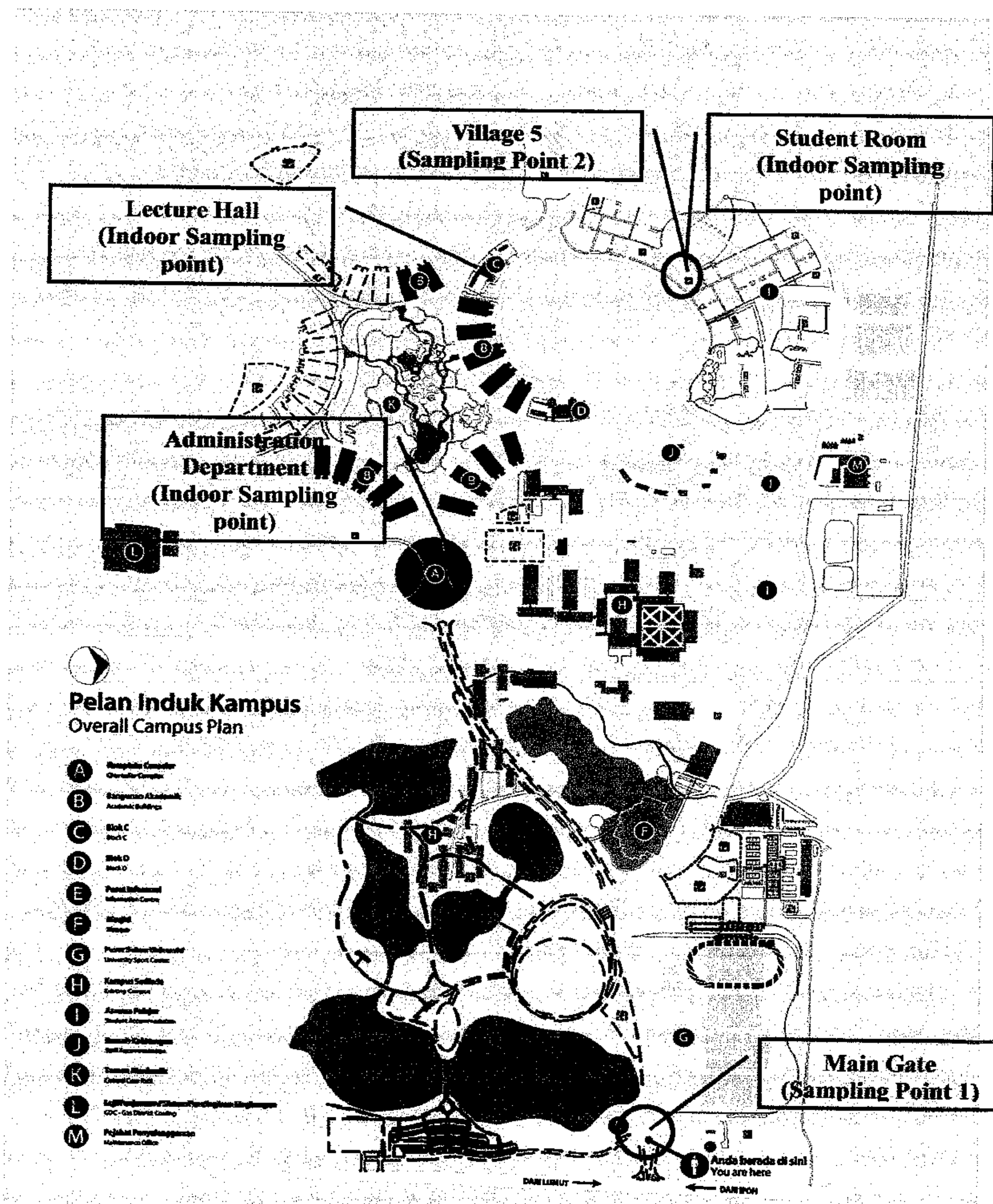


Figure 3.2: Sampling Location

3.1.3 Sampling Device

Device used to monitor the concentration of particulate matter is MiniVol 1100 Low Flow-rate Air Sampler. The air sampler comprises the following major component and it is shown in Figure 2 and Figure 3.3. The device picture is shown in APPENDIX E

Inlet Assembly – The inlet assembly consists of a PM_{10} nozzle body, impactor plate, rain cap and connecting tube with o-ring seals. The PM_{10} nozzle body incorporates a filter holder shroud and insect screen. Ambient air enters the sampler at the inlet assembly via the rain cap and stainless steel mesh screen. The rain cap and mesh screen prevent large debris and precipitation from contaminating the sample. By funneling the air through a nozzle, the air is accelerated and directed towards the impactor plate, which is flat. The impactor plate diverts the air stream. Particles larger than the size cut-point, which tend to be heavier, will hit the impactor plate and be trapped. Particles smaller than the size cut-point will remain airborne. The size cut-point is determined by the air flow rate, acceleration nozzle diameter, and particle density, composition and shape. To maintain the size-selectivity of the sampler by maintaining the size cut-point, ambient air is drawn in at a fixed rate i.e. 3.0 L/min for PM_{10} and $PM_{2.5}$ measurements.

Sampler Main Unit – The sampler main unit houses a microprocessor that controls the sampler operation, a flow control circuit that maintains the air flow at 3.0 L/s and a pump that draws the ambient air into the sampler. The inlet tube connects the main unit to the inlet assembly

Battery Pack – The battery pack is required to operate the sampler in areas where the power mains are unavailable. The battery pack is rechargeable. When fully charged, the pack allows for 24 hours of operation before a recharge is necessary. Practise caution when using the battery pack as it contains sealed lead-acid batteries that might produce small quantities of flammable hydrogen gas.

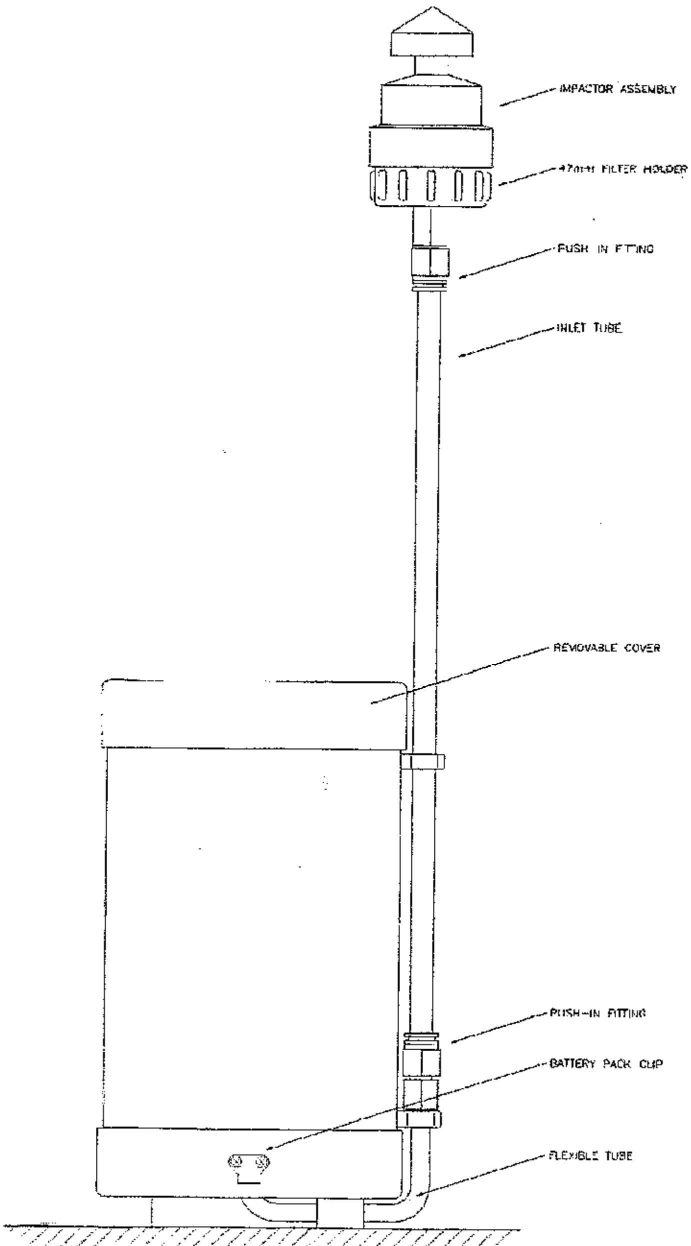


Figure 3.3: MicroVol 1100 Components Layout

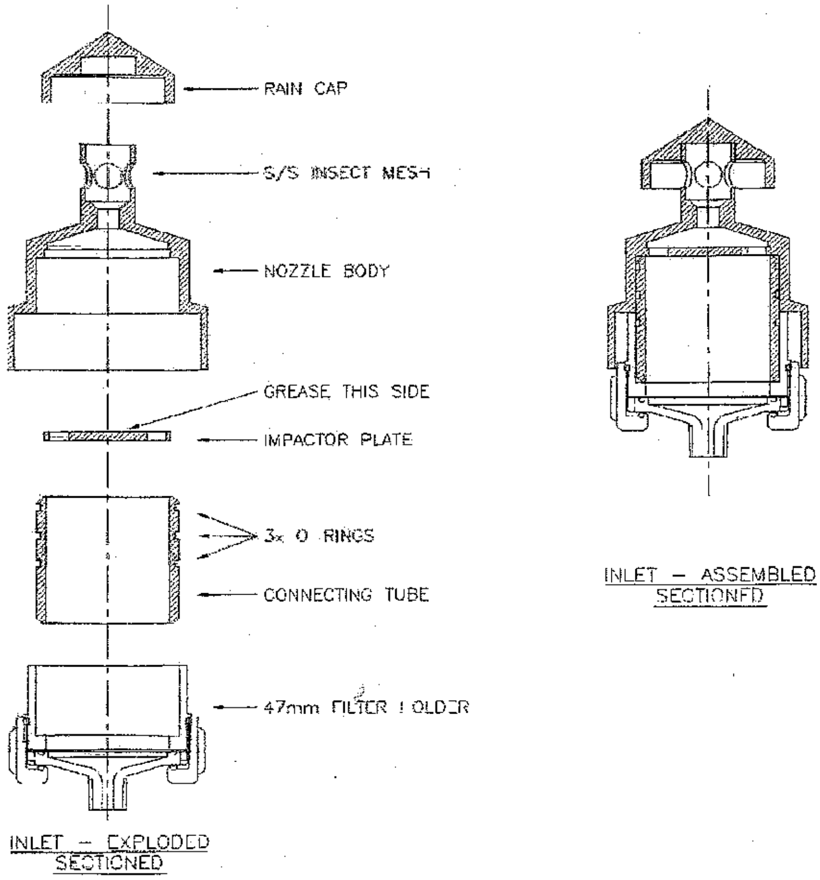


Figure 3.4: MicroVol 1100 Inlet Assembly

The filter used for the device is 47 mm filter disc, before starts monitoring and sampling the particulate matters mass the filter have to be weigh first using an analytical balance and record the reading. The filter then was placed in the filter holder inside the inlet assembly.

The start and end time of the sampling duration was set, and the device will auto on and off based on the set time. The inlet assembly was place over the top of the inlet tube to connect it to the sampler main unit. The device was moved to the sampling area and was placed onto a level surface.

After the monitoring has finished, the filter have to be weight again and the reading will be recorded as weight of filter with residue. All the finding will be recorded in the Table 3.1 and Table 3.2 below.

Table 3.1: Design Table for the Sampling Result

Item	**Result**
Weight of filter (mg)	
Weight of filter with residue (mg)	
Mass of particles (mg)	
Time duration (minutes)	
Air flow rate (L per minute)	

Table 3.2: Design Table for the Sampling Result

Sampling Location Main Gate	**Sampling Time**
	Concentration (μg/m^3)
Weekday	
Weekend	

3.2 Sample Volumes and Concentration Calculation

The equation (1) used to calculate the mass of particulate matter collected on the filter are as below;

$$M_x = (M_f - M_i) \times 10^3 \qquad (1)$$

Where;

M_x = Total mass of particulate matter collected during sampling period (µg)

M_f = **Final mass of the filter (mg)**

M_i = Initial mass of the filter (mg)

10^3 = Unit conversion factor for milligrams (mg) to micrograms (µg)

The total volume of ambient air passing through the air sampler in cubic meter (m^3) can be calculated using this equation (2);

$$V = Q_{avg} \times t \times 10^{-3} \qquad (2)$$

Where;

V = Total sample volume (m^3)

Q_{avg} = Average flow rate over the entire duration of the sampling period (L/min)

t = Duration of sampling period (min)

10^{-3} = Unit conversion factor for liter into cubic meters

As for the particulate matter mass concentration can be obtain from this equation (3);

$$PM_x = \frac{M_x}{V} \qquad (3)$$

Where;

PM_x = Mass concentration of particulate matter ($PM_{2.5}$ or PM_{10}) in µg/m^3

M_x = Total mass of particulate matter collected (µg)

V = Total volume of air sampled (m^3)

CHAPTER 4

RESULT AND DISCUSSION

The main purpose of this project is to measure the particulate matter level in the ambient air around the campus area. The factors that being considered in selecting the sampling location are: (a) Human activities around that area such as the presence of people and transportation activities. (b) The density of the population being exposed to the particulate matter pollutant. (c) The environment condition around that area. The sampling device used to measure the particulate matter concentration is located at the center of the sampling point, where it is not to near nor to far from the pollutant source. The average ambient temperature at early in the morning is around 26°C, at afternoon is around 36°C and at the evening is around 29°C.

There are many factors that can give substantial effect to the particulate matter concentration measurement such as humidity, ambient temperature, wind speed, and also meteorology condition at that area.

The result and the discussion for each sampling point are presented in this chapter. There are 5 sampling point were selected for this project. In order to observe the particulate matter concentration level around the campus, the data obtained during the sampling were analyzed into two categories. (1) For outdoor categories which are for main gate and student village area. (2) For indoor which are student room, lecture hall and also administration department area.

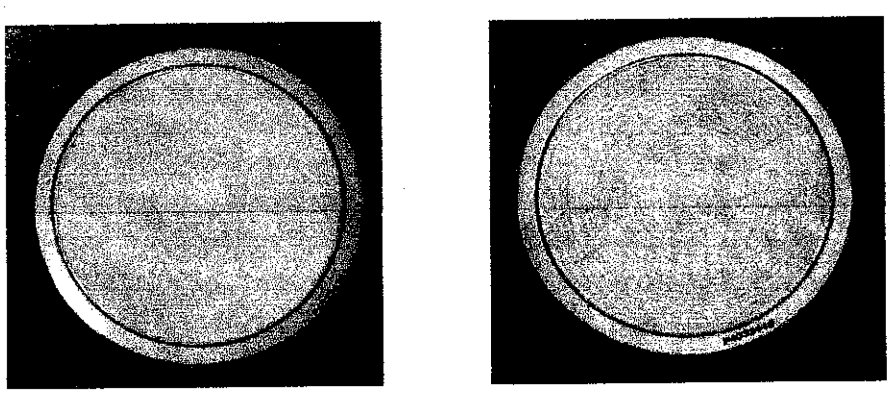
Outdoor PM Concentration

4.1.1 Main Gate Sampling Point

The sampling at the main gate starts at 7.00 a.m. and end at 7.00 a.m. the next day. It is done for weekday and weekend to observe the trend of the particulate matter level with respect to the transportation activities around that area. The device is set at the security guard post at 1 meter from the ground level. It is located at the center of the main entrance.

Table 4.1: PM Concentration for Main Gate

Sampling Location	Sampling Time	Concentration µg/m3
Main Gate	Weekday	69.11
	Weekend	46.30



(a) (b)

Figure 4.1: Filter Used for Main Gate during Weekday (a) Filter before sampling (b) filter after sampling

Table 4.1 shows the particulate matter concentration at main gate sampling point. The table shows that the highest concentration which is 69.11 $\mu g/m^3$ occurs during weekdays. This is due to the active transportation activities around the sampling point. During the first peak hour which is at 7.45 to 8.45 a.m. where all the university staffs and lectures enter the university the average number of vehicles passing through the main gate for one hour is around 100 cars. The number increase during the second peak hour which is around 6.00 to 7.00 p.m. where not just university staffs and lectures going out but also the students.

As for weekend sampling time which is done on Sunday, the concentration shows much lower which is 46.30 $\mu g/m^3$, this is because of less transportation activities since the transportation involve the university staffs and students. Figure 4.1 shows the filter used for the sampling for main gate sampling point during the weekday. The filter after being used shows darker surface compare to before it is being used. The sample calculation is shown in **APPENDIX C** and **D**.

4.1.2 Student Village Sampling Point

As for the student village area sampling point, it is done at different height. The sampling starts at 8.00 a.m. and end at 8.00 a.m. the next day. It is because most of the student starts the lecture around that time. The device is set at 1 meter from the ground level for ground level sampling point. As for level 5 sampling point, the device is set at around 20 meter from the ground level.

Table 4.2: PM Concentration for Student Village

Sampling Location	Sampling Point	Concentration μg/m3
Student Village	Level 5	23.15
	Ground Level	34.72

Table 4.2 shows the particulate matter concentration level for student village sampling point. It shows that ground level experience higher concentration level compared to higher level (level 5). This is because lower level is more nearer to the road which is active transportation activities and also it is more open to the human activities such as students passing by and construction activities. Higher level experience less particulate matter level because not all particulate matter pollutant can travel to higher level. It is because each of the particulate matter has a different mixture of components with a different density. Heavier component tend to settle down at much lower level. The sample calculation is shown in **APPENDIX A** and **B**.

4.2 Indoor

Based on the research that have been done, indoor air quality is much better that the outdoor, but indoor can give significant effect to human health since most of people tend to spend most of their time indoor. For this project there are 3 indoor sampling point was selected which is student room, lecture hall and administration department.

Table 4.3: PM Concentration for Indoor sampling point

	Sampling Point	Concentration µg/m3
Indoor	Student Room	23.15
	Lecture Hall	9.26
	Administration Department	9.26

Table 4.3 shows the particulate matter concentration level for student room, lecture hall and administration department. The table shows that the student room has the highest particulate matter level compared to other sampling point and it shows the same level as the outdoor particulate level for level 5 at student village. This is because the student room's door and window is left open; therefore the level would be the same. As for the lecture hall and administration department shows low and same level of particulate matter. This is due to the good ventilation system that they have. The air conditioned room reduces the penetration of the particulate matter inside the room. Based on research, for non-air conditioned rooms about 70 to 100% of fine particulate will penetrate indoors from the outside air. Most of the air-condition have a filter that capture most of the tiny particles associated with smoke and further reduce the amount of outside air pollution that gets indoors.

CHAPTER 5

CONCLUSION

The particulate matter level for 5 sampling point around the campus has been measured and the data obtained shows that all these sampling point concentration is within the Malaysian standard which is below 150 µg/m3. The main gate sampling point during weekday shows the highest particulate matter level due to active transportation activities and the lowest is at the lecture hall and administration department because of the good ventilation system.

Human activities such as the presence of people, transportation activities and construction activities have been identified as the major source of particulate matter emission around the university campus. Without proper pollution prevention and protection, the increasing numbers of vehicles used and numbers of staffs and students in the campus could lead to more serious pollution problem.

Long term exposure to high level of particulate matter concentration can cause serious health problem such as reduced lung functioning and the development of chronic bronchitis and even premature death. Exposure for many years in the areas with high particulate matter level is considered as long-term. Even being exposed to this high particulate matter concentration for several hours or even several days can aggravate lung disease causing asthma attacks and acute bronchitis, and may also increase lead to respiratory infections.

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APPENDICES

Appendix A: Sample calculation for Village Area (Level 4)

Weight of filter before sampling = 0.1394 g
= 139.4 mg

Weight of filter after sampling = 0.1395 g
= 139.5 mg

Total mass of particulate matter = 0.1395 g – 0.1394 g
= 0.0001 g
= 0.1 mg
= 100 µg

The duration of sampling = 24 hr
= 1440 min

The sample air volume:-

$$V_{m^3} = 0.001 \times Q_{avg} \times t_{\min}$$

By assuming the average flow rate is 3 L/min, the sample air volume is

V = 3 L/min x 1440 min x 0.001

= 4.32 m^3

The particulate matter mass concentration

$$PM_{\frac{\mu g}{m^3}} = 1000_{\mu g/mg} \times \frac{W_{(mg)}}{V_{m^3}}$$

$$= 0.023 \frac{mg}{m^3}$$

$$= 23.15 \frac{\mu g}{m^3}$$

Appendix B: Sample calculation for Village Area (Ground Level)

Weight of filter before sampling = 0.1412 g
= 141.2 mg

Weight of filter after sampling = 0.14135 g
= 141.35 mg

Total mass of particulate matter = 0.14135 g – 0.1412 g
= 0.00015 g
= 0.15 mg
= 150 μg

The duration of sampling = 24 hr
= 1440 min

The sample air volume:-

$$V_{m^3} = 0.001 \times Q_{avg} \times t_{\min}$$

By assuming the average flow rate is 3 L/min, the sample air volume is

V = 3 L/min x 1440 min x 0.001

= 4.32 m^3

The particulate matter mass concentration

$$PM_{\frac{\mu g}{m^3}} = 1000_{\mu g/mg} \times \frac{W_{(mg)}}{V_{m^3}}$$

$$= 0.0347 \frac{mg}{m^3}$$

$$= 34.72 \frac{\mu g}{m^3}$$

Appendix C: Sample calculation for Main Gate Area (Weekday)

Weight of filter before sampling = 0.1374 g

= 137.4 mg

Weight of filter after sampling = 0.1377 g

= 137.7 mg

Total mass of particulate matter = 0.1377 g – 0.1374 g

= 0.0003 g

= 0.3 mg

= 300 μg

The duration of sampling = 24 hr

= 1440 min

The sample air volume:-

$$V_{m^3} = 0.001 \times Q_{avg} \times t_{\min}$$

By assuming the average flow rate is 3 L/min, the sample air volume is

V = 3 L/min x 1440 min x 0.001

= 4.32 m^3

The particulate matter mass concentration

$$PM_{\frac{\mu g}{m^3}} = 1000_{\mu g/mg} \times \frac{W_{(mg)}}{V_{m^3}}$$

$$= 0.069 \frac{mg}{m^3}$$

$$= 69.11 \frac{\mu g}{m^3}$$

Appendix D: Sample calculation for Main Gate Area (Weekend)

Weight of filter before sampling = 0.1353 g
= 135.3 mg

Weight of filter after sampling = 0.1355 g
= 135.5 mg

Total mass of particulate matter = 0.1355 g – 0.1353 g
= 0.0002 g
= 0.2 mg
= 200 μg

The duration of sampling = 24 hr
= 1440 min

The sample air volume:-

$$V_{m^3} = 0.001 \times Q_{avg} \times t_{\min}$$

By assuming the average flow rate is 3 L/min, the sample air volume is

V = 3 L/min x 1440 min x 0.001

= 4.32 m^3

The particulate matter mass concentration

$$PM_{\frac{\mu g}{m^3}} = 1000_{\mu g/mg} \times \frac{W_{(mg)}}{V_{m^3}}$$

$$= 0.046 \frac{mg}{m^3}$$

$$= 46.3 \frac{\mu g}{m^3}$$

Appendix E: Device used for the sampling