ASSESSMENT OF PARTICULATE MATTER 10µM (PM_{10}) TRENDS IN TRONOH

by

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Dissertation submitted in partial fulfilment of
the requirements for the
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(Civil)

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CERTIFICATION OF APPROVAL

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Approved by,

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(Dr. Wesam AlMadhoun)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

SEPTEMBER 2017

CERTIFICATION OF ORIGINALITY

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

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(MUHAMAD AFIQ BIN MUHAMAD JANI)

ABSTRACT

PM_{10} is one of the major pollutant that can contribute significant effect towards the health and environment and usually related with the high particulate event in Malaysia. There were complaints regarding the air quality issue in Tronoh area where the air was seen in hazy condition at which may involve PM_{10}. From initial investigation, the source of emission of PM_{10} may cause by the traffic, industrial and human activities. The objective of this study is to investigate the trends of PM_{10} with the development status and to compare the concentration of PM_{10} with the meteorological parameters such as temperature and humidity. Air monitoring was carried out by using Aeroqual AQM60 which was placed at 3 locations within 2km radius from flyover in Tronoh for 1 weekday and 1 weekend at each location. Based on the 12 hours sampling, the highest average concentration of PM_{10} recorded is 42.28μg/m^3. The calculation was done to compare the average concentration of PM_{10} with air pollution index (API). The results show the index of 42.28 which is below 50 which means the environment is still in good condition. The results also show that temperature and humidity affect the concentration of PM_{10}. The study achieved its objective and should be continued further to improve the air quality in Tronoh.

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Praises to The Almighty Allah for His blessings and mercy that allows me to complete my project. The success of this project required a lot of guidance and assistance and I am extremely privileged to have this along all along the completion of my project. All that I have done is only due to such supervision and assistance and I would not forget to thank them.

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INTRODUCTION

1.1 Background of Study

Air has been a vital need for every living mechanism in this world. The contribution of air to the living mechanism includes human, animal and plant. The process of the air cycle is called respiration process. However, every mechanism inhale the ambient air from time to time (Wallace, 2006). As an example, human and animal breath in oxygen during respiration process while plant requires carbon dioxide. Generally, the air in the atmosphere is built up of different constituent of air components that combined together. The normal air that we consume usually made up of roughly 78% of nitrogen, 21% of oxygen and 0.035% of carbon dioxide. The balance of the constituent consists of inert gases such as neon, helium, nitrous oxide, ozone and etc. (Wallace, 2006). These gases are among the air that exists in the atmosphere.

Composition of Dry Air

Substance	% by volume
Nitrogen, N_2	78.08
Oxygen, O_2	20.95
Argon, Ar	0.93
Carbon dioxide, CO_2	0.033
Neon, Ne	0.0018
Helium, He	0.00052
Methane, CH_4	0.0002
Krypton, Kr	0.00011
Dinitrogen oxide, N_2O	0.00005
Hydrogen, H_2	0.00005
Xenon, Xe	0.0000087
Ozone, O_3	0.000001

Table 1: Composition of Dry Air (Shakhashiri, 2007)

The atmosphere of the earth are made up of few layers. The layers are Troposhere which is 8 – 14.5km from the earth surface, Stratosphere which extends up to 50km from the earth surface, Mesosphere which is the area that goes up to 85km from the Stratosphere, Thermosphere which is 600km from the earth Mesosphere, Ionosphere which extends up to 965km from Thermosphere and Exosphere that extends up to 10000km high. The temperature differs with altitude, so does the density (Boubel at al., 1994).

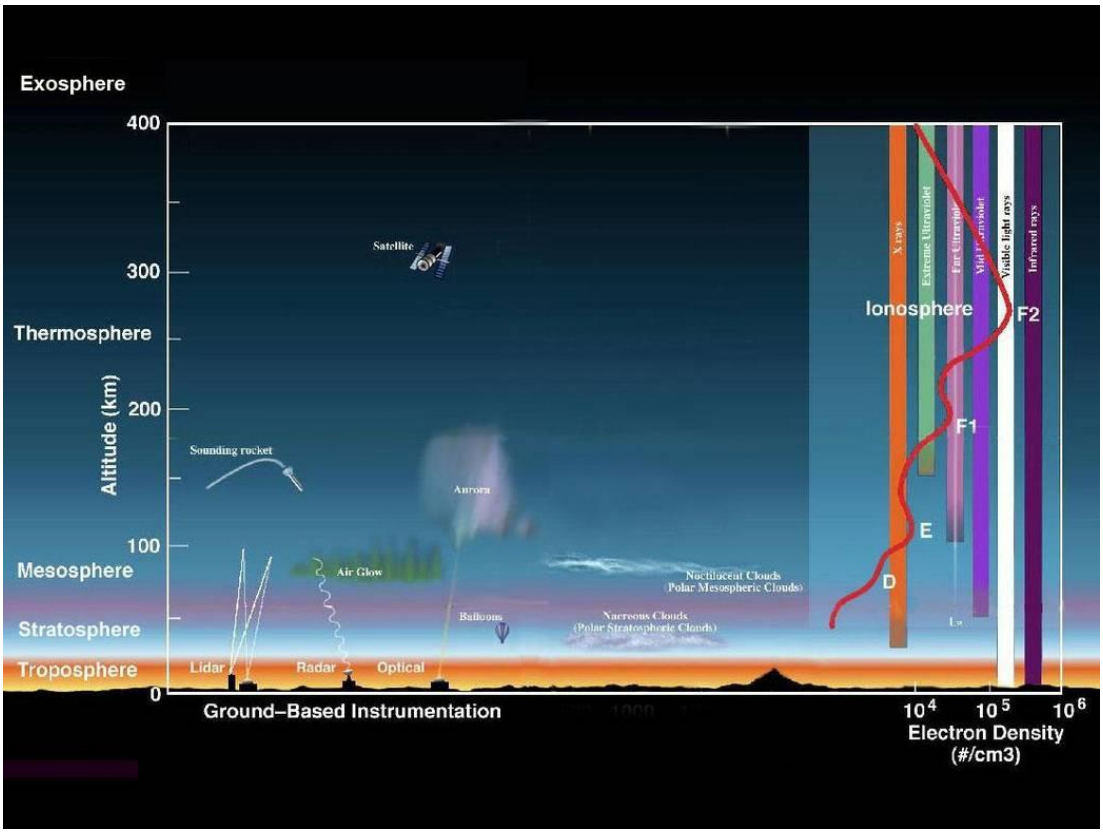


Figure 1: Atmospheric Layers (https://www.nasa.gov)

In the air that we breathe every day, pollutants can be found exist is the constituent of gases (Wallace, 2006). Pollution occurs when the constituent of a particular gas such as in the normal air exceeds the safe state in terms of quantity and percentage. Air pollution can be defined as a condition, which the air is contaminated by foreign substances, or the substances that made up the air themselves (Vallero, 2014).

To support this definition, Vallero (2014) mentioned that the same chemical compound or particle from natural sources, may not be as harmful as it is when they are being emitted by anthropogenic sources. The author added, the best way to determine the polluted and unpolluted atmosphere is to compare the condition of atmosphere against some type of baseline. For example, we can make comparisons between pre industrialized atmospheres during the early industrialized period with the current atmosphere. Vallero (2014) also discussed that air pollution implies the acceptability which further described on the difference of acceptable and unacceptable of air quality around us. Air pollution has been associated with harm, especially to humans in terms of diseases such as respiratory conflicts.

There are many sources that can cause air pollution. Among the sources are natural sources and anthropogenic sources (Boubel et al., 1994). A good example for air pollution that is caused from the natural source is the eruption of volcanoes. During the eruption, the volcano emits particulate matter and pollutant gases such as sulphur dioxide and methane (Boubel et al., 1994). Somehow, this event does not frequently happened and does not contribute so much in air pollution.

Greyson (1990) stated that the contribution to air pollution is greater through the anthropogenic sources. The anthropogenic sources can further divided into industrial sources, utilities and personal sources. For industrial sources, manufacturing contribute a major part in air pollution as the waste products during the manufacturing are mostly pollutants (Boubel et al., 1994). Industrial sources emit consistent pollutants. They produced consistent qualities and quantities of pollutants according to the technology that they used. As for utilities, pollutants can be indirectly emitted through the usage of electrical appliances such as television and refrigerator (Boubel et al., 1994). The usage of these appliances require electricity which has to be generated from electric power plant.

To generate the electricity, the power plant might have to do vigorous burning of coal that will eventually produce energy together with pollutants towards the air (Boubel et al., 1994). Some pollutants will be removed from the furnace but most of them have already been released into the air. For personal sources, it is highly incorporated with human daily activities. Pollutants can be released in the usage of automobile, open burning, incinerator, cooking and etc. From the studies by Boubel et al. (1994), the

author mentioned that the energy release and air pollution emissions of personal sources in the United States are greater than those from industry and utilities combined. Boubel et al. (1994) also mentioned that to control these personal sources of pollution may require regulation and change of lifestyle.

Pollutants can be classified into 2 which are primary pollutant and secondary pollutant (Pahari et al., 2006). Primary pollutants are the substances which are emitted directly from an identifiable source. These pollutants exist after being added or released into the environment. The example of the pollutants are nitrogen oxides, sulphur dioxide and particulate matter 10µm (PM_{10}). Secondary pollutants are pollutants that have been derived from the primary pollutants due to chemical reactions. As an example, hydrocarbons and nitrogen oxides in the environment react to form nitrous compound in the presence of sunlight.

Furthermore, it is important to determine the cycle of the emissions of the pollutants. According to Boubel et al. (1994), emissions are usually less during night time than the day time. It is due to the activities that is carried out whether industrial, utilities or personal activities. Boubel et al. (1994) added, the rate of emissions of pollutants also differ during weekends or holiday and weekdays. The cycle of emissions also depends on the seasons. These trends can be observed through sample collection of the air in a particular area.

The air quality in Malaysia is being controlled according to the air pollution index which is resembled from the air quality set by the World Health Organization (WHO) (Mustafa, 2011). The air pollution index (API) was obstructed by Department of Environment on 1993. Department of Environment are also responsible for observing the air quality within Malaysia using their quality stations throughout the country. The index are used to determine major air pollutants such as ozone, nitrogen dioxide, sulphur dioxide and suspended particles in the air that could cause harm to human health. Department of Environment has set the standard of reading in Malaysia in classifying the air index to determine the air pollution level. Table 2 shows the Air Pollutant Index set up by Department of Environment Malaysia.

API	Status
0 – 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 – 300	Very Unhealthy
More than 301	Hazardous

Table 2: Air Pollutant Index Implemented in Malaysia (DOE, 2017)

According to Department of Environment Malaysia (DOE), the air quality in Malaysia has to be monitored from time to time to determine the changes of the quality status of the ambient air that might affect the human health and surrounding environment. In Malaysia, a guideline called Malaysian Ambient Air Quality Guideline (MAAQG) has been established to classify the air quality status in a particular area. MAAQG is one of the way in maintaining a good air quality (DOE, 2017). Table shows the guideline set by DOE.

Pollutants	Averaging Time	Ambient Air Quality Standard		
		IT-1 (2015)	IT-2 (2018)	Standard (2020)
		$\mu g/m^3$	$\mu g/m^3$	$\mu g/m^3$
Particulate Matter with the size of less than 10 micron (PM_{10})	1 Year	50	45	40
	24 Hour	150	120	100
Particulate Matter with the size of less than 2.5 micron ($PM_{2.5}$)	1 Year	35	25	15
	24 Hour	75	50	35
Sulfur Dioxide (SO_2)	1 Hour	350	300	250
	24 Hour	105	90	80
Nitrogen Dioxide (NO_2)	1 Hour	320	300	280
	24 Hour	75	75	70
Ground Level Ozone (O_3)	1 Hour	200	200	180
	8 Hour	120	120	100
*Carbon Monoxide (CO)	1 Hour	35	35	30
	8 Hour	10	10	10

Table 3: The Malaysian Ambient Air Quality Guideline (DOE, 2017)

The quality of ambient air in Malaysia are monitored by DOE by their network stations that is placed in different locations and activities such as industrial areas, residential areas and traffic areas. There are two methods being used to monitor the air quality (DOE, 2017). They are Continuous Air Quality Monitoring (CAQM) and Manual Air Quality Monitoring (MAQM). The CAQM is set to automatically monitor and collect data of the ambient air quality for 24 hours a day. The CAQM stations are being placed

in 5 different places which include 26% industrial area, 57% residential area, 2% traffic area, 2% background and 13% particulate matter 10µm (PM_{10}) of the total 51 stations. The parameters are as shown in table 4.

Category	Sulphur Dioxide	Nitrogen Oxides	Carbon Monoxide	Ozone	Hydrocarbon	PM10	UV
Industrial	X	X	-	-	X	X	-
Residential	X	X	X	X	X	X	X
Traffic	X	X	-	X	X	X	-
Background	X	X	X	X	X	X	X
PM10	-	-	-	-	-	X	-

Table 4: Parameters measured by CAQM stations (DOE, 2017)

One of the pollutant which has been worrying in the atmosphere is high concentration of particulate matter 10µm (PM_{10}). According to Noor et al. (2011), PM_{10} can be define as particulate matter with the size of less than 10 micrometres. Moreover, PM_{10} is basically the cause of air pollution associated with high particle event in Malaysia (Noor et al., 2011). The trend shows that dry season will cause higher concentration of PM_{10}. Another reason for the event to happen is due to extensive open burning of the forest of Sumatera where the products generated is particulate matter that travelled by the south-west monsoon to all nearby country including Malaysia (Afroz et al., 2003).

According to World Health Organization (WHO), PM_{10} is an inhalable particles that are very small enough to sip into thoracic region or the respiratory system. Among the effect that are caused from the pollutant is respiratory and cardiovascular morbidity, such as aggravation of asthma and respiratory symptoms. If it is not well treated, it will further cause mortality to the person who are exposed to the pollutant. Realizing the importance of having a good quality of air in Tronoh area, this research will emphasis on the PM_{10} concentration in the stated area due to industrial and human activities.

1.2 Problem Statement

The effect of pollution is getting serious and one of the most major pollutants that can be found in ambient air is PM_{10}. The high concentration of the pollutant can cause air pollution and further lead to health issues to human being such as asthma and more respiratory conflicts. According to Hester et al. (1998), for people with asthma, the effects on lung are seen at a very low concentration of pollutant.

There were many complaints that have been received from the residence in Tronoh about the air quality in that area. Observation was made to see the condition at that reported area. From the observation, the condition of that area were seen vague and hazy, proving that there were particulate event happening at the location which was mainly focus at the flyover of Tronoh.

From other observation on the surrounding area of the studied location, it was found that there were a few factors that may affect the emission of PM_{10} in that area. There were factories that aggressively operating and the traffic at the study area was also seemed heavy. Studies have found that urban and industrialized areas atmosphere contain higher concentrations of PM_{10} due to vigorous industrial activities, transportation, domestic and other small sources (DOE, 2017).

In Malaysia, the dispersion of PM_{10} has been focused on the industrial areas. Mustafa (2011) suggested that the quality of air pollution in Malaysia is very much dependant on the level and pace of development both in urban and rural areas. Mustafa (2011) also mentioned that the two largest contributors of emissions in urban areas are from motor vehicles and industrial activity. Another activity that cause the high concentration of pollutant in Malaysia atmosphere is uncontrolled open burning of industrial, municipal and agricultural wastes. The open burning in Malaysia has been identified as a major contributor towards the formation of haze in the 1990 (Mustafa, 2011).

Thus, this research was carried out to investigate the issue of high particulate event in Tronoh area by studying the concentration of PM_{10} to see whether the concentration are within the safe limit or exceed the safe limit based on API and MAAQG.

1.3 Objectives

1. To examine the trend of PM_{10} in Tronoh.

1. To determine the relationship between PM_{10} concentration with development status.
2. To investigate the relationship of PM_{10} concentration with the meteorological parameters (temperature and humidity).

CHAPTER 2
LITERATURE REVIEW

2.1 Air Pollution

According to Flagan et al., (2012), air pollution consists of several arrangement of events such as the generation of pollutants at and their release from a particular source, their mobility and transformation in the atmosphere and how it being removed from atmosphere, and their significant effects or harm that it may bring to human beings, ecosystems and materials. It is almost impossible to reach zero emissions of air pollutants in the current world technically and economically (Flagan et al., 2012). The only effort that can be done is to reduce the amount of emission of pollutants towards the air.

Vallero (2014) mentioned that the air pollution includes acceptability which means that the acceptable or unacceptable condition of a particular time. The author added that people that lived in the developing countries or area are very vulnerable towards the air pollution. Air pollution can occur both indoor and outdoor. Among the pollutants that usually consist in the air pollution are particulate matter (PM), ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and lead (Pb) (Vallero, 2014).

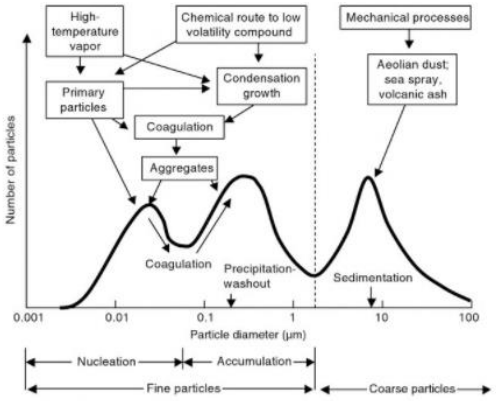


Figure 2: Correlation of pollutant with other factors (Vallero, 2014)

Vallero (2014) added that the rate of air pollution can be relate with the transportation from the source to the location. The pollution can be transported via few mechanisms to the receptor which is human, animals or plants. The main transportation medium is via wind. Vallero (2014) also mentioned that the pollutant will not be transport as a whole from the source to the receptor. The pollutant may experience fluctuations when it is transported.

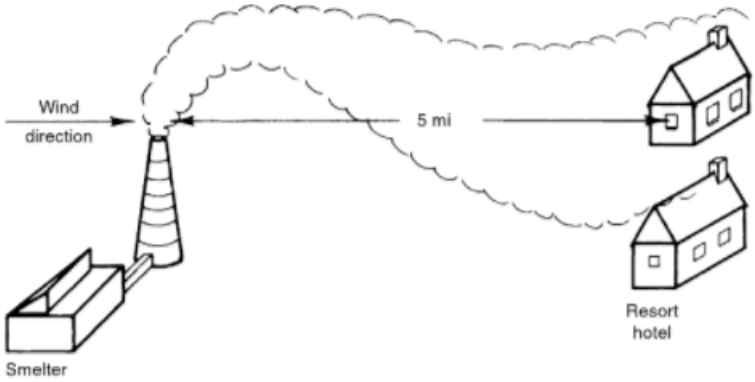


Figure 3: Transportation of pollutant (Vallero, 2014)

Furthermore, Vallero (2014) mentioned that there were increase of awareness towards the air pollution problem. It is also due to public demand which lead to the action of improving the air quality. This matters are supported by the exponential growth of laws, rules and policies all around the world to address and to control air pollution (Vallero, 2014). The laws made were generally to have same objectives and procedures to provide the guideline for the air pollution control.

2.2 Particulate Matter

According to the report from WHO (2003), particulate matter is a complex mixture between organic and inorganic substances. The particulate matter can be divided into two categories of mass and composition which is coarse particle and fine particle with the size of particle ranging from 1.0μm to 10μm (WHO, 2003). Particulate air pollution can be defined as the mixture of solid, liquid or solid and liquid particles found in the air (Hanapi et al., 2012). The suspended particles found in the air may have variety in size, composition and origin (WHO, 2003). WHO (2003) reported that it is easier to categorized particles by 3 properties which are transport and removal of particles from air, deposition within the respiratory system and chemical composition and sources of particles.

There are a few common sources that lead to the particulate matter pollution towards then environment and ambient air such as combustion of fossil fuels from various activities for example the traffic or transportation, the electrical or power generation and the industry (Boubel et al., 1994). Boubel et al. (1994) also mentioned that the other source of common particulate matter pollution are from human and nonhuman activities such as biomass burning, heating, cooking, indoor activities and fire.

These particulate matters often cause respiratory issues when it is being inhaled such as bronchoconstriction and mucus (Yang et al., 2009). Yang et al. (2009) added that the highly water soluble acidic vapors can be easily deposited in the respiratory system with a small penetration to the lung and will eventually cause the respiratory problems such as asthma and lung cancer for long term period.

2.3 Particulate Matter 10µm (PM_{10})

From the definition suggested by Ul-Saufie et al., (2013), PM_{10} can be classified as particulate matter which has the size of less than 10 micrometer in aerodynamic diameter which can be exist as solid, liquid or combination of both solid and liquid particles in the ambient air. As PM_{10} could cause harm especially in human health such as bronchi, lungs and other problems related to respiratory, Noor et al., (2011) stated that it had been given a very cautious attention. Report from Shaadan et al., (2012) mentioned that the PM_{10} concentration is high exceeding the safe level especially at urbanized area and the weather that encouraged the high PM_{10} concentration is during the dry season. Weather during dry season most likely to be low wind speed, low dew point, which can cause less dispersion of pollutant horizontally and the dry condition will have the tendency to cause pollutant accumulation in the air.

Among the sources which can be classified as major in PM_{10} emissions in this country are vehicle exhaust, heat and power plants, industrial, and open burning (DOE, 2017). Ul-Saufie et al., (2013) mentioned that the sources that contribute heavily towards the PM_{10} emissions are from the traffic which is the heavy traffic and also industries that vigorously active.

Hanapi et al., (2012) mentioned that staying exposed towards PM_{10} long enough could drive human to several health issues such as respiratory conflicts, lung tissue damage, cancer and cardiovascular diseases and could even cause fatality.

2.4 Meteorological Effect on PM_{10}

Air pollution formation is likely to be dependent with the intensity of the emissions from the source and other meteorological condition in the ambient air such as wind, temperature, topography and many more (Giri, 2008). Giri (2008), mentioned that at certain shape of topography such as bowl-shaped valley topography will restrict and restrain the movement of the pollutant and makes the pollutant trapped, in other words, restricting the dispersion of the pollutant. The study done by Giri (2008), focused on the influence of PM_{10} dispersion in Kathmandu Valley.

According to Afzal et al., (2014), there should be a positive relationship between PM_{10} concentration and the temperature. The author added that the temperature gives significant effect towards the ambient PM_{10} concentration. The theory behind the statement is as the temperature rises, it will encourage more chemical reaction in the atmosphere which leads to the formation of particulate matter that is divided finely that will give significant contribution towards the PM_{10} concentration in the air. The positive correlation can also be seen with other types of gaseous such as SO_2 and NO_2 which gives strong linkage towards the contribution of PM_{10} concentration in atmosphere as these fine sulfate and nitrate particles are also a part of particles in PM_{10} (Afzal et al., 2014).

Besides that, Afzal et al., (2014) suggested that there are negative relationship between PM_{10} concentration with wind speed, solar radiation and relative humidity. The author supported the idea by the theory that says the increase in wind speed will dilute the PM_{10} in dispersion and hence decrease the concentration of PM_{10}. The reason for negative relationship between solar radiation and PM_{10} is that during the sun radiation, the surface is warmer and the exchange of heat in the air is more intense. So mixing of air and increases the size of eddies which helps reducing the concentration of pollutant through dispersion. Relative humidity is commonly affected by the number of rain occasions which through wash-out processes of the atmospheric aerosols, reduces the concentration of pollutant in the air (Afzal et al., 2014).

2.5 Sources of PM_{10}

As mentioned by Greyson (1990), most of the pollutant in the atmosphere comes from anthropogenic sources which include industrial and human activities. Among the industrial activities that caused the emission of pollutant are wood pulping, paper manufacturing, petroleum and metal refining and metal smelting especially of ores containing sulfides, such as lead, silver and zinc (DOE Australia, 2013). DOE Australia (2013) also mentioned that pollutant can also be emitted from the fossil fuel combustion such as coal-burning power plant.

Besides that, pollutant such as PM_{10} can be released to the atmosphere from the transportation sources such as cars, bus and trucks which involve the burning of fuel which is emitted from the exhaust of the vehicles as an end product (DOE Australia, 2013). According to Kumar et al. (2011), the dominant source of pollution in the urban environment is emission from vehicle using gasoline and diesel fuel.

Daily human activities can also contribute to the released of pollutant to the atmosphere such as consuming food products containing pollutant (preserved dried fruits), food preservatives, wine, bleach, disinfectant and fumigants for pest control (DOE Australia, 2013).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This study was to examine the trend of PM_{10} in ambient air due to industrial and human activities. The study area was focused in one area which is Tronoh, Perak. The results and discussion were based on the nearby area that governed the activities that may be the source of the pollutant. The figure 4 shows the location of Tronoh which was the focused area for this study.

Figure 4: Location of study area

Figure 5: Street view of the flyover at Batu Gajah, Perak

This is the main street that connected Ipoh to Lumut in Perak. Along this Ipoh-Lumut Highways, there are another district like Batu Gajah, Seri Iskandar, Setiawan and Manjung. All these districts are the focal point of the people to run their business which leads to increasing number of vehicles passes the street.

Three different location was selected to place the Air Monitoring instrument with the radius 2 km from the exact study area. Figure 6 illustrated the location of study area in Google Maps. Table 5 show the sign and description for every location.

Color	Description
Red	Exact location of study area
Yellow	Location 1: Roadside
Blue	Location 2: Industrial area
Orange	Location 3: Rural area

Table 5: Location description

Figure 6: Distribution of study area in Google Maps

First point is around 300 meters from the exact location which is the instrument placed at the restaurant beside the main road. Figure 7 shows the street view of location 1.

Figure 7: Street view of Location 1

For the second point, the location is at the mosque which near to residential area and industrial area. The distance from the exact study area is 900 meters. Location 2 is shown in Figure 8.

Figure 8: Street view of Location 2

The last point is 1.2 kilometers away from the exact study area which is at the rural area at Papan village. Nearest to this location there are the factories that manufacture the fine sand that utilized for construction industry. Figure 9 shows the third location.

Figure 9: Street view of Location 3

Batu Gajah having a tropical rainforest climate, which is experienced dry and humid weather with the lowest average temperature 25°C and the highest average temperature of 35°C. Batu gajah also experiences mean rainfall 500mm and 308 days per year.

3.2 Data Collection and Sampling

3.2.1 Data Collection

In this study, all the data collection and sampling will be conducted using Aeroqual 60 Station. The station will be set up and installed in three locations within the study area to record the concentration of PM_{10} and meteorological parameters such temperature and relative humidity. All these data will be recorded throughout a sampling period of 6 days within 3 weeks and the readings are taken by the station at a constant interval of time of 3 minutes interval for 12 hours per day. The air pollution will be sampled for 1 day in weekday and 1 day in weekend for every location. There are 3 locations selected to portray the pollutant behaviour. The number of vehicles will be recorded in every sampling activities to correlate the effect of traffic to the concentration of PM_{10}.

The changes of PM_{10} concentration will be analyse in relation with the number of vehicles and meteorological parameters to know the real time trend of the air pollutant throughout the day of sampling. By doing so, the influence of the traffic and meteorological parameters towards the concentration of PM_{10} can be analysed more precise and accurate.

3.2.2 Equipment

Aeroqual AQM 60 Station is a compact air quality monitoring equipment which designed for low cost and easy deployment equipment. Aeroqual AQM 60 Station is a flexible instrument platform configuration which require less maintenance, small footprint, and easy to handle. This equipment is suitable for monitoring continuous time range for the purpose of air profiling, trending as well as air quality assessment. The built-in sensors located inside the station is used to measure major air pollutants including Ozone (O_3), Nitrogen Dioxide (NO_2), Nitrogen Oxides (NO_x), Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Volatile Organic Compounds (VOC), Hydrogen Sulphide (H_2S), Non-Methane Hydrocarbons (NMHC), Carbon Dioxide (CO_2), Particulate Matter (PM_{10}, $PM_{2.5}$). Aeroqual AQM 60 Station is also designed to measure common meteorological parameters such as temperature, relative humidity, wind speed and direction.

Typical applications of Aeroqual AQM 60 Station includes:

- Urban monitoring – Air quality of local area, Environment Impact Assessment
- Road monitoring – Road and weather information systems (RWIS), Motorways and highways
- Perimeter monitoring – Construction site, Point sources pollution emitters, Power generation plants, Waste sites and landfills
- Open space monitoring – Forest, Natural Environment Studies, Natural parks and reserves

The station consists of several main components:

- Outside components – TSP Inlet, Air Sampling Inlet, Solar Radiation Shields, External USB Port, Thermal Management System (TMS), Power module
- Enclose components – Gas Treatment Module, Gas Modules, Control Module, Particle Monitor, PM Flow Module, Communication Module, External USB Port, Calibration tubes, Wire connectors.

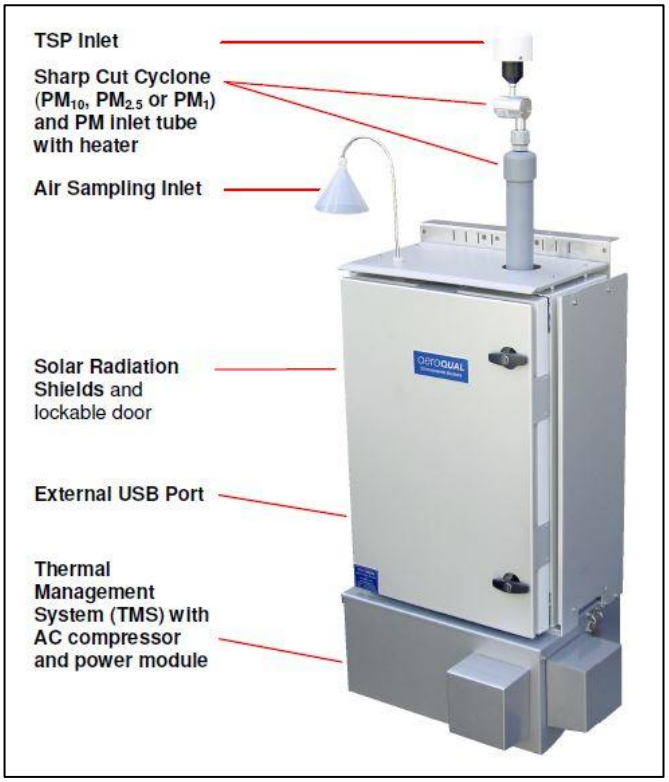


Figure 10: Aeroqual AQM 60 Station external components

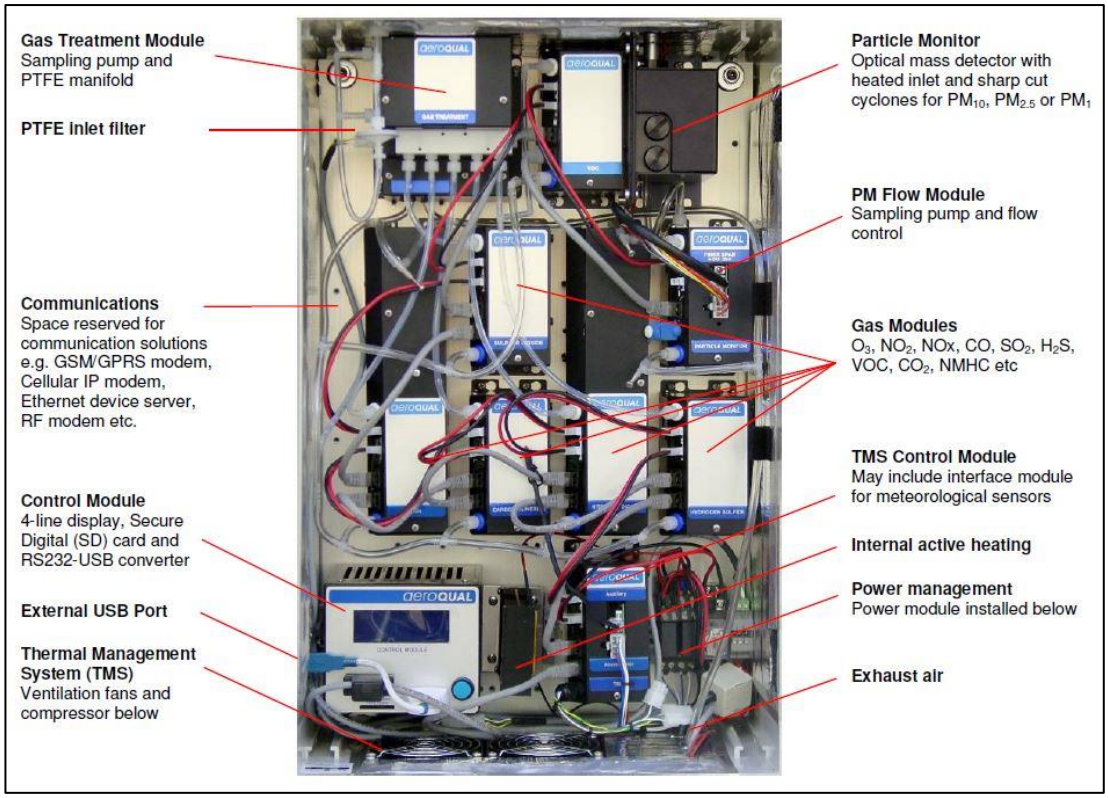


Figure 11: Aeroqual AQM 60 Station enclosed components.

3.3 PM_{10} Analysis

3.3.1 Time Series Analysis

Time series analysis contains methods for determining time series data in order to obtain useful statistics and other characteristics of the data. Time series forecasting is used to utilize a model to predict the upcoming values based on the previous obtained data or value. By using the time series analysis, is it easy to describe and observe the movement history of the PM_{10} with the variable in time. Identification of long term variation of the mean and periodic component will be involved in time series analysis to observe the air pollution environmental levels. Due to that matter, time series analysis will be very helpful in understanding relationship between the cause and effect in this topic.

In the analysis, PM_{10} dispersion will be monitored in hourly basis in a time frame. This is because the hazy condition that can be found in the study area usually occur in the morning time. Therefore, the results expected should be able to model the dispersion of the PM_{10} in the variation of time within the time frame. From the data

obtained, the behavior of PM_{10} in ambient air in Tronoh should be observed and determined.

3.3.2 Traffic Flow Analysis

The traffic flow were recorded during the monitoring done at the roadside. The number of vehicles were recorded based on their classification in Passenger Car Unit (PCU). The relationship between concentration of PM_{10} and the traffic flow were compared using PCU. The calculation of PCU is calculated using the formula:

$$PCU = (Car) + (0.33 \times Motorbike) + (1.75 \times Lorry) + (2.25 \times Truck) + (2.25 \times Bus).$$

3.4 Key Milestone

1. Final Year Project 1 (FYP 1) :

No.	Activities	Week No/ Date													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Topic Selection														
2	Research on Selected Topic														
3	Submission of Extended Proposal														
4	Amendment of Proposal														
5	Proposal Defence														
6	Analysis of Topic														
7	Submission of Interim Draft Report														
8	Submission of Interim Report														

2. Final Year Project 2 (FYP 2) :

No.	Activities	Week No/ Date													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Analysis and Project Work														
2	Progress Report Submission														
3	Project Work														
4	Pre-SEDEX														
5	Draft Report Submission														
6	Submission of Dissertation (Soft Bound)														
7	Technical Paper Submission														
8	Viva														
9	Project Dissertation Submission														

CHAPTER 4

RESULTS AND DISCUSSION

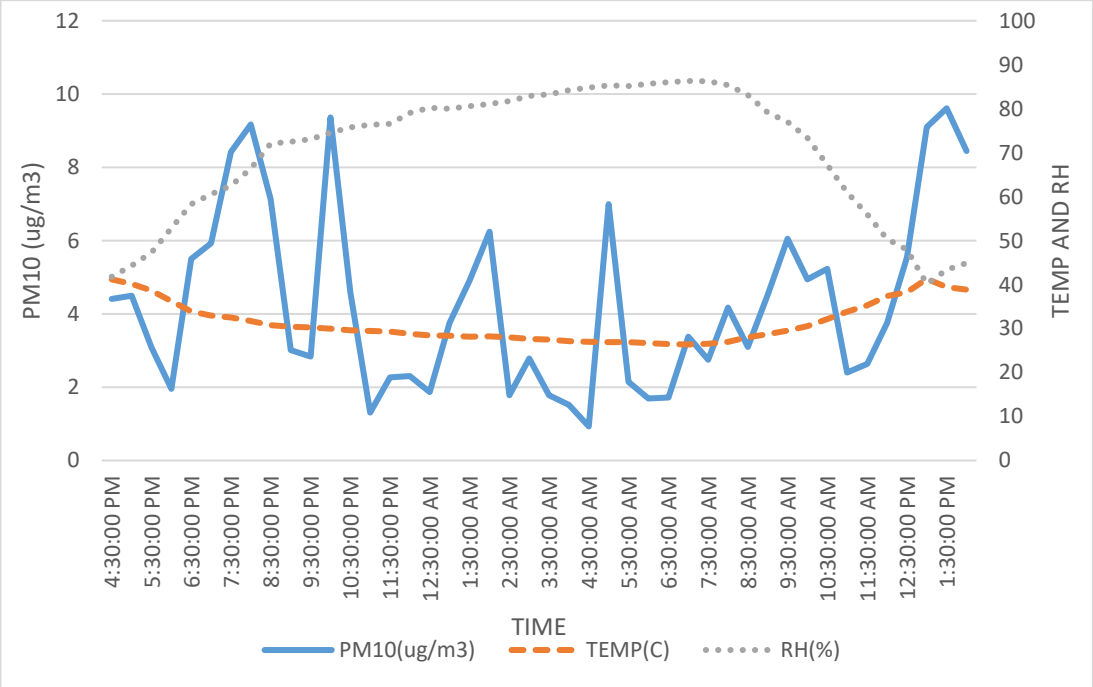
The concentration of PM_{10} was studied from 7 days of sampling at which began at 23rd October 2017 to 18th November 2017. The interval for data recording was set for every 3 minutes for the 24 hours monitoring to study the peak hours for 1 day, and 12 hours of monitoring each day for another 6 days. Approximately, there would be 1880 data that should be retained for the concentration of PM_{10}. The monitoring location were chosen at the roadside, in the radius of industrial activities and in the village residential area. All the three locations are within 2km radius from the flyover to Batu Gajah. The trend for PM_{10} concentration was studied throughout the locations.

The data collected was presented using time series analysis. The analysis was carried out by using Microsoft Excel. The main function of doing the time series analysis is to portray the trend of pollutants with the time. The data obtained from the monitoring can be divided into two parts which is weekdays and weekends. The division of the time frame is mainly due to the trend of activities that occur in the location such as the traffic volume, industrial activities and also human activities. For example, number of vehicles passing the road in the morning time is greater during weekdays than weekend and during afternoon to evening, the number of vehicles are greater during weekend than weekdays. The concentration of PM_{10} is also expected to be greater during the operation hours of factories in the industrial areas.

4.1 One Day Monitoring (Finding Peak Hour)

4.1.1 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity)

The monitoring started at 1615 on 23rd October and ended at around 1400 on 24th October. The objective of the 22 hours monitoring is to gain the peak period of PM_{10} emission to the air. The monitoring was conducted at location 1 which is the roadside. The concentration of PM_{10} against the time for 22 hours is as shown in Graph 1 below.



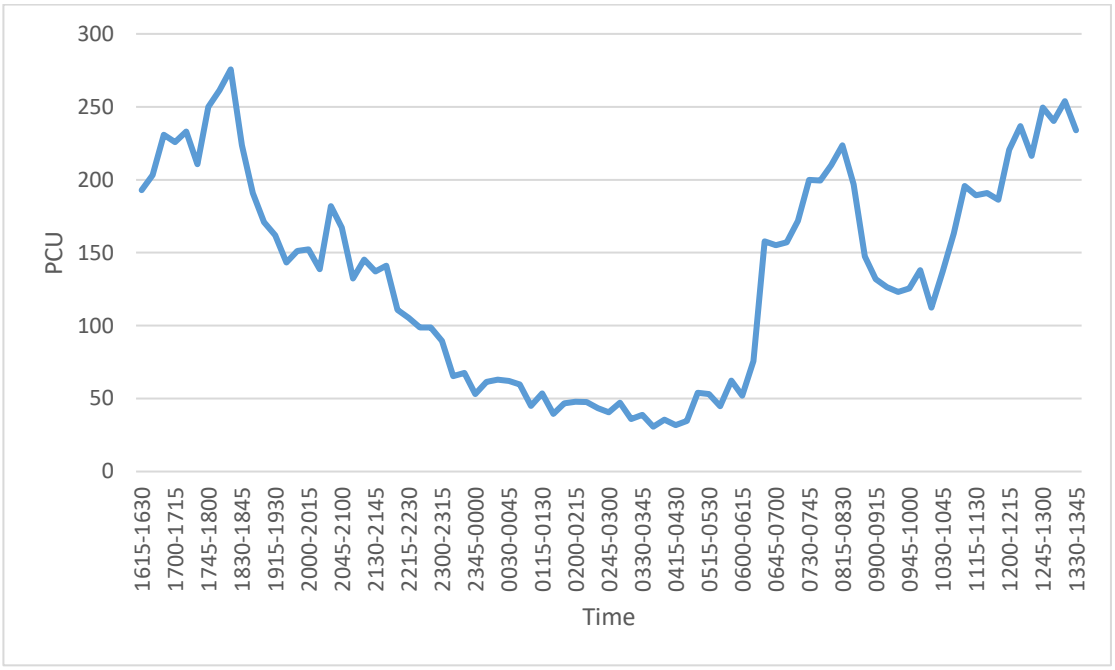
Graph 1: Graph of PM_{10}, Temperature and Humidity against Time

The Graph 1 obtained was the concentration of PM_{10} for the 22 hours period. The graph shows fluctuations of concentration from time to time. The highest reading recorded was around 9 µg/m^3 which occurred at 1930, 2200 and 1330.

To choose the peak hour for the fluctuated data, the result of traffic is compared to represent the peak time of people activity in Tronoh.

4.1.2 Trends of Traffic

The Passenger Car Unit (PCU) is one way to measure the volume of vehicle passing on a certain location. The aim of calculating the PCU is to determine the peak period and also to study the relationship between PCU and the concentration of the pollutant. The number of vehicles recorded in the PCU are the vehicles that passed through the main road.



Graph 2: PCU Index of 22 Hours

The PCU index in the Graph 2 above show the period with the number or volume of vehicles. The highest vehicle passing through the location was recorded during the morning time at 0630 - 0830 where the number of PCU in total is 1475. The other peak period was recorded at 1200 - 1400 where the total number of PCU calculated is 1877. During evening, it shows an increase in PCU which means that the number of vehicles were saturated during the time. In the evening, was seen that the graph shows high reading at 1630 - 1830 with the number of PCU is 1891 in total.

Time	Total of PCU
Morning (0630 hrs to 0830 hrs)	1475
Afternoon (1200 hrs to 1400 hrs)	1877
Evening (1630 hrs to 1830 hrs)	1891

Table 6: Peak Period based on PCU

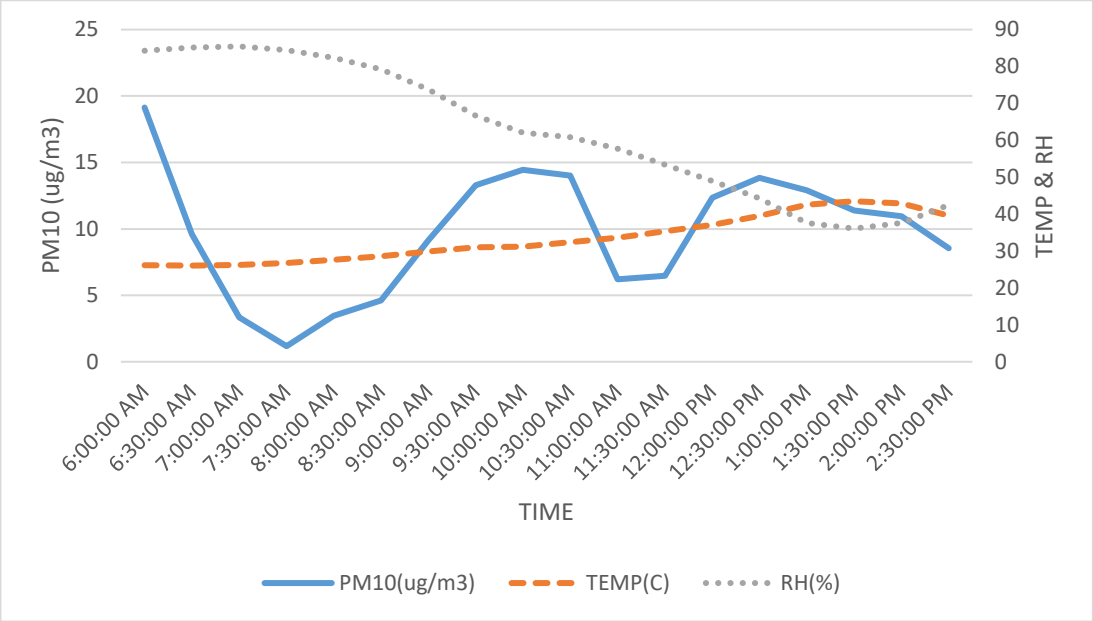
4.1.3 Comparison between PM_{10} concentration and PCU

As stated at the Graph 2 of PCU, the peak hours where the traffic is saturated was seen at 0630 – 0830, 1200 – 1400, and 1630 – 1830 hours. Somehow, the concentration of PM_{10} was at peak at 1930, 2200 and 1330 hours. This shows that other parameters such as meteorological condition must be considered to besides number of vehicles.

From the observation on the graph provided, the trend of PM_{10} shows that as the temperature increase, the concentration of PM_{10} decrease. Theoretically, the concentration should be increasing following the trend of temperature. The highest temperature recorded during the monitoring was in the afternoon at with the reading of 42.35 °C. That was also when the lowest humidity occur which was at 38.1%. The lowest temperature was recorded in the morning with the reading of 26.31 °C and the highest humidity was recorded at the same time with the reading of 86.30%. This condition occur may be due to the wind speed and direction that dilute the pollutant and transport it to other location.

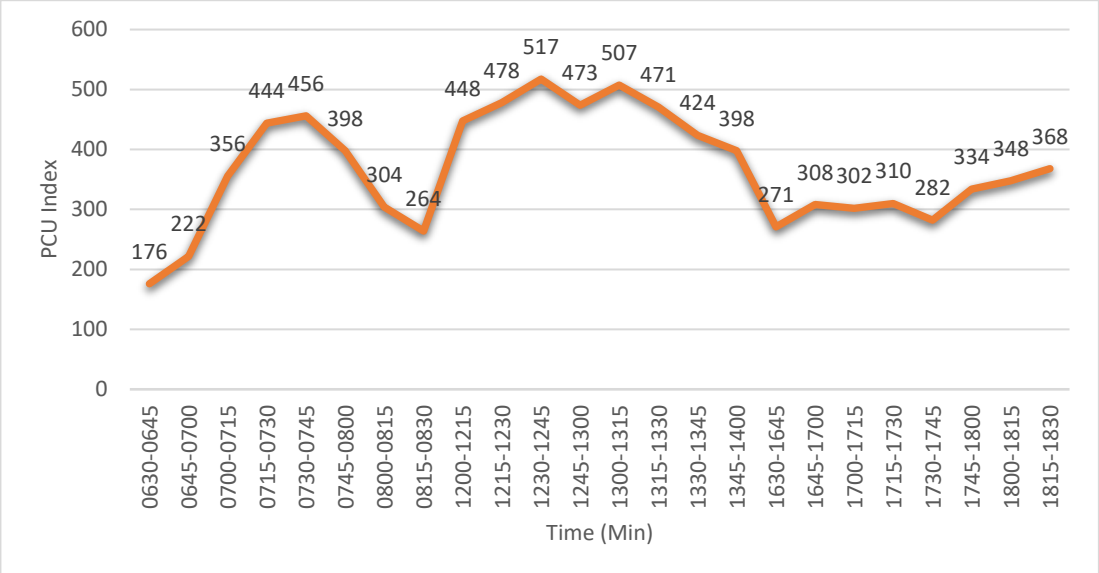
4.2 Results for Location 1 (Roadside)

4.2.1 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity) (Weekday)



Graph 3: Graph of PM10, Temperature and Humidity against Time (Weekday)

4.2.2 Trend of Traffic during Weekdays



Graph 4: PCU Index for Location 1 (Weekday)

Time	Total of PCU
Morning (0630 hrs to 0830 hrs)	2620
Afternoon (1200 hrs to 1400 hrs)	3716
Evening (1630 hrs to 1830 hrs)	2523

Table 7: Peak Period based on PCU

4.2.3 Comparison between PM_{10} concentration, Meteorological Parameters (Temperature and Relative Humidity) and PCU

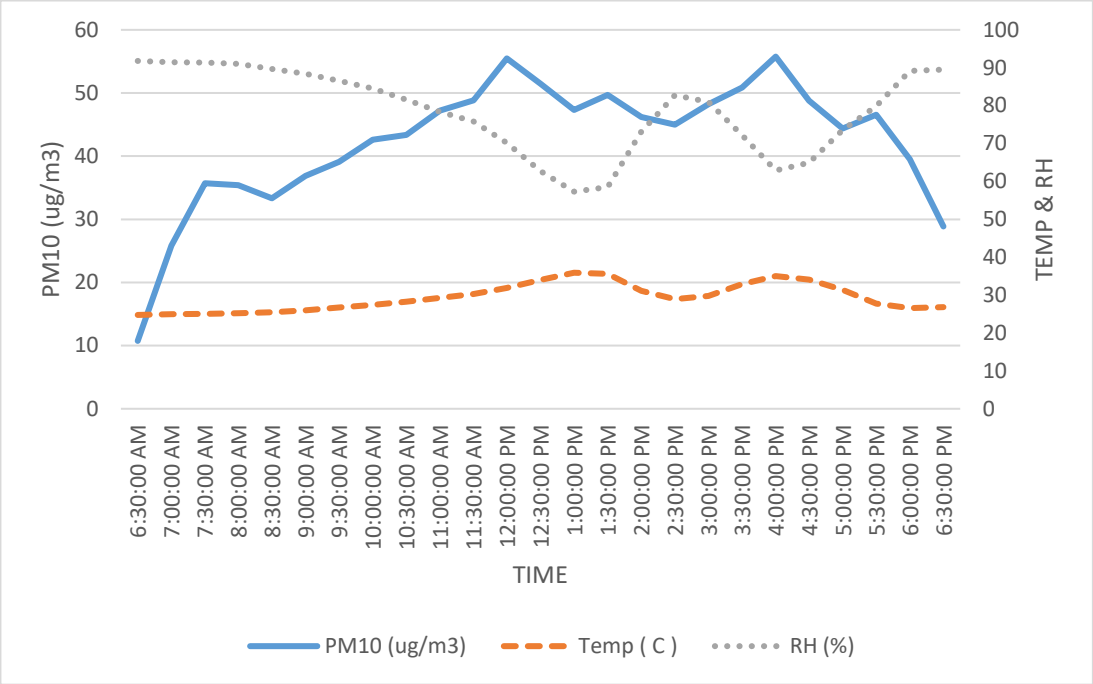
The Graph 3 obtained was the result for location 1 where the equipment was placed at the roadside for 8 hours from 0600 to 1400 hours on weekday mainly to investigate the relationship between the concentrations of PM_{10} with the traffic condition. The graph was at peak during the morning time 0600 - 0645 where the average values are in range of 15 – 20 µg/m^3. This is due to the heavy traffic in the morning where people are busy travelling to their workplace. The graph 3 then decrease towards 3.5 µg/m^3 towards 0800 hours before it started to incline until 1100 hours. The graph was also incline from 1200 to 1300 mainly due to the lunch hour or office break where the traffic was heavy.

The peak concentration from 1200 to 1400 hours was seen at 1230 hours with the PM_{10} concentration of 13.835 µg/m^3.

The Graph 3 was correlated with the PCU graph 4 to investigate the relationship of the traffic and the effect on PM_{10} concentration. The trend of the PM_{10} concentration was not exactly following the PCU trend as meteorological parameters which is temperature, relative humidity and wind also affect the concentration of PM_{10}.

The average temperature during the morning time was 26 °C and it inclined to 1300 hours which was the peak with the reading of 43.501 °C. Then, the temperature started to decline back to 39.6 °C at 1430 hours. The correlation of PM_{10} concentration with the temperature can be from 0730 hours to 1100 hours where the concentration of PM_{10} increases as the temperature increase. This is due to the chemical reaction that vigorously active during high temperature and may lead to formation of PM_{10} in the atmosphere.

4.2.4 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity) (Weekend)



Graph 5: Graph of PM10, Temperature and Humidity against Time (Weekend)

4.2.5 Trends of Traffic during Weekend

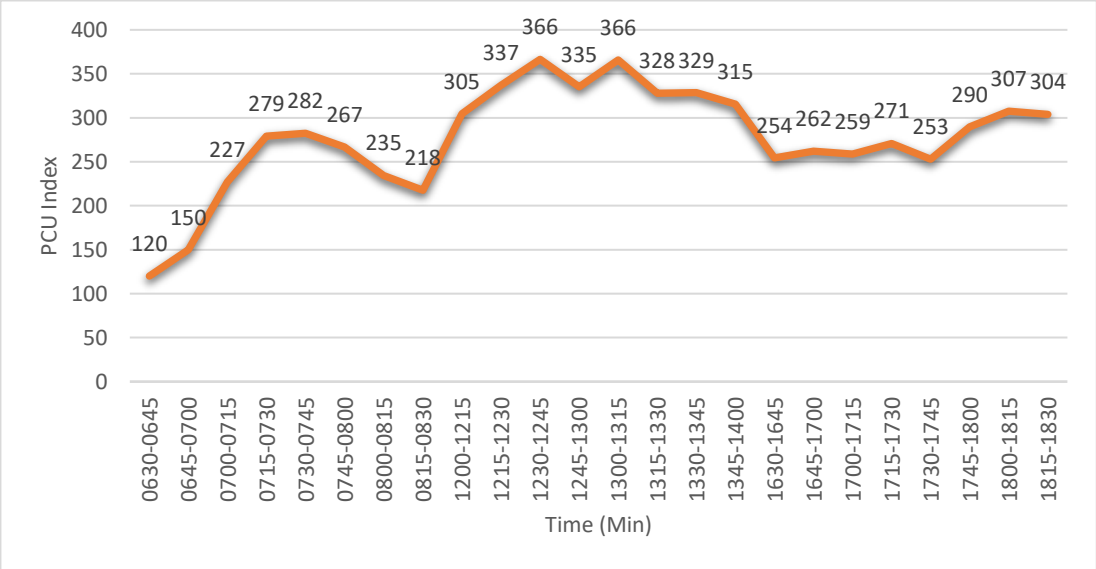


Table 8: PCU Index for Location 1 (Weekend)

Time	Total of PCU
Morning (0630 hrs to 0830 hrs)	1778
Afternoon (1200 hrs to 1400 hrs)	2681
Evening (1630 hrs to 1830 hrs)	2199

Table 9: Peak Period Based on PCU

4.2.6 Comparison between PM_{10} concentration, Meteorological Parameters (Temperature and Relative Humidity) and PCU

The Graph 5 obtained was the result for location 1 where the equipment was placed at the roadside for 12 hours from 0630 to 1830 hours on weekend to study the relationship between the concentrations of PM_{10} with the traffic condition during weekend. The graph 5 started with low concentration of PM_{10} which is at 0630 with the concentration of 10.75 $\mu g/m^3$. This may be due to lower amount of vehicle in the morning time on weekend compared to weekday with the total PCU on weekend from 0630 hours to 0830 hours was only 1778 while on weekday the PCU at 0630 to 0830 hours was 2620. The activity of people on the road on during weekend morning is less than during weekday because they do not need to wake up early to go to work or school.

During the afternoon which is at 1200 to 1400 hours and evening at 1630 to 1830 hours, where the PCU trend increased, the concentration shows the opposite trend which is decreasing. From 1200 - 1400 where the PCU was 2681, the PM_{10} concentration recorded was fluctuated from range of 46 – 54 $\mu g/m^3$. During evening at 1630 – 1830 hours, where the PCU was 2199, the concentration of PM_{10} decreased from 48.8 $\mu g/m^3$ to 28.9 $\mu g/m^3$.

The results obtained was then correlated with the meteorological parameters which is temperature and relative humidity. From 0630 to 1300 hours, the temperature increased from 24.8°C to 35.905 °C. The concentration of increased from the morning to afternoon from 10.75 $\mu g/m^3$ to 49.644 µg/m3. This shows that the temperature affect the concentration of PM_{10} as the concentration will be higher at high temperature as it will encourage more chemical reaction in the atmosphere which leads to the formation of particulate matter that is divided finely that will give significant contribution towards the PM_{10} concentration in the air.

The average concentration in the weekend is higher than in weekday with the concentration of 42.38 μg/m^3 compared to 9.72 μg/m^3. The vehicles in weekend is not heavy at the selected peak hours which is 0630 – 0830, 1200-1400 and 1630 – 1830 hours but it is heavy at throughout the day compared to weekday which is the traffic only heavy at the peak hours.

4.3 Results for Location 2 (Industrial)

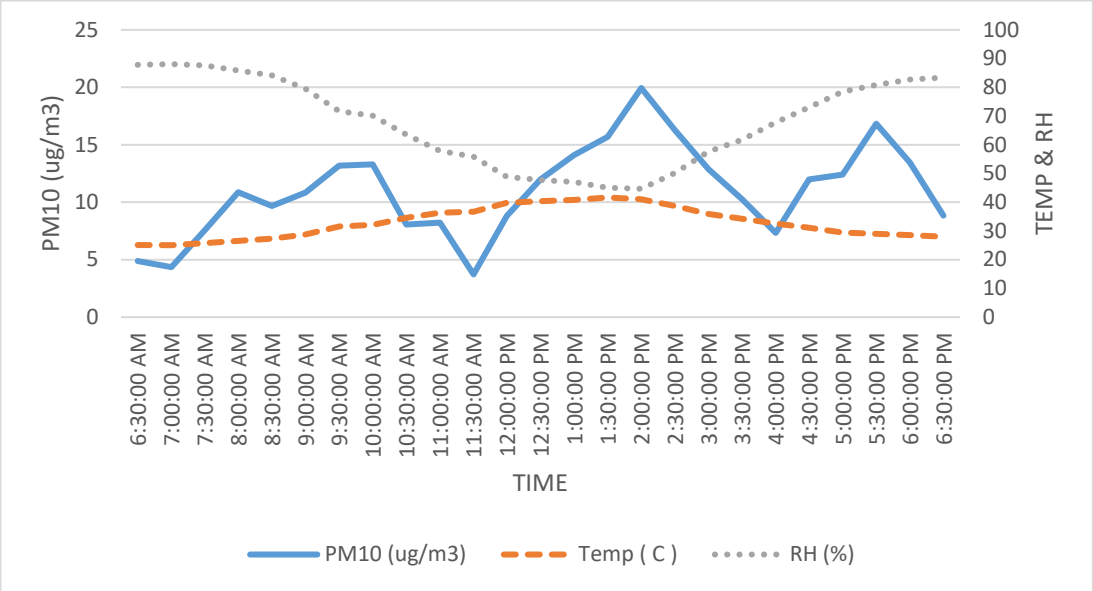
The location was chosen at the industrial and residence area to study about how the industrial activities and human activities from the residences contribute to the level of pollutant in the air.

There are many factories surrounding the area of location 2. The operation was between morning to evening. One factory was seen throwing out smoke from its chamber in the morning time. It is believed that the work carried out by the factories contribute to the reading of the recorded concentration of PM_{10}. The factories that surround the area of location are stated at Table 10 below.

Industry	Scope of work
Industry 1	Manufacturing of electrical and electronic components
Industry 2	Manufacturing of rubber and latex based product for condom
Industry 3	Manufacturing of pre-cast concrete
Industry 4	Manufacturing of can and bottle for beverages
Industry 5	Manufacturing of latex based products for dental and health applications
Industry 6	Manufacturing of stainless steel
Industry 7	Manufacturing of ceramics for home decoration

Table 10: Types of Industries at Location 2

4.3.1 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity) (Weekday)



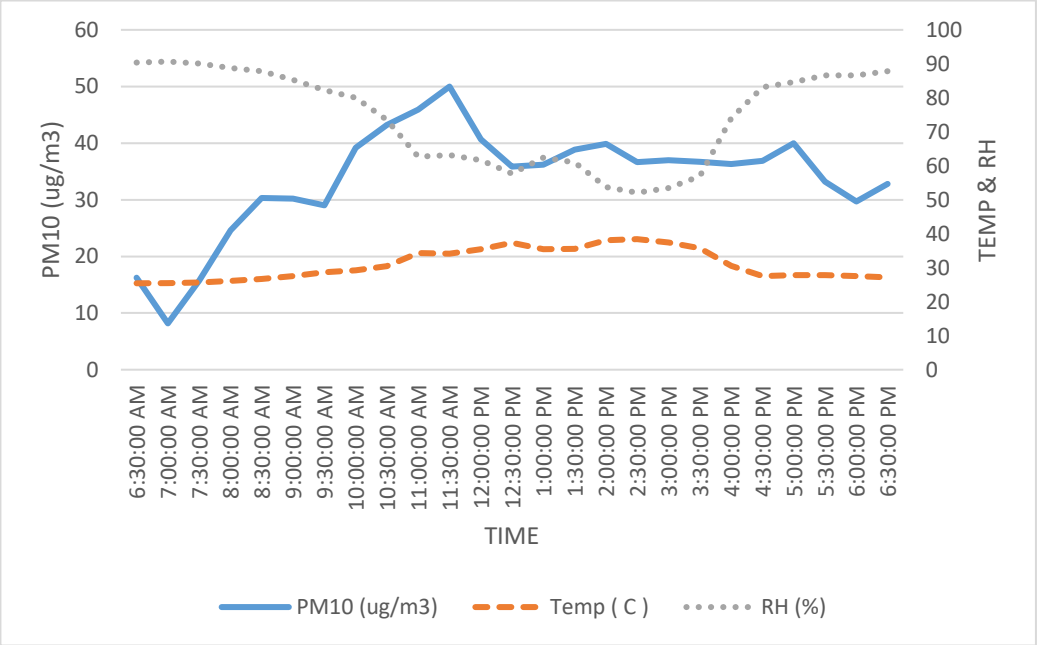
Graph 6: Graph of PM10, Temperature and Humidity against Time (Weekday)

From graph 6, the pattern of PM_{10} concentration shows fluctuations from time to time. During the morning time which at 0700 to 1000 hours, the concentration shows inclination pattern from 4.4 µg/m^3 to 13.305 µg/m^3. This is due to the industrial activity carried out in the morning. Smoke can be seen coming out from several factories surrounding the monitoring location. During the evening time, at 1600 to 1730 hours, the graph shows inclination from 7.33 µg/m^3 to 16.843 µg/m^3. From observation, at this time, the activities from the industry also active which leads to the inclination of PM_{10} concentration.

The relationship between PM_{10} concentration and meteorological parameters can also be established. It can be seen clearly at 1130 hours to 1530 hours. As the temperature increases from 1100 to 1400 from 36.4 °C to 41.09 °C, and the relative humidity from 57.87% to 41.09%, the concentration increased from 8.212 µg/m^3 to 19.939 µg/m^3. When the relative humidity is low, is shows that the condition is dry and dust particle can easily flown by present of wind.

As the temperature decreased at 1400 to 1530 from 41.09 °C to 34.218 °C, the PM_{10} concentration also declined from 19.939 µg/m^3 to 10.27 µg/m^3. This shows that in lower temperature, the chemical reaction in the air is slower.

4.3.2 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity) (Weekend)



Graph 7: Graph of PM10, Temperature and Humidity against Time (Weekend)

During the weekend, the activity conducted by the industry was slower compared to weekday. From observation, there were not many visible activities carried out by the industry. The concentration was only compared to with the meteorological parameters which is temperature and humidity.

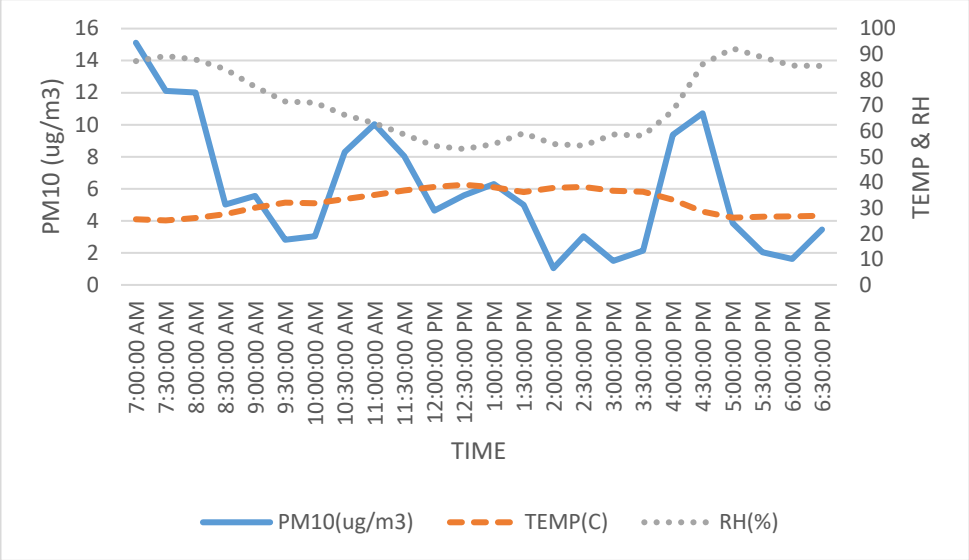
The relationship can be seen at 0700 to 1130 where the concentration inclined from 8.174 µg/m^3 to 49.99 µg/m^3. It is where the temperature increase gradually from 25.63 °C to 34.154 °C and relative humidity decreased from 90.67% to 63.11%. This shows that the high temperature encourage the PM_{10} concentration to be higher.

However, at the highest temperature at 1430 which is 38.146 °C, the concentration of PM_{10} was only 36.63 µg/m^3. This may be due to the presence of other meteorological factor such as wind speed and wind direction.

The average concentration in weekend is higher compared to weekday with 33.73 µg/m^3 and 11.02 µg/m^3 respectively with average relative humidity was 74.26% on weekday and 68.04% on weekend.

4.4 Results for Location 3 (Rural Area)

4.4.1 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity) (Weekday)

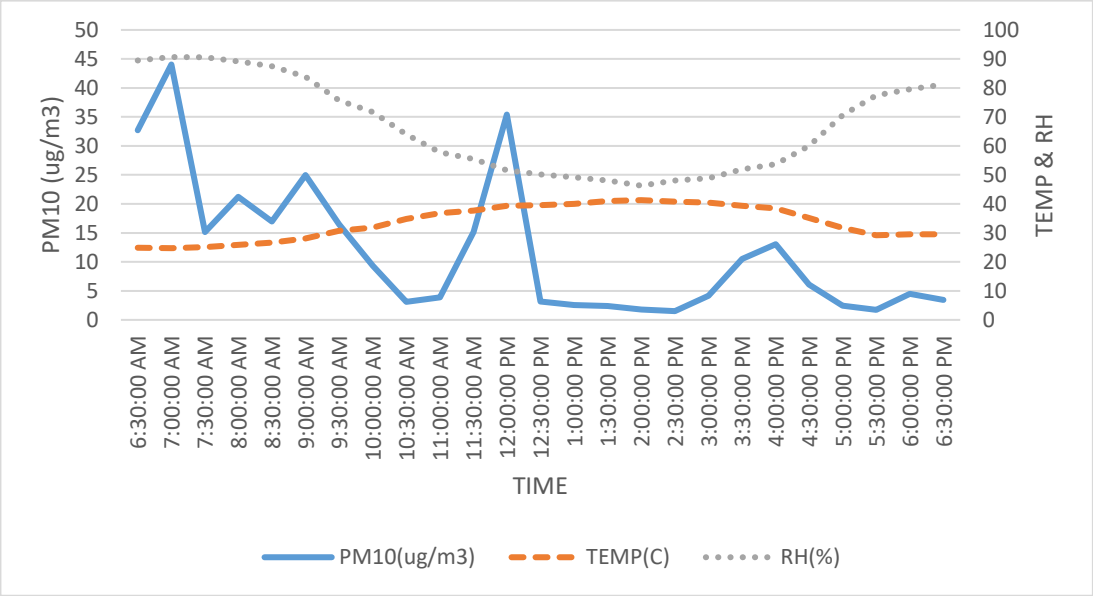


Graph 8: Graph of PM10, Temperature and Humidity against Time (Weekday)

From graph 8, it is clear that the PM_{10} pattern does not follow the pattern of the meteorological condition which is temperature and relative humidity. The concentration was at peak during morning hour at 0700 with the reading of 15.12 $\mu g/m^3$. The graph fluctuated. As the temperature increases, the concentration increase and decrease. It does not follow the theory well.

Based on observation, there was a sand factory nearby the area. It is believed that the concentration of PM_{10} in this location also correlate with the activities from the sand factory. The graph shows increasing pattern from 1530 to 1630. From observation, there were some burning activities from the villagers such as burning dried leaf and rubbish. This activity lead to the small particle and smoke released to the air which may contribute to the inclination of PM_{10} concentration from 2.13 $\mu g/m^3$ to 10.714 $\mu g/m^3$.

4.4.2 Trends of PM_{10} Concentration and Meteorological Parameters (Temperature and Relative Humidity) (Weekend)



Graph 9: Graph of PM10, Temperature and Humidity against Time (Weekend)

The same condition happened in weekend. The concentration does not follow the temperature and relative humidity pattern. The highest concentration recorded was at 0700 hours with the concentration of 44.04 µg/m^3. This was due to the activity conducted by the sand factory that can be seen in the morning which they load the sand to the lorry. For the rest of the day, there were not many activities conducted by the villagers outdoor.

There was one peak in the afternoon at 1200 with the concentration of 35.429 µg/m^3. The temperature recorded during this time was 39.32 °C which is also high during that day. The highest temperature recorded was at 1400 which is 41.23 °C. Somehow, the concentration was only 1.801 µg/m^3. This shows that there are other meteorological factors that are present such as wind.

The average concentration of PM_{10} was 11.83 µg/m^3 during weekend and 5.93 µg/m^3 during weekday with the temperature and relative humidity of 33.69 °C and 66.881% during weekend and 32.21 °C and 71.26% during weekday. The concentration on weekday is lesser as the humidity is greater in weekday compared to weekend.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

The sources of emissions are identified from traffic, industrial and human activities. The PM_{10} concentration in the air depends on several factors that include the type of activity conducted, emission from sources and also the meteorological parameters such as temperature, humidity and wind. The concentration vary from time to time and also from different locations. The trends of PM_{10} were studied by monitoring done at different location in different days and condition.

Besides that, the development status such as the industrial, traffic and human activities also contributed to the PM_{10} concentration in ambient air. The highest average of PM_{10} concentration occurred at the roadside which is at 42.38 $\mu g/m^3$ where the traffic mainly gives big impact towards emission of PM_{10} and flown the small fine dust at road area.

The second highest concentration recorded was at the industrial area which was at 36.63 $\mu g/m^3$. This shows that the industrial area also give significant effect towards PM_{10} emission from the activities they conducted.

Overall, the concentration of PM_{10} in Tronoh were still under the safe state according to API which sets the safe level at 50 and does not exceed the MAAQG that sets at 150 $\mu g/m^3$ for 24 hours duration. The objective was achieved.

Throughout the study, it is best if we can obtain the result for a continuous and longer duration. It is because we can compare more data and see more accurate trend of the pollutant in a particular area. Besides that, we can try to obtain data that has been collected by DOE to compare the results with our monitoring. Lastly, it is best if we can add more sites for monitoring so that mapping.

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