

UNIVERSITI TEKNOLOGI MARA

IMPACT OF METEOROLOGICAL FACTORS ON AIR
POLLUTION TRENDS IN WEST PENINSULAR
MALAYSIA

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**IMPACT OF METEOROLOGICAL FACTORS ON AIR
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MALAYSIA**

ROS SHARINA BINTI HUSSIN

Dissertation submitted in partial fulfillment
of the requirements for the degree of
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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a Panel of Examiners has met on 13rd June 2019 to conduct the final examination of Ros Sharina Binti Hussin on her **Master of Science** thesis entitled “Impact of Meteorological Factors on Air Pollution Trends in West Peninsular Malaysia” in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The Panel of Examiners was as follows:

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ABSTRACT

The aim of this research is to study the impact of meteorological factors on air pollution trends at the industrial area in West Peninsular Malaysia. Data set of air pollutants namely particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃) provided at 3 monitoring sites around densely populated industrial zone which is at Perai, Ipoh and Petaling Jaya. This study uses 5 years (2013 - 2017) of air pollutants and meteorological data set. The Microsoft Excel Software is used to tabulate the graph involve in this study. An investigation of trend for major air pollutants in compliance with Recommended Malaysia Ambient Air Quality Guideline (RMAAQG) have been carried out to identify the concentration of air pollutant data involve either above or below the limit value of RMAAQG. An analysis on the air pollutants (PM₁₀, CO, NO₂, SO₂, O₃) with meteorological parameter which involves rainfall, temperature and humidity have been carried out to identify the correlation of meteorological conditions towards air pollutants released to the atmosphere. This analysis analyzed on the significant value from the Statistical Package for the Social Sciences software (SPSS). An evaluation of impact of air pollution related to meteorological parameter on climate change also had been carried out. Therefore, an adverse impact of climate change to human, economic and environment can be known.

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LIST OF ABBREVIATIONS

Abbreviations

PM ₁₀	Particulate Matter
CO	Carbon Monoxide
NO ₂	Nitrogen Dioxide
SO ₂	Sulfur Dioxide
O ₃	Ozone
API	Air Pollutant Index
UV	Ultra Violet
DOE	Department of Environment
MMD	Malaysia Meteorological Department
VOC	Volatile Organic Compound
Eq.	Equation

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Air pollution is not a new phenomenon and it has been a current issue in many countries in the region of Southeast Asia. It was first recorded in 1982 when regional haze from the burning of biomass has disrupted everyday life in Malaysia (Sham, 1984). In 2015, Southeast Asian haze brought about via mass illegal burning in Indonesia resulted in over a month of haze in Malaysia triggering school closures and disrupting air travel. According to Department of Environment (DOE) (2015), the haze was considered as one of the worst episodes since 1997 as the air quality recorded unhealthy levels with Air Pollutant Index (API) more than 100. This indicates that air pollution issues in Malaysia are crucial to preserve ecosystem as well as to maintain the human health.

Air pollution can be described as the presence of air contaminants such as dusts, fumes, gas, and others which are in immoderate quantities delivered into Earth's environment resulted in unsafe results to the human health, purpose material damage, harm dwelling sources and ecosystem (Afroz et al, 2003). Hence, it additionally affects the economic system and contributes to global warming and climate change as a result of massive greenhouse gas emissions and different pyrogenic products (Huang et al, 2013).

Nowadays, air pollution becomes one of the predominant environmental concerns. The air pollution is normally induced by way of natural activities or anthropogenic activities. The main anthropogenic activities consist of motor vehicles, power generation and industrial activities that are also known as primary pollutants as the main source of air pollution. Due to the interactions between the primary pollutants themselves by chemical or physical form or reaction between the primary pollutants and other atmospheric components, secondary air pollutants can be formed in the atmosphere. In Malaysia, the Recommended Malaysia Ambient Air Quality Guidelines (RMAAQG) is the guideline used for monitoring the air quality which stated by Department of Environment (DOE) under Ministry of Energy,

Science, Technology, Environment & Climate Change (MESTECC). The RMAAQG must to be complied to ensure the concentration of pollutants in acceptable limit for human and environment exposure.

1.2 Problem Statement

Nowadays, the air quality in Malaysia is gradually deteriorated due to industrialization and development. According to Huang K. et al. (2013), Air pollutants come significantly from a variety of sources, including industrial activity, waste products, transport and construction activities. Moreover, many areas were developed and green areas were decreasing rapidly. From an agriculture-base landuse transformed to industry area and promote to negative impact on the environment. Furthermore, majority of job seeker tend to move to the urban or industrial areas for more of work opportunities. Consequently, it increases the population in the urban and industrial areas rapidly (Ismail et. al, 2017). In 2010, the population in the industrial areas such as Seberang Perai, Ipoh and Petaling Jaya was 398020, 657892 and 197949 peoples, but in 2017 it estimated increased to 445180, 673318 and 520689 peoples respectively. Hence, this industrial development and rapid urbanization may cause to deterioration of air quality and harm the human health and the environment as these areas located near to the residential area (Ismail et al, 2017).

Moreover, the urban-industrial emission is detected as the main source of the deterioration of air quality problems (Ismail et. al, 2017). This is due to the atmosphere surrounding that areas is polluted with the several of common air pollutant which may include particulate matter (PM_{10}), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone (O_3). But, according to the Department of Environment, PM_{10} and O_3 are the pollutants concerned due to productive atmospheric condition. The O_3 pollutant was formed in the existence of the sunlight where the reaction of chemical between volatile organic compounds (VOCs) and nitrogen oxides (NO_x) and can increase more O_3 production during dry days. The VOC and NO_x may come from the emission of industries and motor vehicles exhaust especially in urban areas. Besides that, the predominant pollutant that caused unhealthy situation particularly during the dry season in the late Northeast Monsoon (February to March) and Southwest Monsoon (May to October) was PM_{10} (DOE, 2015).

Azmi et al. (2010) also reported that concentration of PM₁₀ and O₃ are primarily associated with regional tropical factors which are biomass burning and intensity of UV radiation. According to Enger & Smith (1999), the PM₁₀ and O₃ pollutants mainly come from emissions of NO_x and VOCs can destroy people's sensitive tissues and also impair respiratory functions. In addition, more than 60,000 of people die prematurely in United States over two years due to excessive exposure to the PM₁₀ pollutant (ALA, 1996). Hence, it shows the pollutants are very harmful to human health. Besides that, pollutant emissions into the atmosphere can lead to climate change. For example, ozone (O₃) in the atmosphere warms the climate, while various particulate matter (PM₁₀) components can affect the climate either warming or cooling. It can be shown when emission of particulate pollutant (black carbon) from the process of combustion activity may contribute to the global warming, while the pollutants that can cool the atmosphere are particulate sulfates (Agency, 2018). Hence, this study is important as to investigate the atmosphere at the industrial areas.

1.3 Objectives of Study

The main goal for this study is to investigate impact of air pollution to climate change at the urban-industrial area especially in Perai, Ipoh and Petaling Jaya. There have been set at several objectives in sequence to achieve this goal:

- i. To identify the trends of air pollutants in compliance with the Recommendation Malaysia Ambient Air Quality Guideline (RMAAQG) at selected industrial area
- ii. To determine the correlation between air pollutants and the meteorological factors
- iii. To evaluate the impact of air pollutants related to meteorological factors on climate change

1.4 Scope of Study

The scope of this study is to identify the air pollutants released into the environment in accordance with the Recommended Malaysia Air Ambient Quality Guideline (RMAAQG). This study has been conducted at three selected areas such as Perai, Ipoh and Petaling Jaya. For the purpose of this study, two types of data, air pollutants and meteorological has been used. For air pollutants, five parameters are consider which are particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃). Meanwhile, for meteorological data, three parameters are consider, rainfall, temperature and humidity. This data is obtained from Department of Environment (DOE) for the air pollutants data and Malaysian Meteorological Department (MMD) for the meteorological data. In addition, air pollutant data and meteorological data is used for detailed analysis using statistical analysis software, SPSS, for approximately 5 years (2013-2017). Based on this analysis, the trend of air pollutants at the industrial areas can be determined. The correlation between the air pollutants and the meteorological parameters can be evaluated. The impact of these air pollutants on the climate change also investigated.

1.5 Significance of Study

The purpose of this study is to present comprehensive information on air pollutant trends and to measure significant correlations on the influence of meteorological conditions on air pollutants in the industrial area's atmosphere. In addition, the results of the study will provide a better awareness of the effect of climate change caused by air pollutants and meteorological parameters for specific industrial areas.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

According to Department of Statistic (2013), air is a composition of gases which consist of 78% of nitrogen, about 21% oxygen and about 1% other gases. According to World Health Organization (WHO) (2018), air pollution; is a term combination related to a few chemical, physical or biological agents that alters the natural atmospheric characteristics. The major issue which affect human health, agriculture, species of wildlife, and the ecosystems is air pollution. Major public health pollutants include particulate matter, carbon monoxide, nitrogen dioxide, sulfur dioxide and ozone (WHO, 2018).

Moreover, people who breathe polluted air, diseases such as heart attacks, respiratory diseases, and lung cancer are all significantly higher than in people who breathe in unpolluted environments. Besides that, the emission of air pollutant from different sources also can cause serious environmental degradation (Enger & Smith, 2000). There was harmful air pollution in October 1948 at Donora, Pennsylvania where the air pollution is caused by pollutants emissions from a steel mills and zinc plant. In addition, the area is in valley where the pollutants trapped and then formed dense smog. Due to that reason, 17 peoples died and 1950 peoples became ill within five days (Cunningham et al, 2005). From that, it shows how dangerous the pollution of air could be to humans.

Essentially, studies on the air quality shows that certain air pollutants at several urban areas are rising significantly and consistently above acceptable limits in accordance with national standards of environmental air quality. Moreover, pollutant emissions into the atmosphere can contribute to climate change (Agency, 2018). Besides, the overall average of temperature has risen from 0.6°C to 0.9°C since 1906, as well as in sensitive Polar Regions (Society, 2018). Climate change impacts also shown on the environment where glaciers have reduced, ice is breaking up more rapidly on rivers and lakes, sizes of animals and plants have changed

and trees are blossoming earlier. Therefore, human should be more concerned where climate change evidently caused by anthropogenic activities (Shaftel H., 2018).

2.2 Air Quality Management in Malaysia

The Department of Environment (DOE), which is responsible for monitoring air quality in Malaysia under the Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC). There are five major of air pollutants focused in Malaysia which are particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃). The monitoring station network have been used by Department of Environment (DOE) in controls the ambient air quality. These monitoring centers is used to identify any important change in the state of air quality that strategically situated in several types of land use namely urban, suburban, rural and industrial areas that may be especially detrimental to the atmosphere and human safety.

There are 52 automatic stations and 19 manual stations engaged in the aerial surveillance systems. The automatic stations are monitoring stations, namely Continuous Air Quality Station (CAQM), while manual stations is use High Volume Sampler (HVS) to monitor air quality. Besides that, the monitoring stations that use High Volume Samplers are acknowledged at 19 separate locations to determine the particulate matter, total suspended particle and heavy metals. Moreover, by mid-April 2017, DOE has upgraded network of air quality monitoring with the increase of 65 continuous monitoring stations under new Environmental Quality Monitoring Program (EQMP).

In addition, Alam Sekitar Malaysia (ASMA) Sdn. Bhd. is accountable for conducting DOE air quality surveillance task. ASMA has been granted a 20-year contract to provide DOE with information on air quality surveillance. Besides that, ASMA is recognized with the setup and governance of 52 continuous air quality monitoring facilities (CAQM). The establishments of the 1989 Malaysian Air Quality Guidelines, the 1997 Air Pollution Index and Haze Action Plans are included as the important air quality management tools endorsed and implemented by the Government of Malaysia.

All 52 continuous air quality monitoring stations (CAQM) in Malaysia are presented in Figure 2.1 and Figure 2.2 for Peninsular and East Malaysia respectively. There are 13 industrial stations, 1 background station, 15 urban stations, 20 suburban stations, and 3 rural stations.



Figure 2.1: Location of Continuous Air Quality Monitoring Station in Peninsular Malaysia (Department of Environment, 2010)

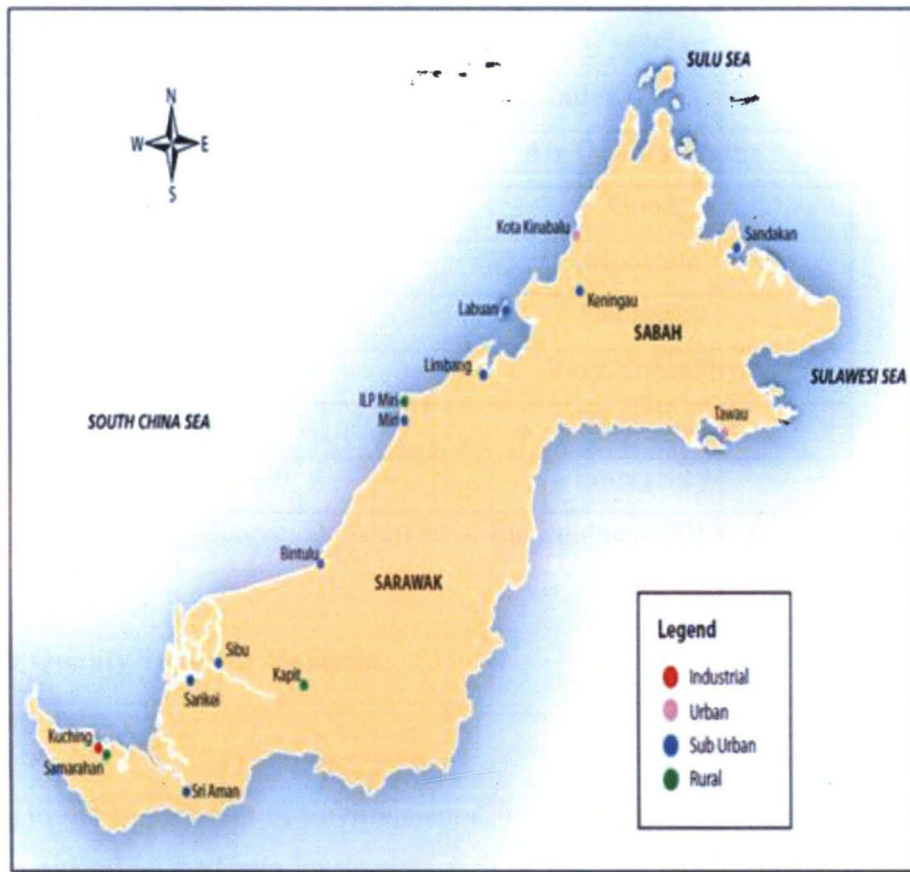


Figure 2.2: Location of Continuous Air Quality Monitoring Station in East Malaysia (Department of Environment, 2010)

2.3 Air Quality Status

The status of air quality in Malaysia is assessed according to the Air Pollutant Index (API), which indicates the atmospheric pollution level. API is determined by calculate on the basis of the daily average concentration of particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃). (Awang et. al., 2000). From the calculation, the maximum average daily concentration from the five pollutants was chosen as the API. It is therefore necessary to report the specific responsible air pollutants for the API value to indicate the relevant category of health effects and to take an action. Moreover, there are five level of air quality status on the classification of API which are good, moderate, unhealthy, very unhealthy and hazardous as shown in Table 2.1 with the range value of APIs for Malaysia's air quality status.

Table 2.1: Air Pollutant Index (API)

API	Air Quality Status
0 – 50	Good
51 – 100	Moderate
101 – 200	Unhealthy
201 – 300	Very Unhealthy
301 - 500	Hazardous
> 500	Emergency

(Source: Department of Environment, 2015)

2.3.1 Air Quality Status in Malaysia

According to the Department of Environment (2015), Malaysia's overall air quality in 2015 was between good to moderate levels almost all of the time, apart from an unhealthy days number reported during trans-boundary haze pollution from Indonesia at a range of places on the western and eastern coast of peninsular Malaysia. This resulted in the country's air quality deterioration. The haze episode worsened due to level of the API in Shah Alam rise to a hazardous level (API more than 300). In 2015, there was a significant deterioration in the general trend of air quality in Klang Valley compared to 2014.

During these periods, Klang Valley shows unhealthy days due to forest and peatland fires in Sumatra and Kalimantan, Indonesia that brings more pollutants to the west peninsular Malaysia. Furthermore, the emissions from industries and motor vehicle exhaust are some of the main sources of Nitrogen Oxide (NO_x) and Volatile Organic Compound (VOC) especially in urban areas. From that, it resulted in the recording of unhealthy days at different places in Klang Valley including in Pulau Pinang, Perak, Kedah, Negeri Sembilan and Johor. Besides that, the unhealthy days in Petaling Jaya was increased in 2015 with 27 days as compared to 2014 with 19 days only. Hence, Ipoh and Perai also shows increases in the number of unhealthy days with 18 and 12 days in 2015 as compared to 2014 with 4 and 2 days only. The pollutants of concerned in these areas were mainly due to particulate matter (PM₁₀).

2.3.2 Health Effect According Air Pollutant Index

The health effect can be known from the API level where for each API level have their own health effects to human (DOE, 2013). The association between the API level and health effect is shown in Table 2.2 with the health advice from DOE to public.

Table 2.2: Health Effect and Advice Based on API

API	Health Effect	Health Advice
0 – 50	Low pollution with no any bad effect on health	No restriction for outdoor activities to the public and maintain healthy lifestyle
51 – 100	Moderate pollution that does not give any bad effect on health	No restriction for outdoor activities to the public and maintain healthy lifestyle
101 – 200	Give bad effect on health to high risk people who have heart and lung complications	Limited outdoor activities for high risk people and public need to reduce the extreme outdoor activities
201 – 300	Worsen the health condition to high risk people with heart and lung complications and affect the public health	Old and high risk people are advised to stay indoors and reduce physical activities while people with health complication are advised to see doctor
301 – 500	Hazardous to high risk people and public health	Public are advised to avoid from outdoor activities while old and high risk people are prohibited for outdoor activities
>500	Hazardous to high risk people and public health	Public are advised to follow orders from National Security Council and always follow the announcement in mass media

(Source: Department of Environment, 2015)

2.4 Recommended Malaysia Ambient Air Quality Guidelines (RMAAQG)

In 1989, a set of guideline of air quality namely Malaysia Ambient Air Quality Guidelines (MAAQG) for air pollutants was created by Department of Environment (DOE). There are five most important air pollutants which are particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃) were observed constantly at 52 locations. Table 2.3 shows the Malaysia Ambient Air Quality Guidelines limit level.

Table 2.3: Malaysia Ambient Air Quality Guideline

Pollutant	Averaging Time	Malaysia Guidelines	
		Ppm	($\mu\text{g}/\text{m}^3$)
Ozone	1 Hour	0.10	200
	8 Hour	0.06	120
Carbon Monoxide	1 Hour	30.00	35**
	8 Hour	9.00	10**
Nitrogen Dioxide	1 Hour	0.17	320
	24 Hour	0.04	
Sulfur Dioxide	1 Hour	0.13	350
	24 Hour	0.04	105
Particulate Matter (PM ₁₀)	24 Hour		150
	12 Month		50

(Source: Department of Environment, 2015)

2.5 Air Pollutants in Environment

There are two classifications of air pollutants which are primary air pollutants and secondary air pollutants (Fernandez et al., 2005). The first main anthropogenic activities consist of motor vehicles, power generation and industrial activities that are also known as primary pollutants as the main source of air pollution. Due to the interactions between the primary pollutants themselves by chemically or physically form or reaction between the primary

pollutants and other atmospheric components, secondary air pollutants can be formed in the atmosphere. Other than that, air pollutants can be categorized based on their physical characteristic which is in form of gaseous and non-gaseous. The gaseous pollutants is classified as a toxic gaseous such as carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃). While non-gaseous pollutant is referred as a non-toxic gaseous which is particles namely particulates matter (PM₁₀) (Redzwan et al, 2003).

2.5.1 Particulate Matter

Particulate Matter (PM₁₀) is a complex combination of extremely small solids particles and liquid suspended in the atmosphere (Hanapi et al, 2012). PM₁₀ with high concentration can affect the human health and ecosystem (Vasudevan, 2006). The term of PM₁₀ is generally used to describe the size of particulates which is 10 μm. Furthermore, this particulate matter is primarily formed by scratch at the surface of the Earth or by deferment of biological substance composed of microorganisms and living things. Other than that, the source of PM₁₀ may come from the anthropogenic sources namely, stationary sources (i.e fuel combustion and industrial boiler) and direct emissions from mobile or transportation related sources (Kindzierski et al, 2009).

2.5.2 Carbon Monoxide

Carbon monoxide is a pollutant that is poisonous gas when at high concentration (Amir, 2007). It is primarily produced by atmospheric photochemical interactions and incomplete carbon fuel combustion process. Moreover, emissions of CO to the atmosphere mainly comes from motor vehicles exhaust, industrial activities and open burning in forest or peatland fires (Kindzierski et al, 2009).

2.5.3 Nitrogen Dioxide

According to Vasudevan (2006), nitrogen dioxide is a structure of nitrogen oxides (NO_x) which produced all the way through the oxidation. Basically, NO₂ is a reddish brown that is extremely reactive. According to Kindzierski W. B. et al. (2009), combustion of hydrocarbon fuel sources with air in the atmosphere creates NO at high temperature. Therefore, the results of the reaction between nitrogen and oxygen contained in the air of the combustion process have reduced the amount of NO₂. Moreover, most of the combustion process will produce NO and NO₂ as well as processes involved in refinement of bitumen, transportation exhaust, and others (Kindzierski et al, 2009). Moreover, NO₂ also is one of the main sources to the production of acid rain that can harmful the ecosystem.

2.5.4 Sulfur Dioxide

The pollutant with a colorless, irritating, soluble in water and proactive gas was namely as Sulfur Dioxide (SO₂) (Amir, 2007). Moreover, SO₂ has also been recognized for its awful smell (Vasudevan, 2006). Sulfur dioxide (SO₂) is formed by hydrocarbon fuel combustion (coal and oil) at high temperatures (Kindzierski et al, 2009). Generally, emissions of this sulfur dioxide associated with industrial operations. Besides that, small quantities of SO₂ can also be found from exhaust emissions of motor vehicles into the atmosphere (Kindzierski et al, 2009).

2.5.5 Ozone

Ozone is a pollutant which is not released directly into the atmosphere. Ozone is produced by the sunlight and heat response of nitrogen oxide (NO_x) and volatile organic carbons (VOCS). (Amir, 2007). In addition, it is a colorless gas with barely sweet smell and is chemically very active with a short average life in the atmosphere (Vasudevan, 2006).

2.6 Management of Meteorological in Malaysia

A total of 140 unmanned automatic weather stations (AWS), 41 auxiliary climate stations and 166 rainfall stations were operated by the Malaysian Meteorological Department (MMD) in 2010. This AWS is also capable of measuring precipitation, atmospheric pressure, temperature, humidity, wind speed, direction of wind and global radiation. Furthermore, AWS is observed on an hourly basis and the measured data will be updated every minutes, 24 hours per day without human assistance (Department, 2010). Figure 2.3 presents the location point of Malaysia's 140 AWS network.

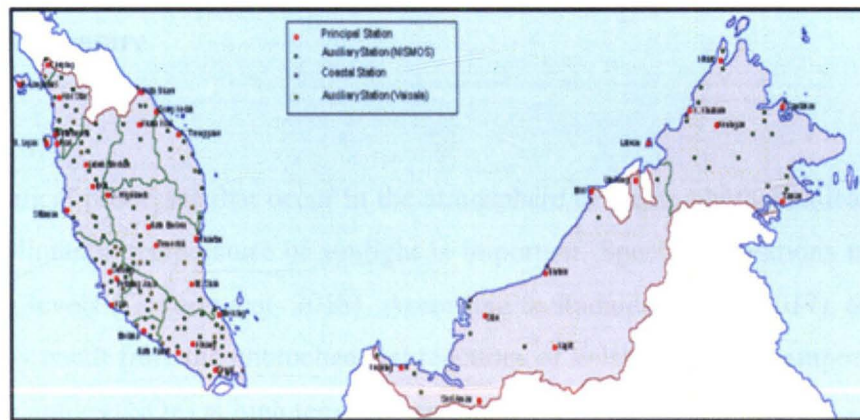


Figure 2.3: The 140 Automatic Weather Stations (AWS) Network (Department, 2010)

2.7 Meteorological Parameter in Air Quality

Meteorological parameters have a significant effect on atmospheric air pollution concentration (Shenfeld L., 2011). If the air in the atmosphere is calm and particulates cannot spread, then the pollutants will increase in concentration (Government, 2018). According to Queensland Government (2018), Meteorological data makes it easier to identify the

pollutants source, foresee air pollution events including reversals and days of high concentration of pollutants can also be simulated and predicted using computer models.

2.7.1 Rainfall

Rain has a scavenging effect when it is washing out from the atmosphere particulate matter and dissolving gaseous pollutants. Due to this effect, particular removal enhances visibility. In addition, the air quality is generally better when there is frequent high rainfall. However, high rainfall can therefore dissolve gaseous pollutants, such as SO₂ and NO₂, where acid rain can result in material or vegetation damage. (Government, 2018).

2.7.2 Temperature

For the chemical processes that occur in the atmosphere to create photochemical smog from the other pollutants, temperature or sunlight is important. Specific conditions may result in higher smog levels (Government, 2018). According to Radaideh J. A. (2017), the formation of ozone may result from the photochemical reactions of volatile organic compounds (VOCs) and nitrogen oxides (NO_x) at high temperatures.

2.7.3 Humidity

Relative air content of humidity or water vapor is recorded at a given temperature as a percentage of water saturation vapor pressure. In many atmospheric thermal and photochemical reactions, water vapor is important. Since water molecules are tiny and strongly polar, they can firmly bind to many substances (Government, 2018). If attached to particles suspended in the atmosphere, the percentage of light dispersed by the particles (measuring visibility) can be increased significantly. If the air molecules bind to corrosive

gasses, such as carbon dioxide, the gas dissolves in the air and creates an acid solution that can harm health and assets (Government, 2018).

2.8 Statistical Software

The SPSS Statistics statistical software is a software package used for statistical analysis that is interactive or batched. It was acquired by IBM in 2009 for a long time by SPSS Inc. IBM SPSS Statistics is named for the current versions (2015). The descriptive assessment is carried out to evaluate the form, dispersion and allocation of information for the research fields. The most vital information to obtain out of a data set is the measurement tendency and the measurement of variability. The measurement tendency

These are the measurements of tendency, namely; mean, median, mode, and skew while for variability measurements consist of standard deviation, variance and range. SPSS Statistics 22 has been used in this study to analyze the descriptive statistics for each data set. In order to measure descriptive statistics, these are some of the formulas summarized. The Pearson correlation was carried out to evaluate the connection between various air pollutants and meteorological parameter namely; temperature, humidity and rainfall.

2.9 Effects of Air Pollution

Air pollution can damage us if sufficiently elevated levels accumulate in the atmosphere. Every pollutant emitted into the atmosphere can affect human health directly or indirectly. A range of air pollutants were recognized or assumed to harm human health and have long been recognized in the environment. Not only can pollutants from these sources demonstrate an issue in the instant area of these sources, but they can also transport lengthy distances. There are American citizens reside in regions where metropolitan smog, particulate pollution and poisonous pollutants face severe health challenges (Patrick et al, 2018). As a consequence, individuals subjected to adequately elevated concentrations of air pollutants may suffer inflammation of the eyes, nose and throat along with difficulty breathing and

exasperating current pulmonary and heart issues like pneumonia. In addition, in severe instances, long-term exposure to air emissions can also trigger disease and harm to the respiratory neurological and cardiovascular scheme. According to Nasir et al. (2000), the overall health result of the 1997 haze incident was projected incorporate 285,227 asthma attacks, 118,804 cases of childhood bronchitis, 3889 instances of adult acute bronchitis, 2003 hospital entry, 26,864 hospital admissions and 5,000,760 limited days of operation. It demonstrates that air pollutants are hazardous to beings in particular. Table 2.4 below reveals the kinds of health impacts that the most prevalent pollutants experience at high concentrations.

Table 2.4: Types of Health Effects of the Air Pollutant

Pollutants	Health Concerns
Particulate Matter	Fine particles can be transported close into the lungs, triggering swelling and aggravating heart and pulmonary illness
Nitrogen Dioxide	The pollutants irritates the cells of the body and improves the symptoms of those struggling from pulmonary disease
Carbon Monoxide	The pollutants stops the body from absorbing oxygen where contribute to a substantial decrease in the oxygen supply to the core, particularly in individuals of heart illness.
Sulfur Dioxide	Respiratory tract issue, continuous damage to the pulmonary tissue
Ozone	Issues with the pulmonary tract such as hard breathing and decreased function of the pulmonary also includes asthma, dry eyes, nasal congestion, decreased opposition to disease and potentially early aging of the pulmonary tissue

Air pollution can trigger a range of impacts on the environment, including acid rain, eutrophication, fog, wildlife impacts, ozone depletion, and worldwide climate change (Patrick et al, 2018). Acid rain is generally rainfall containing dangerous nitric and sulfuric acid

quantities. According to United States Environmental Protection Agency (2018), these acids are mainly created by atmospheric oxides of nitrogen and sulfur oxides. The acids were formed as dry and wet precipitation. For instance, gas and particulate matter for dry rainfall, while rain, snow and fog for wet rainfall. Acid rain can influence the atmosphere, such as damage to forests, groundwater and acidification of water bodies. Therefore, transform water unfit for marine life and other fauna. It also accelerates the deterioration of houses, statues and carvings that form part of the domestic heritage (Patrick et al, 2018).

Furthermore, eutrophication is also one of the effects of air pollution. The eutrophication is a water deterioration occurs when the water body has high concentrations of nutrients such as nitrogen resulting in increased algae production and causes fish species depleted (Airgo, 2018). Furthermore, even in the aging of the pond this is a natural method, but human operations can also speed eutrophication. For instance, nitrogen oxide emissions from energy plants, transportation and industry activities add to the quantity of nitrogen reaching marine habitats (Patrick et al, 2018). Moreover, haze occurs when sunlight meets tiny air pollution particles. From that, it reduces the vision of the human eye on the clarity, colour and texture of our vision. The main source of pollutants usually directly produced from power plant, transportation exhaust, industrial processes and mass burning activities (Patrick et al, 2018).

Besides that, wildlife ecosystems may also be affected by harmful pollutants emitted to the atmosphere or deposited on the ground. According to United States Environmental Protection Agency (2018), a study shows that air pollutants lead to abnormalities, reproductive failure and increases animal disease (Patrick et al, 2018). Hence, in aquatic ecosystems, of significant concern are constant air pollution pollutants that slowly deteriorate the environment. These pollutants accumulate in sediments and may increase the concentration of animal tissues in a food chain at gradually higher levels than in water or air (Patrick et al, 2018).

Other than that, air pollution can also cause ozone depletion. Ozone is a gas that exists at surface level as well as in the Earth's upper atmosphere recognized as the stratosphere. Ground-level ozone is a pollutant capable in harming human health. Ozone creates a stratosphere layer that prevents earthly lives from the sun's harmful UV rays (Patrick et al, 2018). According to Airgo (2018), emission of carbon dioxide to the atmosphere have increased massively since the Industrial Revolution began, partially destroying this protective

layer and leading to the ozone layer depletion. This is mainly due to the production and emission of chlorofluorocarbons (CFCs). At stratospheric levels, CFCs convert into chlorine that reacts with ultraviolet rays to massively destroy ozone (Airgo, 2018).

According to Patrick et al. (2018), the Earth's atmosphere has a sensitive natural gas balance that traps some of the sun's heat near the Earth's surface. The greenhouse gasses absorb heat and re-emit it in every direction, warming the ground level of the Earth. Moreover, the greatest impact of greenhouse effect is due to present of carbon dioxide, methane and nitrous oxide. Therefore, cause the Earth's average temperature to rise, a phenomenon known as global warming. Many researchers agree that climate change can significantly affect human health, rising sea levels, drought and floods, agricultural and ecosystem damage (Airgo, 2018).

2.9.1 Climate Change Effect

The environmental impacts of global climate change have already been observed. Polar ice caps have decreased, ice has broken on rivers and lakes sooner, locations of plants and animals have switched and plants have flowered way earlier (Shaftel H., 2018). There are now occurring the impacts that researchers had earlier forecasted may occur from climate change, including reduction of arctic ice, increased sea-level, and more extreme heat waves. Furthermore, researchers believe that global temperatures will keep rising over the coming decades, mainly as a result of beings-made greenhouse gases. The Intergovernmental Panel on Climate Change (IPCC), that involves more than 1,300 US and other researchers, foresees an increase in temperature of 2.5 to 10°F within the next decade.

According to the IPCC, the level to which climate change affects individual countries will change over time and the opportunity of different cultural and environmental systems to mitigate or embrace change. The IPCC estimates that rises above 1990 levels in global mean temperature of less than 1.8°F to 5.4°F (1°C to 3°C) will create positive effects in some countries and negative effects in others. Annual net costs will rise over time as global temperatures increase. In addition, the IPCC declares that the variety of published data shows that the net cost of damage to climate change is probably to be substantial and rise over time. (Stocker et al, 2013). Table 2.5 below shows the climate change effects that separated into

several main areas which are oceans, freshwater resources agriculture and food supply, wildlife species and human health.

Table 2.5: Climate Change Effects

Area	Effects
Oceans	The increase in sea level due to water flow from ice melting and and temperature increases
Freshwater Resources	Change the allocation of freshwater triggered by high evaporation rates and enhance drought and flood phases
Agriculture and Food Supply	Prolonged weakness in plant and food supply caused by changes in the variety, duration, intensity and frequency of rainfall
Wildlife Species	Most species have been influenced by increasing temperatures. For example, researcher Bill Fraser tracked the decline of Adélie penguins on Antarctica, where their numbers dropped from 32,000 breeding pairs in 30 years to 11,000.
Human Health	Worsened respiratory diseases such as asthma and death can double during days of uncommon high temperature and humidity.

(Sources: NGS, 2018)

2.10 Studies of Air Quality in Malaysia

In Malaysia, many studies have been conducted on air pollution. Most of them have focused on urban area such as Kuala Lumpur, as this is due to high number in term of population, transport, industrial, commercial and residential factors. Moreover, it also depends on technological development, climate and topography. In another study, meteorological factors were determined to affect air pollution quality directly (Ismail et al, 2017).

Studies on the air quality in Petaling Jaya had been done by Amir A. (2007). From the study, concentration of PM_{10} in August was obtained as the highest pollutant that occurs due to the haze period. The PM_{10} concentration exceeded 50% above the limit value of Recommended Malaysia Ambient Air Quality Guidelines ($50\mu\text{g}/\text{m}^3$). In addition, meteorological parameters such as rainfall and wind speed also strongly influenced PM_{10} , O_3 and CO concentration in the study area. Moreover, Amir A. (2007) also found that the air quality in Petaling Jaya is dominantly moderate with API is 51 to 100 for the whole year 2005 that indicates the moderate condition of air quality status in Petaling Jaya. However, the API reading almost reached 500 during the haze period where consider as an emergency warning. The level of pollution at this condition is very dangerous and can harm human health especially those who have heart and lung disease. It can be concluded that the PM_{10} is originating fully from the common source which is vehicle source and the meteorological conditions play an important role in influencing the air pollutants concentration in Petaling Jaya.

A study on the spatial and temporal characteristics of air pollutants concentrations have been carried out by Zizi et al. (2018). They reported that practically all the averaged concentration of atmospheric pollutants recorded at Nilai, Petaling Jaya and Seberang Perai are under the allowable value recommended by the Malaysian Department of Environment (DOE). It has been resulted that the highest average concentration of PM_{10} recorded at Nilai was in 2012 with value of $60.48\ \mu\text{g}/\text{m}^3$ while, the maximum value is recorded in 2008 which is $315\ \mu\text{g}/\text{m}^3$. The mean average concentration of PM_{10} recorded at the station throughout these 5 years was significantly dissimilar and was found to be slightly above than the value suggested by the Malaysian Ambient Air Quality Guideline (MAAQG) for the 24-hr averaged concentration ($50\mu\text{g}/\text{m}^3$). The PM_{10} and O_3 were more closely to be discussed because of its strong correlation with the transboundary sources, due to number of motor vehicles and emission by industrial activities near the monitoring stations.

Moreover, the study resulted on the correlation between the air pollutants recorded to be the most significant correlated in Nilai. While, for Petaling Jaya and Seberang Perai the correlation was significantly correlated between the air pollutants and some of the meteorological parameters. Moreover, the high concentration of ozone (O_3) concentration recorded at Nilai, Petaling Jaya and Seberang Perai are interesting and needs further research. Meteorological factors mainly humidity and the ambient temperature are expected to be associated with the concentration of ozone and suspended particulate matter. Furthermore, in terms of monthly variation there has been an clear temporal variation of all three area that were seen to be similarly increase during the month of June until August where the highest PM_{10} concentration were recorded on June at value of $68.326 \mu\text{g}/\text{m}^3$, $59.432 \mu\text{g}/\text{m}^3$ and $51.13 \mu\text{g}/\text{m}^3$ respectively which might be due to Southeast monsoon.

Azman, Ahmad and Mohd (2017) also investigated on the air quality pattern in Northern Region of Peninsular Malaysia (2002-2012) which covered Perlis, Kedah, Pulau Pinang and Perak. Among these states, the air quality in Penang was the worst in Northern Region. The station in Perai, Pulau Pinang contributes highest number of dissimilarity to the graph. It is performed alone and gives a significant indicator of air quality where as not good air condition in that area. Besides that, 1,066 out 4,838 industries have potential to contribute air pollution in Pulau Pinang, most located in Perai area where consist of wood industries (2.75%), electronics (27.52%), metals (39.45%), chemical industries (24.77%) and rubber industries (5.50%). The study also found that SO_2 , NO_2 and O_3 are the major pollutants contributing to degradation of air quality in the Northern region due to the combustion process from vehicles and industries.

Rahman A. et al (2015) studies on the assessment of ambient air pollution trend in Klang Valley, Malaysia. This study aims to investigate the trend of ambient air pollution (i.e. PM_{10} , CO, NO_2 , O_3) for eight selected Malaysian air monitoring stations in Klang valley over five years from 2007 to 2011. The study involves in integrated statistical analysis to compare the air pollution with the recommended Malaysian Ambient Air Quality Guidelines (MAAQG) standard and to determine the correlation between pollutants and meteorological factors. Furthermore, the spatial trends of air pollutants for Northeast and Southwest Monsoon have been assess by the geographical information system (GIS) software. Besides, the Principal Component Analysis (PCA) was used to determine the major sources of the air pollution.

Hence, from the statistical analysis showed the hourly trends of PM₁₀, CO, O₃ and NO₂ in the Klang Valley were below the MAAQG standard. However, Klang recorded the highest concentration of PM₁₀, while Petaling Jaya recorded the highest concentrations of CO and NO₂ and Shah Alam recorded the highest O₃. The 24-hour data for PM₁₀ was found to exceed the MAAQG throughout the five years. All pollutants were positively correlated with each other with the exception of CO and O₃. The meteorological factors, i.e. ambient temperature, wind speed and humidity were also significantly correlated with the pollutants. The spatial distribution map indicated that the PM₁₀ levels remain highly concentrated during the Southwest Monsoon, while the CO levels were highly concentrated during the Northeast Monsoon. Besides that, NO₂ and O₃ were highly determined during the first inter-monsoon.

Mabahwi et al. (2015) studied the urban air quality and human health effect in Selangor. The survey site was located between five stations monitoring which near to the residential. They reported that health survey to residents in Selangor proves that majority of the residents only suffer with acute respiratory infections during haze mostly in June 2013. They also found that 60% of residents experience acute respiratory infection, which are cough, difficulty of breathing and sore throat, while 40% did not have any symptoms. The study shows that it happen during the haze located at Klang due to highest API reading. Furthermore, it also stated that Malaysia was experienced the worst level of haze in 2013 which forced the government to declare emergency status in Kuala Lumpur, Selangor and Pahang.

According to the Ministry of Health Malaysia (2012), in 2011, diseases of respiratory system are one of the major causes of hospitalization with the percentage of 10.36%. Besides that, one of the major causes of death in 2011 was also diseases of respiratory system with percentage of 19.48% (Ministry, 2012). Based on the studies by Mabahwi et al (2015), it is have significant impact of bad urban air quality and human health effects.

2.10 Conclusion

Department of Environment (DOE) is the one who responsible to monitor and control air pollution in Malaysia. Besides that, the five types of pollutants are being monitored continuously by DOE namely particulate matter (PM₁₀), sulphur dioxide (SO₂), carbon monoxide (CO), nitrogen dioxide (NO₂) and ozone (O₃). The monitoring work is carry out by

Continuous Air Quality Monitoring Station (CAQM). In Malaysia, the Air Pollutant Index (API) is measure to indicate the level of pollution in the atmosphere which presents the status of the air quality. Malaysia Meteorological Department (MMD) is responsible to support the weather condition in Malaysia. Besides that, MMD also responsible in monitoring atmospheric composition in Malaysia and provide information on the meteorological aspects of air pollution such as wind speed, wind direction, humidity and rainfall.

There are many studies have been done in Malaysia about the air quality status especially in Klang Valley. Other than that, those studies were about the investigations on the trends or air pollution in Malaysia and effect of air pollutant concentration by meteorological parameters. From that, the study on the trends of air quality and correlation on the meteorological parameter and air pollutants can be done for other areas in Malaysia. Besides, it can be recommended to study using advance software such as Statistical Package for the Social Sciences (SPSS) software. So, the correlation between air pollutants and environmental can be analyzed more accurately.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter shows the stages that have been taken for this study from the start to the end of research as shown in Figure 3.1. That figure presents the work flow in this study which first with selection of study area until the last stage, conclusion and recommendation. For this study, the areas that involve are at the industrial areas which are Perai, Ipoh and Petaling Jaya.

First stage in this study is to gather information related to the study by collecting from research journal, articles, books and online sources. Next, comprehensive literature review has been done to get a clear understanding on the relevant topic. The most important stage in this work flow is the collection of data from Department of Environment (DOE) i.e. PM₁₀, CO, NO₂, SO₂, O₃ and Malaysian Meteorological Department (MMD) i.e. Rainfall, Temperature, Relative Humidity. Generally, when the data is obtained, the analysis and investigation can be done.

There are three analysis involve namely to identify the trends of air pollutants in compliance with the Recommendation Malaysia Air Ambient Quality Guideline (RMAAQG), to determine the correlation between the air pollutants and the influence of meteorological conditions in the study area and to evaluate the impact of air pollutants related to meteorological conditions on climate change. Lastly, the conclusion and recommendation of this study can be generated.

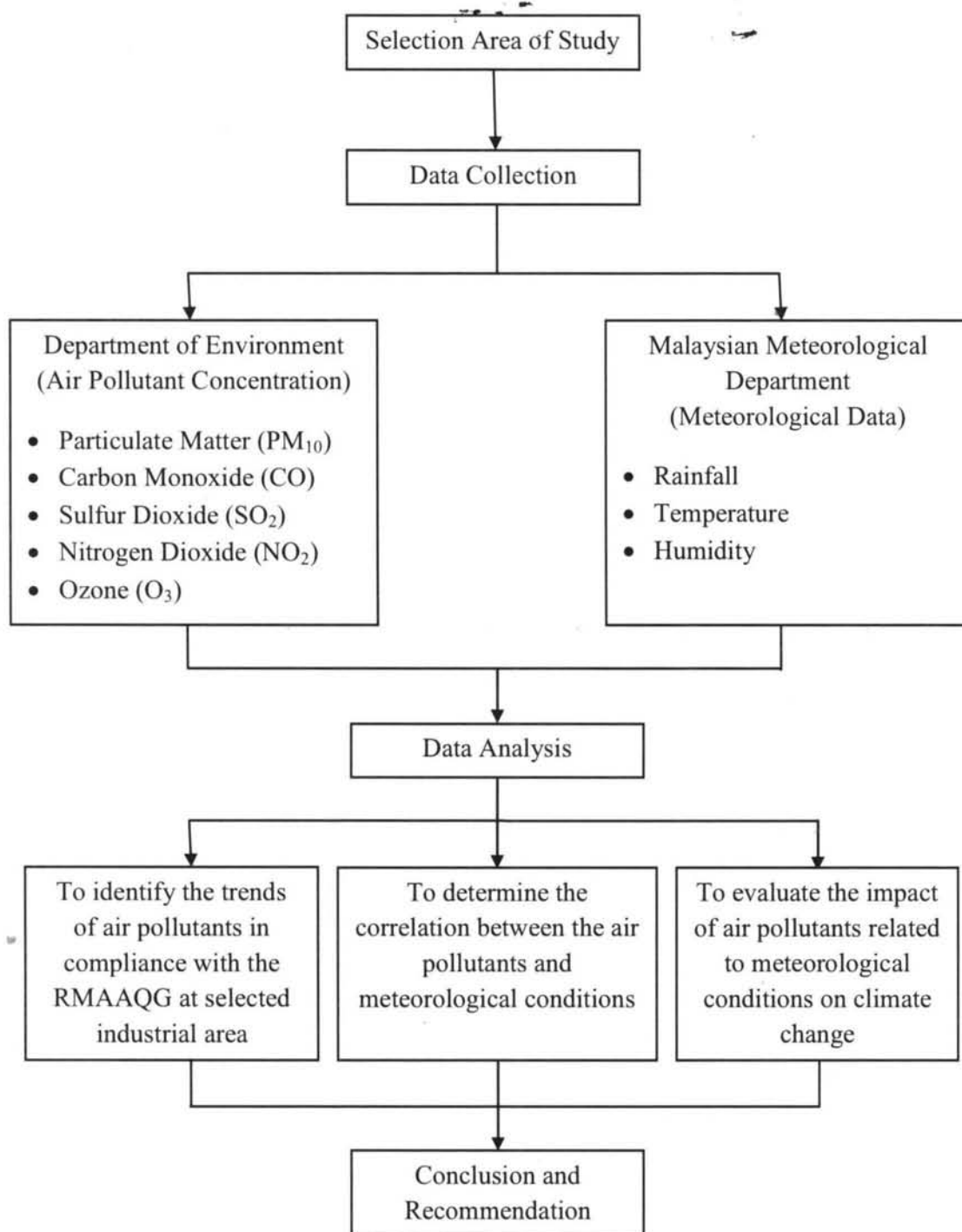


Figure 3.1: The Work Flow of the Study

3.2 Area of Study

The selected area for this study is in Northern region and Klang Valley. Figure 3.2 shows the location area of this study that includes of three (3) study area namely Perai, Ipoh and Petaling Jaya. These areas are also known as industrial areas that highly developed in Malaysia. The industrial expansion, rapid urbanization and increase high volume of vehicles caused air quality problems and are threats to both the natural environmental and public health (Ismail et.al, 2017).

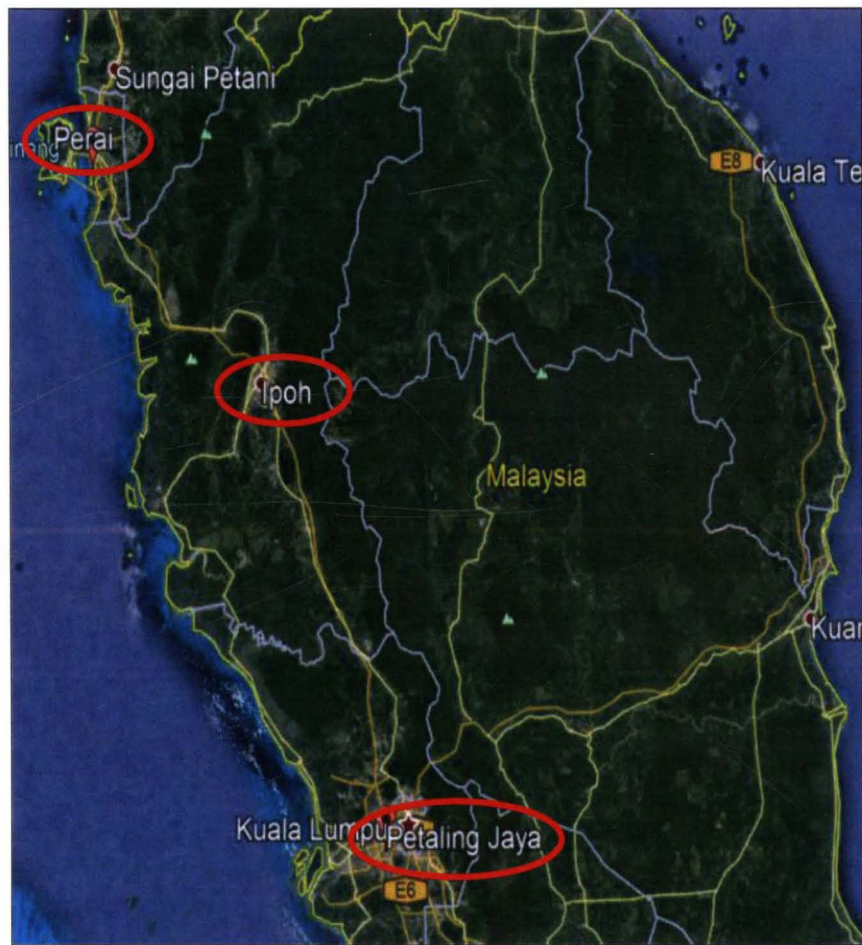



Figure 3.2: Location of Study Area (Map, 2018).

The  symbol showing the selected industrial area.

3.2.1 Perai

Perai is in the state of Penang which is located in the Northern region of Peninsular Malaysia and has been rapidly industrialized and urbanized. This area is located with coordinate of 5°22'40.263"N and 100°23'56.989"E (Map, 2018). According to the 2010 Census conducted by Malaysia's Department of Statistics, Perai had a population of 14,433. Perai lies at the estuary of the Perai River, which empties into the Penang Strait. The town is located at the river's southern bank, bordering the town of Butterworth to the north. The Perai Industrial Estate encompasses much of Perai's seafront between the Perai River and the Penang Bridge, whilst the township of Seberang Jaya is situated to the east of Perai (Perai, 2018).

3.2.2 Ipoh

Ipoh is in the state Perak which is located in Northern region of Peninsular Malaysia with coordinate 4°35'50"N and 101°04'30"E (Map, 2018). It covers 64,300 hectares area of mainly former tins mining industry. In recent years, Ipoh's popularity as a tourist destination has been significantly boosted by efforts to conserve its British colonial-era architecture. There are many heavy industries such as Tasek, Bercham and IGB Industrial Areas. Tasek Industrial Area has various industries such as plastics, non-metal, rubber bases, food, printing and wood bases (Ismail et.al, 2017).

3.2.3 Petaling Jaya

Petaling Jaya is in the state Selangor which is located in Klang Valley with coordinate 3°05'50"N and 101°38'40"E (Map, 2018). It covers 9,720 hectares area and the capacity of population is very dense with 197,949 people in 2010. This area is mainly former rubber estates in the 1950's. Now, the area is mostly surrounded by residential, commercial, light industrial and green areas.

3.3 Data Collection

The set of data are obtained from DOE and MMD. For the purpose of this study, data of air pollutants (PM_{10} , CO, NO_2 , SO_2 , and O_3) and meteorological (Rainfall, Temperature and Relative Humidity) are collected from year 2013 to 2017. There are two types of tool used for the data collection in this study. The tools involve are Continuous Air Quality Monitoring (CAQM) Station and Automatic Weather Stations (AWS).

3.3.1 Continuous Air Quality Monitoring Station (CAQM)

According to Department of Environment (2013), the concentration of air pollutants is measured by 52 automatic air quality stations all the way through Malaysia. Figure 3.3 shows the machine which known as Continuous Air Quality Monitoring (CAQM). The CAQM measures the concentration of PM_{10} , SO_2 , NO_2 , CO and O_3 . Basically, the air monitoring stations that involved in this study are at Sekolah Kebangsaan Cenderawasih (Perai), Sekolah Menengah Jalan Tasek (Ipoh) and Sekolah Rendah Sri Petaling (Petaling Jaya).



Figure 3.3: Continuous Air Quality Monitoring (CAQM) Station

3.3.2 Automatic Weather Stations (AWS)

The Automatic Weather Station (AWS) is a machine that measure precipitation, atmospheric pressure, temperature, humidity, wind speed, wind direction and global radiation as shown in Figure 3.4 (Malaysian Meteorological Department (MMD), 2018). AWS is observed on an hourly basis and the measured data will be updated every minutes, 24 hours per day without human assistance. There are 140 AWS operated by MMD (MMD, 2018). Generally, the stations involved in this study are station at Perai, Ipoh and Petaling Jaya.



Figure 3.4: Automatic Weather Station (AWS)

AWS consist of the following main apparatus which are tipping bucket rain gauge, temperature sensor, weather vane and anemometer as shown:

i. Tipping Bucket Rain Gauge

Tipping bucket rain gauge is a weather tool that determines the level of rainfall or precipitation as shown in Figure 3.5 and 3.6 (Shepard D., 2017). It has a funnel that leads to two small metal collectors (MMD, 2018). Hence, when the two small metal collectors collect 0.2 mm of rainwater, the weight of the water leads them to tip and empty themselves (MMD, 2018). When the two small metals collector tips, an electrical contact is made (MMD, 2018). Therefore, the quantity of rainfall and intensity will be recorded over time (MMD, 2018). However, the maximum detectable rate is 200mm/hr (MMD, 2018).



Figure 3.5: Tipping Bucket Rain Gauge (MMD, 2018).



Figure 3.6: Tipping Bucket Rain Gauge (MMD, 2018).

ii. Temperature Sensor:

Temperature sensor is a device that provides integrated circuit technology in mixture with an accurate thermometer resistance element to enable accurate measurements. as shown in Figure 3.7 (MMD, 2018). It is used by vertically inserting the dry and wet bulb thermometer on a backing inside of the Stevenson screen as shown in Figure 3.8 (MMD, 2018). The wet bulb is therefore wrapped with muslin and tied to a wick. The wick is then immersed in a container of distilled water (MMD, 2018).



Figure 3.7: Temperature Sensor (MMD, 2018).



Figure 3.8: Temperature Sensor (MMD, 2018).

3.4 Data Analysis

This study involves three main analyses as shown in Figure 3.1 that indicates three different results. The three main analyses are trends of air pollution at the selected industrial area, the trends of pollutants in compliance with the Recommendation Malaysia Air Ambient Quality Guideline (RMAAQG), correlation between the air pollutants and the influence of meteorological conditions in the study area and the impact of air pollutant related meteorological conditions on climate change.

The first analysis is a general analysis on the trends of air pollution. The data of air pollutants obtained from DOE will be analysed by using Microsoft Office Excel software for 5 years duration of data from 2013 to 2017. The air pollutants data will be analysed to identify the trend of air pollution using the Air Pollutant Index (API) analysis. Hence, the trends will be analysed as the concentration of air pollutant data involve either above or below limit value of Recommended Malaysia Ambient Air Quality (RMAAQG). The graph involved in this analysis is a bar chart that acts as concentration of air pollutants. Besides, the limit line for RMAAQG also being constructed on the same graph.

Next, the analysis is to evaluate the correlation between the air pollutant and the influence of meteorological parameters. The data involved in this analysis are data of air pollutants obtained from DOE and meteorological data that obtained from MMD for 5 years duration (2013-2017). The descriptive statistics will be carried out to determine the shape, dispersion and the

distributions of the data for the study area. These raw data is analyzed by using statistical software SPSS Statistic 22 where the data are analyzed by addressing meteorological data and air pollutants data on the same graph. Then, the correlation between influences of meteorological data can be reported with the occurring of air pollutants data on the graph.

The third analysis is an investigation on the impact of air pollutants related to meteorological conditions on climate change. The data of meteorological will be analyzed for example the temperature reading is illustrated by using the software. From the graph analysis, it describes the increment and decrement of temperature. Essentially, the impact of air pollution towards climate change can be determined.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

The rapid development of urbanization and industries in Malaysia shows that, the issues on the air pollution need to take into a proper action. Moreover, the industrial area is one of the major sources that contribute to the serious air pollution such as in Perai, Ipoh and Petaling Jaya. According to Department of Environment (2015), the numbers of unhealthy days were recorded in Petaling Jaya is 27 days as compared to 19 days in 2014. From that, it is crucial to monitor the trends of air pollutants in this study area. Besides, this chapter will present data of air pollutants concentration and meteorological parameter for year 2013 to 2017. There are two types of data involved which are air pollutants concentration data and meteorological data. Five (5) main air pollutants concentration involved are particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃) and three (3) meteorological parameters namely Temperature, Rainfall and Humidity.

The trend of air pollutants was analyzed to determine the trends of the air pollution using the Air Pollutant Index (API) analysis and the pollutants concentration either above or below limit value of Recommended Malaysia Ambient Air Quality Guideline (RMAAQG). This analysis was done for three selected area namely Perai, Ipoh and Petaling Jaya. Furthermore, each of air pollutant analyzed annually from 2013 to 2017. After that, the influences of meteorological conditions on the trend of air pollutants were analyzed to evaluate the correlation between meteorological parameters and air pollutants. This analysis also completed for three selected areas which are Perai, Ipoh and Petaling Jaya from 2013 to 2017. Finally, the impact of air pollutants related to meteorological factor on climate change was analyzed to evaluate the adverse impact of climate change towards human, economic and environment.

4.2 Trend of Air Pollutants

4.2.1 Air Pollutant Index (API) Analysis

The trend of air pollution was determined by the Air Pollutant Index (API) analysis. The API is calculated based on the average daily air pollutants concentration which involved PM₁₀, CO, NO₂, SO₂ and O₃. The API analysis shows the maximum index of the air pollutants in Perai, Ipoh and Petaling Jaya for 2013 to 2017.

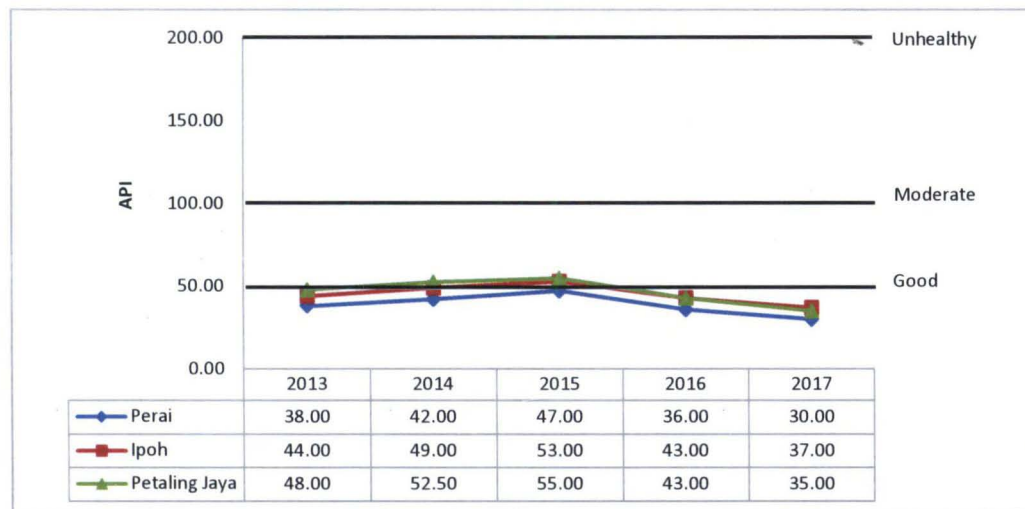


Figure 4.1: Annual API at Perai, Ipoh and Petaling Jaya

Figure 4.1 shows annual API at Perai, Ipoh and Petaling Jaya in year 2013 to 2017. The API results indicates that API for these places were in good (API: 0-50) condition except for 2015, where the API was slightly moderate (API: 50-100) at Ipoh and Petaling Jaya. The API value was contributed by PM₁₀ for all places in these years. This analysis shows that API measurement for Perai was predominantly “good”, where the API was in the range of 30.00-47.00. The highest API at Perai was 47 measured in 2015. While in Ipoh and Petaling Jaya, the air quality was predominantly “good” in all years except for 2015 and the range of API was 37.00-49.00 and 35.00-55.00 respectively. The highest API at Ipoh and Petaling Jaya were 53.00 and 55.00 respectively. The API measurement at Petaling Jaya was 4% and 15% higher compared to Ipoh and Perai respectively. The air quality status for Perai, Ipoh and Petaling Jaya were constantly increased from 2013 to 2015 and constantly decrease from 2015 to 2017. The constant increase at Perai, Ipoh and Petaling Jaya was probably due to the haze event from the biomass burning in Southern Sumatera and Kalimantan in Indonesia, which had caused severe haze event in Malaysia (DOE, 2015).

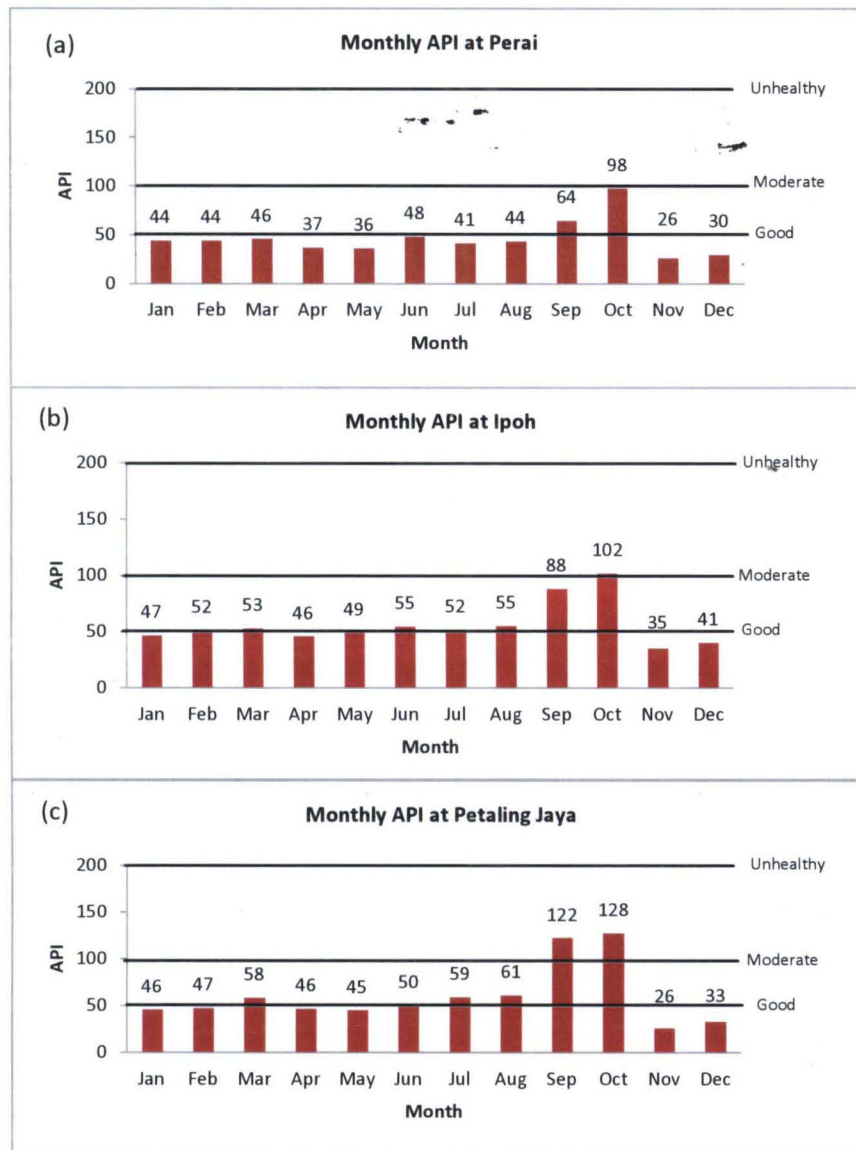


Figure 4.2: Monthly API at (a) Perai, (b) Ipoh and (c) Petaling Jaya in 2015

Figure 4.2 shows monthly API at Perai, Ipoh and Petaling Jaya in 2015. This analysis shows that September and October were experienced the worst air quality compared to other months. This was due to the smoke that comes from the open burning in Indonesia as mentioned earlier. The API in Petaling Jaya (API: 128) was the critical compared to Perai (API: 98) and Ipoh (API: 102) in October. Based on the Meteorological Department of Malaysia (MMD), wind was moving from the Sumatera towards the West Peninsular Malaysia during the southwest monsoon season in September and October (Refer to Figure 4.3). The West Peninsular Malaysia experienced dried season with minimum rainfall during this season, except for Sabah and East Malaysia (Malaysian Meteorological Department, 2016). Due to

this reason, PM_{10} was not significantly washed out by rainfall and remained in the atmosphere at high concentration. The API was started to decrease in November and December because of the interchanging season from southwest monsoon to northeast monsoon (November to March). The wind direction was diverted and moved towards the east coast of Peninsular Malaysia, Sabah and Sarawak. The API value was significantly changed from moderate to good.

Similar haze episode in August 2005 also reported that PM_{10} was the pollutant that contributed to the high API value. This haze episode was considered severe as Peninsular Malaysia is concerned when the whole part of Klang Valley and its surrounding areas were badly affected by the smoke haze. It reached its peak when a Haze Emergency was declared on 11 August 2005 in two areas, namely Pelabuhan Klang and Kuala Selangor as the API in both areas exceeded 500. By 16 August 2005, the air quality returned to normal in Klang Valley, as the haze shifted to the northern states of Perlis, Kedah and Penang (DOE, 2005).

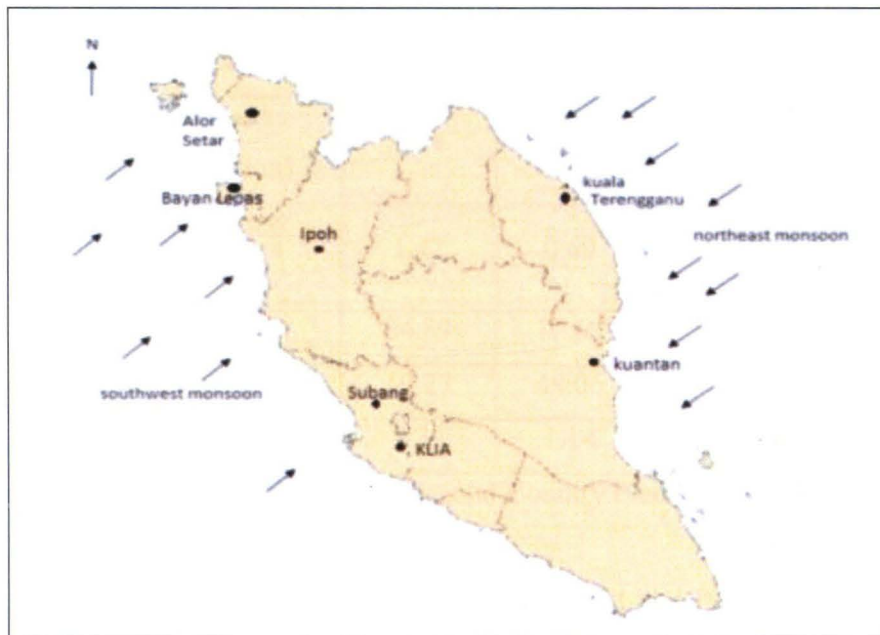


Figure 4.3: Wind Direction during Monsoon (Source: Satari et al, 2015)

For other years, API in Ipoh and Petaling Jaya were higher than Perai. This is probably due to small haze event during June to October and also different proportional of land use that effect quantity of stationary source (e.g., factories) and mobility source (e.g., transportation).

Literature has reported that air quality in Petaling Jaya was significantly deteriorated due to the rapid urbanization that leads to increase activity of construction and transportation (Ling et al, 2010).

Table 4.1: Percentage Land Use in Perai, Ipoh and Petaling Jaya

Area	Percentage Land Use (%)		
	Perai	Ipoh	Petaling Jaya
Residential (Transportation)	14.56	7.42	14.72
Industrial (stationary sources)	8.01	2.65	6.39
Commercial	1.76	0.81	2.42
Institutional- (Transportation)	3.54	3.50	10.56 -
Open space & Recreational	0.96	1.52	7.00
Undeveloped Land	11.36	16.10	21.84
Road Networks (Transportation)	8.84	7.44	18.40
Infrastructure & Utilities	1.42	0.69	2.55
Agriculture	34.89	10.69	5.55
Forest & Green Area	10.27	48.06	9.15
Water Bodies	4.39	1.14	1.42

(Source: Federal Department of Town and Country Planning (PLAN), 2012)

Table 4.1 shows the percentage of land use in Perai, Ipoh and Petaling Jaya. In Perai, it indicates that the percentage of land use from stationary source which is industrial area (8.01%) was higher compared to Ipoh (2.65%) and Petaling Jaya (6.39%). Meanwhile, the percentage of land use in Petaling Jaya that had the potential source of pollution from the mobility sources was higher compared to Perai and Ipoh. This land use includes residential, institutional and road networks where 14.72%, 10.56%, 18.4% in Petaling Jaya while 14.56%, 3.54%, 8.84% in Perai and 7.42%, 3.5%, 7.44% in Ipoh respectively. Moreover, the green areas in Perai (10.27%) and Ipoh (48.06%) were larger compared to Petaling Jaya (9.15%).

For overall, Petaling Jaya shows higher percentage (50.1%) of source of pollution based on the land use which is more critical compared to Perai (35%) and Ipoh (21%). Due to this reason, the API was significantly higher in Petaling Jaya compared to Perai and Ipoh.

In general, the API was in good condition except for 2015, where the API was slightly moderate at Ipoh and Perai. The air quality status significantly increased in 2015 due to the biomass burning in Southern Sumatera and Kalimantan in Indonesia, which had caused severe haze event in Malaysia. The API value was contributed by PM₁₀ for all places in these years.

4.2.2 Trend of Air Pollutants in Compliance With the Recommendation Malaysia Ambient Air Quality Guideline (RMAAQG)

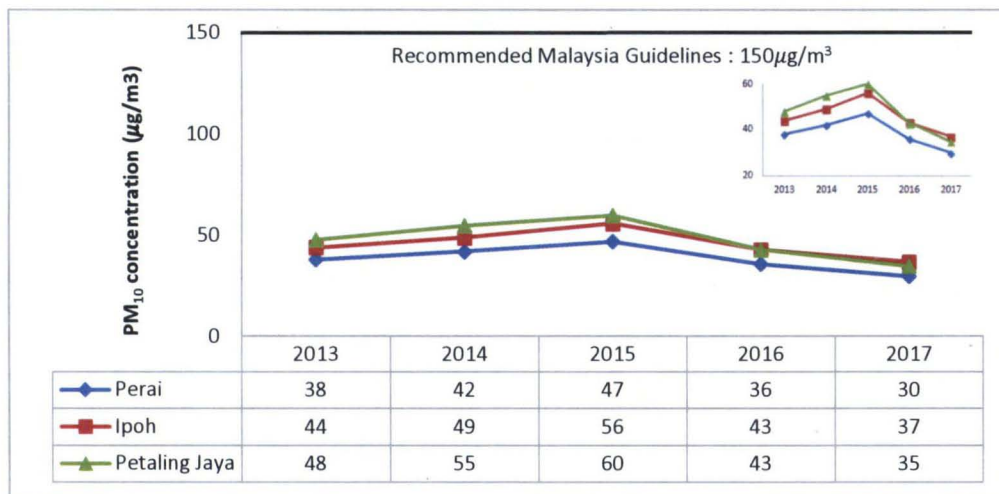


Figure 4.4: Annual Average Concentration of PM₁₀ at Perai, Ipoh and Petaling Jaya, 2013 – 2017 (Insert Figure 4.4: Small Scale of PM₁₀ Concentration)

Figure 4.4 shows the annual average trend of PM₁₀ concentration at Perai, Ipoh and Petaling Jaya from 2013 to 2017. The annual trend for these areas indicates that the trend with an average about 74% at Perai, 69% at Ipoh and 68% at Petaling Jaya were below RMAAQG limit (150µg/m³). Besides, there was an acute increase of PM₁₀ in 2015 where the concentration of PM₁₀ for Perai was 47µg/m³ by 11% increment and for Ipoh was 56µg/m³ by 13% increment and also for Petaling Jaya was 60µg/m³ by 8% increment from 2014. The increment percentage in 2015 was higher compared to other years (Refer to Insert Figure 4.4).

Furthermore, the API reading was increased with the highest pollutant among the five years (2013-2017) with 55 due to severe haze occurred in 2015. Therefore, it shows that the haze problem is one of the main problems that increased the PM₁₀ concentration. According to Department of Environment (2015), PM₁₀ concentration was the main pollutants that contribute to the haze problem in 2015. Other than that, the increase of PM₁₀ concentration also may comes from the industrial activities and combustion of fuels in the study areas (Vasudevan, 2006).

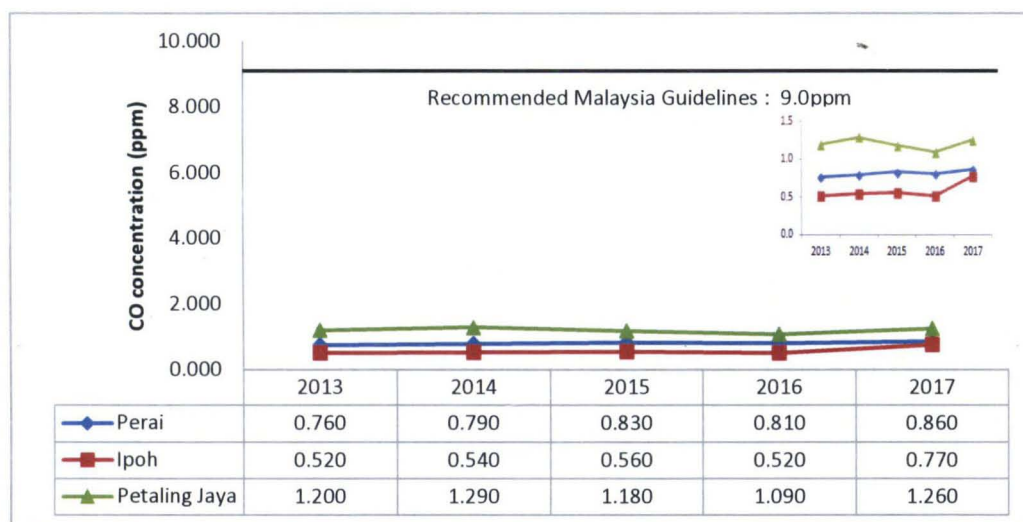


Figure 4.5: Annual Average Concentration of CO at Perai, Ipoh and Petaling Jaya, 2013 – 2017 (Insert Figure 4.5: Small Scale of CO Concentration)

Figure 4.5 shows the annual average trend of CO concentration at Perai, Ipoh and Petaling Jaya from 2013 to 2017. The annual trend for these areas indicates that the trend with an average value of 91% at Perai, 94% and 86.62% at Petaling Jaya were below the RMAAQG limit (9ppm). Although the concentration of CO not achieving the RMAAQG limit, there was a slightly increase of CO in 2017 where the concentration of CO for Perai was 0.86ppm, for Ipoh was 0.77ppm and for Petaling Jaya was 1.26ppm (Refer to Insert Figure 4.5). It shows that the increment was about 6% at Perai, 32% at Ipoh and 13% at Petaling Jaya.

According to Ministry of Transport Malaysia (2017), it stated that the average daily traffic in Petaling Jaya for 2017 is 153,545 compared to 2016 which only 138,711. Hence, it shows an increase of average daily traffic in Petaling Jaya by 9.7% from 2016 to 2017. Therefore, the high increase of daily traffic will increase the emission from the motor vehicles which can contribute to the increase of CO concentration 2017 at Petaling Jaya. Vasudevan (2006)

reported that the CO concentration may cause by the emission from the motor vehicles. Another study also proved that a large number of vehicles, poor conditions of road and inefficiency of public transport have directly cause major traffic problem in Klang Valley which contributes to the large amount of CO (Abdullah et al, 2012).

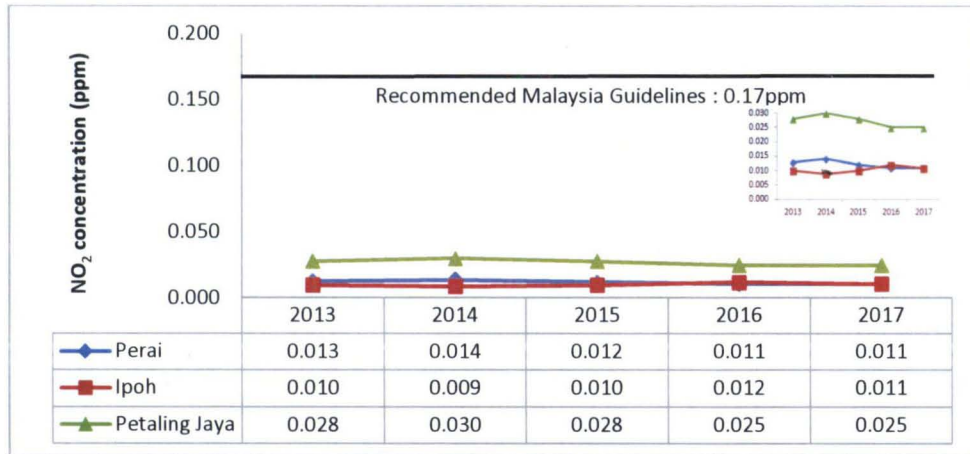


Figure 4.6: Annual Average Concentration of NO₂ at Perai, Ipoh and Petaling Jaya, 2013 – 2017 (Insert Figure 4.6: Small Scale of NO₂ Concentration)

Figure 4.6 shows the annual average trend of NO₂ concentration at Perai, Ipoh and Petaling Jaya from 2013 to 2017. The annual trend for these areas indicates that the NO₂ concentration were below the RMAAQG limit value which is 0.17ppm. This indicates that the NO₂ concentration at Perai, Ipoh and Petaling Jaya were averaging at 92.82%, 93.88% and 84% below the RMAAQG limit value. There was no significant change of NO₂ concentration among the years (2013-2017). However, in Petaling Jaya it shows slightly higher compared to Perai and Ipoh (Refer to Insert Figure 4.6). This may due to a significant increase in the number of motor vehicles in urban area and other sources of NO₂ are manufacturing industries and processing as stated in Table 4.2 where exist of industries that emit the NO₂.

According to Ministry of Transport Malaysia (2017), the average daily traffic in 2014 for Perai, Ipoh and Petaling Jaya are 48588, 78210, and 144308 respectively. Hence, this shows that Petaling Jaya has the highest number of average daily traffic with 66.3% and 45.8% higher than Perai and Ipoh respectively. Hence, it is indicates Petaling Jaya has slightly higher of NO₂ concentration produce compared to Perai and Ipoh. Besides that, the study areas were located near to the industrial areas where have various types of industry such as plastics, chemical, metals, rubber bases and wood bases as stated in Table 4.2. However,

most of the NO₂ comes from the motor vehicles exhaust compared to other sources. Nevertheless, the annual average concentration of NO₂ remains almost constant and below the RMAAQG limit.

Table 4.2: Types of Industry and gas emission

Area	Types of Industry	Emission
Perai	Wood Base	PM ₁₀
	Plastic Manufacturing	CO ₂
	Metal	NO ₂
	Chemical	SO ₂
	Electronics	O ₃
Ipoh	Wood Base	PM ₁₀
	Rubber Base	CO ₂
	Chemical	NO ₂
	Plastic Manufacturing	SO ₂
	Automotive	O ₃
Petaling Jaya	Electronics	CO ₂
	Steel	NO ₂
	Chemical	SO ₂
	Plastic Manufacturing	O ₃
	Automotive	

(Map, 2018)

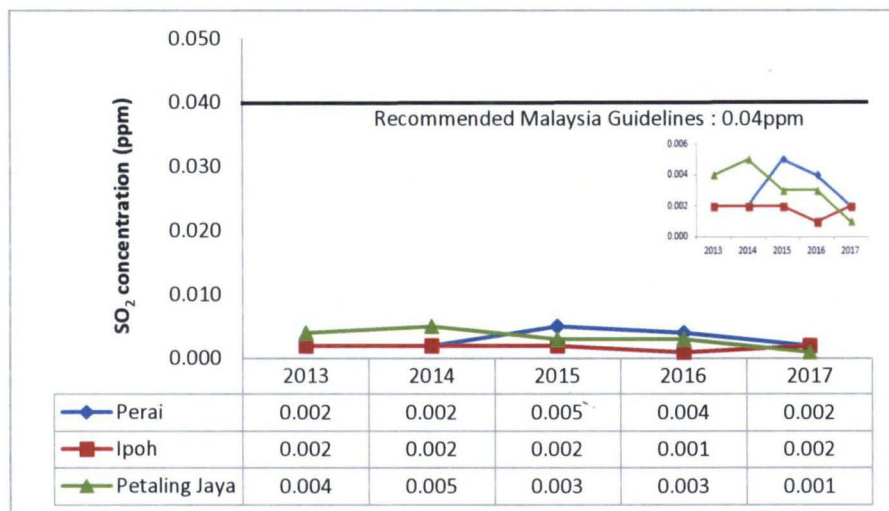


Figure 4.7: Annual Average Concentration of SO₂ at Perai, Ipoh and Petaling Jaya, 2013 – 2017 (Insert Figure 4.7: Small Scale of SO₂ Concentration)

Figure 4.7 shows the annual average trend of SO₂ concentration at Perai, Ipoh and Petaling Jaya from 2013 to 2017. The annual trend for these areas indicates that the SO₂ concentration was below the RMAAQG limit value which is 0.04ppm. This indicates that the SO₂ concentration at Perai, Ipoh and Petaling Jaya were averaging at 92.5%, 95.5% and 92% respectively below the RMAAQG limit value. It shows that, this pollutant is in control since the reading is below than RMAAQG limit value. However, it is still one of the dangerous pollutants to human health that need to be control and concern where the main sources of SO₂ comes from industrial activity processes material that contain sulphur such as the generation of electricity from coal, oil or gas that contains sulphur (Fernandez et al, 2005). In addition, all the study areas are located near to the industrial area. For example, the study area in Ipoh is located near to Tasek Industrial Area which they have plastics, rubber bases and wood bases industries as shown in Table 4.2. However, SO₂ also present in motor vehicle emissions as the result of fuel combustion.

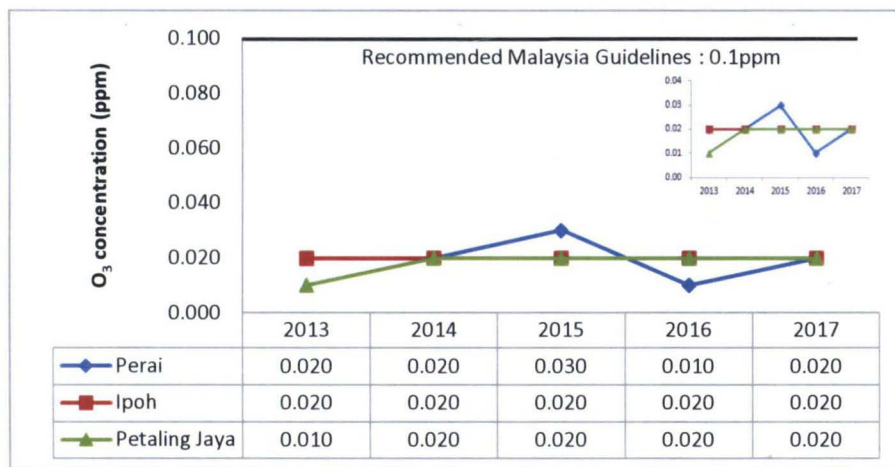


Figure 4.8: Annual Average Concentration of O₃ at Perai, Ipoh and Petaling Jaya, 2013 – 2017 (Insert Figure 4.8: Small Scale of O₃ Concentration)

Figure 4.8 shows the annual average trend of O₃ concentration at Perai, Ipoh and Petaling Jaya from 2013 to 2017. The annual trend for these areas illustrate that the O₃ concentration was below the RMAAQG limit value which is 0.1ppm. It indicates that the O₃ concentration at Perai, Ipoh and Petaling Jaya were averaging at 80%, 80% and 82% respectively below the RMAAQG limit value. Hence, this pollutant is still in control since the reading still below the RMAAQG limit value. From the figure, the highest O₃ concentration at Perai is 0.03ppm in 2015 which may due to the haze episode in September to October which is 70% below the

RMAAQG. However, it is still one of the dangerous pollutants to human health that need to be control and concern.

As the urbanization process is occurring, the demand of vehicles is increase dramatically (Abdullah, Samah & Jun, 2012). This can be proved in increase of number of average daily traffic in Perai from 2014 to 2015 with 48588 and 86718 respectively (JKR, 2015). Then, this may cause to the increment of O_3 concentration that depend on reaction in lower atmosphere involving hydrocarbons which is automobile exhaust (Vasudevan, 2006). Besides, because it is such a corrosive gas, O_3 in the lower atmosphere is known as toxic ozone and a number of chemical reactions produce it. One of them occurs inside automobile engines, where oxygen (O_2) and nitrogen gas (NO_2) combine to form nitric oxide (NO). This gas reacts with O_2 to form NO_2 . On present of sunlight, NO_2 breaks down again to release an oxygen atom, which in turn combines with an oxygen atom to form O_3 . Emissions from industrial factories and energy stations that burn fossil fuels also generate O_3 through a similar process (Deziel, 2018). Besides, it is formed by the reaction of Volatile Organic Carbon (VOCs) and nitrogen oxide (NO_x) in the present of sunlight and heat (Amir, 2007).

4.3 Correlation between Air Pollutant and Meteorological Condition

Table 4.3: Correlation between air pollutant and meteorological parameter

Location	Pollutants	Statistical Analysis	Meteorological parameter		
			Rainfall	Temperature	Humidity
Perai	PM ₁₀	Correlation Coefficient (r)	-0.387**	0.438**	-0.416**
		Significant value (2-tailed: p<0.01 or p<0.05)	0.002	0.000	0.001
	CO	Correlation Coefficient (r)	0.114	-0.059	0.122
		Significant value (2-tailed: p<0.01 or p<0.05)	0.386	0.652	0.352
	NO ₂	Correlation Coefficient (r)	-0.146	-0.040	-0.253
Significant value (2-tailed: p<0.01 or p<0.05)		0.266	0.759	0.051	
SO ₂	Correlation Coefficient (r)	0.050	-0.354**	-0.019	
	Significant value (2-tailed: p<0.01 or p<0.05)	0.702	0.006	0.884	
O ₃	Correlation Coefficient (r)	0.087	-0.036	0.189	
	Significant value (2-tailed: p<0.01 or p<0.05)	0.510	0.787	0.149	
Ipoh	PM ₁₀	Correlation Coefficient (r)	-0.432**	0.451**	-0.451**
		Significant value (2-tailed: p<0.01 or p<0.05)	0.001	0.000	0.000
	CO	Correlation Coefficient (r)	-0.007	0.052	-0.090
		Significant value (2-tailed: p<0.01 or p<0.05)	0.958	0.692	0.492
	NO ₂	Correlation Coefficient (r)	-0.242	0.200	-0.044
Significant value (2-tailed: p<0.01 or p<0.05)		0.062	0.125	0.741	
SO ₂	Correlation Coefficient (r)	-0.051	0.028	-0.029	
	Significant value (2-tailed: p<0.01 or p<0.05)	0.696	0.831	0.827	
O ₃	Correlation Coefficient (r)	-0.409**	0.306*	-0.419**	
	Significant value (2-tailed: p<0.01 or p<0.05)	0.001	0.017	0.001	
Petaling Jaya	PM ₁₀	Correlation Coefficient (r)	-0.335**	0.382**	-0.310*
		Significant value (2-tailed: p<0.01 or p<0.05)	0.009	0.003	0.016
	CO	Correlation Coefficient (r)	0.100	-0.123	0.226
		Significant value (2-tailed: p<0.01 or p<0.05)	0.446	0.351	0.083
	NO ₂	Correlation Coefficient (r)	0.269*	-0.077	0.164
Significant value (2-tailed: p<0.01 or p<0.05)		0.037	0.557	0.211	
SO ₂	Correlation Coefficient (r)	-0.118	0.022	0.091	
	Significant value (2-tailed: p<0.01 or p<0.05)	0.369	0.866	0.490	
O ₃	Correlation Coefficient (r)	-0.189	0.432**	-0.436**	
	Significant value (2-tailed: p<0.01 or p<0.05)	0.149	0.001	0.000	

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Table 4.3 shows the correlation coefficients (r-value) and significant value ($p < 0.01$ or $p < 0.05$) between air pollutants (PM_{10} , CO, NO_2 , SO_2 , and O_3) and meteorological parameters (Rainfall, Temperature and Humidity) at Perai, Ipoh and Petaling Jaya in 2013 to 2017. Statistical analysis reveals that there have meaningful significant correlations between air pollutants and meteorological parameters at Perai, Ipoh and Petaling Jaya. Interestingly, PM_{10} shows significant correlation between the meteorological parameters (rainfall, temperature and humidity) at Perai, Ipoh and Petaling Jaya. In addition, this analysis also found others significant correlation at Perai (SO_2 -Temperature), Ipoh (O_3 -Rainfall, O_3 -Temperature and O_3 -Humidity) and Petaling Jaya (NO_2 -Rainfall, O_3 -Temperature and O_3 -Humidity).

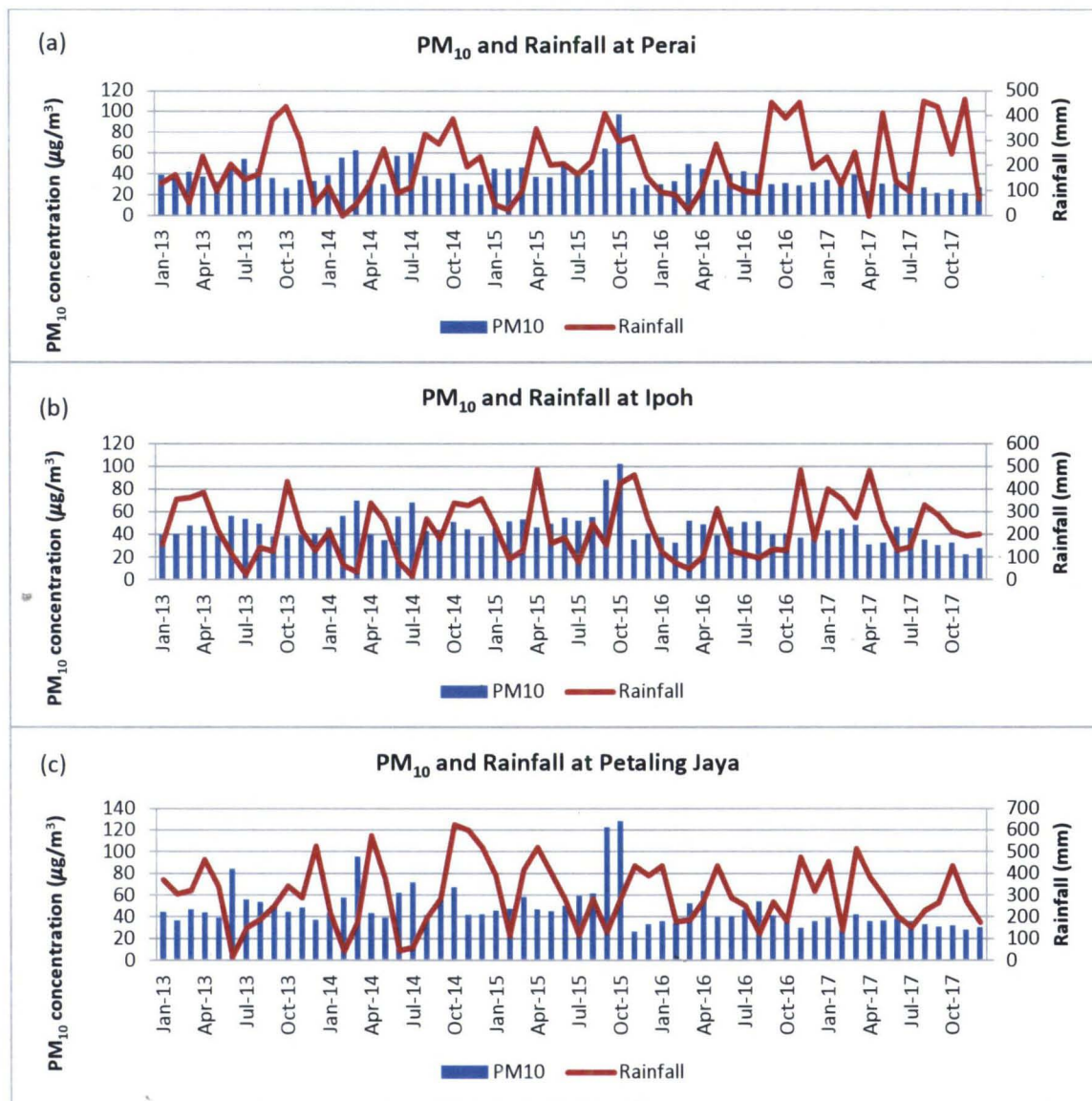


Figure 4.9: Monthly PM_{10} Concentration and Rainfall at (a) Perai (b) Ipoh and (c) Petaling Jaya

Based on Table 4.3, PM₁₀ was significantly correlated with rainfall at Perai ($r=-0.39$, $p<0.01$), Ipoh ($r=-0.43$, $p<0.01$) and Petaling Jaya ($r=-0.34$, $p<0.01$). This result indicates that PM₁₀ was significantly removed during rainfall. Similar finding was reported by previous studies, where the associations between meteorological parameters and particulates were found that the increase of rainfall establishes negative correlation with PM₁₀ (Dominick et al., 2006 & Yoo et al., 2014). Refer to Figure 4.9 (a-c), increase in rainfall amount and duration cause a decrease in the concentration of PM₁₀ due to the washout effect and solubility of the pollutant that was observed in April and October to November (haze month) for all years, indicating that relationship between PM₁₀ and rainfall is consistent. Moreover, during April and October to November transitional period, West Peninsular Malaysia received high amount of rainfall and winds from various direction. Due to this reason, PM₁₀ was significantly had scavenging effect from the rainfall event. Hence, this analysis suggesting that rainfall is significant to remove PM₁₀.

Moreover, PM₁₀ also shows significant correlation between temperature in Perai ($r=0.44$), Ipoh ($r=0.45$) and Petaling Jaya ($r=0.38$) where the significant value is less than 0.01 ($p<0.01$). This positive significant correlation indicates that increased of the temperature increases the concentration of PM₁₀ in Perai, Ipoh and Petaling Jaya. Refer to Figure 4.10 (a-c); there is no clear trend between PM₁₀ and temperature. Generally, the trends shows there have increase of PM₁₀ concentration in June to July, indicating that relationship between PM₁₀ and temperature consistent. During June to July southwest monsoon, West Peninsular Malaysia experienced dried season with minimum rainfall during this season. Due to this reason, PM₁₀ was significantly increase with increase of the temperature and remained in the atmosphere at high concentration. According to the previous study by Pepper et al. (2006), they found that the effect of increased temperatures on PM₁₀ concentrations may be explained by the process of thermally-induced convection. As the ground heats up during the day, gusts and winds increase, leading to increased diffusion of PM₁₀. Besides, during non-rainy days, the atmospheric temperature will increase and the concentration of pollutants may also be found to be on higher side, due to the failure of natural scrubbing process.

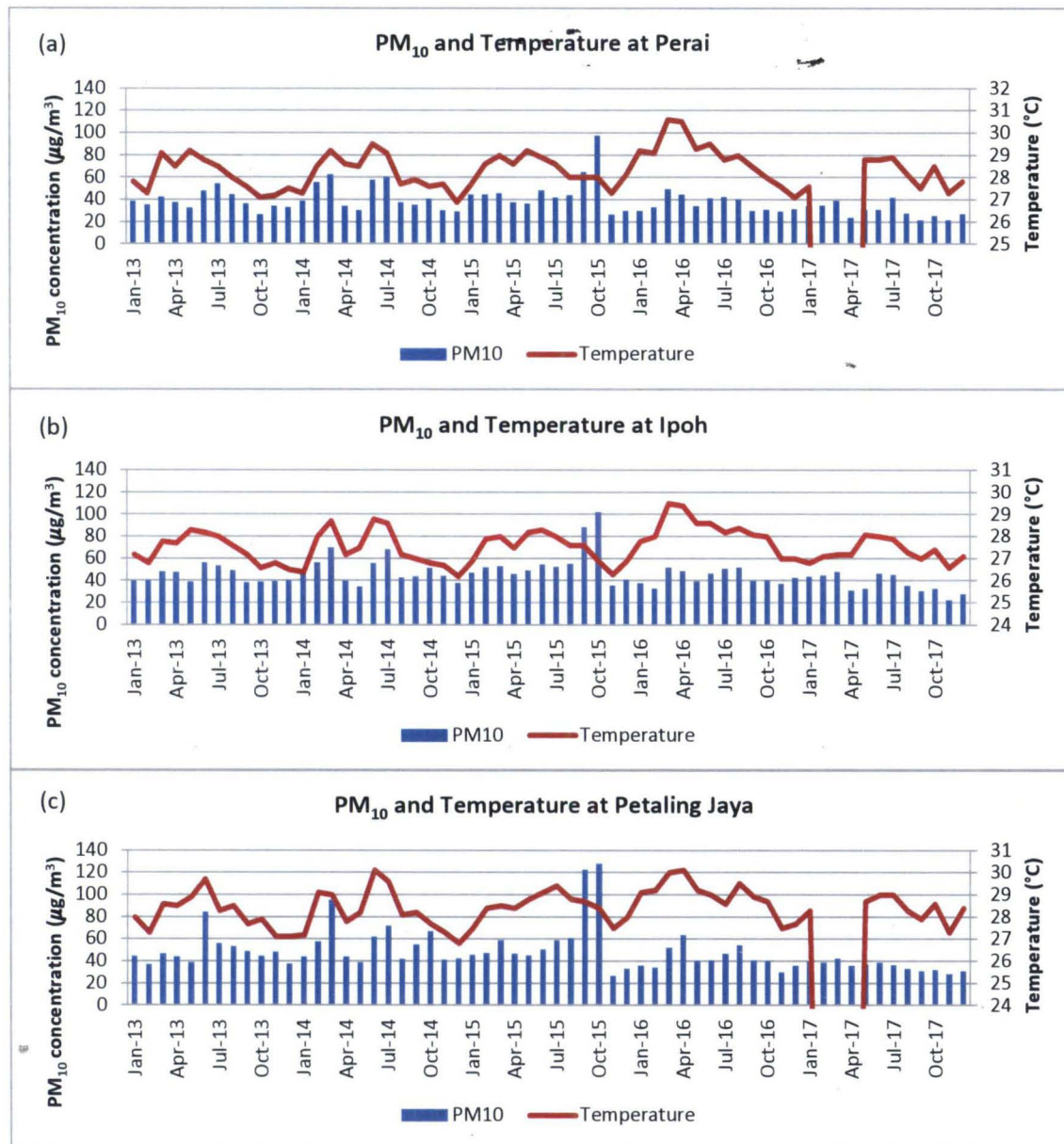


Figure 4.10: Monthly PM₁₀ Concentration and Temperature at (a) Perai (b) Ipoh and (c) Petaling Jaya

In addition, PM₁₀ also shows significant correlation between Humidity at Perai ($r=-0.42$, $p<0.01$), Ipoh ($r=-0.45$, $p<0.05$) and Petaling Jaya ($r=-0.31$, $p<0.01$). This significant negative correlation indicates that PM₁₀ may trap or dissolve in water droplets in the air. Similar finding was reported from the previous studies by Jayamurugan et al. (2013), where the PM₁₀ ($r=-0.71$) were negatively correlated with humidity. Refer to Figure 4.11; the dissolve effect of PM₁₀ was observed in April and October to November (haze month) for all years, indicating that relationship between PM₁₀ and humidity is consistent.

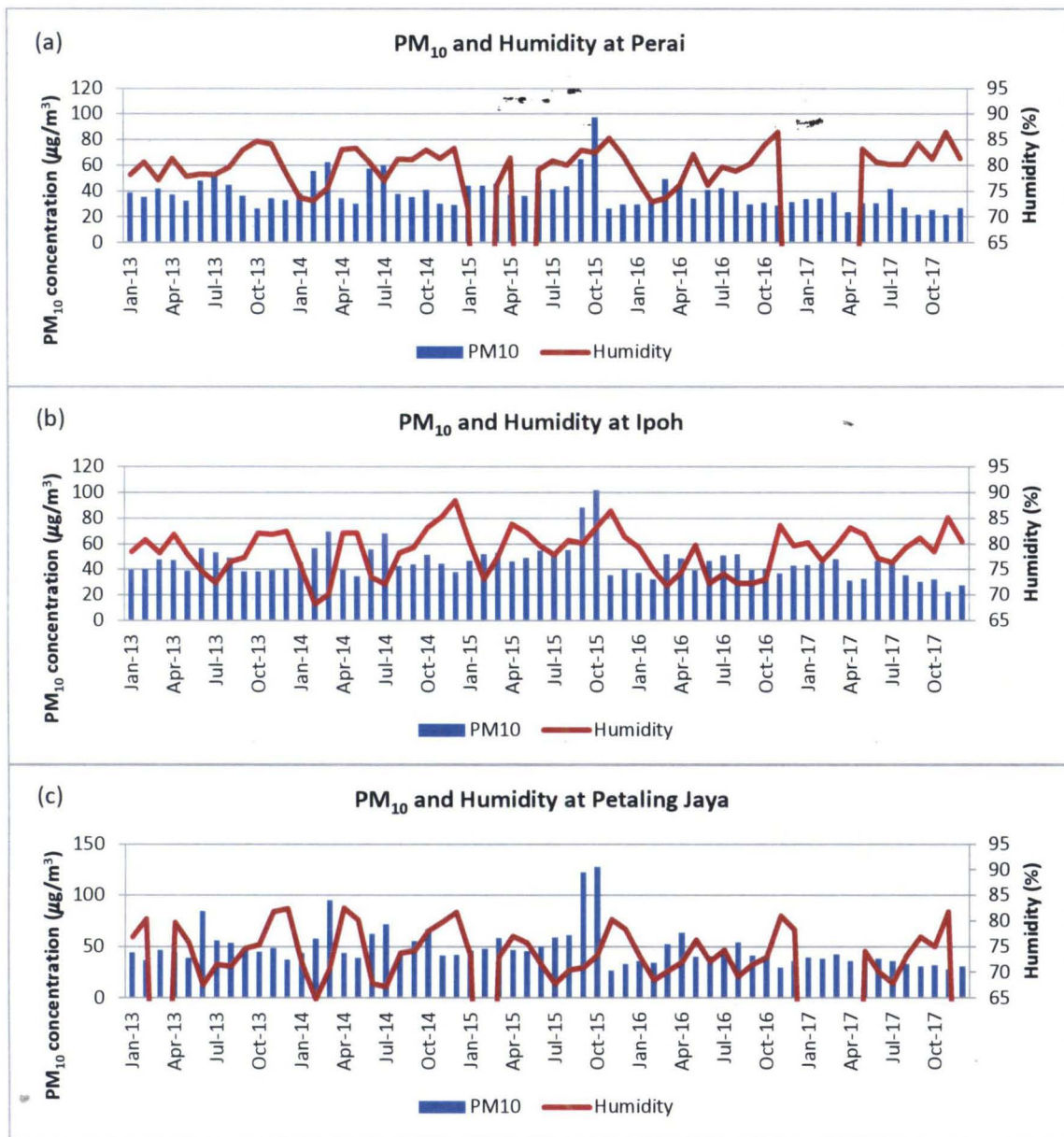


Figure 4.11: Monthly PM₁₀ concentration and Humidity at (a) Perai (b) Ipoh and (c) Petaling Jaya

Moreover, during April and October to November transitional period, West Peninsular Malaysia received high amount of rainfall and winds from various direction. Due to this reason, the percentage of humidity during this period also high, hence significantly dissolve the PM₁₀ in water droplets in the air. Therefore, this analysis suggesting that humidity is significant to dissolve the concentration of PM₁₀ at Perai, Ipoh and Petaling Jaya. Theoretically, the rate of absorption of particulate in the atmosphere increases with the increase of humidity. Moreover, humidity value in Ipoh (88.5%) was higher than the humidity value in Perai (86.5%) and Petaling Jaya (82.5%). Due to this reason, PM₁₀ may

significantly dissolve in water droplets in the air at Ipoh compared to Perai and Petaling Jaya. The rain also acts as natural scrubber during monsoon and brings down the particulate level in the atmosphere. The influence of humidity and rain on particulate could be high wet season, to result in moderate negative correlation during wet season.

Table 4.3 shows that O₃ have a significant correlation between Rainfall (r=-0.41, p<0.01) at Ipoh. This significant negative correlation indicates that O₃ was significantly removed during rainfall. Similar finding was reported by the previous study that indicates O₃ is significantly removed by the rainfall (Yoo et al, 2014). Refer to Figure 4.12; the washout effect of O₃ was observed in April and October to November (haze month) for all years, indicating that relationship between PM₁₀ and rainfall is consistent in Ipoh. Due to the high amount of rainfall that received during transition monsoon in April and October, it significantly washout the O₃ concentration.

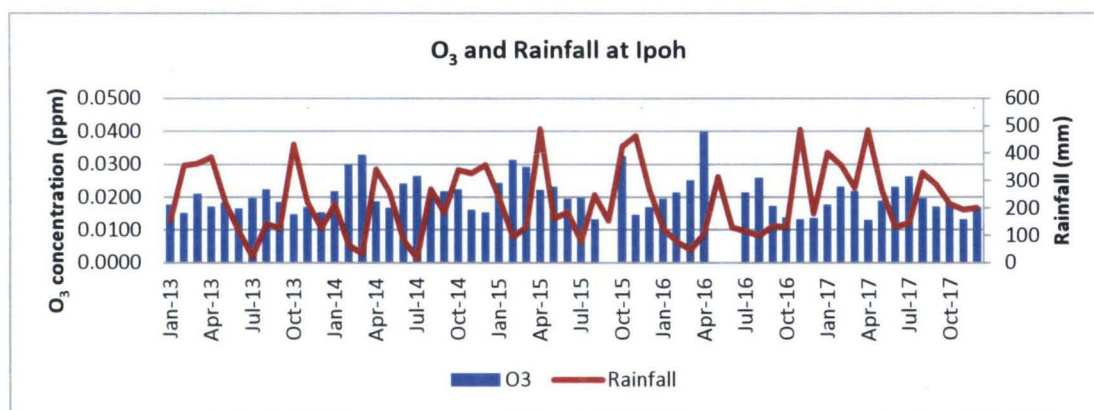


Figure 4.12: Monthly O₃ concentration and Rainfall at Ipoh

In addition, rainy weather is typically associated with low O₃ concentration in the water droplets as a result of dissolved wet O₃ (Refer Eq. 4.1). In the meantime, Ipoh is in the valley area compared to Perai and Petaling Jaya where O₃ can be trapped in the valley. High concentration of O₃ can therefore be removed from rainfall's scavenging effect. Literatures have reported that valley area has significant to trap more pollutants compared to flat surface or hilly area (Airgo, 2018).



O₃ also shows that there have a positive significant correlation between Temperature (O₃-Temperature) at Ipoh and Petaling Jaya where the correlation coefficient is 0.31 ($r=0.31$, $p<0.05$) and 0.43 ($r=0.43$, $p<0.01$) respectively. This positive significant correlation indicates that increase of the temperature increases the concentration of O₃ in Ipoh and Petaling Jaya. This result is as expected where temperature has an influence on the concentration of O₃ in the atmosphere. Similar finding from the past research proved that O₃ is heavily influenced by sunlight and temperature in a local environment (Awang et al, 2000 and Amir, A., 2007). Refer to Figure 4.13; there is no clear trend between O₃ and temperature at Ipoh and Petaling Jaya. Generally, the trends shows there have in increase of O₃ concentration in June to July. During June to July southwest monsoon, West Peninsular Malaysia experienced dried season with minimum rainfall during this season. Due to this reason, O₃ was significantly increase with increase of the temperature and remained in the atmosphere at high concentration.

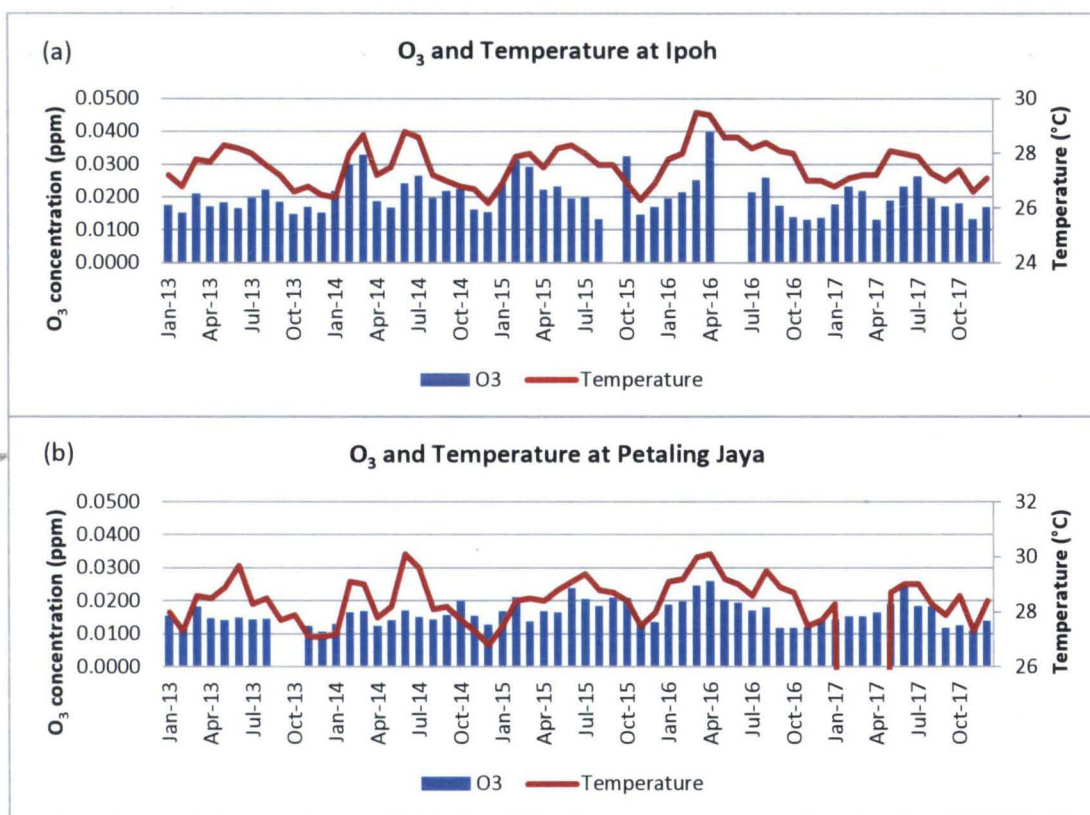


Figure 4.13: Monthly O₃ concentration and Temperature at (a) Ipoh (b) Petaling Jaya

Theoretically, the formation of O₃ requires four key elements which are nitrogen dioxide (NO₂), volatile organic compounds (VOC), heat and sunlight. The first two are emitted

directly as a result of human activity, while the last two depend on the weather; as a result, air quality can be expected to worsen with high temperature, and especially in hot summer days without clouds, where there is also an abundance of sunlight. In general, NO₂ and VOCs provide extra oxygen atoms that combine with atmospheric oxygen (O₂) to form ozone (O₃). Equation 4.2 and 4.3 explains how ozone can be formed from nitrogen dioxide (NO₂).



Ipoh and Petaling Jaya also shows negative significant correlation between O₃-Humidity where the correlation coefficient is -0.42 (r=-0.42, p<0.01) and -0.44 (r=-0.44, p<0.01) respectively. This negative correlation indicates that O₃ may trap or dissolve in water droplets in the air. Similar finding was reported from previous studies by Jayamurugan et al. (2013), O₃ (r=-0.64) were negatively correlated with humidity. Refer to Figure 4.14; the trend shows that there was dissolved effect on O₃ concentration in November to December (southwest monsoon) for all years at Ipoh and Petaling Jaya, indicating that correlation between O₃ and humidity is consistent. This analysis suggests that humidity is significant to dissolve O₃ at Ipoh and Petaling Jaya. This could be due to the increasing rate of O₃ absorption in the atmosphere as humidity increases. The rain also acts as natural scrubber during monsoon and brings down the O₃ concentration in the atmosphere. The influence of humidity and rain on O₃ could be high in wet season, to result in moderate negative correlation during wet season. In addition, due to high humidity in Ipoh (88.5%) and Petaling Jaya (82.5%), O₃ may trap or dissolved in water droplets in the air.

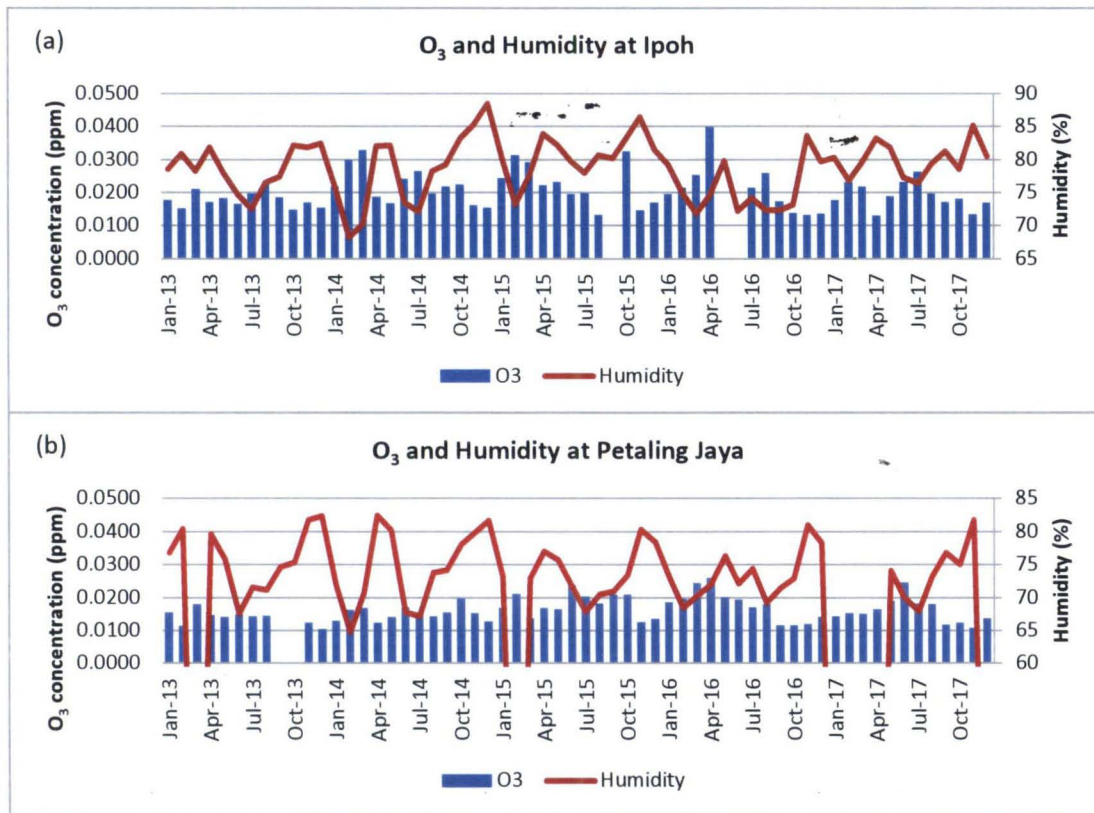
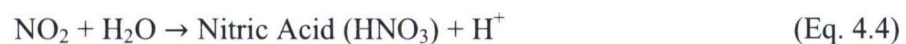


Figure 4.14: Monthly O₃ concentration and Humidity at (a) Ipoh (b) Petaling Jaya

Table 4.3 shows that there have a significant positive correlation between NO₂-Rainfall ($r=0.27$, $p<0.05$) at Petaling Jaya. This result indicates that NO₂ has no significant effect on washout or scavenging effect from the rainfall event. This is probably due to the haze episode that occurs from September to October that prolong the dry season (Southwest Monsoon) in Petaling Jaya and emission of NO₂ from transportation and industrial activities. Refer to Figure 4.15; there is no clear trend between NO₂ and Rainfall at Petaling Jaya. Theoretically, NO₂ may dissolve in rainfall and formed acid rain (HNO₃) and reacted with other gasses to produce secondary pollutant (e.g., O₃) (Theodore & Theodore, 2010). The washout mechanism of NO₂ by rainfall has played an important role in producing acid rain (Yoo et al, 2014). NO₂ rise into the atmosphere from automobiles is transformed by reaction with oxygen and water vapour to form nitric acid as shown by Equation 4.4 (Vasudevan, 2006).



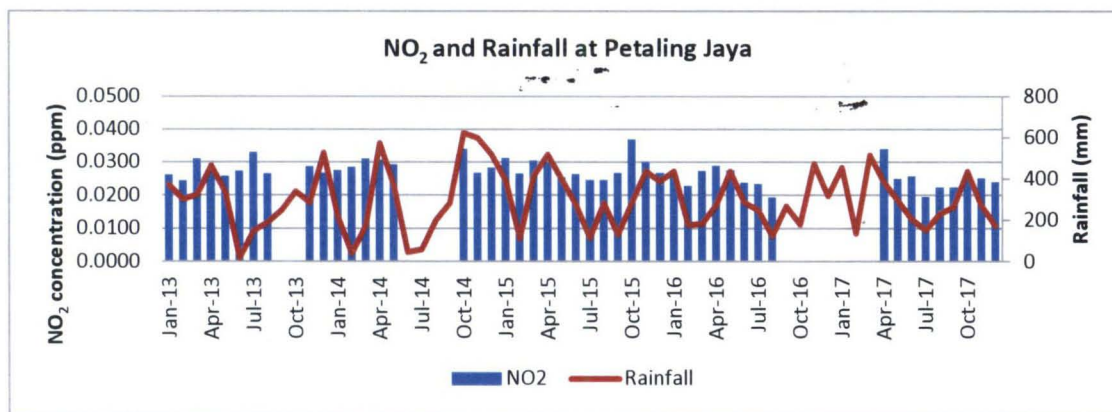


Figure 4.15: Monthly NO₂ concentration and Rainfall at Petaling Jaya

Table 4.3 shows that Perai have a significant negative correlation between SO₂-Temperature ($r=-0.35$, $p<0.01$). This result indicates that SO₂ has no significant effect from the temperature in Perai. Refer to Figure 4.16; there is no clear trend between SO₂ and temperature at Perai. This is probably due to the SO₂ concentration in Perai was lower compared than the SO₂ concentration in Ipoh and Petaling Jaya. Due to this reason, there is no significant reaction occurred between SO₂ and temperature Perai. Theoretically, SO₂ is emitted both naturally and anthropogenically through volcanic eruptions and combustion of fossil fuel (coal) (Refer to Eq. 4.5). Reaction of SO₂ with H₂O in the air can form sulfuric acid (H₂SO₄), another form of acid rain. Due to this reason, SO₂ has no significant effect from temperature at atmosphere in Perai.



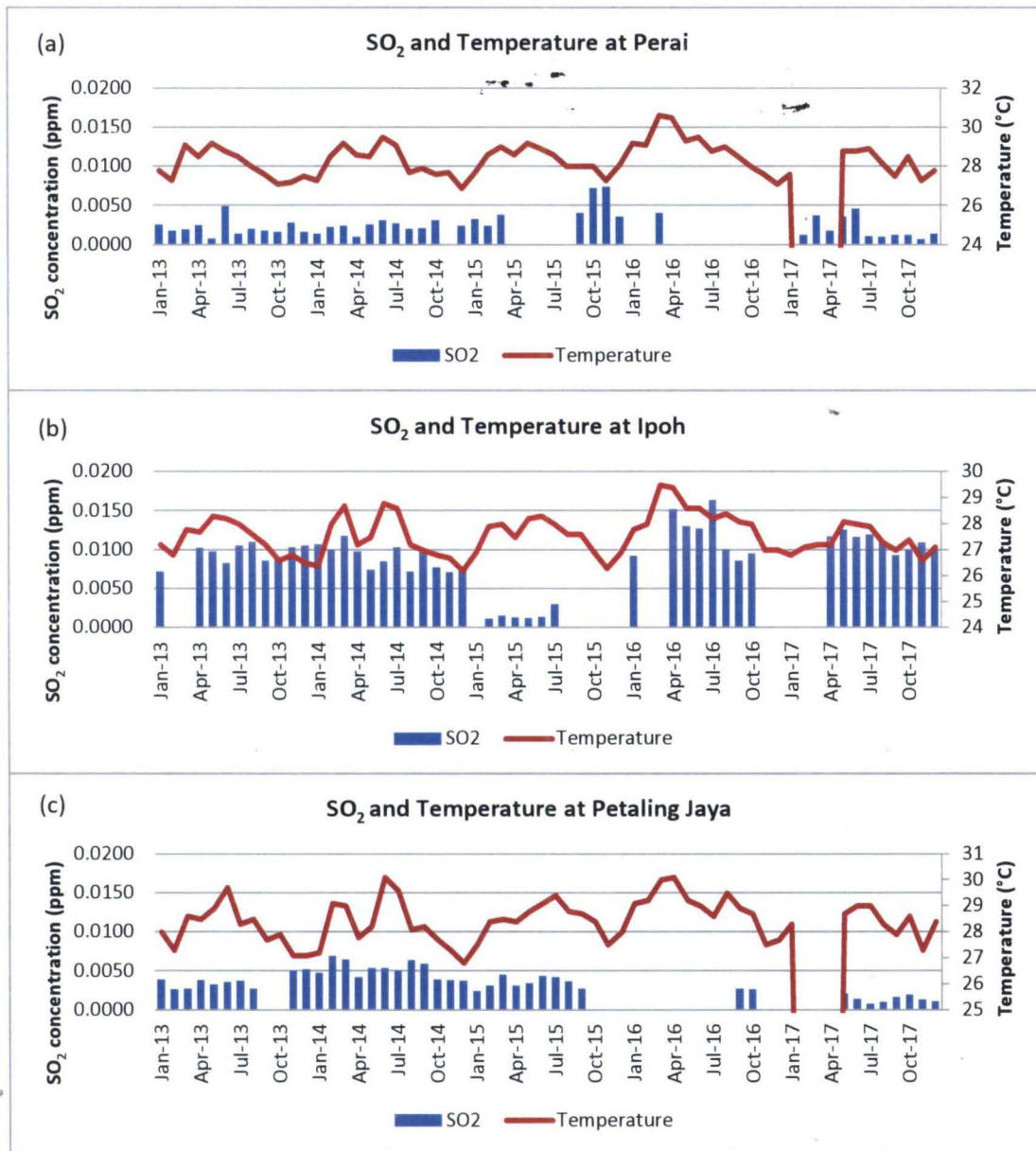


Figure 4.16: Monthly SO₂ concentration and Temperature at (a) Perai, (b) Ipoh and (c) Petaling Jaya

The correlation between air pollutant and the influence meteorological parameters shows that a significant value and reflect the real condition in the atmosphere. PM₁₀ and O₃ show the pollutants that most significantly correlated between the meteorological parameter at Perai, Ipoh and Petaling Jaya in 2013 to 2017. This study was similar with the previous study reported by Amir A. (2007) in Petaling Jaya where PM₁₀ is originating fully from the common source which is vehicle source and the meteorological conditions play an important role in influencing the air pollutants concentration in Petaling Jaya.

4.4 Impact of Air Pollutant Related to Meteorological Condition on Climate Change

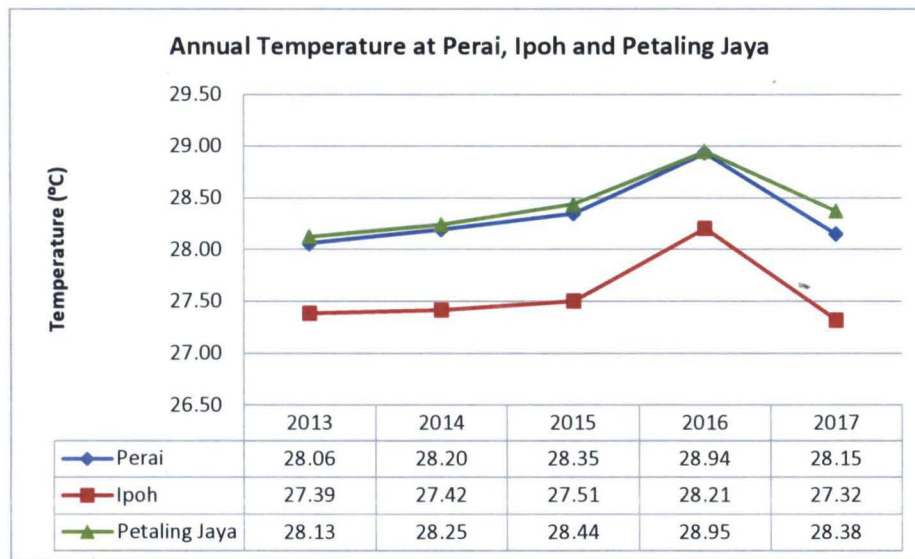


Figure 4.17: Annual Temperature at Perai, Ipoh and Petaling Jaya from 2013-2017

Figure 4.17 shows the annual temperature at Perai, Ipoh and Petaling Jaya from 2013 to 2017. The annual temperature indicates that temperature for Perai, Ipoh and Petaling Jaya were increased except for 2017, where the temperature decreases at Perai, Ipoh and Petaling Jaya. The analysis shows that the increase of temperature reading occurred is almost constant from 2013 to 2015 with small increment at Perai (0.5% - 0.53%), Ipoh (0.1% - 0.3%) and Petaling Jaya (0.4% - 0.7%). Furthermore, there was an acute increase of temperature in 2016 for Perai, Ipoh and Petaling Jaya where the temperature was 28.94°C by 2.1% increment, 28.21°C by 2.5% increment and 28.95°C by 1.8% increment from 2015 respectively. Hence, in 2017 the temperature decreases to 28.15°C (2.8%), 27.32°C (3.3%) and 28.38°C (2.1%) at Perai, Ipoh and Petaling Jaya respectively. Literatures have reported that mean annual temperature in Indonesia also has increased by about 0.3°C and expected to increase by 0.8 °C by 2030. Moreover, Singapore also is not insulated from the impact of climate change. From 1972 to 2014, the annual mean temperature has increased from 26.6°C to 27.7°C (Case et al, 2007). In addition, the temperature for Perai, Ipoh and Petaling Jaya were significantly increased in 2016 due to the effect of the biomass burning in Southern Sumatera, Indonesia occurred in August 2016. Besides, API reading was increased among the five years (2013-2017) with API is slightly moderate (API: 50-100) condition at Ipoh (API: 53) and Petaling

Jaya (API: 55) in 2015. Meanwhile, API is good (API: 0-50) condition at Perai (API: 47) in 2015. The API value was contributed by PM_{10} for Perai, Ipoh and Petaling Jaya.

Based on the Malaysian Meteorological Department (MMD), wind was moving from the Sumatera towards the West Peninsular Malaysia brings together more pollutants that can increase the temperature namely as PM_{10} and O_3 . Moreover, West Peninsular Malaysia experienced dried season with minimum rainfall during southwest monsoon, except for Sabah and East Malaysia (MMD, 2016). From that, PM_{10} and O_3 was not significantly washout by rainfall and remained in the atmosphere at high concentration. Other than that, the industrial processes also contribute to the high emission of air pollutants at study area. According to the Huang et al (2013), burning of fossil fuels from industrial areas is a major source of both air pollutants and greenhouse gases. Air pollution also has a short term regional climate effect – pollutants like black particles, ozone and its precursors contribute to warming and are consequently recognized as short-lived climate pollutants. Therefore, due to this reason, it shows that air pollution affect the significant increased of the temperature reading (related climate change) at Perai, Ipoh and Petaling Jaya in 2016.

Similar finding was reported by previous studies, where the association between climate change driven air quality such as PM_{10} that adversely affects human health directly or indirectly (Tagaris et al, 2009). According to Patrick et al (2018), the global warming or climate change adversely affects the ecosystem, economic and human health. Generally, climate change can cause drought, flooding, deforestation, homelessness and extinction of animal and plant species resulting in famine and disease. Research shows that the climate change leads to sea level rise and changes in rainfall patterns. Earth's warming climate is causing sea levels to rise as warmer air temperatures are causing glaciers and land ice to melt. As the melt water flows into the ocean, the increase in the total amount of water causes the sea level to rise. Besides, the unpredictable rainfall may due to the warmer atmosphere be able to hold more moisture, and globally water vapour increases by 7% for every degree centigrade of warming. How this will translate into changes in global precipitation is less clear cut but the total volume of precipitation is likely to increase by 1-2% per degree of warming. Moreover, mechanisms leading to climate change impacting human health directly or indirectly include heat wave, shortages of food and water supplies, malnutrition, vector-borne disease, food and waterborne diseases. The heat wave affects the human health as the extreme temperature leads to fever, skin problem and other disease and worsening of existing

lung and heart problem such as asthma during days of uncommon high temperature and humidity (Patrick et al, 2018).

Besides that, the rising of temperature due to climate change will in turn affect the economy. The market impacts of outdoor works, which include impacts on labour productivity, health expenditures and agricultural crop yields, are projected to lead to global economic costs that gradually increase to 1% of global GDP by 2060 (OECD, 2016). Due to this annual temperature analysis, it is important to understand the increment of temperature by air pollutants released by human activities which generate the occurrence of climate change.

4.5 Conclusion

This chapter obtained three types of data analysis. The data analyses involved are analysis on the trend of air pollutants in compliance with Recommended Malaysia Ambient Air Quality Guideline (RMAAQG), the analysis the correlation between the air pollutants and the influence of meteorological conditions, and analysis the impact of air pollutants related to meteorological conditions on climate change

The first analysis is a study on the trends of air pollutants at Perai, Ipoh and Petaling Jaya which illustrates the general view of air pollutants trends for 5 years period from 2013 to 2017. It observed the status of the pollutants concentration in the study area whether below or above the RMAAQG limit. From the findings, it indicates that all the air pollutants concentration below the RMAAQG limit. However, the PM_{10} concentration in 2015 shows increment from 2014 where the concentration of PM_{10} for Perai was $47\mu g/m^3$ by 11% increment and for Ipoh was $56\mu g/m^3$ by 13% increment and also for Petaling Jaya was $60\mu g/m^3$ by 8%. This is due the severe haze event occurred in 2015 which also increases the API reading with the highest pollutant among the five years (2013-2017). The API analysis shows that API for Petaling Jaya was 4% and 15% higher compared to Ipoh and Perai respectively. The findings indicates that these places were in good (API: 0-50) condition except for 2015, where the API was slightly moderate (API: 50-100) at Ipoh and Perai. The air quality status for Perai, Ipoh and Petaling Jaya were significantly increased in 2015 due to the severe biomass burning in Southern Sumatera and Kalimantan in Indonesia, which had caused severe haze event in Malaysia. The API value was contributed by PM_{10} for all places in these years.

The second analysis indicates influences of meteorological conditions on the air pollutants are analyzed to evaluate the correlation between meteorological parameter and air pollutants for 5 years duration (2013-2017). The raw data is analyzed by using statistical software (SPSS Statistics 22) by addressing meteorological data and air pollutants data. Statistical analysis reveals that there is meaningful significant correlation between air pollutants and meteorological parameters at Perai, Ipoh and Petaling Jaya. Interestingly, PM_{10} shows significant correlation between meteorological parameters (rainfall, temperature and humidity) at Perai, Ipoh and Petaling Jaya. In addition, there also found significant correlation at Perai

(SO₂-Temperature), Ipoh (O₃-Rainfall, O₃-Temperature and O₃-Humidity) and Petaling Jaya (NO₂-Rainfall, O₃-Temperature and O₃-Humidity).

PM₁₀ was significantly correlated with rainfall at Perai ($r=-0.39$, $p<0.01$), Ipoh ($r=-0.43$, $p<0.01$) and Petaling Jaya ($r=-0.34$, $p<0.01$). This result indicates that PM₁₀ was significantly removed during rainfall. PM₁₀ also shows the significant positive correlation between PM₁₀ and temperature in Perai ($r=0.44$), Ipoh ($r=0.45$) and Petaling Jaya ($r=0.38$) where the significant value is less than 0.01 ($p<0.01$). Significant negative correlation between PM₁₀ and Humidity found at Perai ($r=-0.42$, $p<0.01$), Ipoh ($r=-0.45$, $p<0.05$) and Petaling Jaya ($r=-0.31$, $p<0.01$). This indicates that PM₁₀ may trap or dissolve in water droplets in the air. The rain also acts as natural scrubber during monsoon and brings down the particulate level in the atmosphere. The influence of humidity and rain on particulate could be high wet season, to result in moderate negative correlation during wet season.

Moreover, O₃ have a significant negative correlation between Rainfall ($r=-0.41$, $p<0.01$) at Ipoh. This indicates that O₃ is significantly removed by the rainfall and the washout effect of O₃ was observed in April and October to November (haze month), indicating that relationship between PM₁₀ and rainfall is consistent. Due to the high amount of rainfall that received during transition monsoon in April and October, it significantly washout the O₃ concentration. Ipoh and Petaling Jaya shows a positive significant correlation between O₃-Temperature where the correlation coefficient is 0.31 ($r=0.31$, $p<0.05$) and 0.43 ($r=0.43$, $p<0.01$) respectively. This result is as expected where temperature has an influence on the concentration of O₃ in the atmosphere. Ipoh and Petaling Jaya also shows negative significant correlation between O₃-Humidity where the correlation coefficient is -0.42 ($r=-0.42$, $p<0.01$) and -0.44 ($r=-0.44$, $p<0.01$) respectively. This is due to dissolved effect on O₃ concentration in November to December (southwest monsoon).

There have a significant positive correlation between NO₂-Rainfall ($r=0.27$, $p<0.05$) at Petaling Jaya. This result indicates that NO₂ has no significant effect on washout or scavenging effect from the rainfall event. This is probably due to the haze episode that occurs from September to October that prolong the dry season (Southwest Monsoon) in Petaling Jaya. Perai have a significant negative correlation between SO₂-Temperature ($r=-0.35$, $p<0.01$). This result indicates that SO₂ has no significant effect from the temperature in Perai. This is probably due to the SO₂ concentration in Perai was low compared than the SO₂

concentration in Ipoh and Petaling Jaya. Due to this reason, there is no significant reaction occurred between SO_2 and temperature Perai.

Finally, the impact of air pollutants related to meteorological conditions on climate change also analyzed for 5 years data. The analysis illustrates the impact of air pollution released as the increment of temperature which shows the occurrence of global warming or climate change since there were significant correlation between air pollutants and meteorological conditions. The positive correlation between O_3 and PM_{10} to temperature showed there have effect of air pollutants related to meteorological conditions on climate change. Moreover, emissions of O_3 and PM_{10} precursors increase at higher ambient temperatures. The reactions that form O_3 occur faster with greater sunlight and higher temperatures. In addition, air pollution and climate change issues converge in the increasing background concentrations of O_3 . Despite mostly not exceeding any air quality standards, the rising background level of O_3 will probably lead to reduced plant growth as well as adverse effects on human health, ecosystem and economy.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A comprehensive study on potential impact of meteorological change on air pollution – related climate change effect where studied at the industrial area in West Peninsular Malaysia illustrates that there are five (5) main air pollutants monitored by Department of Environment (DOE) namely particulate matter (PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂) and ozone (O₃). Many researchers made the research on air pollution studies. However, this study had completed the three (3) objectives which are to identify the trends of air pollutants in compliance with the Recommendation Malaysia Ambient Air Quality Guideline (RMAAQG), to determine the correlation between the air pollutant and the influence of meteorological condition and to evaluate the impact of air pollutants related to meteorological conditions on climate change.

The API analysis shows that API for Petaling Jaya was 4% and 15% higher compared to Ipoh and Perai respectively. The findings indicates that these places were in good (API: 0-50) condition except for 2015, where the API was slightly moderate (API: 50-100) at Ipoh and Perai. The API value was contributed by PM₁₀ for all places in these years. Investigation on the trends of air pollutants in compliance with the Recommendation Malaysia Ambient Air Quality Guideline (RMAAQG) indicates that all the pollutants concentration is well below the RMAAQG limit. However, the PM₁₀ concentration in 2015 shows an increment where the concentration of PM₁₀ for Perai was 47µg/m³ by 11% increment and for Ipoh was 56µg/m³ by 13% increment and also for Petaling Jaya was 60µg/m³ by 8% increment from 2014. This is due to the haze problem that increased the PM₁₀ concentration.

Evaluation on the correlation between the air pollutant and the influence of meteorological condition determined by using the correlation matrix where analyzed the effect of rainfall, temperature and humidity to air pollutants. Statistical analysis reveals that there is meaningful significant correlation between air pollutants and meteorological parameters at Perai, Ipoh and Petaling Jaya. Interestingly, PM₁₀ shows significant correlation between meteorological

parameters (rainfall, temperature and humidity) at Perai, Ipoh and Petaling Jaya. In addition, there also found significant correlation at Perai (SO₂-Temperature), Ipoh (O₃-Rainfall, O₃-Temperature and O₃-Humidity) and Petaling Jaya (NO₂-Rainfall, O₃-Temperature and O₃-Humidity). PM₁₀ was significantly correlated with rainfall at Perai ($r=-0.39$, $p<0.01$), Ipoh ($r=-0.43$, $p<0.01$) and Petaling Jaya ($r=-0.34$, $p<0.01$). This result indicates that PM₁₀ was significantly removed during rainfall. PM₁₀ also shows the significant positive correlation between PM₁₀ and temperature in Perai ($r=0.44$), Ipoh ($r=0.45$) and Petaling Jaya ($r=0.38$) where the significant value is less than 0.01 ($p<0.01$). Significant negative correlation between PM₁₀ and Humidity also found at Perai ($r=-0.42$, $p<0.01$), Ipoh ($r=-0.45$, $p<0.05$) and Petaling Jaya ($r=-0.31$, $p<0.01$). This indicates that PM₁₀ may trap or dissolve in water droplets in the air.

Moreover, there have a significant negative correlation between O₃-Rainfall ($r=-0.41$, $p<0.01$) at Ipoh. Ipoh and Petaling Jaya shows a positive significant correlation between O₃-Temperature where the correlation coefficient is 0.31 ($r=0.31$, $p<0.05$) and 0.43 ($r=0.43$, $p<0.01$) respectively. This result is as expected where temperature has an influence on the concentration of O₃ in the atmosphere. Ipoh and Petaling Jaya also shows negative significant correlation between O₃-Humidity where the correlation coefficient is -0.42 ($r=-0.42$, $p<0.01$) and -0.44 ($r=-0.44$, $p<0.01$) respectively. The correlation between air pollutant and meteorological parameters shows that a significant value and reflect the real condition in the atmosphere. PM₁₀ and O₃ show the pollutants that most significantly correlated between the meteorological parameter at Perai, Ipoh and Petaling.

The temperature analysis indicates the impact of air pollution released as the increment of temperature which shows the occurrence of global warming or climate change. The temperature reading occurred is almost constant from 2013 to 2016 with small increment in range 0.4% - 1.8% in Petaling Jaya. Meanwhile, at Perai and Ipoh, the increasing temperature reading shows an increment 0.5% - 2% and 0.1% - 2.5% respectively from 2013 to 2016. Then, the small decrement occurred from 2016 to 2017 for Perai, Ipoh and Petaling Jaya with 2.8%, 3.3% and 2.1%. It illustrates that the temperature increasing from 2013 to 2016 for all study areas in range 27.39°C to 28.95°C. Due to this annual temperature data, it is important to understand the increment of temperature by air pollutants released by human activities which generate the occurrence of climate change. In conclusion, meteorological conditions play an important role in influencing the air pollutants concentration – related climate change effect.

5.2 Recommendation

From this study, it is recommended that the Department of Environment (DOE) should provide and monitor the concentration of carbon dioxide (CO₂) in the atmosphere. It is the most crucial gases that contribute to the climate change. Moreover, DOE also should strictly monitor the emission of air pollutants from the industry. In addition, it is recommended providing intensive education on the impact of climate change to human health and environment, which is one of the main elements in sustainability management in Malaysia. The extensive education should be involving the exposure on climate change that occurs in Malaysia with government association. For example, the government needs to provide better facilities and services of public transportation and promote the using of public transport in order to reduce the number of vehicles. Other than that, it can be recommended to extend this study by using others advance software. From that, the correlation between air pollutants and meteorological condition can be analyzed more accurately. Furthermore, it also recommended extending this study with health data from the hospital to know the impact of air pollution towards human health more precisely.

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APPENDICES

APPENDIX A

The pollutants concentration compliance with the Recommended Malaysia Ambient Air Quality Guidelines (RMAAQG) (2013-2017)

APPENDIX B

Air Pollutant Monthly Data at Perai, Ipoh and Petaling Jaya (2013-2017)

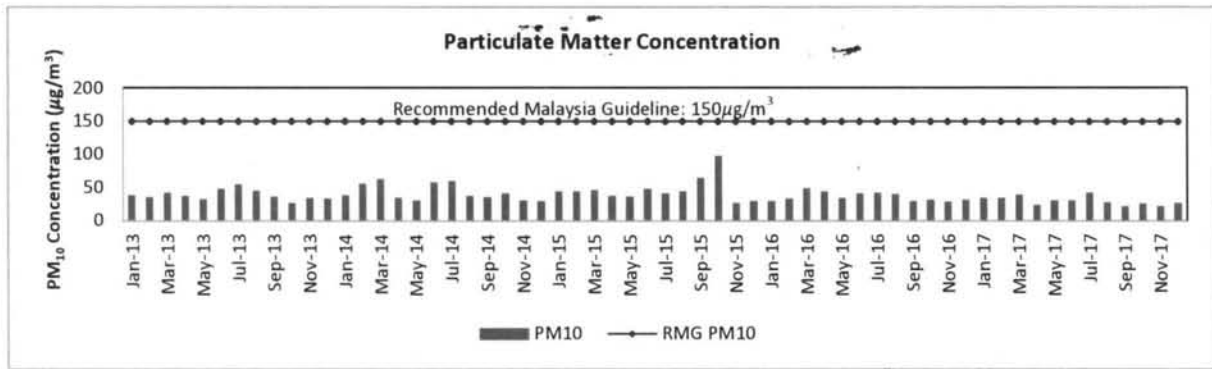
APPENDIX C

Meteorological Monthly Data at Perai, Ipoh and Petaling Jaya (2013-2017)

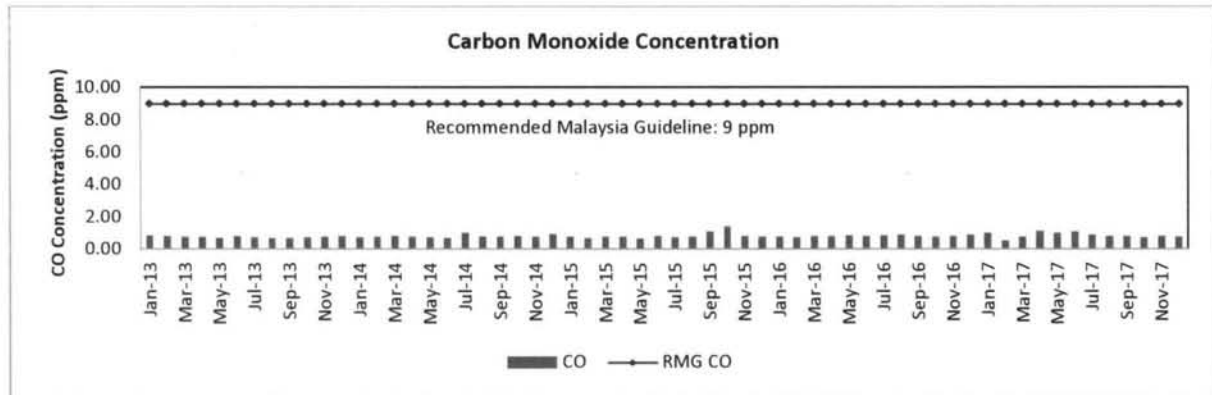
APPENDIX A

The pollutants concentration compliance with the Recommended Malaysia
Ambient Air Quality Guidelines (RMAAQG) (2013-2017)

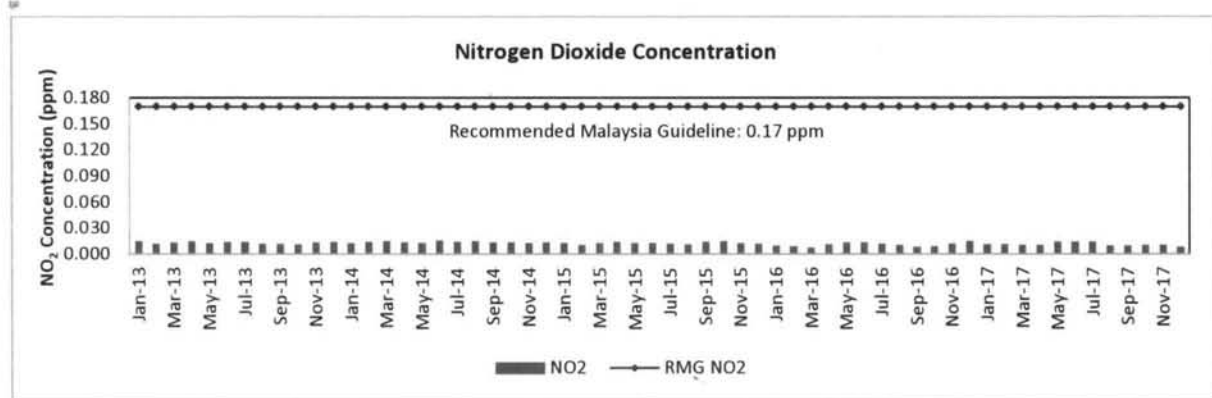
Perai



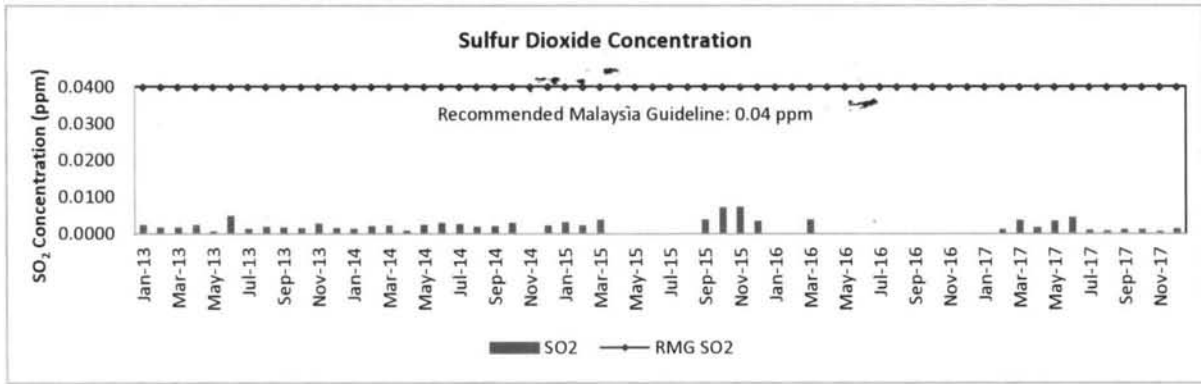
Particulate Matter (PM₁₀) Concentration at Perai in 2013 to 2017. Source from Department of Environmental Malaysia.



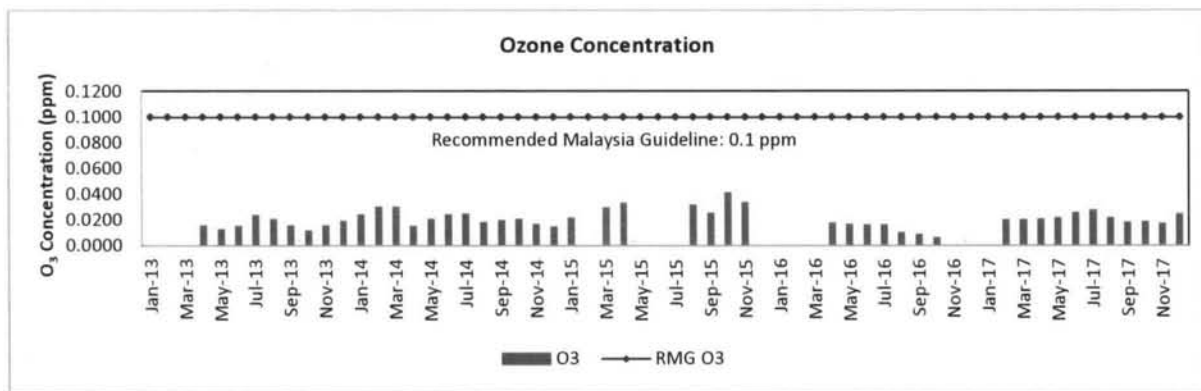
Carbon Monoxide (CO) Concentration at Perai in 2013 to 2017. Source from Department of Environmental Malaysia.



Nitrogen Dioxide (NO₂) Concentration at Perai in 2013 to 2017. Source from Department of Environmental Malaysia.

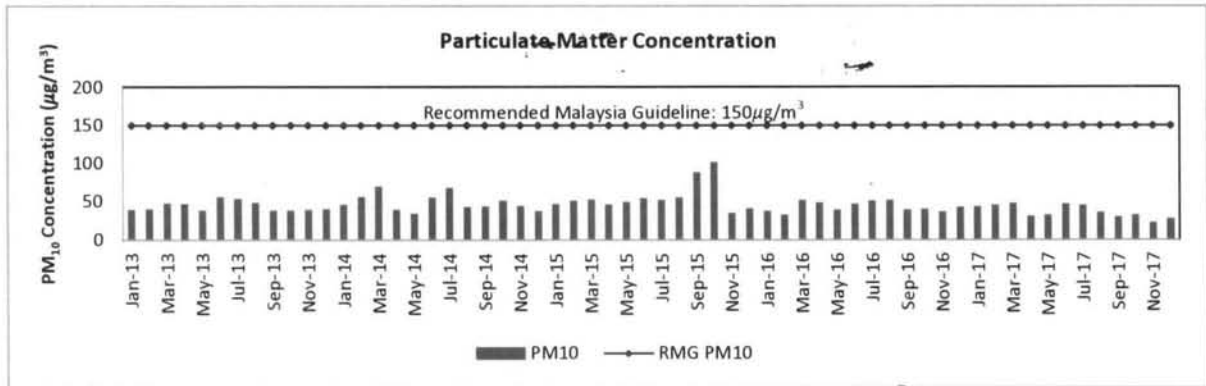


Sulfur Dioxide (SO₂) Concentration at Perai in 2013 to 2017. Source from Department of Environmental Malaysia.

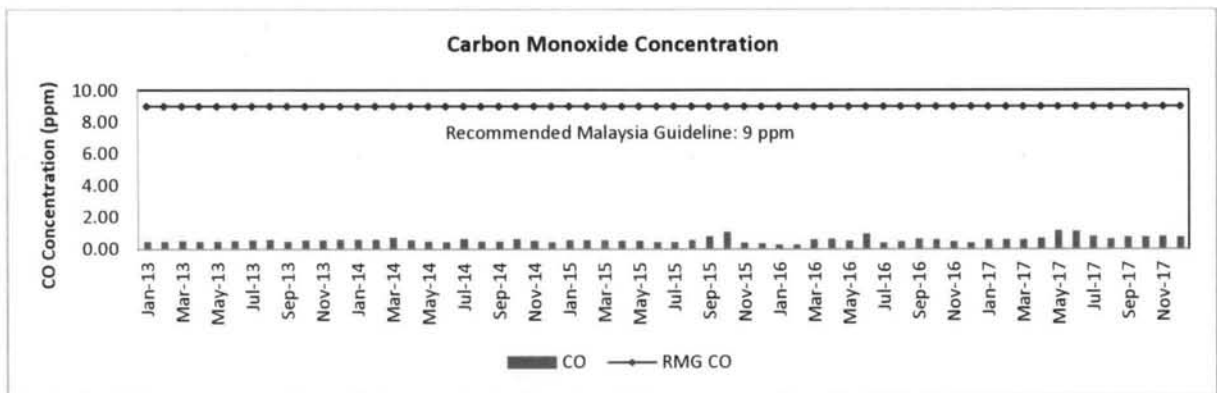


Ozone (O₃) Concentration at Perai in 2013 to 2017. Source from Department of Environmental Malaysia.

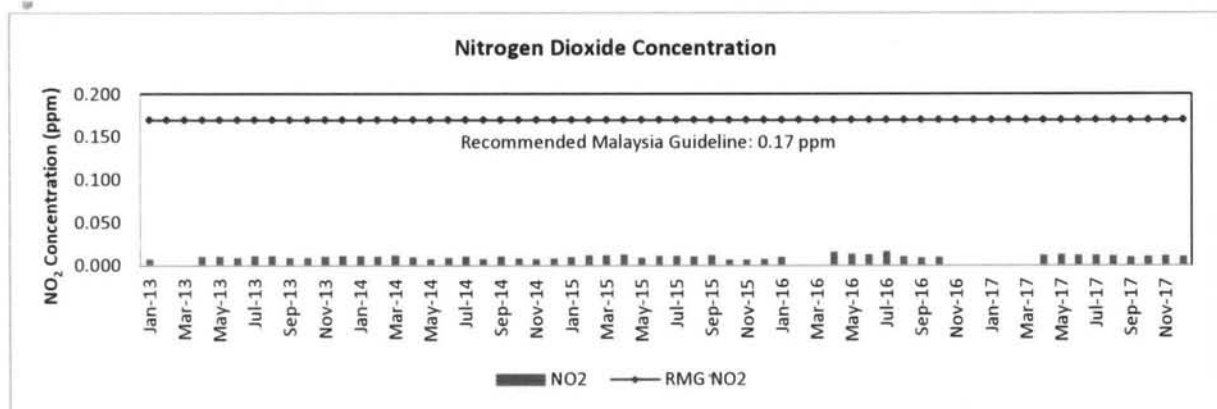
Ipoh



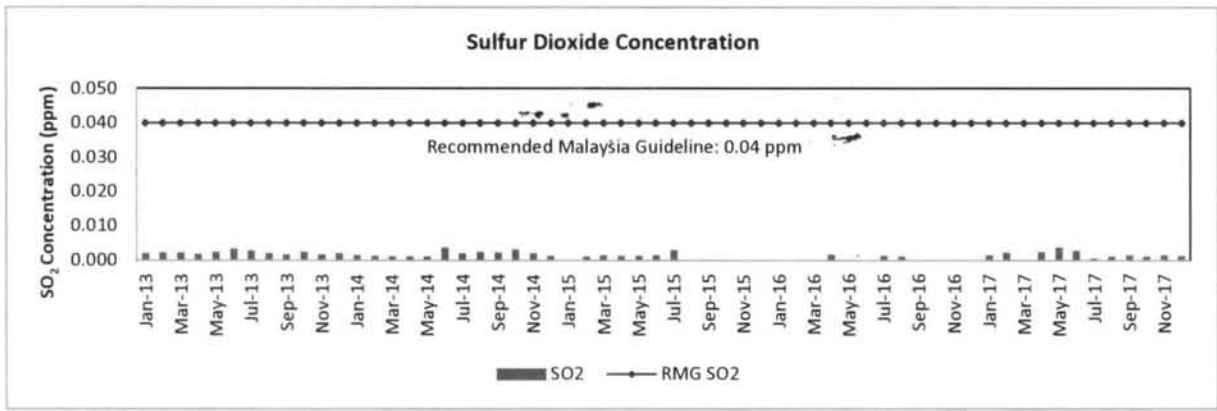
Particulate Matter (PM₁₀) Concentration at Ipoh in 2013 to 2017. Source from Department of Environmental Malaysia.



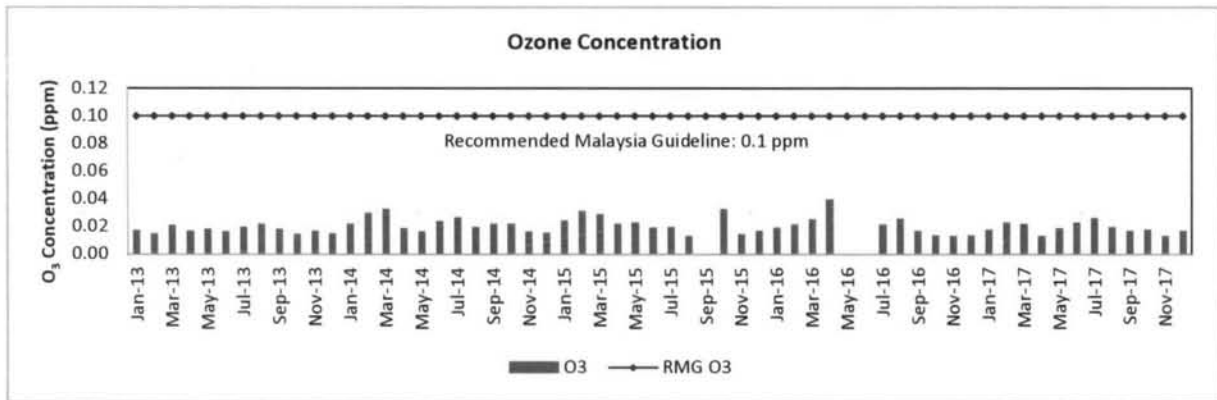
Carbon Monoxide (CO) Concentration at Ipoh in 2013 to 2017. Source from Department of Environmental Malaysia.



Nitrogen Dioxide (NO₂) Concentration at Ipoh in 2013 to 2017. Source from Department of Environmental Malaysia.

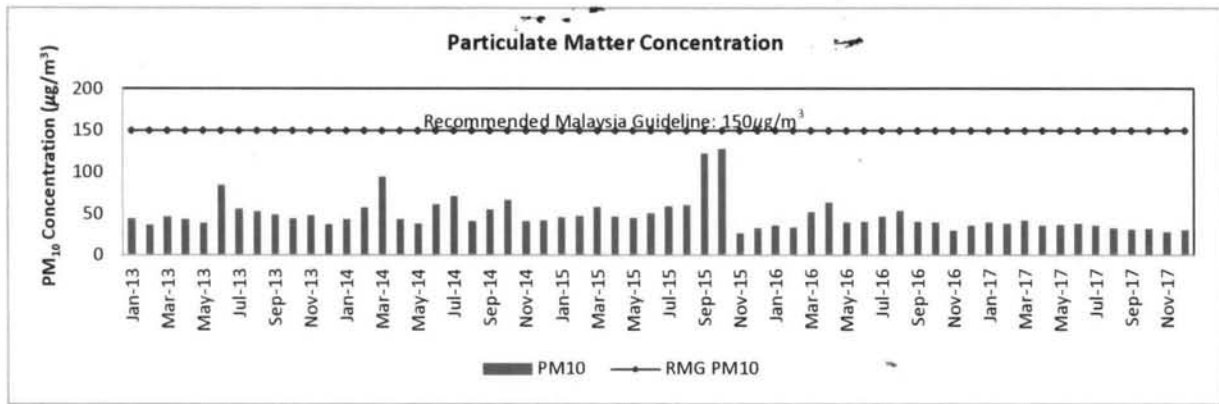


Sulfur Dioxide (SO₂) Concentration at Ipoh in 2013 to 2017. Source from Department of Environmental Malaysia.

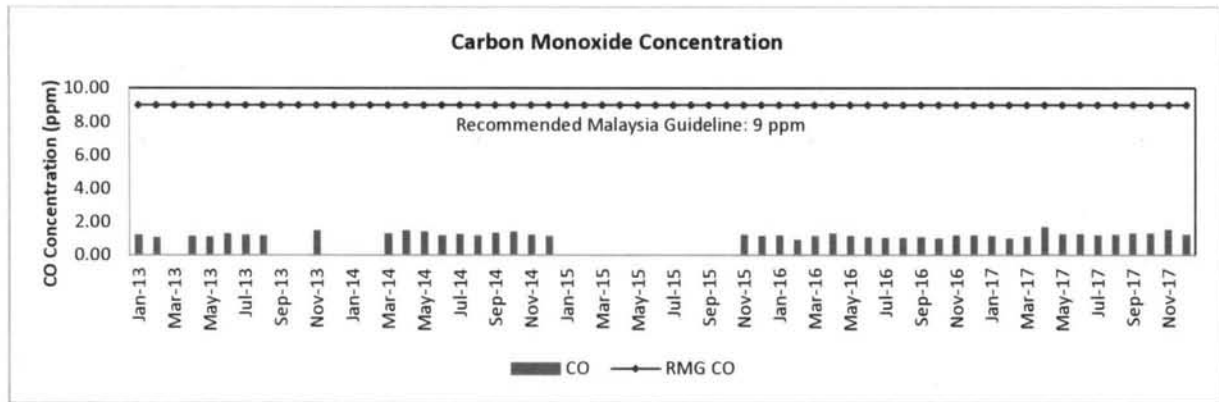


Ozone (O₃) Concentration at Ipoh in 2013 to 2017. Source from Department of Environmental Malaysia.

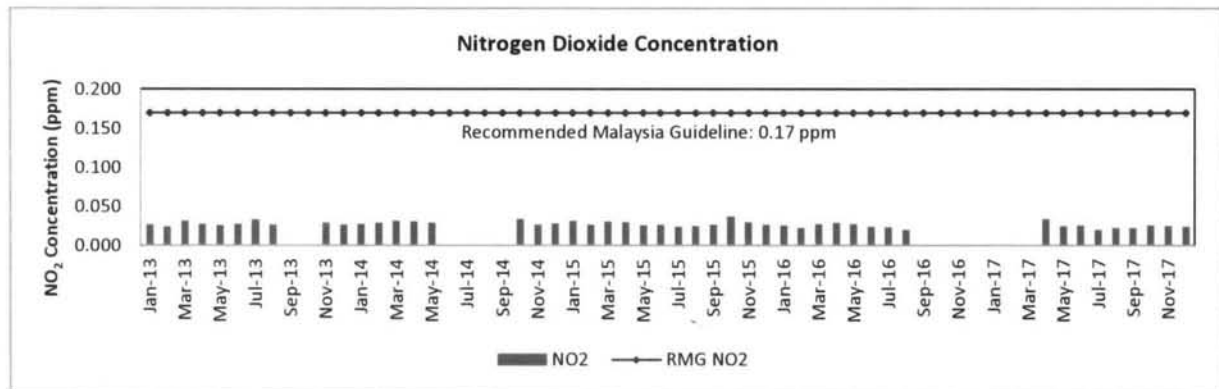
Petaling Jaya



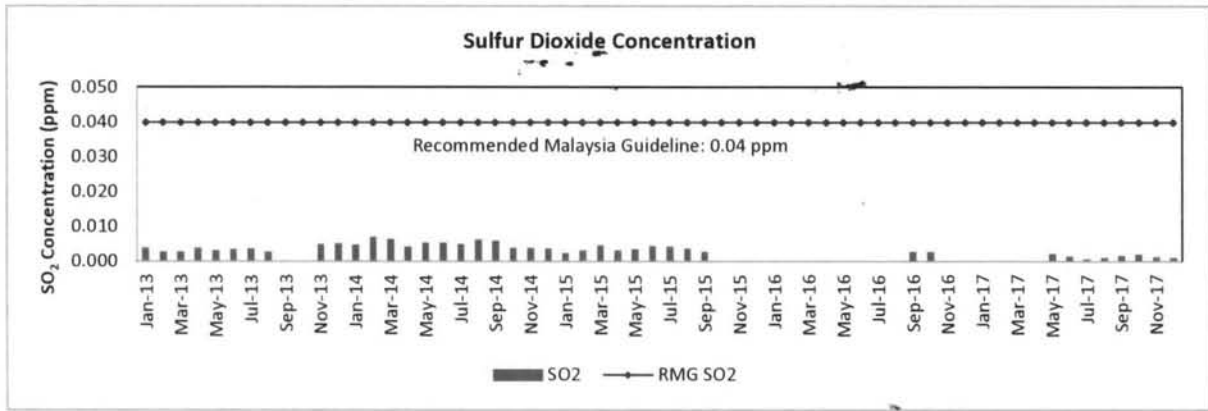
Particulate Matter (PM₁₀) Concentration at Petaling Jaya in 2013 to 2017. Source from Department of Environmental Malaysia.



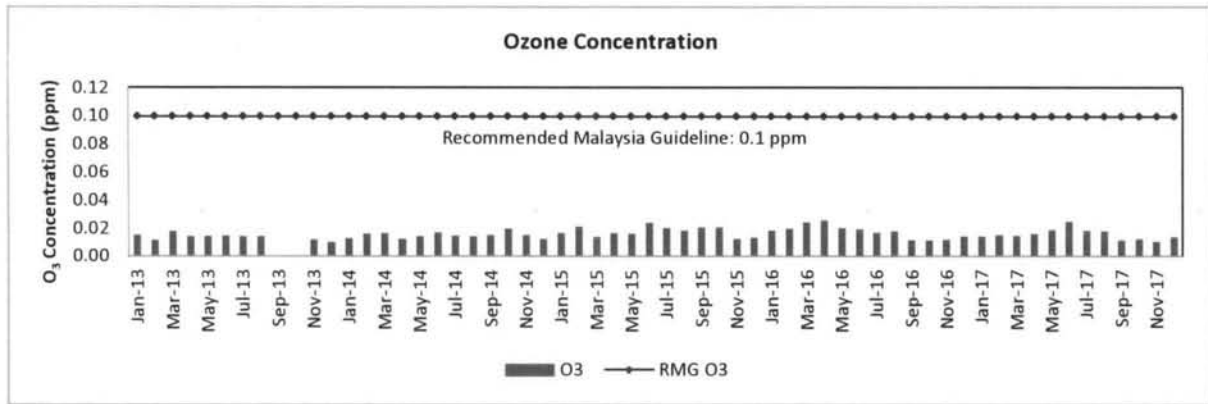
Carbon Monoxide (CO) Concentration at Petaling Jaya in 2013 to 2017. Source from Department of Environmental Malaysia.



Nitrogen Dioxide (NO₂) Concentration at Petaling Jaya in 2013 to 2017. Source from Department of Environmental Malaysia.



Sulfur Dioxide (SO₂) Concentration at Petaling Jaya in 2013 to 2017. Source from Department of Environmental Malaysia.



Ozone (O₃) Concentration at Petaling Jaya in 2013 to 2017. Source from Department of Environmental Malaysia.

APPENDIX B

Air Pollutant Monthly Data at Perai, Ipoh and Petaling Jaya (2013-2017)

Air Pollutants Monthly Data at Perai (2013 - 2017)

Month	RMG PM10	PM10	%	RMG CO	CO	%	RMG O3	O3	%	RMG SO2	SO2	%	RMG NO2	NO2	%
Jan-13	150	39	74.27	9	0.83	90.73	0.1	-	-	0.04	0.0026	93.50	0.17	0.014	91.59
Feb-13	150	35	76.60	9	0.81	90.96	0.1	-	-	0.04	0.0018	95.50	0.17	0.012	92.94
Mar-13	150	42	72.10	9	0.77	91.47	0.1	-	-	0.04	0.0019	95.25	0.17	0.013	92.24
Apr-13	150	37	75.24	9	0.75	91.67	0.1	0.0161	83.90	0.04	0.0025	93.75	0.17	0.015	91.41
May-13	150	33	78.28	9	0.68	92.48	0.1	0.0126	87.40	0.04	0.0008	98.00	0.17	0.012	92.71
Jun-13	150	48	68.12	9	0.81	90.99	0.1	0.0154	84.60	0.04	0.0049	87.75	0.17	0.014	91.82
Jul-13	150	54	63.85	9	0.74	91.75	0.1	0.0238	76.20	0.04	0.0014	96.50	0.17	0.014	92.00
Aug-13	150	44	70.36	9	0.70	92.26	0.1	0.0211	78.90	0.04	0.0020	95.00	0.17	0.012	93.18
Sep-13	150	36	76.02	9	0.69	92.37	0.1	0.0157	84.30	0.04	0.0018	95.50	0.17	0.012	93.24
Oct-13	150	26	82.56	9	0.73	91.93	0.1	0.0120	88.00	0.04	0.0016	96.00	0.17	0.011	93.35
Nov-13	150	34	77.24	9	0.78	91.31	0.1	0.0161	83.90	0.04	0.0028	93.00	0.17	0.013	92.35
Dec-13	150	33	77.96	9	0.80	91.15	0.1	0.0193	80.70	0.04	0.0016	96.00	0.17	0.014	92.00
Jan-14	150	38	74.55	9	0.72	92.02	0.1	0.0244	75.60	0.04	0.0014	96.50	0.17	0.013	92.47
Feb-14	150	55	63.04	9	0.76	91.54	0.1	0.0301	69.90	0.04	0.0022	94.50	0.17	0.014	91.76
Mar-14	150	62	58.43	9	0.81	90.96	0.1	0.0304	69.60	0.04	0.0024	94.00	0.17	0.015	91.29
Apr-14	150	34	77.28	9	0.77	91.41	0.1	0.0154	84.60	0.04	0.0010	97.50	0.17	0.013	92.18
May-14	150	30	80.06	9	0.72	91.99	0.1	0.0211	78.90	0.04	0.0026	93.50	0.17	0.013	92.53
Jun-14	150	57	61.95	9	0.68	92.45	0.1	0.0243	75.70	0.04	0.0031	92.25	0.17	0.016	90.82
Jul-14	150	60	60.05	9	1.01	88.74	0.1	0.0246	75.40	0.04	0.0027	93.25	0.17	0.014	91.88
Aug-14	150	38	74.93	9	0.78	91.28	0.1	0.0182	81.80	0.04	0.0020	95.00	0.17	0.014	91.59
Sep-14	150	35	76.65	9	0.78	91.31	0.1	0.0196	80.40	0.04	0.0021	94.75	0.17	0.014	92.06
Oct-14	150	41	72.83	9	0.80	91.16	0.1	0.0208	79.20	0.04	0.0031	92.25	0.17	0.013	92.24
Nov-14	150	30	79.90	9	0.78	91.37	0.1	0.0170	83.00	0.04	-	-	0.17	0.013	92.53
Dec-14	150	29	80.50	9	0.91	89.90	0.1	0.0148	85.20	0.04	0.0024	94.00	0.17	0.013	92.35
Jan-15	150	44	70.44	9	0.78	91.38	0.1	0.0221	77.90	0.04	0.0032	92.00	0.17	0.013	92.59
Feb-15	150	44	70.44	9	0.68	92.50	0.1	-	-	0.04	0.0024	94.00	0.17	0.010	94.00
Mar-15	150	46	69.54	9	0.75	91.62	0.1	0.0297	70.30	0.04	0.0038	90.50	0.17	0.012	92.82
Apr-15	150	37	75.35	9	0.76	91.56	0.1	0.0336	66.40	0.04	-	-	0.17	0.014	91.82
May-15	150	36	75.83	9	0.65	92.79	0.1	-	-	0.04	-	-	0.17	0.012	92.82
Jun-15	150	48	67.90	9	0.80	91.11	0.1	-	-	0.04	-	-	0.17	0.012	92.76

Month	RMG PM10	PM10	%	RMG CO	CO	%	RMG O3	O3	%	RMG SO2	SO2	%	RMG NO2	NO2	%
Jul-15	150	41	72.41	9	0.74	91.79	0.1	-	-	0.04	-	-	0.17	0.012	93.18
Aug-15	150	44	70.97	9	0.78	91.33	0.1	0.0317	68.30	0.04	-	-	0.17	0.011	93.29
Sep-15	150	64	57.05	9	1.05	88.28	0.1	0.0253	74.70	0.04	0.0040	90.00	0.17	0.014	91.82
Oct-15	150	98	34.96	9	1.39	84.59	0.1	0.0412	58.80	0.04	0.0072	82.00	0.17	0.015	91.41
Nov-15	150	26	82.34	9	0.81	91.01	0.1	0.0341	65.90	0.04	0.0074	81.50	0.17	0.013	92.59
Dec-15	150	30	80.31	9	0.76	91.57	0.1	-	-	0.04	0.0036	91.00	0.17	0.012	93.24
Jan-16	150	30	80.16	9	0.79	91.26	0.1	-	-	0.04	-	-	0.17	0.009	94.47
Feb-16	150	33	78.18	9	0.72	91.95	0.1	-	-	0.04	-	-	0.17	0.009	94.82
Mar-16	150	49	67.25	9	0.79	91.24	0.1	-	-	0.04	0.0040	90.00	0.17	0.007	95.71
Apr-16	150	44	70.43	9	0.81	91.00	0.1	0.0180	82.00	0.04	-	-	0.17	0.011	93.29
May-16	150	34	77.22	9	0.84	90.61	0.1	0.0169	83.10	0.04	-	-	0.17	0.013	92.41
Jun-16	150	41	72.76	9	0.79	91.18	0.1	0.0165	83.50	0.04	-	-	0.17	0.013	92.12
Jul-16	150	42	71.94	9	0.83	90.73	0.1	0.0163	83.70	0.04	-	-	0.17	0.012	93.18
Aug-16	150	40	73.40	9	0.87	90.33	0.1	0.0102	89.80	0.04	-	-	0.17	0.010	93.94
Sep-16	150	30	80.21	9	0.79	91.18	0.1	0.0087	91.30	0.04	-	-	0.17	0.008	95.41
Oct-16	150	31	79.35	9	0.76	91.52	0.1	0.0063	93.70	0.04	-	-	0.17	0.009	94.88
Nov-16	150	29	80.76	9	0.81	90.98	0.1	-	-	0.04	-	-	0.17	0.012	93.12
Dec-16	150	31	79.04	9	0.90	90.00	0.1	-	-	0.04	-	-	0.17	0.015	91.47
Jan-17	150	34	77.32	9	1.02	88.71	0.1	-	-	0.04	-	-	0.17	0.011	93.71
Feb-17	150	34	77.16	9	0.51	94.31	0.1	0.0204	79.60	0.04	0.0012	97.00	0.17	0.011	93.71
Mar-17	150	39	74.06	9	0.75	91.67	0.1	0.0202	79.80	0.04	0.0037	90.75	0.17	0.010	93.94
Apr-17	150	23	84.44	9	1.09	87.86	0.1	0.0208	79.20	0.04	0.0018	95.50	0.17	0.010	93.94
May-17	150	30	79.68	9	1.01	88.78	0.1	0.0221	77.90	0.04	0.0036	91.00	0.17	0.014	91.88
Jun-17	150	30	79.75	9	1.07	88.09	0.1	0.0261	73.90	0.04	0.0046	88.50	0.17	0.014	92.00
Jul-17	150	42	72.15	9	0.90	90.03	0.1	0.0279	72.10	0.04	0.0011	97.25	0.17	0.014	91.65
Aug-17	150	27	81.85	9	0.81	91.01	0.1	0.0217	78.30	0.04	0.0010	97.50	0.17	0.010	94.35
Sep-17	150	22	85.58	9	0.79	91.18	0.1	0.0183	81.70	0.04	0.0012	97.00	0.17	0.010	94.35
Oct-17	150	25	83.07	9	0.73	91.93	0.1	0.0189	81.10	0.04	0.0012	97.00	0.17	0.010	94.18
Nov-17	150	22	85.59	9	0.82	90.86	0.1	0.0175	82.50	0.04	0.0007	98.25	0.17	0.010	94.06
Dec-17	150	27	82.12	9	0.77	91.39	0.1	0.0249	75.10	0.04	0.0014	96.50	0.17	0.008	95.18

Air Pollutants Monthly Data at Ipoh (2013 - 2017)

Month	RMG PM10	PM10	%	RMG CO	CO	%	RMG O3	O3	%	RMG SO2	SO2	%	RMG NO2	NO2	%
Jan-13	150	40	73.52	9	0.48	94.71	0.1	0.02	82.40	0.04	0.002	95.25	0.17	0.007	95.76
Feb-13	150	40	73.26	9	0.47	94.79	0.1	0.02	84.90	0.04	0.002	94.75	0.17	-	-
Mar-13	150	48	68.27	9	0.52	94.19	0.1	0.02	79.10	0.04	0.002	94.75	0.17	-	-
Apr-13	150	47	68.51	9	0.49	94.60	0.1	0.02	83.00	0.04	0.002	95.50	0.17	0.010	94.00
May-13	150	39	74.27	9	0.47	94.73	0.1	0.02	81.80	0.04	0.002	94.00	0.17	0.010	94.24
Jun-13	150	56	62.41	9	0.51	94.29	0.1	0.02	83.60	0.04	0.003	91.75	0.17	0.008	95.12
Jul-13	150	53	64.36	9	0.53	94.08	0.1	0.02	80.50	0.04	0.003	93.25	0.17	0.011	93.82
Aug-13	150	49	67.25	9	0.57	93.68	0.1	0.02	77.80	0.04	0.002	95.25	0.17	0.011	93.53
Sep-13	150	38	74.52	9	0.48	94.68	0.1	0.02	81.50	0.04	0.002	96.00	0.17	0.009	94.94
Oct-13	150	38	74.36	9	0.54	94.00	0.1	0.01	85.30	0.04	0.003	93.75	0.17	0.009	94.76
Nov-13	150	39	73.99	9	0.55	93.85	0.1	0.02	83.20	0.04	0.002	95.75	0.17	0.010	93.94
Dec-13	150	40	73.04	9	0.59	93.43	0.1	0.02	84.80	0.04	0.002	95.25	0.17	0.011	93.82
Jan-14	150	46	69.42	9	0.57	93.68	0.1	0.02	78.30	0.04	0.001	96.50	0.17	0.011	93.71
Feb-14	150	56	62.47	9	0.58	93.50	0.1	0.03	70.00	0.04	0.001	97.00	0.17	0.010	94.12
Mar-14	150	70	53.52	9	0.69	92.37	0.1	0.03	67.20	0.04	0.001	97.25	0.17	0.012	93.06
Apr-14	150	40	73.60	9	0.56	93.77	0.1	0.02	81.40	0.04	0.001	97.25	0.17	0.010	94.29
May-14	150	35	76.99	9	0.49	94.58	0.1	0.02	83.40	0.04	0.001	97.50	0.17	0.007	95.65
Jun-14	150	56	62.91	9	0.45	95.00	0.1	0.02	75.90	0.04	0.004	91.00	0.17	0.009	95.00
Jul-14	150	68	54.43	9	0.63	93.05	0.1	0.03	73.60	0.04	0.002	95.00	0.17	0.010	93.94
Aug-14	150	43	71.58	9	0.48	94.67	0.1	0.02	80.50	0.04	0.003	93.75	0.17	0.007	95.76
Sep-14	150	44	70.79	9	0.49	94.60	0.1	0.02	78.20	0.04	0.002	94.50	0.17	0.010	94.12
Oct-14	150	51	65.90	9	0.61	93.20	0.1	0.02	77.70	0.04	0.003	92.00	0.17	0.008	95.47
Nov-14	150	44	70.38	9	0.50	94.46	0.1	0.02	83.80	0.04	0.002	95.00	0.17	0.007	95.82
Dec-14	150	38	74.84	9	0.43	95.23	0.1	0.02	84.70	0.04	0.001	96.75	0.17	0.008	95.47
Jan-15	150	47	68.82	9	0.53	94.09	0.1	0.02	75.70	0.04	-	-	0.17	0.009	94.65
Feb-15	150	52	65.62	9	0.54	94.02	0.1	0.03	68.70	0.04	0.001	97.25	0.17	0.012	93.12
Mar-15	150	53	64.67	9	0.54	94.05	0.1	0.03	71.00	0.04	0.002	96.25	0.17	0.012	92.94
Apr-15	150	46	69.34	9	0.49	94.52	0.1	0.02	78.00	0.04	0.001	96.75	0.17	0.012	92.76
May-15	150	49	67.22	9	0.51	94.30	0.1	0.02	76.80	0.04	0.001	97.00	0.17	0.008	95.06
Jun-15	150	55	63.49	9	0.44	95.12	0.1	0.02	80.70	0.04	0.001	96.50	0.17	0.011	93.76

Month	RMG PM10	PM10	%	RMG CO	CO	%	RMG O3	O3	%	RMG SO2	SO2	%	RMG NO2	NO2	%
Jul-15	150	52	65.31	9	0.42	95.33	0.1	0.02	80.20	0.04	0.003	92.50	0.17	0.011	93.47
Aug-15	150	55	63.26	9	0.54	94.01	0.1	0.01	86.80	0.04	-	-	0.17	0.010	94.24
Sep-15	150	88	41.16	9	0.81	90.95	0.1	-	-	0.04	-	-	0.17	0.012	92.82
Oct-15	150	102	32.06	9	1.09	87.92	0.1	0.03	67.60	0.04	-	-	0.17	0.007	96.06
Nov-15	150	35	76.43	9	0.39	95.69	0.1	0.01	85.40	0.04	-	-	0.17	0.006	96.24
Dec-15	150	41	72.89	9	0.36	96.00	0.1	0.02	83.10	0.04	-	-	0.17	0.007	95.65
Jan-16	150	37	75.00	9	0.29	96.74	0.1	0.02	80.70	0.04	-	-	0.17	0.009	94.59
Feb-16	150	32	78.34	9	0.24	97.30	0.1	0.02	78.60	0.04	-	-	0.17	-	-
Mar-16	150	52	65.42	9	0.59	93.45	0.1	0.03	74.90	0.04	-	-	0.17	-	-
Apr-16	150	49	67.54	9	0.63	93.01	0.1	0.04	60.20	0.04	0.002	96.00	0.17	0.015	91.06
May-16	150	39	73.93	9	0.52	94.19	0.1	-	-	0.04	-	-	0.17	0.013	92.35
Jun-16	150	46	69.02	9	0.97	89.17	0.1	-	-	0.04	-	-	0.17	0.013	92.53
Jul-16	150	51	66.09	9	0.39	95.67	0.1	0.02	78.60	0.04	0.001	97.00	0.17	0.016	90.35
Aug-16	150	52	65.59	9	0.48	94.61	0.1	0.03	74.10	0.04	0.001	97.50	0.17	0.010	94.06
Sep-16	150	40	73.48	9	0.62	93.07	0.1	0.02	82.80	0.04	-	-	0.17	0.009	94.94
Oct-16	150	40	73.05	9	0.60	93.30	0.1	0.01	86.20	0.04	-	-	0.17	0.010	94.41
Nov-16	150	37	75.34	9	0.48	94.62	0.1	0.01	86.90	0.04	-	-	0.17	-	-
Dec-16	150	43	71.43	9	0.39	95.63	0.1	0.01	86.40	0.04	-	-	0.17	-	-
Jan-17	150	44	70.98	9	0.58	93.55	0.1	0.02	82.30	0.04	0.001	96.50	0.17	-	-
Feb-17	150	45	70.12	9	0.60	93.29	0.1	0.02	76.90	0.04	0.002	94.25	0.17	-	-
Mar-17	150	48	67.82	9	0.60	93.34	0.1	0.02	78.20	0.04	-	-	0.17	-	-
Apr-17	150	31	79.23	9	0.68	92.46	0.1	0.01	87.00	0.04	0.003	93.75	0.17	0.012	93.12
May-17	150	33	78.28	9	1.16	87.06	0.1	0.02	81.10	0.04	0.004	91.00	0.17	0.013	92.59
Jun-17	150	46	69.05	9	1.10	87.76	0.1	0.02	76.90	0.04	0.003	93.25	0.17	0.012	93.18
Jul-17	150	45	69.74	9	0.81	91.03	0.1	0.03	73.80	0.04	0.001	98.50	0.17	0.012	93.00
Aug-17	150	36	76.31	9	0.64	92.85	0.1	0.02	80.50	0.04	0.001	97.50	0.17	0.011	93.47
Sep-17	150	30	79.67	9	0.74	91.76	0.1	0.02	83.00	0.04	0.001	96.50	0.17	0.009	94.53
Oct-17	150	32	78.39	9	0.75	91.70	0.1	0.02	82.00	0.04	0.001	97.25	0.17	0.010	94.12
Nov-17	150	22	85.05	9	0.80	91.10	0.1	0.01	86.70	0.04	0.001	96.50	0.17	0.011	93.59
Dec-17	150	27	81.71	9	0.78	91.35	0.1	0.02	83.20	0.04	0.001	97.00	0.17	0.010	94.06

Air Pollutants Monthly Data at Petaling Jaya (2013 - 2017)

Month	RMG PM10	PM10	%	RMG CO	CO	%	RMG O3	O3	%	RMG SO2	SO2	%	RMG NO2	NO2	%
Jan-13	150	44	70.62	9	1.21	86.58	0.1	0.02	84.60	0.04	0.004	90.25	0.17	0.026	84.65
Feb-13	150	36	75.76	9	1.05	88.31	0.1	0.01	88.60	0.04	0.003	93.50	0.17	0.024	85.71
Mar-13	150	46	69.10	9	-	-	0.1	0.02	82.00	0.04	0.003	93.25	0.17	0.031	81.76
Apr-13	150	44	70.79	9	1.13	87.47	0.1	0.01	85.40	0.04	0.004	90.50	0.17	0.027	84.06
May-13	150	38	74.41	9	1.07	88.10	0.1	0.01	85.90	0.04	0.003	92.00	0.17	0.026	84.88
Jun-13	150	84	43.94	9	1.28	85.78	0.1	0.01	85.20	0.04	0.004	91.25	0.17	0.027	84.00
Jul-13	150	56	62.95	9	1.22	86.48	0.1	0.01	85.70	0.04	0.004	90.75	0.17	0.033	80.59
Aug-13	150	53	64.68	9	1.19	86.77	0.1	0.01	85.50	0.04	0.003	93.25	0.17	0.027	84.41
Sep-13	150	49	67.64	9	-	-	0.1	-	-	0.04	-	-	0.17	-	-
Oct-13	150	44	70.45	9	-	-	0.1	-	-	0.04	-	-	0.17	-	-
Nov-13	150	48	67.95	9	1.49	83.49	0.1	0.01	87.80	0.04	0.005	87.50	0.17	0.029	83.18
Dec-13	150	37	75.21	9	-	-	0.1	0.01	89.50	0.04	0.005	87.00	0.17	0.027	84.24
Jan-14	150	44	70.92	9	-	-	0.1	0.01	87.10	0.04	0.005	88.25	0.17	0.028	83.76
Feb-14	150	57	61.74	9	-	-	0.1	0.02	83.70	0.04	0.007	82.75	0.17	0.029	83.24
Mar-14	150	95	36.78	9	1.29	85.69	0.1	0.02	83.20	0.04	0.006	84.00	0.17	0.031	81.71
Apr-14	150	43	71.04	9	1.48	83.58	0.1	0.01	87.70	0.04	0.004	89.50	0.17	0.031	82.00
May-14	150	38	74.42	9	1.40	84.48	0.1	0.01	85.90	0.04	0.005	86.75	0.17	0.029	82.82
Jun-14	150	62	58.90	9	1.17	87.03	0.1	0.02	83.00	0.04	0.005	86.75	0.17	-	-
Jul-14	150	71	52.43	9	1.25	86.09	0.1	0.02	85.00	0.04	0.005	87.50	0.17	-	-
Aug-14	150	41	72.44	9	1.17	86.99	0.1	0.01	85.80	0.04	0.006	84.25	0.17	-	-
Sep-14	150	55	63.39	9	1.32	85.34	0.1	0.02	84.50	0.04	0.006	85.25	0.17	-	-
Oct-14	150	67	55.38	9	1.39	84.53	0.1	0.02	80.20	0.04	0.004	90.25	0.17	0.034	80.00
Nov-14	150	41	72.56	9	1.24	86.27	0.1	0.02	84.70	0.04	0.004	90.50	0.17	0.027	84.24
Dec-14	150	42	72.01	9	1.16	87.12	0.1	0.01	87.30	0.04	0.004	90.75	0.17	0.028	83.29
Jan-15	150	46	69.66	9	-	-	0.1	0.02	83.30	0.04	0.002	94.00	0.17	0.031	81.59
Feb-15	150	47	68.54	9	-	-	0.1	0.02	78.90	0.04	0.003	92.25	0.17	0.027	84.35
Mar-15	150	58	61.27	9	-	-	0.1	0.01	86.40	0.04	0.005	88.75	0.17	0.031	82.06
Apr-15	150	46	69.04	9	-	-	0.1	0.02	83.20	0.04	0.003	92.25	0.17	0.030	82.47
May-15	150	45	70.09	9	-	-	0.1	0.02	83.60	0.04	0.003	91.50	0.17	0.025	85.06
Jun-15	150	50	66.61	9	-	-	0.1	0.02	76.20	0.04	0.004	89.25	0.17	0.026	84.53

Month	RMG PM10	PM10	%	RMG CO	CO	%	RMG O3	O3	%	RMG SO2	SO2	%	RMG NO2	NO2	%
Jul-15	150	59	60.82	9	-	-	0.1	0.02	79.60	0.04	0.004	89.50	0.17	0.025	85.59
Aug-15	150	61	59.43	9	-	-	0.1	0.02	81.80	0.04	0.004	91.00	0.17	0.025	85.53
Sep-15	150	122	18.54	9	-	-	0.1	0.02	79.20	0.04	0.003	93.25	0.17	0.027	84.24
Oct-15	150	128	14.95	9	-	-	0.1	0.02	79.20	0.04	-	-	0.17	0.037	78.29
Nov-15	150	26	82.55	9	1.23	86.35	0.1	0.01	87.40	0.04	-	-	0.17	0.030	82.35
Dec-15	150	33	78.19	9	1.12	87.54	0.1	0.01	86.50	0.04	-	-	0.17	0.027	84.29
Jan-16	150	36	76.19	9	1.20	86.72	0.1	0.02	81.40	0.04	-	-	0.17	0.026	84.71
Feb-16	150	34	77.43	9	0.90	90.01	0.1	0.02	80.40	0.04	-	-	0.17	0.023	86.53
Mar-16	150	52	65.41	9	1.13	87.47	0.1	0.02	75.50	0.04	-	-	0.17	0.027	83.94
Apr-16	150	63	57.76	9	1.29	85.66	0.1	0.03	74.10	0.04	-	-	0.17	0.029	83.06
May-16	150	40	73.49	9	1.15	87.20	0.1	0.02	79.80	0.04	-	-	0.17	0.028	83.76
Jun-16	150	40	73.05	9	1.05	88.34	0.1	0.02	80.80	0.04	-	-	0.17	0.024	85.94
Jul-16	150	47	68.99	9	1.02	88.65	0.1	0.02	83.10	0.04	-	-	0.17	0.024	86.18
Aug-16	150	54	64.03	9	1.02	88.66	0.1	0.02	82.10	0.04	-	-	0.17	0.019	88.59
Sep-16	150	41	72.91	9	1.05	88.36	0.1	0.01	88.40	0.04	0.003	93.25	0.17	-	-
Oct-16	150	40	73.45	9	0.97	89.27	0.1	0.01	88.40	0.04	0.003	93.50	0.17	-	-
Nov-16	150	30	80.26	9	1.16	87.06	0.1	0.01	88.10	0.04	-	-	0.17	-	-
Dec-16	150	36	76.25	9	1.18	86.93	0.1	0.01	85.90	0.04	-	-	0.17	-	-
Jan-17	150	39	73.84	9	1.14	87.33	0.1	0.01	85.80	0.04	-	-	0.17	-	-
Feb-17	150	38	74.50	9	0.98	89.11	0.1	0.02	84.80	0.04	-	-	0.17	-	-
Mar-17	150	42	71.96	9	1.09	87.89	0.1	0.02	84.90	0.04	-	-	0.17	-	-
Apr-17	150	36	76.16	9	1.70	81.17	0.1	0.02	83.60	0.04	-	-	0.17	0.034	80.00
May-17	150	36	75.73	9	1.26	86.03	0.1	0.02	81.00	0.04	0.002	94.75	0.17	0.025	85.35
Jun-17	150	38	74.62	9	1.25	86.13	0.1	0.02	75.40	0.04	0.001	96.50	0.17	0.026	84.88
Jul-17	150	36	76.03	9	1.18	86.92	0.1	0.02	81.80	0.04	0.001	98.25	0.17	0.020	88.53
Aug-17	150	33	78.11	9	1.22	86.42	0.1	0.02	82.00	0.04	0.001	97.50	0.17	0.022	86.82
Sep-17	150	31	79.58	9	1.30	85.54	0.1	0.01	88.20	0.04	0.002	96.00	0.17	0.022	86.82
Oct-17	150	32	78.76	9	1.28	85.79	0.1	0.01	87.60	0.04	0.002	95.25	0.17	0.026	85.00
Nov-17	150	28	81.49	9	1.52	83.09	0.1	0.01	89.20	0.04	0.001	96.75	0.17	0.025	85.12
Dec-17	150	30	79.76	9	1.20	86.66	0.1	0.01	86.30	0.04	0.001	97.25	0.17	0.024	85.82

APPENDIX C

Meteorological Monthly Data at Perai, Ipoh and Petaling Jaya (2013-2017)

Meteorological Monthly Data at Perai, Ipoh and Petaling Jaya (2013 – 2017)

Month	Perai			Ipoh			Petaling Jaya		
	Rainfall (mm)	Temperature (°C)	Humidity (%)	Rainfall (mm)	Temperature (°C)	Humidity (%)	Rainfall (mm)	Temperature (°C)	Humidity (%)
Jan-13	127.8	27.8	78.2	158.4	27.2	78.6	371.2	28.0	76.9
Feb-13	162.8	27.3	80.7	358.0	26.8	80.9	304.8	27.3	80.5
Mar-13	52.0	29.1	77.2	364.6	27.8	78.3	323.2	28.6	Def.
Apr-13	237.2	28.5	81.4	386.4	27.7	81.9	464.2	28.5	79.7
May-13	100.2	29.2	77.9	222.4	28.3	77.9	338.2	28.9	75.9
Jun-13	205.6	28.8	78.3	115.0	28.2	74.7	19.2	29.7	67.6
Jul-13	145.4	28.5	78.2	24.2	28.0	72.5	151.2	28.3	71.6
Aug-13	166.2	28.0	79.6	144.6	27.6	76.6	189.8	28.5	71.2
Sep-13	382.2	27.6	83.0	128.4	27.2	77.4	249.4	27.7	74.7
Oct-13	437.0	27.1	84.8	433.2	26.6	82.2	341.2	27.9	75.4
Nov-13	300.8	27.2	84.2	223.4	26.8	81.9	289.8	27.1	81.8
Dec-13	45.8	27.5	78.9	129.2	26.5	82.5	527.8	27.1	82.4
Jan-14	116.0	27.3	73.8	217.0	26.4	75.9	220.8	27.2	72.0
Feb-14	0.0	28.5	73.2	64.6	28.0	68.3	42.4	29.1	64.8
Mar-14	44.4	29.2	75.7	35.2	28.7	70.3	175.2	29.0	70.8
Apr-14	128.6	28.6	83.2	341.4	27.2	82.1	573.2	27.8	82.5
May-14	267.2	28.5	83.4	260.8	27.5	82.2	372.2	28.2	80.2
Jun-14	89.4	29.5	80.6	83.0	28.8	73.5	46.6	30.1	67.8
Jul-14	114.6	29.1	77.1	18.2	28.6	72.2	59.4	29.6	67.2
Aug-14	326.8	27.7	81.3	269.6	27.2	78.3	199.2	28.1	73.8
Sep-14	287.0	27.9	81.1	182.8	27.0	79.3	282.6	28.2	74.2
Oct-14	386.8	27.6	83.1	341.2	26.8	83.2	624.0	27.7	78.1
Nov-14	195.4	27.7	81.4	329.0	26.7	85.3	600.6	27.3	79.9
Dec-14	235.4	26.9	83.4	358.4	26.2	88.5	518.8	26.8	81.7
Jan-15	45.8	27.7	71.6	238.4	26.9	80.4	392.2	27.5	73.2
Feb-15	22.8	28.6	Def.	93.8	27.9	73.2	113.8	28.4	Def.

Month	Perai			Ipoh			Petaling Jaya		
	Rainfall (mm)	Temperature (°C)	Humidity (%)	Rainfall (mm)	Temperature (°C)	Humidity (%)	Rainfall (mm)	Temperature (°C)	Humidity (%)
Mar-15	101.8	29.0	76.2	132.0	28.0	77.5	414.4	28.5	73.0
Apr-15	349.4	28.6	81.5	489.2	27.5	83.9	519.0	28.4	77.1
May-15	202.6	29.2	Def.	163.8	28.2	82.3	398.2	28.8	75.8
Jun-15	208.0	28.9	79.2	187.2	28.3	79.7	276.6	29.1	71.7
Jul-15	164.8	28.6	80.9	80.0	28.0	78.0	115.6	29.4	67.9
Aug-15	217.6	28.0	80.1	249.0	27.6	80.7	283.6	28.8	70.5
Sep-15	410.8	28.0	83.0	155.8	27.6	80.2	130.2	28.7	71.0
Oct-15	296.2	28.0	82.6	427.2	26.9	83.3	287.2	28.4	73.5
Nov-15	316.8	27.3	85.4	464.4	26.3	86.5	436.4	27.5	80.3
Dec-15	156.6	28.1	82.0	269.8	26.9	81.5	390.2	28.0	78.4
Jan-16	94.8	29.2	77.3	124.0	27.8	79.3	435.6	29.1	73.2
Feb-16	85.6	29.1	72.9	76.8	28.0	75.0	178.0	29.2	68.5
Mar-16	21.2	30.6	73.7	49.0	29.5	71.9	186.2	30.0	70.3
Apr-16	110.2	30.5	76.3	106.8	29.4	74.6	275.6	30.1	72.0
May-16	288.2	29.3	82.2	315.5	28.6	79.8	435.2	29.2	76.4
Jun-16	124.0	29.5	76.3	131.4	28.6	72.3	288.4	29.0	72.2
Jul-16	99.2	28.8	79.7	115.6	28.2	74.2	251.8	28.6	74.4
Aug-16	92.4	29.0	79.0	99.0	28.4	72.4	124.4	29.5	69.3
Sep-16	455.0	28.5	80.4	135.2	28.1	72.4	269.0	28.9	71.5
Oct-16	393.6	28.0	83.9	134.0	28.0	73.2	181.0	28.7	73.0
Nov-16	453.4	27.6	86.5	487.2	27.0	83.7	475.4	27.5	81.0
Dec-16	189.8	27.1	Def.	180.0	27.0	79.7	319.8	27.7	78.3
Jan-17	236.4	27.6	Def.	404.0	26.8	80.3	456.4	28.3	Def.
Feb-17	123.1	Def.	Def.	357.4	27.1	76.8	140.0	Def.	Def.
Mar-17	255.4	Def.	Def.	275.4	27.2	79.6	515.6	Def.	Def.
Apr-17	N.A	Def.	Def.	484.3	27.2	83.2	386.4	Def.	Def.
May-17	412.6	28.8	83.3	265.6	28.1	81.9	298.0	28.7	74.1
Jun-17	140.2	28.8	80.7	132.8	28.0	77.3	205.0	29.0	70.1
Jul-17	98.2	28.9	80.2	146.6	27.9	76.4	153.2	29.0	68.0
Aug-17	459.4	28.2	80.3	331.8	27.3	79.4	230.2	28.3	73.2
Sep-17	437.7	27.5	84.3	286.6	27.0	81.3	266.8	27.9	76.9
Oct-17	246.4	28.5	81.3	216.4	27.4	78.6	435.6	28.6	75.1
Nov-17	466.0	27.3	86.5	196.2	26.6	85.2	271.8	27.3	81.8
Dec-17	68.4	27.8	81.4	202.8	27.1	80.5	175.6	28.4	Def.

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The author's name is Ros Sharina Binti Hussin. She was born in Hospital Banting on 26 June 1994. She had finished her study in Science at Malacca's Matriculation College in year 2012. One year later, she pursued her study in Civil Engineering at Universiti Teknologi MARA. She graduated with honors degree in Civil Engineering in 2018. As time goes by, she enrolled in Universiti Teknologi MARA for her Master of Science in Environmental Engineering in 2019.

