UNIVERSITI
TEKNOLOGI
PETRONAS

Progress Report (FYP)

Assessment of Malaysian Ambient Air Quality Guidelines

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(15036)

January 2015

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ABSTRACT

Air Pollution is one the environmental risk that gives high impact to human health. Due to that concern, in 1989 Malaysia has formulated a guideline namely Malaysian Ambient Air Quality Guidelines (MAAQG) which contain a concentration limit for major pollutants such as ozone, carbon monoxide, nitrogen dioxide, sulphuric dioxide, particulate matter, total suspended solid and lead at their average time. These guidelines have been set to maintain the air quality and protect the public health. However, there is no revision has been made so far on this guidelines since 1989 until now.This research is intended to revisit the concentrations limit in MAAQG correspond to ozone, nitrogen dioxide, particular matter (PM_{10}) and sulphur dioxide to determine whether is it important or require to have a new guidelines and validity of existing concentration limit. These selected pollutants are chosen as they have been review by WHO which reflects the availability of new evidence on the health effects of these pollutants and their relative importance with regard to current and future health effects of air pollution in each WHO region (WHO,2005). This research used the secondary data from DOE that focusing in Petaling Jaya. Petaling Jaya was selected because this place is considered as the most polluted city in Klang Valley. The set of data which contain the concentrations of pollutants where it is collected on hourly basis has been tabulated and analysed to assess the air pollution trend in Petaling Jaya from 2007-2011 and it is compared with the concentration limit stated in MAAQG. All the selected pollutants were above the MAAQG at certain period of time based on hourly basis. In this study, NO_2 was highly concentrated followed by PM_{10}, O_3 and SO_2. A new concentration limit for these selected pollutants has been proposed based on the behaviour of the pollutant and WHO Air Quality Guidelines. Future research will be undertaken to cover widened study area and implement more advance method to reassess the MAAQG.

CHAPTER 1: INTRODUCTION

1.1 Project Background

Air comprises the composition of gases and water vapour which are nitrogen, oxygen, and other gases that all needed to sustain living things. Nitrogen is the major gas which occupies the air by 78 %, followed by 20.95 % oxygen, 0.93 % argon, 0.039 % carbon dioxide and small amount of other gases. All these gases are classified as dry air composition where water vapour is excluded due to the fact that the composition of water vapour may vary depends on locations, temperature, time, humidity and altitudes. Table 1 illustrates the composition of dry air in the earth atmosphere. (Tring, 2012)

Table 1: Dry Air Composition (Tring, 2012)

Substance	Percentage by Volume (%)
Nitrogen, N_2	78.08
Oxygen,O_2	0.93
Carbon Dioxide, CO_2	0.033
Neon, Ne	0.0018
Helium, He	0.00052
Methane, CH_4	0.0002
Krypton, Kr	0.00011
Nitrogen (I) oxide, N_2O	0.00005
Xenon, Xe	0.0000087
Ozone, O_3	0.000001

Air pollution is the introduction of particulates, biological molecules and other harmful materials into the earth's atmosphere, which can lead to death to humans and damage to other living organisms (Brooke, 2014). Air pollution is caused by man's activity such as burning of fossil fuel, emission from industries and manufacturing activities, household and farming chemicals which is the household cleaning and fertiliser dust that emit harmful chemical into the air and cause air pollution. Besides man's activity, natural events can also result to air pollution when there is a forest fires, wind erosion,

volcanic eruption, pollen dispersal, evaporation of organic compound and natural radioactivity. (eSchool, 2010)

Generally, air pollutants can be divided into two categories; primary and secondary pollutants. Primary pollutants are pollutants that are released directly into the air such as carbon monoxide (CO), oxides of nitrogen (NO_x, NO), Sulphur Oxide (SO_x), volatile organic compound (VOC_s), and particulate matter. Secondary pollutants are react with primary pollutants or emitted chemical to form in the air. Examples of secondary pollutants are ozone, formaldehyde, peroxy acetyl nitrate, acid mist and etc. Specifically for Malaysia, the common primary pollutants are CO,PM_{10}, meanwhile for the secondary pollutants are $SO_{2,}NO_2$ and O_3 (DOE,2014).

Based on the major air pollutants which are exist in Malaysia such as ozone, carbon monoxide, nitrogen dioxide, sulphur dioxide, particulate matter, total suspended particulate and lead; the Department Environment (DOE) has set the guidelines known as Malaysian Ambient Air Quality Guidelines (MAAQG) that defines the concentration limits of each pollutants to monitor the air quality status. Those selected air pollutants are classified as pollutants, which might adversely affect the health and welfare of the public health The average time listed in the guideline is varies from 1 hour to 24 hour for different type of air pollutants which represents the period of time over which measurement is monitored and reported for the assessment.(DOE, 1997). Table 2 shows the MAAQG by DOE.

Table 2: The Malaysian Ambient Air Quality Guideline (DOE, 2014)

Pollutant	Averaging Time	Malaysian Guidelines (Concentration)	
		PPM	(μg/m^3)
Ozone	1 Hour 8 Hours	0.10 0.06	200 120
Carbon Monoxide	1 Hour 8 Hours	30.0 9.0	35* 10*
Nitrogen Dioxide	1 Hour 24 Hours	0.17 0.04	320 10
Sulphur Dioxide	1 Hour 24 Hours	0.13 0.04	350 105
Particulate Matter	1 Hour 12 months		150 50
Total Suspended Particulate (TSP)	24 Hours 12 Months		260 90
Lead (Pb)	3 Months		1.5

Note: **** mg/m3**

The ambient air quality is monitored in 2 ways which are; Continuous Air Quality Monitoring (CAQM) and Manual Air Quality Monitoring (MAQM). The differences between these two ways are CAQM will monitor automatically the air quality by collecting data or measure data continuously in 24 hours a day. The monitoring system is done through 52 network stations that is located in residential areas, traffic areas and industrial areas .The stations of CAQM were divided into 5 categories which are industrial, traffic, residential, background and particulate matter with size less than 10 micrometers (PM_{10}).(DOE, 2014). Table 3 provides the parameter measured in 5 categories of CAQM stations. (DOE, 2014).

Table 3: Parameter measured in 5 categories (DOE, 2014)

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

Meanwhile, MAQM measurement is manually collected and is delivered to the laboratory for analysis. The High Volume Sampler located at 19 sites are used to collect pollutants such as PM_{10}, TSP and heavy metals such as lead, mercury, iron, sodium and copper. For every 6 days, the samples will be measured at once. (DOE, 2014).

In Malaysia, the status of air quality is determined by the Air Pollution Index (API). (DOE, 2014). The air pollution index system is easily to be understood in the form of ranges of numbers compared to use the actual air pollutant concentration. The ranges of index values are categorised to good, moderate, unhealthy, very unhealthy, hazardous, and emergency. If the API value exceeds the value of 500, the air is identified as hazardous and high risk to people and public health. Table 4 describes the air pollutant index with its health effect.(DOE, 2014)

Table 4: Air Pollutant Index- Health Effect (DOE, 2014)

API	Status	Health Effect	Health Advice
201 – 300	Very Unhealthy	Worsen the health condition and low tolerance of physical exercises to people with heart and lung complications. Affect public health.	Old and high risk people are advised to stay indoor and reduce physical activities. People with health complications are advised to see doctor
> 300	Hazardous	Hazardous to high risk people and public health	Old and high risk people are prohibited for outdoor activities. Public are advised to prevent from outdoor activities
> 500	Emergency	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

API for a given time period is obtained by includes the sub index values for all five pollutants in the API system which is sulphur dioxide, nitrogen dioxide, carbon monoxide, particulate matter and ozone are calculated using the sub-index functions for the air quality data collected from the Continuous Air Quality Monitoring Stations. The corresponding air quality data are subjected to the necessary quality control processes and quality assurance procedures, prior to the sub-index calculation (DOE, 1997). The API value reported for a given time period represents the highest API value among all the sub-API values calculated during the particular time period. The predominant parameter will contribute towards a particular API value is normally indicated alongside the API value. For instance, during the high particulate events in 1997, the predominant air pollutant parameter was PM_{10} thus the API values reported were primarily based on the PM_{10} sub-index.

Air pollution is one of environmental problem that gives impact to the health of society and environment. The polluted air can lead to respiratory irritation or breathing difficulties when doing an exercise or outdoor activity. According to Air Quality Information for the Sacramento Region (Spare The Air : Health effects of Air Pollution, 2014) the individual’s risk depends on the current health status, the pollutant type and concentration, with the length of the person’s exposure to the polluted air. People that are easily to be exposed to the health problems from air pollution are individuals with heart disease such as coronary artery disease or congestive heart failure, individuals with lung disease such as asthma, pregnant woman, outdoors workers, and children under age of 14 whose lungs are still developing and athlete who exercise vigorously outdoors.

When air pollution reached to the high levels, it can causes immediate health problems such as health problems which are aggravated cardiovascular and respiratory illness, damaged cells in the respiratory system, and could added stress to lung and heart because these organs work harder to supply the body with oxygen. At the worst cases, long term exposure to polluted air can cause permanent health effects which accelerated aging of the lungs, loss of lung capacity, decreased lung function, development of diseases such as asthma, bronchitis, emphysema and possibly lead to cancer (Spare The Air : Health effects of Air Pollution, 2014) . Leh, et al. (2011) examined the rate of acute respiratory infection (ARI) and asthma among residents in Kuala Lumpur shows that the rate of ARI and asthmatic cases was higher in the more urbanised areas (areas that close to city centre, high density, high trip and less green area) compared to less urbanised area. The reason of this matter is due to urbanised areas have higher population and industrial activities which emit higher concentration of pollutants to the atmosphere thus affecting the human's health.

In terms of environmental aspect, air pollution results in acidification where the chemical reactions involving air pollutants can create acidic compound that may cause harm to buildings and vegetation. The sulphuric acid emitted to the air may combines with the water droplets from clouds, then forming acid rain. Acid rain that falls over an area would kill trees and harm animals. Moreover the plants also can be destroyed as the acid rain infiltrates into the soil, thus changing the chemistry of the soil making it unsuitable for living things that rely on soil as habitat or for nutrition. (eSchooltoday, 2010). Meanwhile damage due to air pollution on buildings is really a serious concern since the service life of buildings is reduced. Air pollutants deteriorate by various ways such as deposition, removal, abrasion and direct chemical attack, indirect chemical attack and corrosion .The effect of air pollution on materials can be seen in terms of discoloration, structural failing and soiling and material loss. Hence, air pollution can also causes economic losses due to the damages caused since frequent operation and maintenance is required to overcome the negative effects. (Rao, et al, 2014)

1.2 Problem Statements

Every country has the ambient air quality standards or guideline to monitor the air quality. The significance of having the standards or guideline is to provide a basis for protecting public health from adverse effects of environmental pollutants, and for eliminating or reducing to a minimum, contaminants that are known or likely to be hazardous to human health and well-being. (Schwela, 1998).

As a developing country, Malaysia has an ambient air quality guideline to protect the public health and improving the quality of nation's air. Nevertheless, the guidelines for certain pollutants standards are adopted from World Health Organization as a basis, thus it is not reflect the reality of Malaysia. This is because Malaysia has different environmental conditions and climate as it has tropical rainforest climate which is hot and humid throughout the year that is differ from Europe countries. Thus, certain parameters have to be considered in developing the guidelines such as prevailing exposure levels, environmental conditions, social, economic and cultural condition.

Malaysia has started used the guideline since 1989 and since then Malaysia has not making any revision or review for the betterment of the guidelines. Because of that, the air pollution in Malaysia still not achieved the desired performance especially during high particulate events. The concentration limit of each pollutants used in the guideline was only suit at the previous years back then, and Malaysia has undergoes rapid development in terms of social economy, population and etc. Concession, the concentration limit stated in the guideline is not fit with the current condition.

According to Japan Time (2013), hundreds of schools in Muar have been closed due to the serious haze which is caused by the forest fire in Indonesia. The air quality status at that time was unhealthy. History recorded that the highest API reading was 860 during 1997-1998. The reason of the increasing air pollution from time to time in this country might because of the guidelines is not periodically reviewed and no serious penalties are enforced if the guidelines are not met. .Therefore it is very crucial for the Malaysia to propose a new guideline as it can improve and enhance the air quality. This study perhaps can assist the Malaysia authority to develop the new guidelines or even set the standards based on local research and findings for the pollutants.

1.3 Objectives

1) To revisit the Malaysian Ambient Air Quality Guidelines respected to SO_2, NO_2,PM_{10}, and $O_{3.}$
2) To propose new air quality guidelines for Malaysia respected SO_2, NO_2, , and PM_{10}.

1.4 Scope of Study

This study will revisit the MAAQG and focus on four pollutants which are SO_2, No_2, PM_{10}, and O_3. The reasons of choosing these selected pollutants are due to the fact that of the affects caused on human .Besides that these major pollutants have been examined by WHO(2005) regarding its effect on health The study area will be focused on city centre which is mainly located at Petaling Jaya. In addition to that, the concentrations of four pollutants from DOE for 4 years have been analysed to obtain the overall pattern for each pollutants and compared with the ambient air quality guidelines provided by Malaysia.

CHAPTER 2: LITERATURE REVIEW

2.1 Urbanization and Population

According to Qinsong et al. (2011) development of human civilization is greatly influenced by urbanization process and has become significant in human progress. Moreover, negative effects could be produced due to rapid growth of urbanization gives especially on environment pollution, and natural resource destruction such as air pollution.

In China, there was a study conducted to assess the impact of urbanization on air environment with urban environmental entropy model based on case study. This study conducted to investigate the effect of urbanization on air environment based on new concept of urban environmental entropy. From this research, the entropy concept was used to determine the relationship of the urbanization process and its impact on the air environment.

According to Fang and Huang (2003) and Feng (2007), there are four stages in accordance to entropy values to investigate the characteristics of the interaction relationship between urbanization and urban ecological environment. The first stage of low entropy indicates the agriculture civilization is the primary industry and during this stage the entropy value is above zero. The urbanization and the development are slow. The second stage of high entropy shows it is a period of developing industrial civilization.

The entropy value is larger than zero and increases gradually. In this stage the economy develops extensively and urbanization lags behind the industrialization. Thus the quality of environment has a rapid deterioration. The third stage means negative entropy as at this late stage of industrialization, the tertiary industry (service sector) rises rapidly.

The entropy value is negative but the absolute value of entropy increases. Since the urbanization exceeds the industrialization, the quality of environment improves gradually with urbanization development level. The last stage indicates moderate entropy. In this stage the development direction of future urbanization. The tertiary industry has developed dramatically and the primary industry (agriculture, forestry, fishing and mining) and the secondary industry (manufacturing) continue to decline. The entropy value is negative but the environmental quality continues to improve.

The result shown in a case study of the 17 cities in Shadong was conducted according to the urban environmental entropy model established by the generalized thermodynamic entropy. There were 16 cities that have negative environment entropy which means there is positive correlation between the development of urbanization and air environment. However, there was numbers of city in China that have the fastest developing speed of urbanization, the improvement of air quality are lesser than cities whose urbanization level is relatively lower.

Another research conducted by Barbera, et. al. (2009) to study type of environmental problem for an urban air space where the pollutants increase due to rise in industrialization and urbanization and are transported by the wind. This research propose hydraulic model to study effects of industrialization and urbanization on air pollution propagation is proposed. The study is divided into 5 sections; in the first section the lines of modelling of extended thermodynamics theory there is derived the hyperbolic model describing the effects of industrialization and urbanization on air pollution propagation.

The second section performs a linear stability analysis around the steady state solutions, whereby in the third section the investigation of the behaviour of the traveling wave solution admitted by the governing system in point. In the next section, the discontinuous travelling wave solutions obtained from the combination of the behaviour within a phase plane with the Rankine- Hugoniot shock conditions. Finally in the last section, both continuous and discontinuous traveling solutions are stable for the PDE model by looking at the numerical solutions of the full system. At the end of this research, the researchers remark that the hyperbolic model they have proposed allows for analytical solutions. The investigation of further features of the ecological problem such as the degradation of resource biomass and the conversation of this resource by a suitable afforestation programs have been conducted by the researches.

There are many research conducted globally to investigate the impact of urbanization on the air quality. It shows that urbanization is one of the main factors which contributed to the deterioration of the air quality. Same goes to Malaysia, as a development country, there will be rapid urbanization process happened.When a country reached high population, there will be huge amount of human activities such as emission of gas pollutant from vehicles, industries, power generation and open burning. Due to rapid urbanize process; the air pollution of Malaysia is worsening.

The population of Malaysia during 2006 is about 26,748,000 and had the average population growth rate of 2.6 % since 1999 (EPU,2006). Meanwhile, during 2004 the urban population was about 62.8%.

Meanwhile the urban population has reached 62.8 % in 2004. In 2009, the total population of Malaysia is estimated at 27.9 million (“Malaysian Population- Demographics,” 2014). The latest Malaysian population reported in The Star Online (2014) is roughly at 30 million. It is expected that the number of residents in Malaysia is growing and this can lead to bigger deterioration of the air quality if the serious mitigation measure is not taken.

2.2 Major Source Pollutants in Malaysia

Air pollution come from several sources which are from localized and transboundary. Sources come from localized such as stationary and mobile. Afroz et al.(2003) and Hashim et al. (2004) claimed the major source of pollutant in Malaysia was the emission from the mobile sources such as vehicles, airplanes and engine equipment which contributing to at least 70 %-75 % of the total air pollution. Others second largest group belongs to the sources from stationary; those that came from cement plants, power plants, industrial waste incinerators, iron and steel mills from suburban areas and industrial, emission of dusts from urban construction and quarries, burning of old oil palm trees in plantations and open burning at some solid waste dumpsites.

This type of sources contributed about 20 %-25 %. Transboundary pollutants are open biomass burning from Indonesia which produces smoke haze has become annual phenomenon and lead to deterioration in the local air quality in Malaysia (Mahmud, 2013). The transported air pollution from forest fire not only happened in this country but also in other countries in the region as well such as Brunei and Singapore. (Hashim, 2004)

Basically there are five (5) air pollutants which consist of particulate matter (PM_{10}), ozone (O_3),sulphur oxide ($SO_{2,}$), nitrogen dioxide (NO_2)and carbon monoxide (CO) in which they were monitored continuously at 52 locations(DOE, 2014) .

According to DOE (2014), the largest pollution source in Malaysia is still from motor vehicles back from 1999 to 2013. This category of sources emitted carbon monoxide, CO gas approximately at 95 % in the year of 2013. There was a slight increase of 0.4 % CO level in 2013, compared to 2012. Despite of the large amount of emission accounted, the levels recorded were still compliance to the Malaysian Ambient Air Quality Guidelines (DOE, 2014). Based on this findings, it is proven that the trend of CO concentration remain constant since the year back in 1999 to 2013.

Meanwhile, the nitrogen dioxide, NO_2, concentration remains high in urban and industrial areas because of the significant increase in the number of motor vehicles and combustion processes. The power plants was contributed about 62 % , followed by 26 % from motor vehicles, 6 % from industries and 7 % from other sources. The annual average concentration of NO_2 in the ambient air from 1999 to 2013 remains almost constant and well below the Malaysia Ambient Air Quality guidelines (DOE,2014). Thus, there is no significant improvement has been shown in terms of the concentration for these type of pollutants and no any effective mitigation measures that has been taken to overcome this problem. Figure 1 and 2 illustrates CO and NO_2 concentrations from year 1999 to 2013.

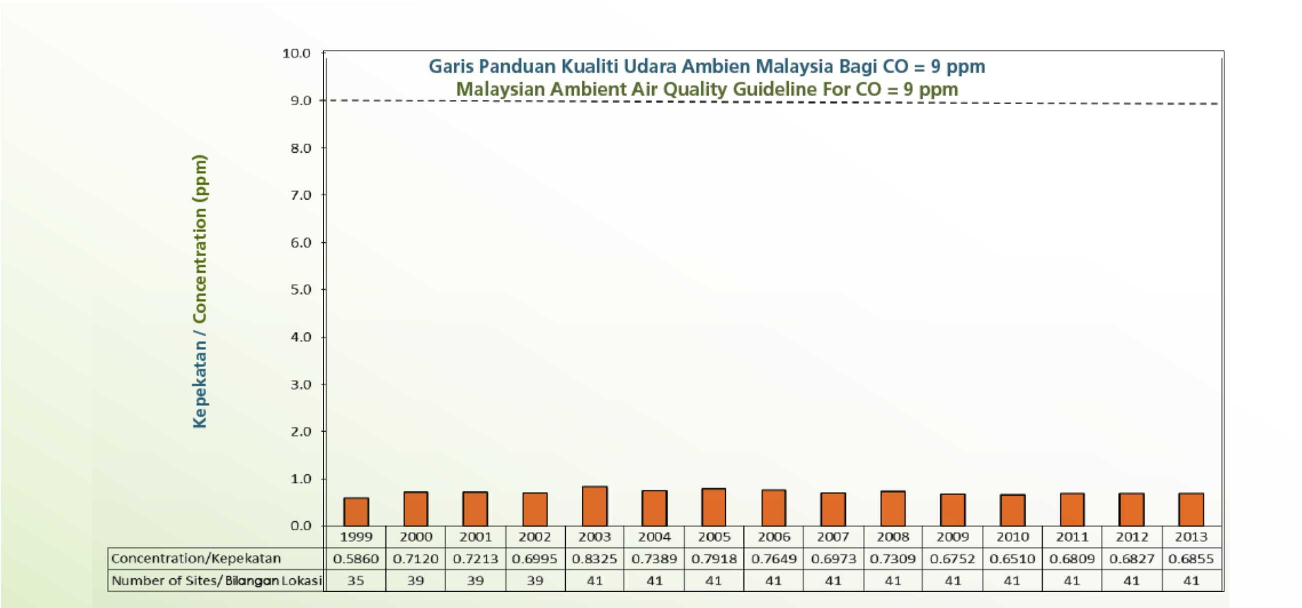


Figure 1: The concentrations of CO from year 1999 to 2013 (DOE,2014)

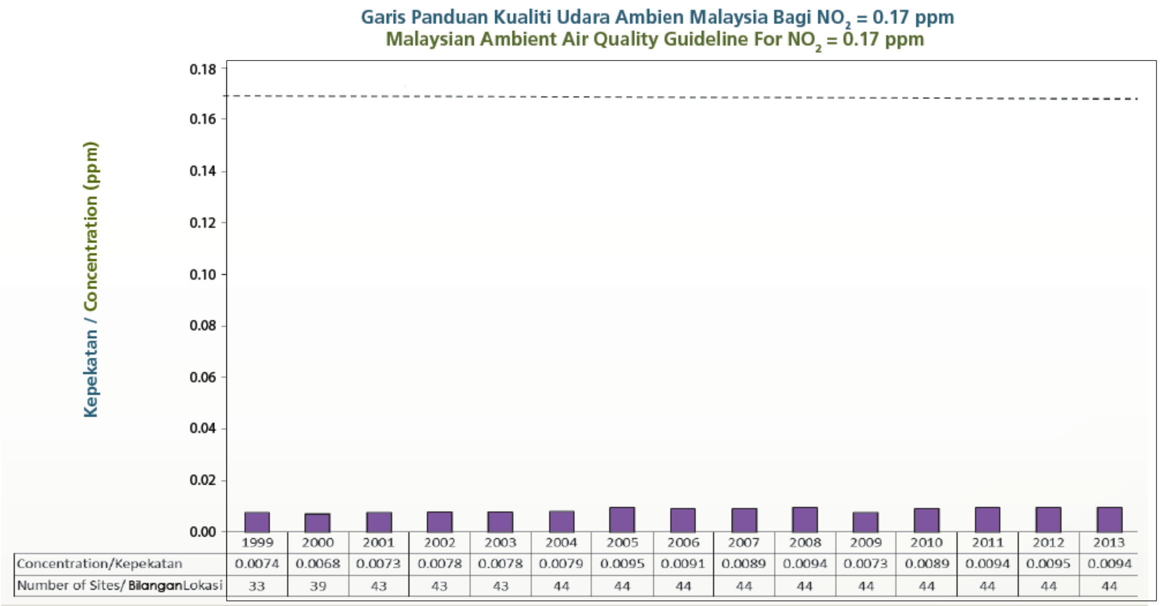
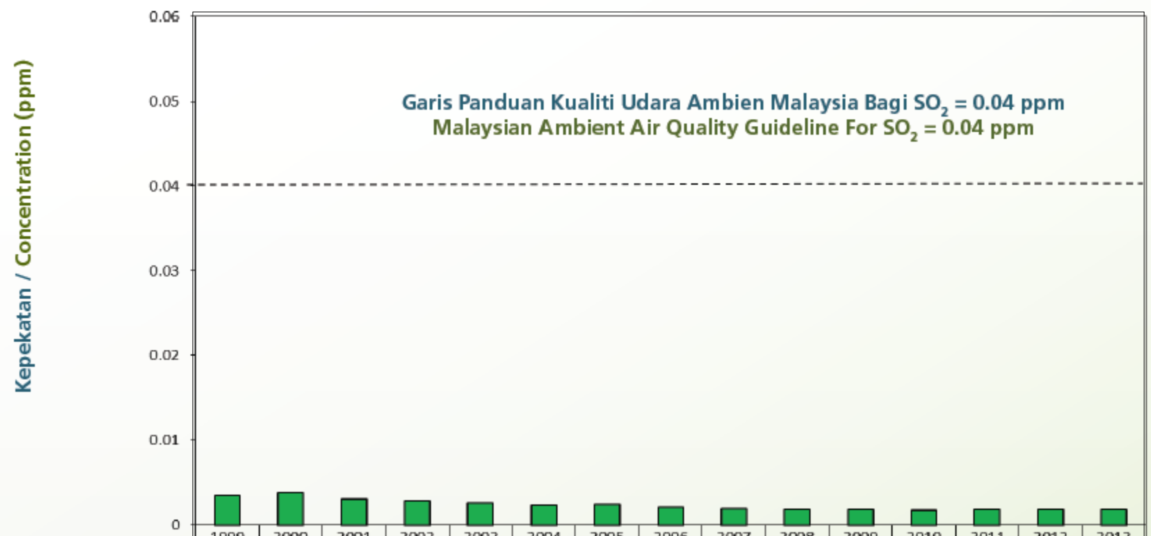


Figure 2: The concentrations of NO_2 from year 1999 to 2013 (DOE, 2014)

Figure 2 : Concentrations of NO_2 from the year 1999 to 2013 (DOE,2014)

Whereas the emission of SO_2 , DOE reported in 2014, the annual average concentration indicates a declining trend between 1999 and 2013 and it is below the limit of 0.04 ppm as formulated in the Malaysian Ambient Air Quality Guidelines. The reasons for this good changes are because the use of better fuel quality EURO-2M in this country starting from September 2009 and also stricter enforcement by DOE as well as the wide use of natural gas for industrial to be used in industrial combustion process and vehicles. (DOE, 2014). The mitigation taken by the authority has successfully reduced the concentration of SO_2after the year of 2007 and remains constant towards the year of 2013. Figure 3 shows the concentration of SO_2 from the year 1999-2013.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Concentration/Kepekatan	0.0035	0.0038	0.003	0.0029	0.0026	0.0023	0.0024	0.0021	0.0019	0.0018	0.0018	0.0017	0.0018	0.0018	0.0018
Number of Sites/ Bilangan Lokasi	39	43	43	43	44	44	44	44	44	44	44	44	44	44	44

Figure 3: The concentrations of NO2 from year 1999 to 2013 (DOE, 2014)

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According to DOE in 2013, ozone concentration has increased slightly by two (2) percent compared to 2012 but still the overall trend on the annual average daily maximum one-hour ozone concentrations were below the limit of 0.1 ppm based on the Malaysian Ambient Quality Guidelines. In details, this type of pollutant recorded the higher levels in urban area because of the large traffic volume and the atmospheric conditions which is conducive and leaded to the formation of ozone.

Same goes to rural and sub urban areas, the ozone pollution was also dominant. This is because of the downwind effect transporting ozone pollution came from the sources of ozone precursors namely nitrogen oxides (NOx) and volatile organic compound (VOC) emitted from motor vehicles and industries (DOE, 2014).This statement is true because theoretically ozone can be transported long distance by wind. Thus, rural areas can also experience the high level of ozone.

Even though the ozone concentration were below the limit of 0.1 ppm MAAQG, but still there is pollution issue for this type of pollutant based on the result reported above by DOE. According to United States Environmental Protection Agencies (2012) even the low levels of ozone can cause health effects. This is more likely to affect the people who suffering lung disease, children, older adults and society who are active in outdoors activities (EPA, 2012). Figure 4 indicates the concentration of ozone from 1999 to 2013.

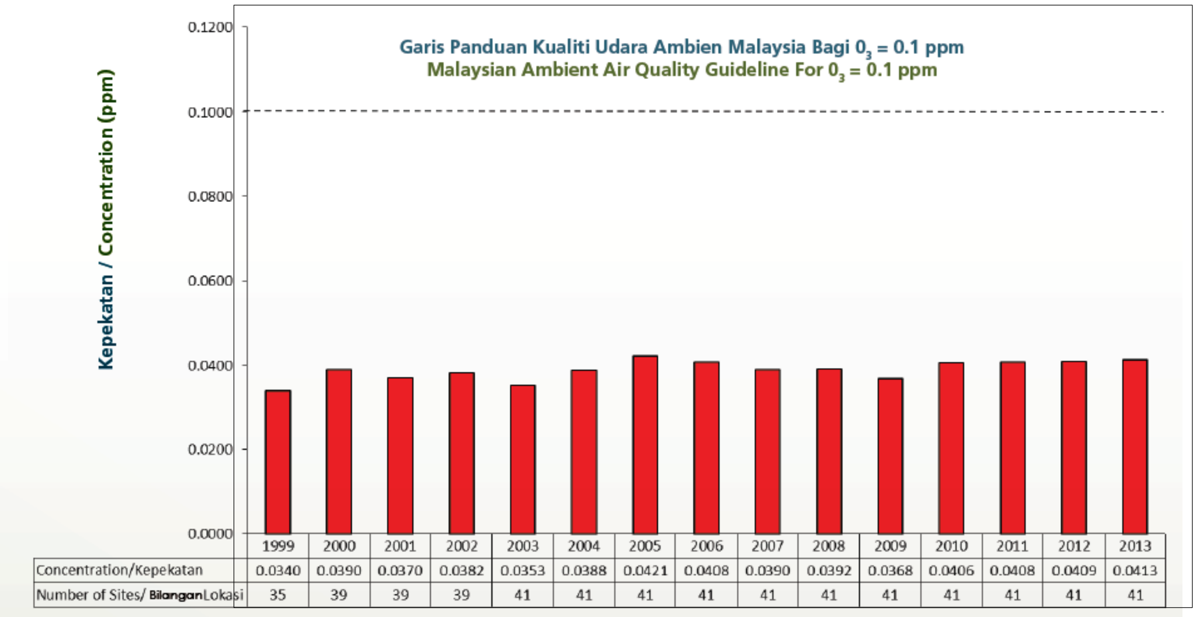
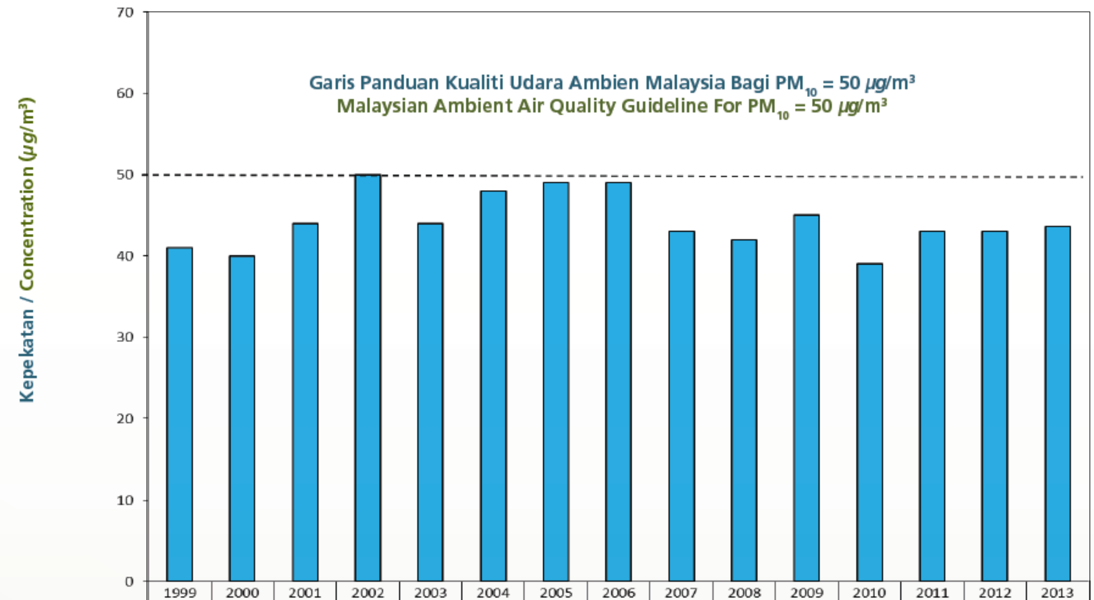


Figure 4: The concentration of Ozone from 1999 to 2013 (DOE, 2014)

Finally, the annual average value of PM_{10} in the ambient air was recorded at 44 µg/m_3, which is slightly below the MAAQG that set the concentration limit of 50 µg/m_3. In 2013, the concentrations increased slightly by two (2) percent compared to 2012 (DOE, 2014). There was local peat land fires and transboundary smoke haze incidences which lead to the greater PM_{10} recorded intermittently in several areas in Johor, Melaka and Negeri Sembilan since June to September 2013. Based on the figure 5 shown below, the trend of the annual average levels of PM_{10} concentration in the ambient air from 1999 to 2013 is in accordance with the MAAQG. In 2002, PM_{10} has reached the concentration limit in MAAQG which is 50 µg/m_3 and become the highest level recorded in the respective years.

From the observation, the annual average concentrations of PM_{10} almost reached the limit stated in the guideline compared to other pollutants which are far below from the concentration limit set in the guideline. In other words, there are high human activities and industrial process that cause to the large amount of PM_{10}.



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Concentration/Kepekatan	41	40	44	50	44	48	49	49	43	42	45	39	43	43	44
Number of Sites/ Bilangan Lokasi	45	50	50	50	51	51	51	51	51	51	51	52	52	52	52

Figure 5: The concentration of PM_{10} from 1999 to 2013 (DOE, 2014)

According D. Dominick et al. (2012) in his research: Spatial assessment of air quality patterns in Malaysia using multivariate analysis, $PM_{10}$was the higher contributor of the air pollution in the respective study areas. This is true because the result from the DOE also shows that PM_{10} almost hit the concentration limit regulated in the MAAQG compared to other pollutants. The study conducted aims to study the possible sources of air pollutants and the spatial patterns within the eight selected Malaysian air monitoring stations in two year database (2008-2009). The analysis named multivariate analysis was applied on the database. It incorporated Hierarchical Agglomerative Cluster Analysis (HACA) to ingress the spatial patterns, whilst Principal Component Analysis (PCA) to identify the main sources of the air pollution and Multiple Linear Regression (MLR) to determine the percentage contribution of each air pollutant.

From this research, the result of HAZA grouped the eight monitoring stations into three different clusters according to the characteristics of the air pollutants and meteorological parameters. Meanwhile the PCA analysis showed that the main sources of air pollution were emissions from motor vehicles, areas of high population density, industry and aircraft. The MLR analysis shows that the main pollutant which contributed to variability in the API at all stations was PM_{10} rather than any other pollutants (O_3,NO_2 ,CO and SO_2). On top of that, further MLR analysis illustrates the main air pollutant which influenced the high concentration of PM_{10} was carbon monoxide (CO).

The reasons for this because of the combustion processes particularly cause by motor vehicles. D. Dominick et al. (2012) recommended that the blue print should be implement as it can reduce motor vehicle exhaust emission as well as in gas emission from industry, factories and other anthropogenic sources. The authorities related and agencies could collaborate to produce the blue print which is if it is effectively implemented it can lead to a cleaner and healthier environment in the long run.

2.3 Health impact due to Air Pollution

Based on findings from section 2.2, it can be concluded that all the pollutants never been exceed the concentration limit stated in the guidelines. However it would be different if the concentration of pollutants is focused on Klang Valley. There was a study showed that during non-haze episodes, total suspended particulate matter was the main pollutant and its concentration at a few sites in the Klang Valley often exceeded the MAAQG (1989). (Afroz, R et al., 2003). Furthermore, even though the pollutants were below the MAAQG, it was found that high impacts of the pollutants on cardiovascular and respiratory morbidity at levels below the guidelines stated in MAAQG. (Hisham, 2004)

This section will discuss in what extent the air pollution in Malaysia has affected the public health. Air pollution is a major environmental risk to health (WHO, 2014). If the air pollution levels could be reduced, some burden disease such as heart disease, stroke, lung cancer and both chronic and acute respiratory diseases including asthma can be decreased. Additionally, it can also lead to death. WHO (2014) reported ambient air in both cities and rural areas was estimated to cause 3.7 million premature deaths worldwide in 2012. Some 88 % of those premature deaths occurred in low and middle income countries, and the greatest number in the WHO Western Pacific and South East Asia regions**.**

According Malaysian Health Fact 2014 (table 6), the data showed disease of respiratory system leading as ten principal causes of hospitalisation in private hospitals which located at the second highest causes of death in MoH hospitals in 2013. Table 6 and 7 below illustrates the ten principal causes of hospitalisation in MoH & private hospital, 2013 and admissions and outpatient attendances, 2013 respectively.

Table 6: Ten Principal Causes of Hospitalisation in MoH & private hospital (MOH, 2013)

No.	Diseases	Percentage
1	Diseases of the circulatory system	24.70 %
2	Diseases of the respiratory system	21.70 %
3	Certain infectious and parasitic diseases	13.66 %
4	Neoplasms	13.62 %
5	Diseases of the digestive system	4.93 %
6	Injury, poisoning and certain other consequences of external causes	4.75 %

Table 7: Admissions and Outpatient Attendances (MoH, 2013)

Hospital	Total
Government	
- Ministry of health	
Admission:	
Ante-natal attendance	5,794,544
Post-natal attendance	556,852
Child attendance	7,715,883
- Non Ministry of health	
Hospitals	
Admission	139,545
Outpatient Attendances	2,001,530
Private Hospital	
Admission	1,020,397
Outpatient Attendances	3,867,668

From table 7, it can be seen children is the major group that admitted to hospital and air pollution can easily attack this group of people. Michelle Willhem(2008) claimed that there is evidence show the exposures of environmental can attack at the earliest stage where it can lead to premature born (before 37 weeks of gestation) or low weight (less than 2500 grams), or to be born with certain birth defects. These babies have high risk to die while in infancy and chance to survive from any disease is minimal. The babies might suffer from respiratory, digestive problem and high risk of brain. Meanwhile, children in the early phase of their development is such a critical period, the maturation of several biological systems such as brain, immune system, lung and air toxics can impair lung function and neurodevelopment, or exacerbate existing conditions such as asthma (Willhem, 2008) .Figure 6 shows the effect of air pollution on the developing respiratory system.

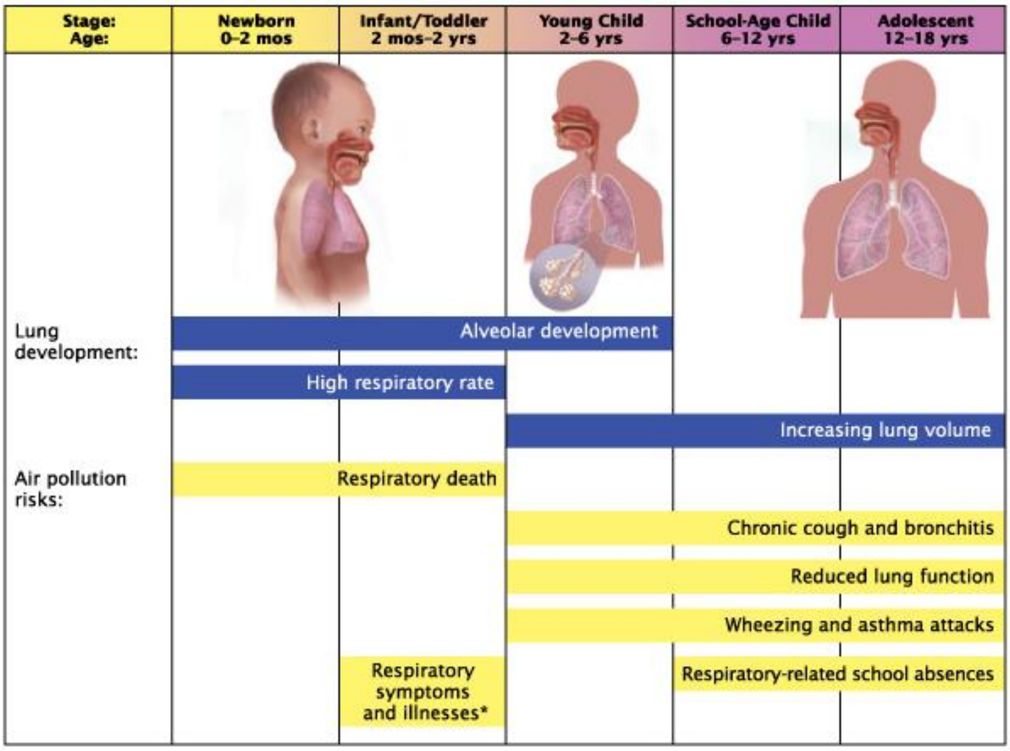


Figure 6: Air Pollution Effect on the Developing Respiratory System (Wilhem, 2008)

There are some factors why children can have high exposure to the effect of air pollution rather than adults. According to Michelle Wilhem(2008) the immune system, lungs and brain are immature at birth and continuously undergoes development until the age of 6, where the cell layer lining the inside of the respiratory tract is particularly permeable during this age period. Willhem also claimed that children have a larger lung surface area in relation to their body weight, and breathe 50 % more air per kilogram of body weight compared to adults.

Furthermore, children love to spend more time outdoors doing activities thus they are breathing more air outside compared to adults. Adults spend more time indoors due to work and most of their times are spent in the office. Based on the Community Health System (CHS), children living near freeways and heavy traffic have markedly reduced lung function by the time they become adults, and are more likely to have asthma. Hence, if the air pollution gradually increased it can affect the future generation's health.

2.3 Malaysian Ambient Air Quality Guidelines

World Health Organization is the organization that is responsible to assist the countries in decreasing the effect of air pollution on health. This organization has provided the guidance to countries in setting their national ambient air quality standards through the WHO Ambient Air Quality Guidelines (TWG, 2009). Malaysia is one of the developed countries that adopted the WHO Ambient Air Quality Guidelines in providing its own guidelines. Malaysia has formulated the guidelines since 1989 with several major of air pollutants and its concentration limit but since then, there is none revision has been made so far based on the guidelines formulated in 1989 with current guidelines used.

Ambient air quality standards identify individual pollutants and the concentrations at which they become harmful to the public health and the environment. The standards are typically set without regard to economic feasibility for attainment. Instead, they focus on public health, including the health of ‘‘sensitive’’ populations
such as asthmatics, children and the elderly and public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and aquatic
resources, and buildings. (Afroz, R et.al, 2003) .

Every country and city level in Asia has own range of air quality standards mostly based on the WHO guidelines at the time of development.Governments either at country or city level in Asia have adopted a range of air quality standards mostly based on the prevailing WHO guidelines at the time of development. The countries or cities should develop standards after considering prevailing exposure levels, meteorological and topographical conditions, socio-economic levels, natural background concentration and population susceptibility among others (TWG, 2009). Many countries in Asia have established their standards in maintaining the air quality. The earliest set was published in 1978 which is Philippines and Republic of Korea. Nepal was the latest one to adopt the standards in 2003. Korea has made the most revision/modification (six times) up until 2009. (TWG, 2009). Table 8 illustrates the summary of status of establishment and revision of ambient air quality standards in Asia

Table 8: The Summary of Status of Establishment and Revision of Ambient Air Quality Standards in Asia (TWG, 2009)

Countries	Has existing standards	Year standards were first establish	Year standards revised/modified
Bangladesh	Yes	1997	2005
Cambodia	Yes	2000	No
China	Yes	1982	1996,2000
Hong Kong SAR	Yes	1987	*
India	Yes	1982	1994,2009
Indonesia	Yes	1999	No
Nepal	Yes	2003	Currently undergoing review
Philippines	Yes	1978	1992
South of Korea	Yes	1978	1983,1991,1993, 2001,2007,2009
Sri Lanka	Yes	1994	2008
Thailand	Yes	1981	1995,2001,2004,2007
Vietnam	Yes	1995	2001,2005,2009
Malaysia	No	-	-

In the study written by Mohd Yusoff, M. (1987) on Air Pollution Control Legislation Research, to establish the latest scientific knowledge based on the experienced experts on the qualitative and quantitative relationship between various levels of exposure to pollutants with short and long term effects on health and welfare required a lot of money, time and research efforts. This is might be one of reasons why some developing countries are not willing to commit in this matter partly because the air quality criteria are already established in the more developed. Besides that if these countries decrease the concentration limit for every pollutant, it bring significant impact to the industry as they have to reduce the production rate which produce certain pollutants. But still, most of developing countries right now they have their own standards to control the air quality, it is just the matter of Malaysia as developing country which undergoes rapid urbanization process should improve the guideline or develop the standards to reduce the serious health risk caused by air pollution. The significance of having the standards is because in order to develop the standards, the several parameters are highly investigated that can produce the findings which are more suitable to local scenario. Besides that, the stringent penalties are going to be enforced if there the concentration exceeds the limit stated in the standards because it is legally bind. Table 6 display the summary of ambient air quality standards in certain Asian countries including Malaysia.

Table 9: Ambient Air Quality Standards in certain Asian countries (μg/m^3) (WHO, 2014)

Countries	$PM_{2.5}$		PM_{10}		SO_2		NO_2		O_3		CO('000)		Pb
	24-hr	Annual	24-hr	Annual	24-hr	Annual	24-hr	Annual	1-hr	8-hr	1-hr	8-hr	Annual
Bangladesh	65	50	150	50	365	80	-	100	235	157	40	10	0.5
Cambodia	-	-	-	-	300	100	100	-	200	-	40	10	0.5
China Grade I	-	-	50	40	50	20	80	40	160	-	10	-	1
Chine Grade II	-	-	150	100	150	60	120	80	200	-	10	-	1
China Grade III	-	-	250	150	250	100	120	80	200	-	20	-	1
Hong Kong SAR	-	-	180	55	350	80	150	80	240	-	30	10	-
Sri Lanka	50	25	100	50	80	-	100	-	200	-	30	10	-
Thailand	-	-	120	50	300	100	-	-	200	140	34.2	10.3	-
India1	60	40	100	60	80	50	80	40	180	100	4	2	0.5
	$PM_{2.5}$		PM_{10}		SO_2		NO_2		O_3		CO('000)		Pb
	24 Hour	Annual	24 Hour	Annual	24 Hour	Annual	24 Hour	Annual	1 Hour	8 Hour	1 Hour	8 Hour	Annual
India2	60	40	100	60	80	20	80	30	180	100	4	2	0.5
Indonesia*	-	-	150	-	365	60	150	100	235	-	30	-	1
Philippines	-	-	150	60	180	80	150	-	140	60	35	10	1
Nepal*	-	-	120	-	70	50	80	40	-	-	-	10	0.5
Republic of Korea	-	-	100	50	131	52	113	56	196	118	28.6	10.3	0.5
Vietnam	-	-	150	50	125	50	-	40	-	120	30	10	0.5

Malaysia	-	-	150	50	105	350*	10	320*	200	120	35	-	1.5

Notes: *Based on 1 hr. averaging time; India 1: Residential, industrial, rural and other area; India 2: Ecological sensitive area; China: Grade I is for Natural Protection Area and Other areas which need special protection; China Grade II is for Residential, Commercial, Industrial and Rural Area

Based on table 9, the concentration limit of ambient air guidelines for Malaysia is quite lenient compared to other countries. For instance the concentration limit of PM_{10} for Malaysia is lenient compared to Thailand. Thailand is also one of the developed countries and has total population approximately about 30 million and undergoes rapid urbanization which is greater than Malaysia.

CHAPTER 3: METHODOLOGY

3.1 Introduction

The ambient guidelines for major air pollutants have been formulated in the MAAQG as listed in table 2. In this study, there are four selected pollutants to be examined for assessment namely sulphur dioxide, particulate matter (PM10), ozone and nitrogen dioxide. These four pollutants are selected because they lead to biggest impact on public health especially on cardiovascular and respiratory system. This study intended to revisit the Malaysian Ambient Air Quality Guidelines respected to SO2, No2, O3 and PM10 and their dose-response relationship on human health effects. This can help to determine whether it is important to develop new guidelines and to check the validity of the guidelines itself. At the end of this research, a new concentration limit of the selected pollutants is formulated.

3.2 Study Area

Petaling Jaya is chosen as selected study area. The main reason for this selection is because Petaling Jaya has experienced the worst air pollution in the Klang Valley, the largest and highest populated urban area in Malaysia. The air monitoring station in Petaling Jaya is situated at Sri Petaling Primary School, Petaling Jaya; Selangor. This area is surrounded by commercial areas, industries, residential and having high volume of traffic road.

3.3 Period of Study

The study period required in this research will be for four years starting from 2007 to 2010 from January to December. That particular study period was in 4 years due to limited and time constraint for the research that only carried out for seven months.

3.4 Study sample

In this research, the secondary data is obtained from Department of Environment (DOE). The study sample is all concentrations data of the selected pollutant (O_3, SO2,NO_2, PM10) taken from 6 continuous air quality monitoring (CAQM) stations located throughout the Klang Valley.

3.5 Measurement Method for All Pollutants

Samples of each pollutant concentrations were collected by DOE using the monitoring instruments of the CAQM stations which had been approved by United States Environmental Protection Agency (USEPA) as shown in table 10 (Tong SL, 1999). The monitoring instrument has the ability to measure air pollutants such as NO2, O3, SO2, CO, PM10 and PM2.5 as well as meteorological parameters (humidity, temperature, wind speed and directions). There is also software in the instrument to retrieve the data sample that has been collected.

Table 10: Air quality monitoring equipment used in CAQM stations (Tong SL, 1999)

Equipment	Parameter Measured	Detection Principle
API 100A	Suplhur Dioxide	UV Fluorescene
API 200A	Nitrogen Oxides	Chemisluminescene
API 300	Carbon Monoxide	Gas filter correlation
API 400	Ozone	UV absorption
BAM 1020	Particulate matter less than 10 microns (PM_{10})	Beta attenuation

3.6 Data Analysis

The set of data were received from DOE and analysed using Microsoft Excel. The hourly trend of CO, O3, SO2 and NO2 in Petaling Jaya started from 2007 to 2010 has been compared to the Malaysian Ambient Air Quality Guidelines (MAAQG). The MAAQG has provided the minimum requirements for outdoor air quality in order to give protection to public health. The number of days where the concentration of each pollutant was exceeding 100 ug/m^3 was tabulated in this study. According to Siti Rahmah A. Rahman *et al*. through her research entitled ‘The Assessment of Air Pollutant in Klang Valley’ in 2015, PM10 concentration at 100 ug/m^3 is regarded to be moderate for sensitive sub-groups that consist of elderly, pregnant women and children, meanwhile the exposure level that exceeds 150 ug/m^3 is not healthy for public, and this may lead to serious health problem for the sensitive group.

3.7 Time Series Analysis

Time series analysis is a process to analyse time series data to obtain the extraction of meaningful statistics and other items of the data. In this study, time series analysis would be used to describe the movement or pattern of pollutants in time. The maximum concentration for each pollutant against time will be plotted to understand the cause and effect relationship of the study. All the selected pollutants dispersion is monitored in hourly basis per day.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Introduction

All the selected pollutants have been analysed for four years (2007-2010) from January until December. The data were taken from the monitoring station located in Petaling Jaya. This area is one of the most polluted areas in Klang Valley. The concentration of NO2, PM10, SO2 and O3 was taken based on an hourly basis daily. These data were tabulated using Microsoft Excel and studied by using descriptive statistical analysis to discern the pattern of the pollutant concentration. The result from the analysis will be used to propose a new guideline for selected pollutants.

4.2 The Comparison of Ambient Air Pollutants and Malaysian Ambient Air Quality Guidelines

All the selected pollutants have been analysed and studied throughout the year 2007 to 2010 from January to December. The graph for average hourly concentration of pollutants against time has been plotted to observe the overall pattern of the pollutant. The average hour concentration throughout the years for the pollutants was below the MAAQG. Nevertheless the concentration of NO2 and O3 were recorded as the highest in Petaling Jaya as this area is surrounded of residential, industries and commercial areas.

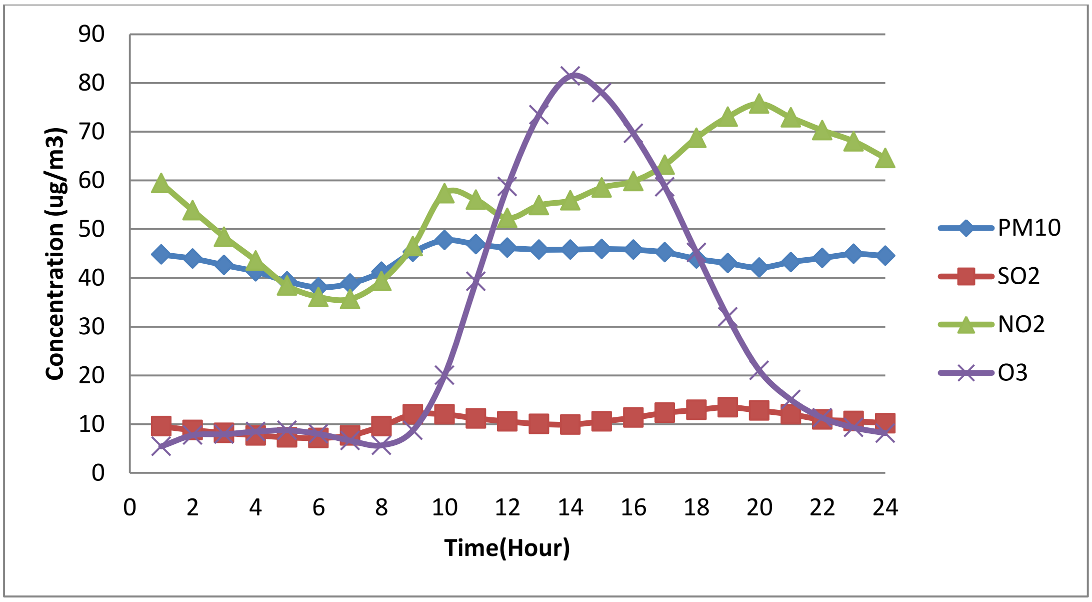


Figure 7: 1-Hour Averaging Time of PM_{10}, SO_2, NO_2, and O_3

Even though all the pollutants were below the MAAQG but the concentration of all pollutants for this study at certain time can adversely affect the health. NO_2 was recorded as the highest concentration compared to the other pollutant in Pealing Jaya. The pattern of each pollutant will be discussed into the next section.

4.2.1 Concentration of PM_{10}

In this study, the concentration of PM_{10} by hourly was significantly high which ranged from 5 to 402 ug/m^3. The number of days where concentration of PM10 that was exceeded 100 ug/m^3 and above has been recorded in table 11. In 2009, PM10 has recorded the highest number of days where its concentrations were above 100 ug/m^3 as compared to other years. This is because in July to August 2009, there was high particulate event happened .During this incident, the suspended particulate PM_{10} from Sumatra has been transported by south west monsoon wind to the west coast of Peninsular Malaysia and lead to serious air pollution in Klang Valley (DOE, 2009). Addition to that, domestic factor such as industries activity and human activities surrounded the area made the condition even worse. The graph for maximum daily concentration of PM_{10} for each month that exceeded the guideline in MAAQG also has been plotted to observe the pattern against time. However, only pollutant at certain time that has been observed as the most critical concentration of PM10 will be discussed in this section.

Figure 8 shows four graphs that have been plotted in the same month which is in July 2009. From the graph, the value of PM_{10} was higher towards the evening from 5pm onwards. This is due to high vehicle emission and human activity that happened around the time. Nevertheless, the concentration of PM_{10} for every month is divergent. In the month of March 2008, the highest concentration of PM_{10} throughout the years (2007-2010) was at 10 pm which is 402 ug/m^3. The exact reason for the concentration to rise sharply cannot be identified. As overall, PM_{10} was concentrated at 10 am to 12 pm and started to decline until 2 pm. Then it was rose up again from 5 P.M to 8 P.M.

Table 11: Total number of days from 2007 to 2010 when PM10 concentration exceeds 100 ug/m^3

PM10	Total Number of Days where MAAQG exceeded			
Year	>100 ug/m^3	>150 ug/m^3	>200 ug/m^3	>250 ug/m^3
2007	36	2	2	0
2008	74	3	6	5
2009	270	41	5	1
2010	63	4	1	0

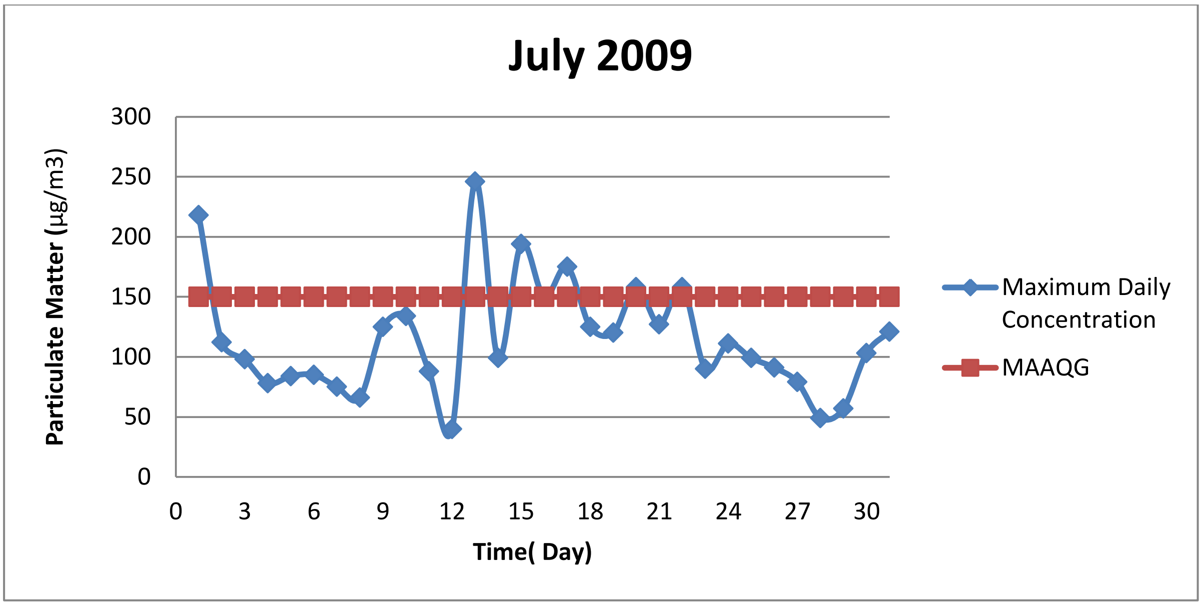


Figure 8a: The Maximum Daily Concentration of PM_{10} in July 2009

a) The hourly concentration of PM10 in day 15th of July 2009

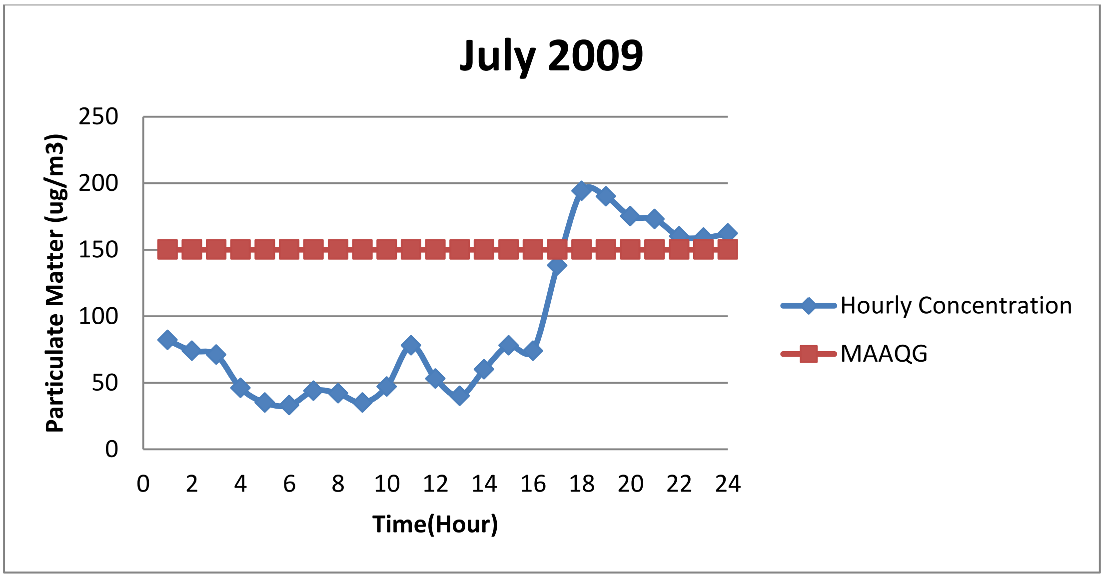


Figure 9b: The Maximum Daily Concentration of PM_{10} in day 15th of July 2009

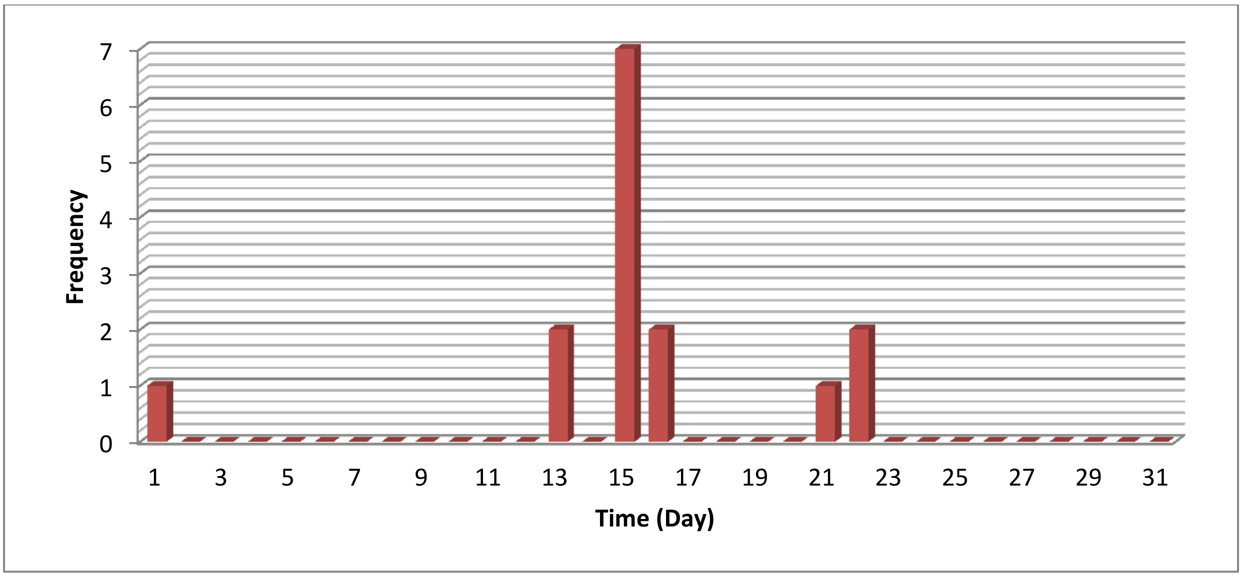


Figure 10(c): The Number of Incidences when PM_{10} exceeded MAAQG by day in July 2009 (>150ug/m^3)

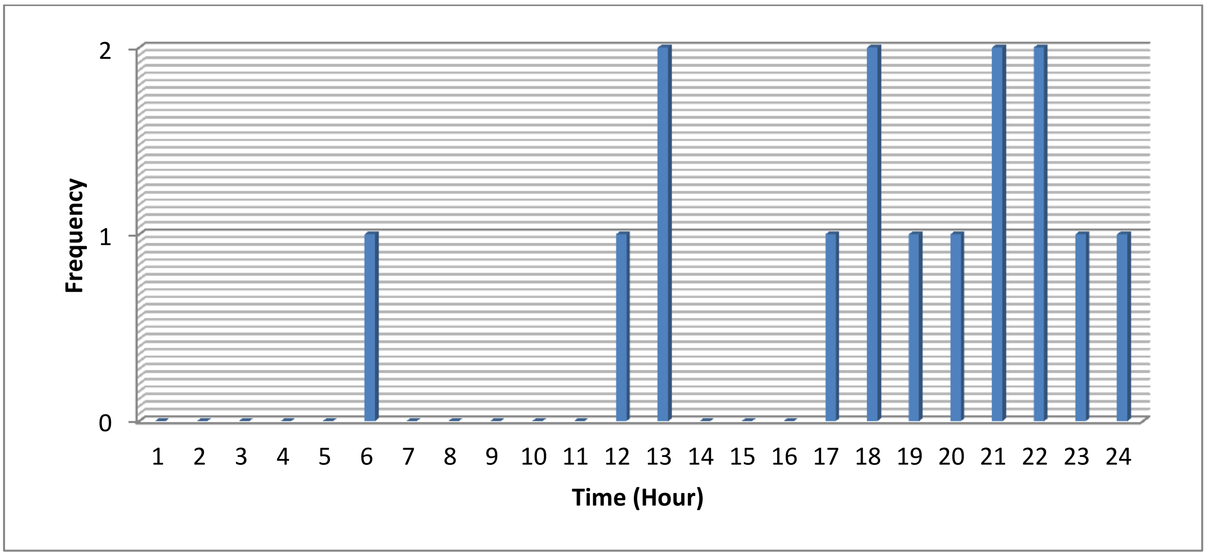


Figure 11(d): The Number of Incidences when PM10 exceeded MAAQG by hourly in July 2009 (>150ug/m^3)

According to WHO (2005) the concentration of PM_{10} at lowest as 75 ug/m^3 would be expected to increase about 1.2% of short-term mortality over the AQG value and the increment for each 10 ug/m^3 would produce around 0.5% mortality. WHO claimed that these findings applied to city in developed and developing countries including Malaysia. In this study, it has been found that almost every month at certain period that hourly concentration for PM_{10} has exceeded the lowest limit in WHO that promotes the increment of daily mortality.

4.2.2 Concentration of NO2

The hourly concentration of nitrogen dioxide ranged from 0 up to 216 ug/m^3 in the years from 2007 to 2010 and the concentration values are below the 1 hour averaging time in MAAQG(320 ug/m^3). The highest concentration was recorded in October 2009 at 2 P.M .The sources of NO_2 in Petaling Jaya are likely come from the emission of motor vehicles as was mentioned by Abdullah et al. (2012).

There is also another factors contribute to the concentration of this pollutant such as fuel combustion. The high temperature and pressure will oxidizes the nitrogen in the fuel to produce NO_2 with sufficient oxygen. Besides, the main contributor of NO_2 also comes from industrial activity, domestic fuel sources, and the long-range transport of air pollutants.(Rajab, J. M et *al*, 2011). For example, there was open burning happened in 2002 related to agricultural activity which involved 500 hectares and promoted to unhealthy level. (Mahmud, 2005)

Table 12 demonstrates the number of days for SO2 which exceeds 200 ug/m^3. According to WHO (2005) NO_2 at short term concentration which exceeds 200 ug/m^3 has toxicity and gives bad impact to health. The number of days for hourly concentration of NO2 is much lower compared to PM10. Only two days in those four years that it's concentrations were above 200 ug/m^3. However the highest concentrations for most of the days were above 100 ug/m^3. Furthermore NO2 was exceeding the 24 hour averaging limit in MAAQG for most of the days started from 2009 to 2011 which is 0.04 ug/m^3. Figure 9 represents the trend of NO2 in October 2009 where the highest value of NO2 was recorded and figure 10 shows the average concentration where NO2 was exceeded the MAAQG in March 2008 (>0.04 ppm)

Table 12: Total Number of Days from 2007 to 2010 when NO2 exceeding the 200 ug/m^3

NO2	Total Number of Days where MAAQG exceeded			
Year	>100 ug/m^3	>150 ug/m^3	>200 ug/m^3	>250 ug/m^3
2007			1	0
2008			0	0
2009			1	0
2010			0	0

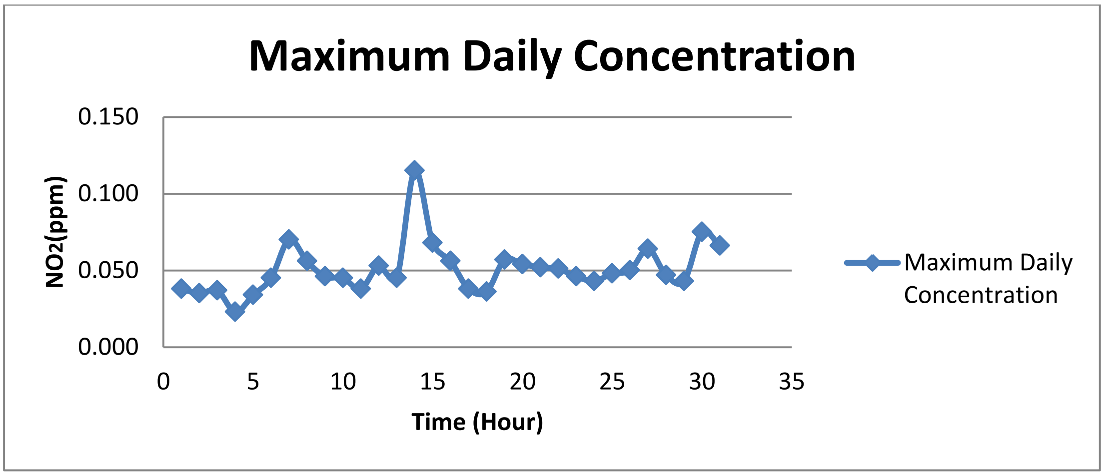


Figure 9: The Maximum Daily Concentration of NO2 in October 2009 (< 0.17 ppm)

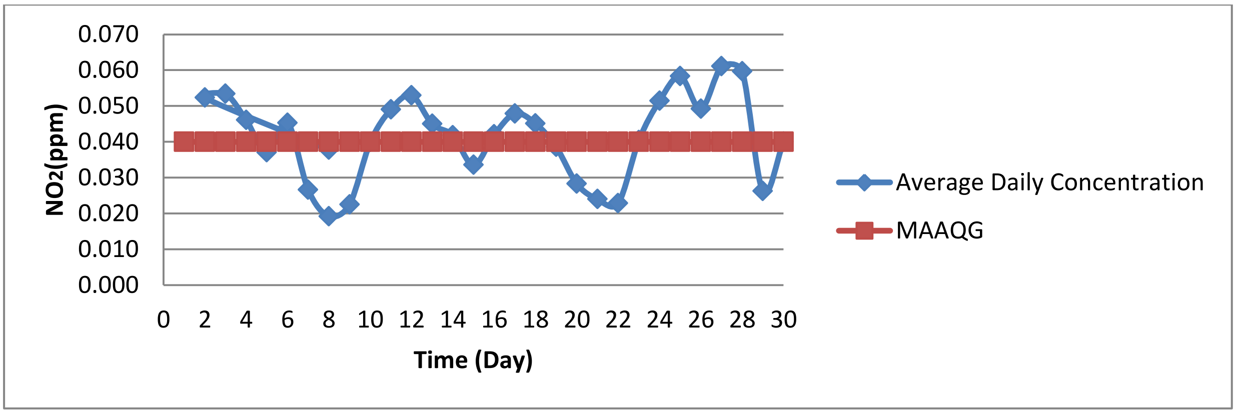


Figure 10(a): The Average Concentration Daily of NO_2 in June 2008 when Exceeded MAAQG (> 0.04 ppm)

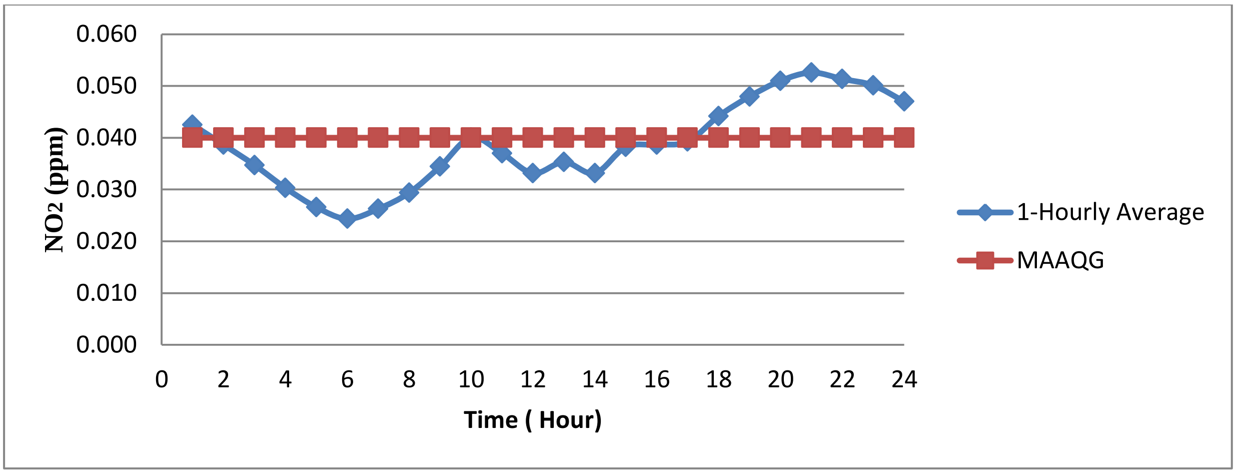


Figure 10(b): The Average Concentration Hourly of NO_2 in June 2008 when Exceeded MAAQG (> 0.04 ppm)

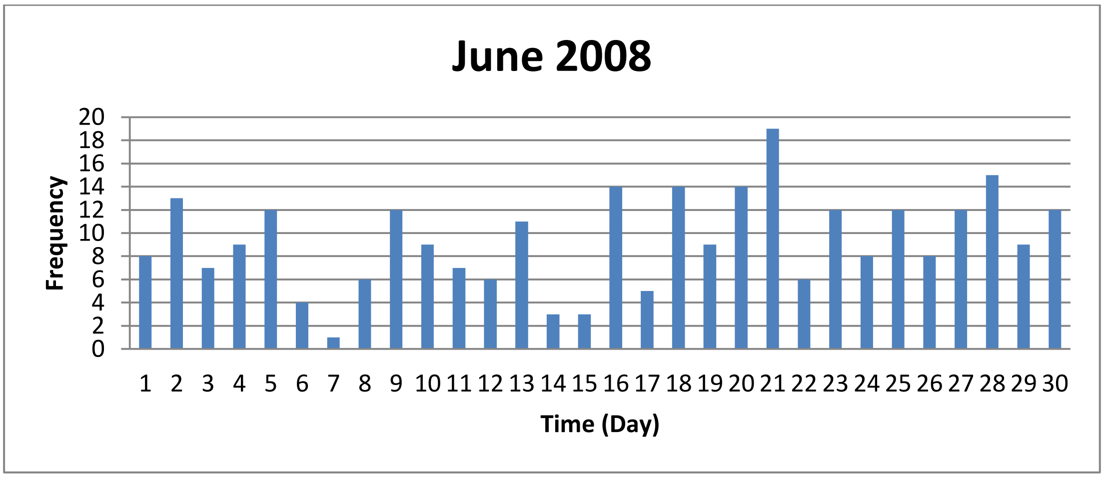


Figure 10(c): The Number of Incidences when NO_2 exceeded MAAQG by day in June 2008 (>0.04 ppm)

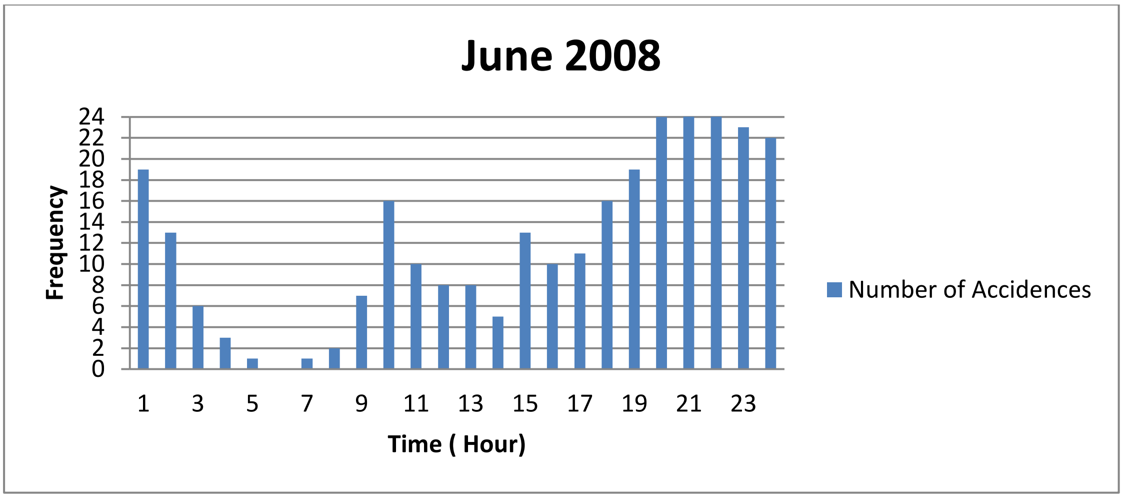


Figure 10(c): The Number of Incidences when NO_2 exceeded MAAQG by Hour in June 2008 (>0.04 ppm)

The concentration of NO2 was increasing started from 6 am to 8 am and this time is considered as peak hours where people are going out for work and other activities; it is declined from 10 A.M to 2 PM and started to increase abruptly towards evening and reach its peak value at 9 P.M. As overall, the concentration of NO2 was the highest in 2008 and the factor that led to its concentration was not related to high particulate event that happened in Sumatra during 2009, but it is due to the domestic factors such as industrial processes and human activities.

4.2.3 Concentration of O_3

Ozone is produced in the atmosphere by photochemical reactions with the presence of sunlight and precursor pollutants. Examples of precursor pollutants are volatile organic compound and oxides of nitrogen (NOx). It can be destroyed when react with NO2 and it is deposited to the ground. (WHO, 2005)

In this study the concentration of ozone was ranged from 0 to 254 ug/m^3 meaning to say the value was exceeded the guideline in MAAQG . Table 13 illustrates the number of days for the concentration of ozone which above the MAAQG. The highest numbers of days were recorded in 2009. The factors that contribute to the high level of ozone formation into the atmosphere are due to human activities or are elevated during very dry and hot weather.

The time-series study that was conducted by WHO stated that the concentration at 120 ug/m^3 shown health effects but without clear evidence of threshold. The findings in the study had the evidence from both chamber and field studies which indicates there will be individual variation in response to ozone.(WHO, 2005).

Figure 11 below demonstrates the maximum concentration of ozone against time in June 2009. From the graph, the value of ozone starts to rise sharply from 10 A.M and reach its peak value at 5 P.M. Then it started to decrease after 5 P.M onwards.

Table 13: Total Number of Days from 2007 to 2010 when O3 exceeding the MAAQG (> 200 ug/m^3)

Ozone	Total Number of Days where MAAQG exceeded			
Year	>100 ug/m^3	>150 ug/m^3	>200 ug/m^3	>250 ug/m^3
2007			4	1
2008			9	0
2009			16	0
2010			5	0

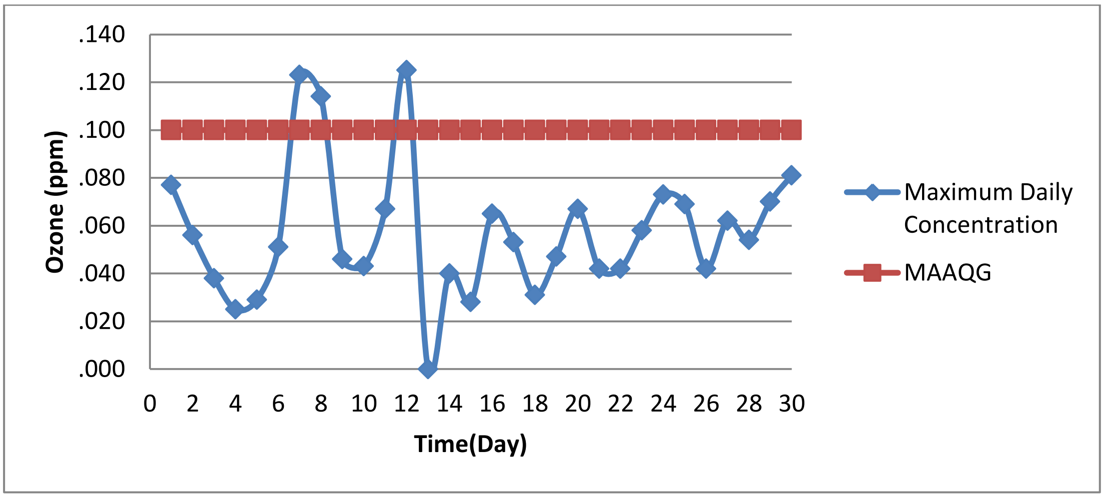


Figure 11(a): The Maximum Daily Concentration of Ozone in June 2009

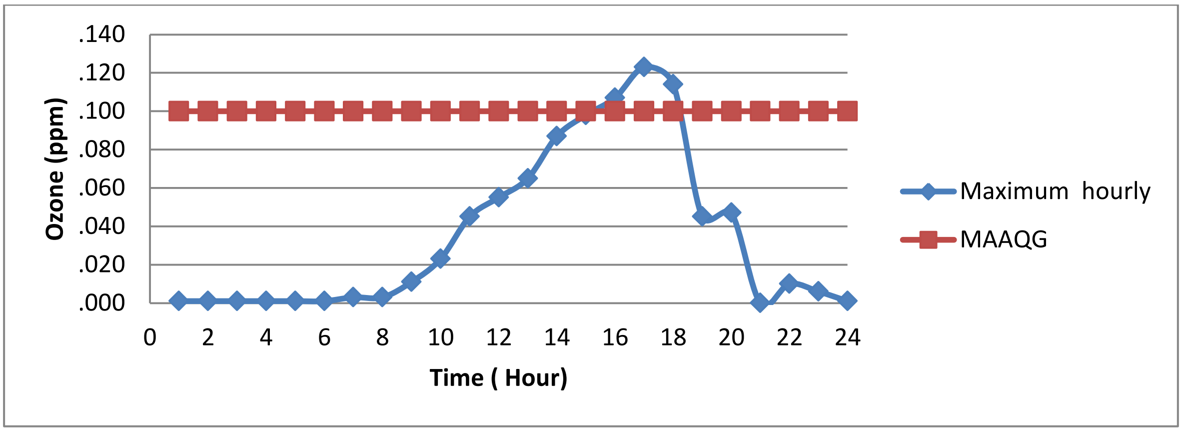


Figure 11(b): The Maximum Hourly of Ozone in day 7th of June 2009

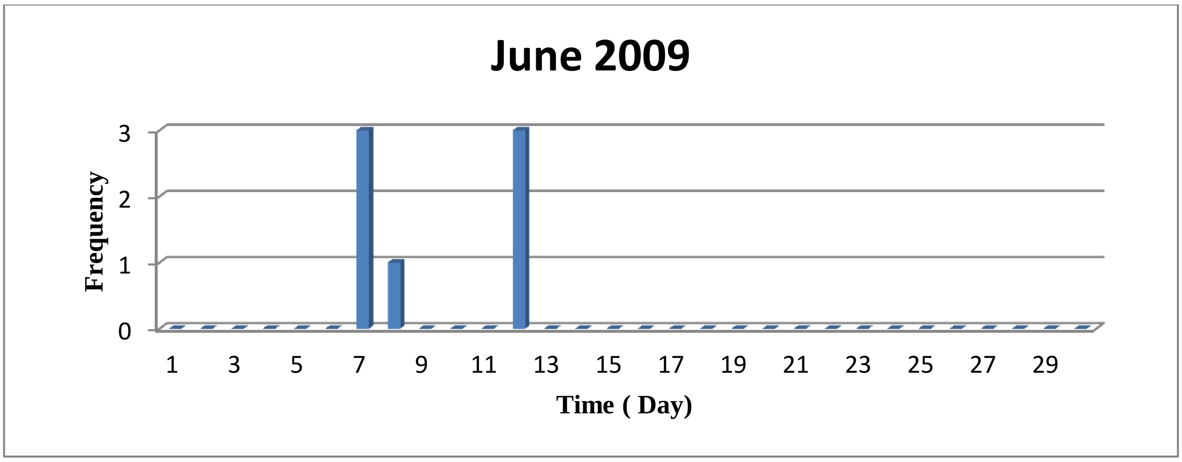


Figure 11(c): The Number of Incidences when Ozone Exceeded MAAQG by Day in June 2009 (>0.10 ppm)

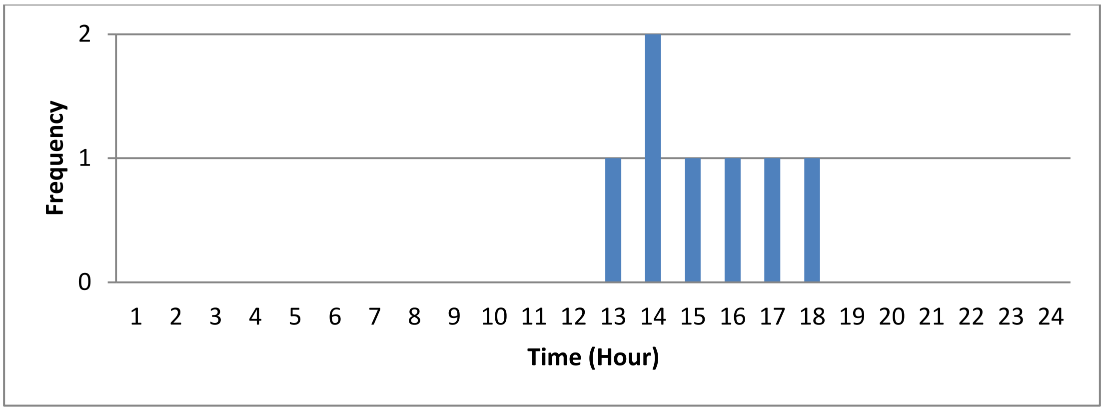


Figure 11(c): The Number of Incidences when ozone exceeded MAAQG by hourly in June 2009 (>0.10 ppm)

4.2.3 Concentration of SO2

In this study, the concentration of SO2 is considered to be low throughout the years compared to other sample pollutant in the study area. From 2007-2011 the value of SO2 ranged from 0 to 256 ug/m^3 and the average was 9 to 12 ug/m^3 . Sulphur Dioxide in Klang Valley is usually comes from the burning of coals, Liquefied Petroleum Gases (LPG) for cooking purpose, and natural gases. This means these activities were not significantly high in the study area and thus did not contribute much to the concentration of this pollutant. Table 14 illustrates the number of days where the SO2 concentration above the MAAQG.

Table 14: Total Number of Days from 2007 to 2010 when SO2 exceeding the MAAQG (> 105 ug/m^3)

Sulfur Dioxide	Total Number of Days when exceeded MAAQG (>105 ug/m^3)			
Year	>100 ug/m^3	>150 ug/m^3	>200 ug/m^3	>250 ug/m^3
2007	0	0	0	0
2008	2	2	2	0
2009	3	0	0	0
2010			1	0

The number of days where the concentrations of SO2 above 0.04 ug/m^3 are only 6 days in 2008 , 3 days in 2009 and only 1 day in 2010. The concentrations of SO2 though out the years are fairly good. Only at certain time that the concentrations were exceeded the MAAQG. Figure 12 represents the maximum concentrations of SO2 in February 2009. The concentration started to increase drastically from 5 P.M onwards before it started to decrease from 8 P.M to 12 A.M.

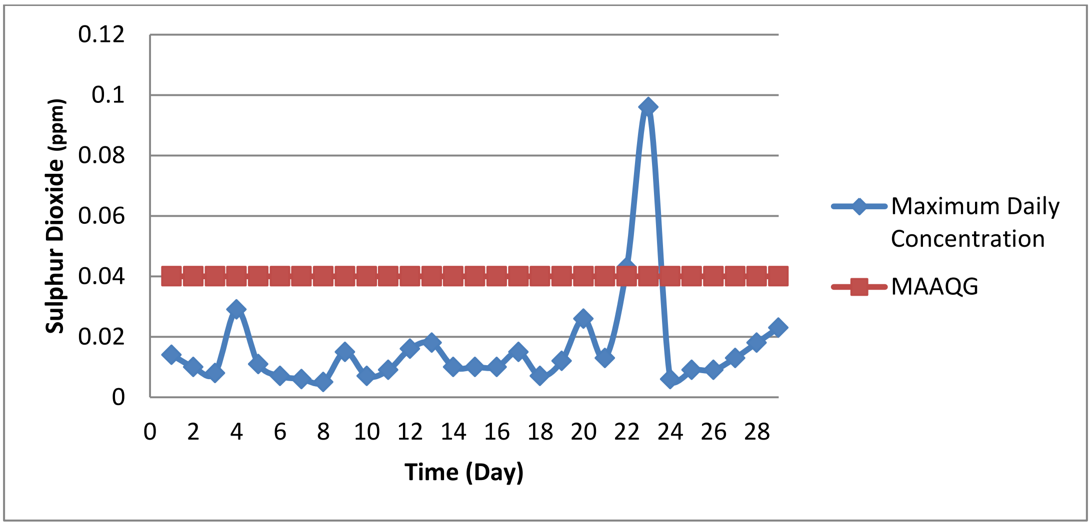


Figure 12(a): The Maximum Daily Concentration of SO_2 in February 2009

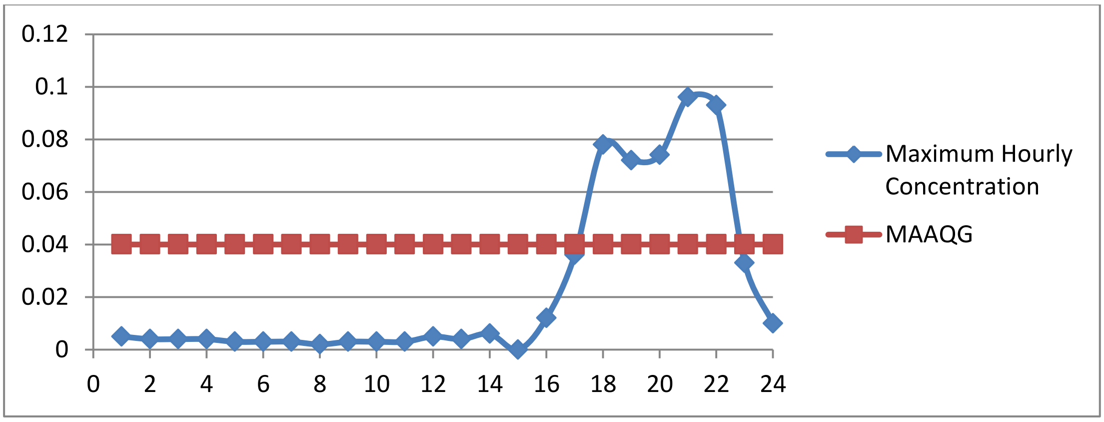


Figure 12(b): The Maximum Hourly Concentration of SO_2 in February 2009

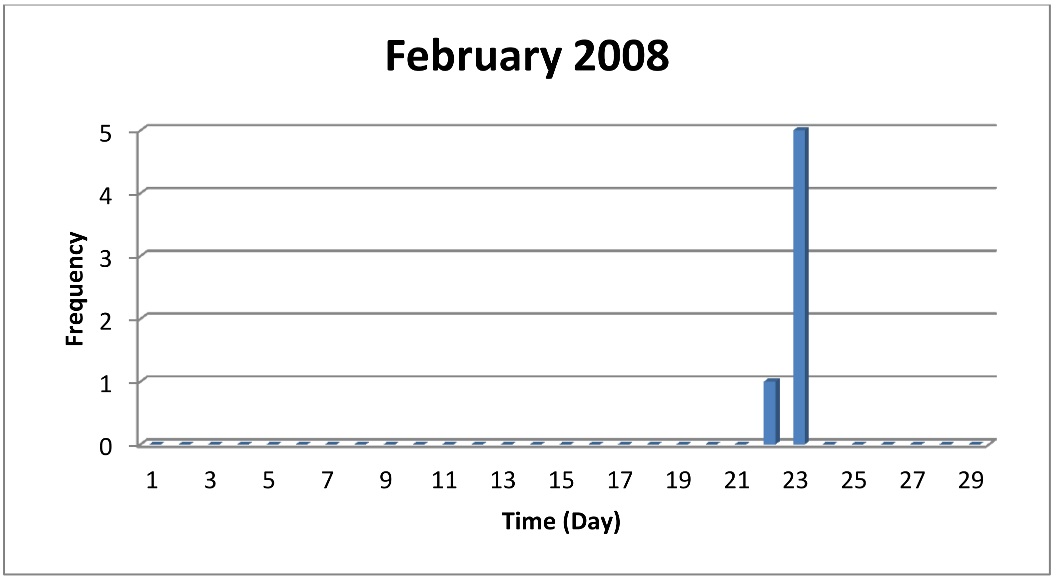


Figure 12(c): The Number of Incidences when SO2 exceeded MAAQG by day in February 2008 (> 0.04 ppm)

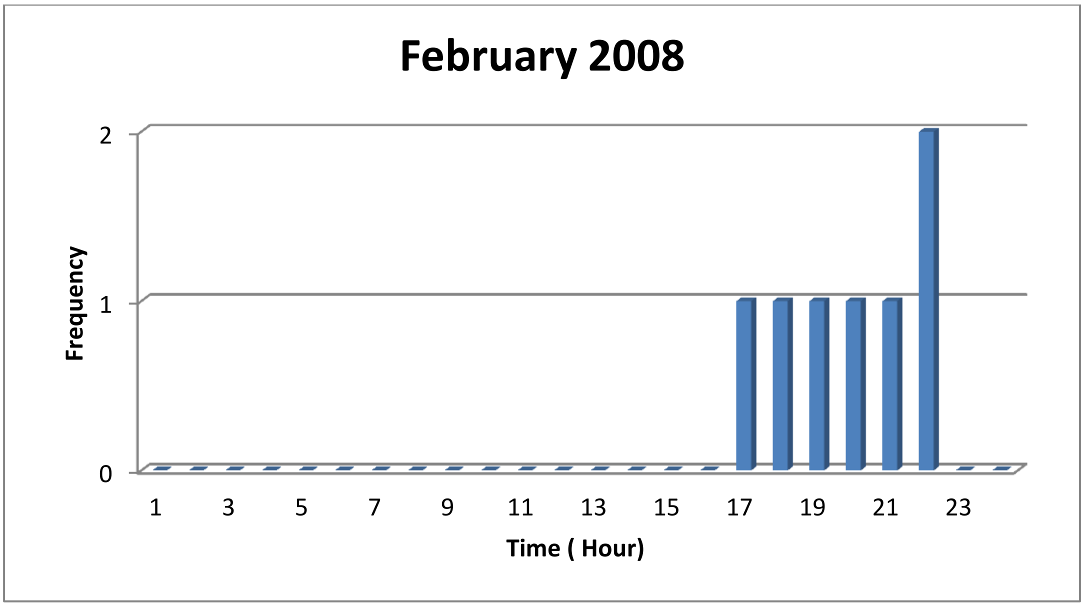


Figure 12(d): The Number of accidences when SO2 exceeded MAAQG by hour in February 2008 (> 0.04 ppm)

4.3 The Proposal of New Concentration Limit in MAAQG

This research is intended to propose a new value for selected pollutant in the Malaysian Ambient Air Quality Guidelines by referring to scientific research that has been conducted by WHO in 2005. They had published the document entitled WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulphur Dioxide to assist all WHO regions in developing their ambient air quality guidelines.

These guidelines are claimed to be based on expert evaluation of current scientific evidence and applicable to all WHO region. In this revision edition, they have provided the interim target for ozone, sulphur dioxide, and PM as incremental steps for developing country before they wanted to reach WHO standards and are compatible to be used in high polluted country with serious consequences health to lower concentrations. If any of the countries could meet these targets, significant reductions in risks for chronic health effects from air pollution could be achieved.

Anyhow, developing countries should intend to make a progress towards the guidelines values for the betterment of the air quality thus reduce the health risk in all areas.

The findings from this study have shown that pollutant such as NO2 ,PM10 and O3 were significantly high in Petaling Jaya since this area is surrounded by residential area, industries and commercial area, and it is assumed that the concentration could be even worst in the economic region such as Klang Valley. It is recommended for the related authorities to revise again the MAAQG to improve the air quality. However for the pollutant that is fairly good and frequently at stable concentration such as SO2, the preventive measure should also need to be taken to maintain or even reduce its concentration to a safe level for everyone including to a sensitive group of people such as pregnant women, children and elderly.

Table 15 illustrates the proposed concentration limit for PM10, SO2, O3 and NO2 adopted from WHO (2005).These values are come out based on the 98^{th} percentile distribution on the concentration values throughout the period of study. However, this new suggested concentration need to be further reviewed with scientific research and epidemiological evidence in order to formulate the concentration limit that is suitable with Malaysia’s condition such as socio-economy and meteorological condition.

Table 15: Proposed New Concentration Limit for MAAQG (WHO,2005)

Pollutant	Existing concentration limit (ug/m^3)	98th Percentile	Proposed Concentration Limit (ug/m^3)	Averaging Time	Basis for selected level
PM10	150	55-156	100	24 Hour	Based on publish risk from multi-centre studies and meta-analyses (about 2.5% increase of short-term mortality over the AQG value)
SO2	105	7-133	50	24 Hour	Intermediate goal based on controlling motor vehicle emissions, industrial emission and emission from power production. It would be reasonable and feasible goal for some developing countries which would improve the health
O3	120	61-160	100	8 hour	Provides adequate protection of public health, though some health effects may occur below this level. Exposure to this level associates with • an estimated 1-2% increase in daily mortality • Extrapolation from chamber and field

					studies based on the likelihood that real life exposure tends to be repetitive and chamber studies exclude highly sensitive or clinically compromised subjects, or children. • Likelihood that ambient zone is a marker for related oxidants.
NO2	320	53-140	200	1 hour	Remain unchanged in comparison to the existing WHO AQG levels.

CHAPTER 7: CONCLUSION AND RECOMMENDATION

7.1 Conclusion

In conclusion, Petaling Jaya recorded a fluctuation level of air pollution started from 2007 until 2010. All pollutants were above the guidelines at certain period of time because of several factors that contributes to the increment of the concentrations. Nitrogen dioxide was the major contributor to the air pollution in Petaling Jaya followed by particulate matter and ozone.

Based on the findings, the guidelines that have been design to protect the public health need to be revised and transform it to standards to provide the adequate protection to the public since the percentage of people admit to hospital because of air pollution are significantly high.

Most countries or cities in this world would have their Ambient Air Quality Standards to protect the public health and environment. Some of them even have lower income compared to Malaysia but they had revised their standards; some of the countries also formulated the guidelines later than Malaysia. This country need to invest some time and money to improve the guidelines that would benefit the citizens and environment.

7.2 Recommendations

For future research, it is recommended to conduct the study in any other polluted area; not only focusing in Petaling Jaya to get more reliable results as this guidelines will be implemented to the whole Malaysia.

Besides that, it would be necessary to determine the percentage of pollution for each source in the Petaling Jaya to get an overview which source is the main contributor in the study area.

CHAPTER 8 : REFERENCES

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APPENDIXES

Table A-1 : The Tabulation Data of SO2 Concentration

Year	Month	Mode	min	max	mean	Percentile 98th
2007	1	0.001	0	0.028	0.003774963	0.012
	2	0.003	0	0.029	0.003242902	0.002587671
	3	0.002	0	0.025	0.004417722	0.013
	4	0.003	0	0.019	0.004	0.01116
	5	0	0.001	0.023	0.004388418	0.01
	6	0.003	0	0.019	0.004360182	0.011
	7	0.003	0	0.018	0.004272727	0.04704
	8	0.003	0	0.021	0.003509194	0.009
	9	0.003	0	0.021	0.004154971	0.01034
	10	0.003	0	0.016	0.004150355	0.011
	11	0.003	0	0.024	0.004101322	0.0114
	12	0.003	0	0.028	0.003994649	0.012
2008	1	0.003	0	0.027	0.004828239	0.015
	2	0.003	0	0.096	0.005582202	0.018
	3	0.003	0	0.032	0.005551282	0.016
	4	0.003	0	0.028	0.004164464	0.011
	5	0.004	0	0.021	0.004731534	0.011
	6	0.004	0	0.034	0.00463583	0.012
	7	0	0	0.015	0.003786629	0.01
	8	0.003	0	0.023	0.004	0.01
	9	0.003	0	0.027	0.004768668	0.05
	10	0.003	0	0.038	0.003852601	0.01118
	11	0.003	0	0.028	0.004482456	0.012
	12	0.002	0	0.019	0.004080851	0.011
2009	1	0.002	0	0.06	0.004334758	0.01598
	2	0.002	0	0.014	0.003364632	0.01
	3	0.003	0	0.016	0.00359517	0.01
	4	0.003	0	0.012	0.00353997	0.009
	5	0.003	0	0.015	0.004123755	0.011
	6	0.004	0	0.016	0.004804985	0.011
	7	0.003	0.001	0.024	0.004164306	0.009
	8	0.002	0	0.018	0.003166902	0.009
	9	0.003	0.001	0.023	0.003414454	0.00946
	10	0.003	0	0.028	0.00335452	0.009
	11	0.002	0	0.02	0.003	0.00928
	12	0.002	0	0.016	0.002841727	0.01
	1	0.002	0	0.03	0.003	0
	2	0.002	0	0.03	0.003039936	0.011

	3	0.001	0	0.033	0.00254096	0.01086
	4	0.002	0	0.031	0.003047478	0.014924
	5	0.004	0	0.024	0.004001437	0.01
	6	0.005	0	0.026	0.004	0.011
	7	0.004	0	0.024	0.004884101	0.01656
	8	0.002	0	0.021	0.002543732	0.009
	9	0.002	0	0.024	0.003477273	0.01282
	10	0.003	0	0.026	0.003900568	0.014
	11	0.002	0	0.023	0.00322807	0.01134
	12	0.002	0	0.016	0.0026	0.007
2010	1	0.002	0	0.03	0.003251412	0.012
	2	0.002	0	0.03	0.003039936	0.011
	3	0.001	0	0.033	0.00254096	0.01086
	4	0.002	0	0.031	0.003047478	0.014924
	5	0.004	0	0.024	0.004001437	0.01
	6	0.005	0	0.026	0.004272727	0.011
	7	0.004	0	0.054	0.004884101	0.01656
	8	0.002	0	0.021	0.002543732	0.009
	9	0.002	0	0.024	0.003477273	0.01282
	10	0.003	0	0.026	0.003900568	0.014
	11	0.002	0	0.023	0.00322807	0.01134
	12	0.002	0	0.011	0.0026	0.007

Table A-2 : The Tabulation Data of NO2 Concentration (ppm)

Year	Month	Mode	min	max	mean	Percentile 98th
2007	1	0.023	0.02	0.089	0.026003	0.05782
	2	0.03	0.003	0.084	0.029994	0.067
	3	0.025	0.007	0.0082	0.031805	0.0618
	4	0.025	0	0.019	0.066	0.066
	5	0.025	0.005	0.07	0.029861	0.055
	6	0.024	0.011	0.07	0.032874	0.061
	7	0.029	0.004	0.071	0.030403	0.057
	8	0.026	0.008	0.085	0.030515	0.074
	9	0.025	0.01	0.068	0.031141	0.05596
	10	0.024	0.009	0.071	0.032145	0.05992
	11	0.029	0.006	0.068	0.02987	0.05634
	12	0.025	0.005	0.071	0.026732	0.05692
2008	1	0.02	0.007	0.108	0.033426	0.07136
	2	0.024	0.004	0.085	0.033069	0.06778
	3	0.021	0.005	0.079	0.031827	0.067
	4	0.043	0.006	0.093	0.036496	0.0664
	5	0	0.011	0.08	0.013293	0.058
	6	0.032	0.006	0.084	0.038597	0.07238
	7	0.025	0.003	0.054	0.72912	0.048
	8	0.028	0.01	0.078	0.031266	0.05656
	9	0.02	0.003	0.065	0.02463	0.05
	10	0.016	0	0.062	0.022332	0.04906
	11	0.026	0.003	0.082	0.707372	0.063
	12	0.022	0.001	0.088	0.733502	0.069
2009	1	0.025	0.002	0.098	0.031579	0.071
	2	0.025	0.009	0.086	0.034035	0.06532
	3	0.025	0.007	0.075	0.029223	0.057
	4	0.017	0	0.061	0.019674	0.047
	5	0.019	0	0.059	0.022099	0.052
	6	0.028	0.001	0.071	0.027858	0.027857988
	7	0.022	0.002	0.08	0.027509	0.05632
	8	0.017	0	0.068	0.021782	0.044
	9	0.015	0	0.083	0.021783	0.05656
	10	0.021	0.002	0.115	0.030531	0.06126
	11	0.015	0	0.079	0.023095	0.05732
	12	0.022	0.002	0.0085	0.476	0.064
2010	1	0.021	0.001	0.076	0.029129	0.06388
	2	0.025	0	0.076	0.030353	0.06028
	3	0.034	0.003	0.074	0.030463	0.063
	4	0.025	0	0.083	0.032873	0.065
	5	0.035	0.004	0.084	0.06888	0.035328147

	6	0.03	0.004	0.083	0.06	0.031054094
	7	0.025	0.003	0.081	0.030207	0.058
	8	0.031	0.003	0.086	0.031921	0.064
	9	0.022	0.008	0.073	0.03115	0.05832
	10	0.027	0.005	0.083	0.029713	0.06392
	11	0.025	0.005	0.079	0.028258	0.05436
	12	0.022	0.006	0.102	0.028118	0.0599

Table A-3: The Tabulation of PM10 Concentration (ug/m^3)

Year	Month	Mode	min	max	Percentile 98th	mean
2007	1	35	6	132	66	36.74419
	2	35	8	99	75	40.54483
	3	43	14	131	90.14	52.11828
	4	49	7	124	96	51.30115
	5	35	9	89	68	40.87297
	6	46	10	112	81	46.94554
	7	48	14	120	92.64	52.46576
	8	58	6	127	97	53.32884
	9	34	6	222	85.24	42.05512
	10	31	24	68	96.36	42.90995
	11	37	17	65	86.88	41.25575
	12	32	6	205	91.72	39.26054
2008	1	43	5	217	107.3	42.6061
	2	34	5	282	103	50.24112
	3	27	5	402	97.32	41.66762
	4	32	5	151	79.52	40
	5	45	6	143	85.68	46.66753
	6	40	6	113	77	41.53172
	7	50	6	163	81	44.51384
	8	41	10	227	89.44	50.17619
	9	37	5	303	100.72	47.27688
	10	34	6	76	63	35.07379
	11	25	7	67	55	28.85693
	12	29	5	70	55	28.10152
2009	1	25	5	156	66.68	35
	2	44	6	111	87.18	42.86293
	3	27	5	90	68.28	32.78442
	4	33	5	196		
	5	33	6	139		
	6	54	15	176		
	7	64	17	246		
	8	28	5	181		
	9	31	6	199		
	10	47	5	255		
	11	37	7	93		
	12	36	6	97		

	2010	1	36	5	234	81.6	39.83832
		2	47	7	163	87.04	47.12173
		3	38	7	135	87.04	47.12173
		4	42	7	127	101.7	46.64385
		5	41	5	114	85	47.01361
		6	39	6	127	89	43.43509
		7	35	7	94	76	40.55782
		8	26	5	172	78.48	40.28473
		9	33	7	120	76	38.26154
		10	43	6	146	99.56	46.70254
		11	32	5	124	77	35.7847
		12	27	5	176	83.8	36.93897

Table A-4 : Tabulation Data of O3 Concentration (ug/m3)

Year	Month	Mode	min	max	Percentile 98th
2007	1	2	0	160	101.64
	2	2	0	198	140
	3	2	0	254	130
	4	4	0	176	130
	5	0	0	210	98
	6	2	0	150	116
	7	2	0	168	122.6
	8	2	0	152	84
	9	4	0	128	100
	10	2	0	160	105.48
	11	2	0	120	92
	12	2	0	170	106
2008	1	4	0	240	131.04
	2	2	0	240	146
	3	4	0	220	134
	4	2	0	208	140
	5	0	0	224	116
	6	0	0	158	111.52
	7	0	0	126	88
	8	2	0	168	111.6
	9	2	0	136	110
	10	2	0	142	116
	11	4	0	212	121.36
	12	2	0	218	115.76
2009	1	0	0	234	145.28
	2	0	0	220	149.36
	3	0	0	212	144
	4	2	0	184	120
	5	4	0	178	116
	6	4	2	250	155.92
	7	4	0	166	113.84
	8	4	0	162	122
	9	4	2	46	108.84
	10	42	20	196	61.06104651
	11	2	0	146	105.16
	12	2	0	236	155.28
2010	1	4	2	190	147.8
	2	2	2	194	160
	3	4	2	206	148
	4	4	2	184	133.2
	5	2	2	206	140
	6	2	0	206	112
	7	4	2	178	114
	8	2	0	188	107.68

	9	0	0	188	119.6
	10	0	0	184	100
	11	2	0	184	106
	12	2	0	122	94

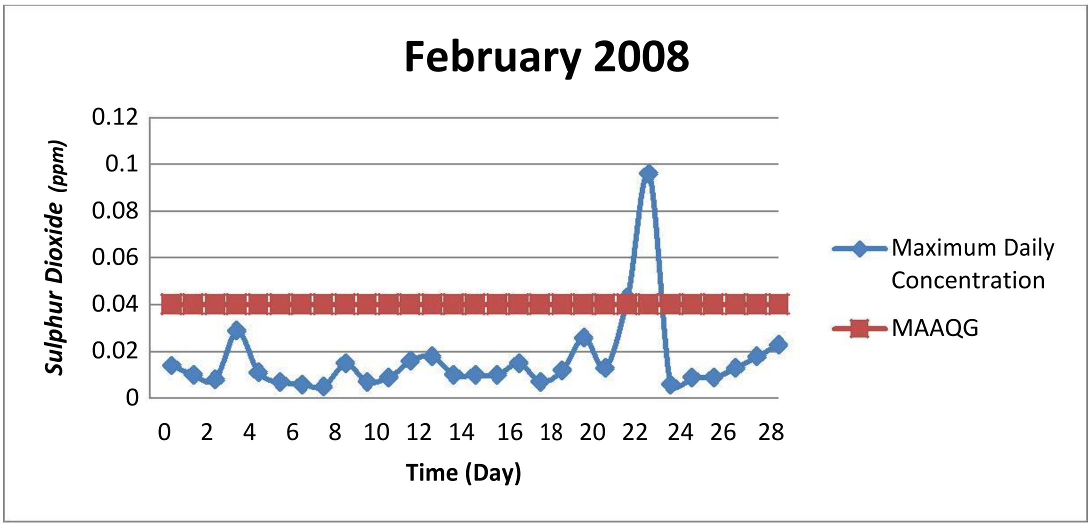

Figure A-1: The Maximum Daily Concentration for Sulphur Dioxide

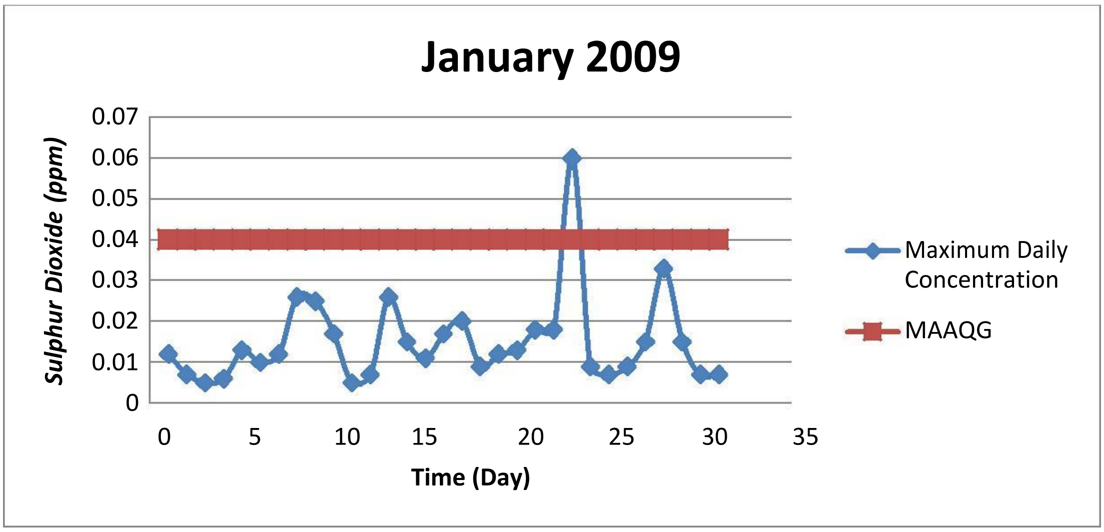

Figure A-2: The Maximum Daily Concentration for Sulphur Dioxide

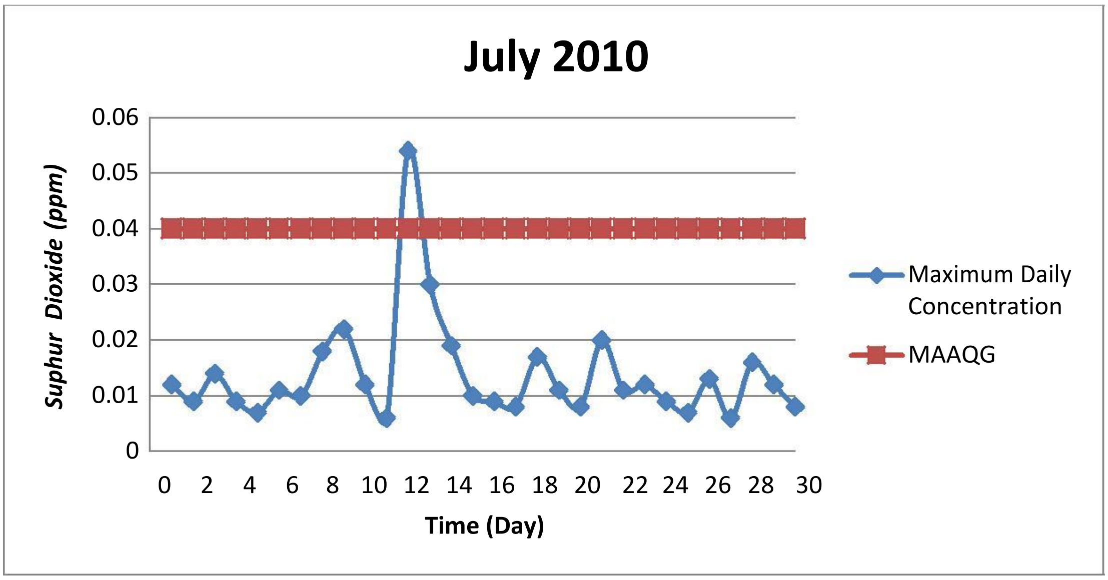

Figure A-3: The Maximum Daily Concentration for Sulphur Dioxide

Figure A-4: The Maximum Daily Concentration for PM10

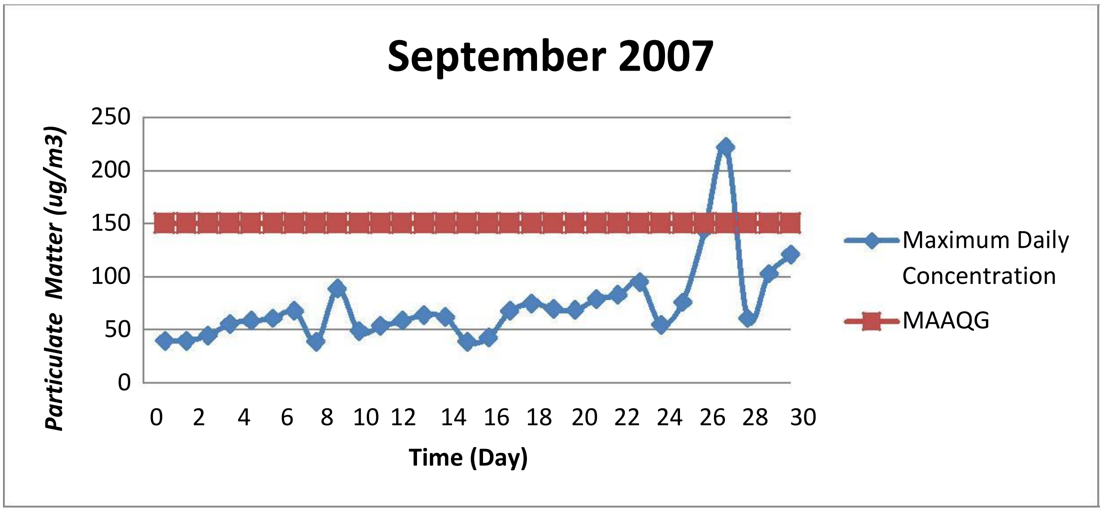

Figure A-4: The Maximum Daily Concentration for PM10

Figure A-5: The Maximum Daily Concentration for PM10

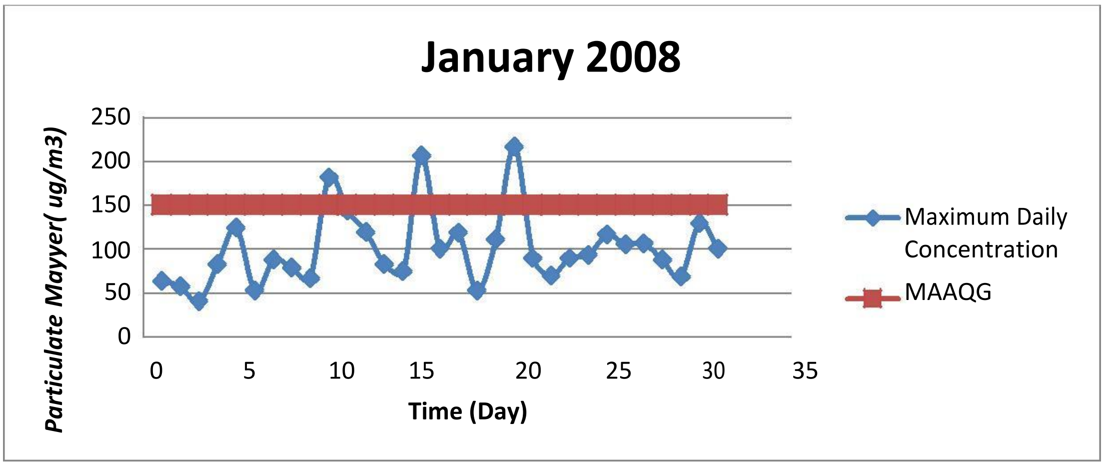

Figure A-5: The Maximum Daily Concentration for PM10

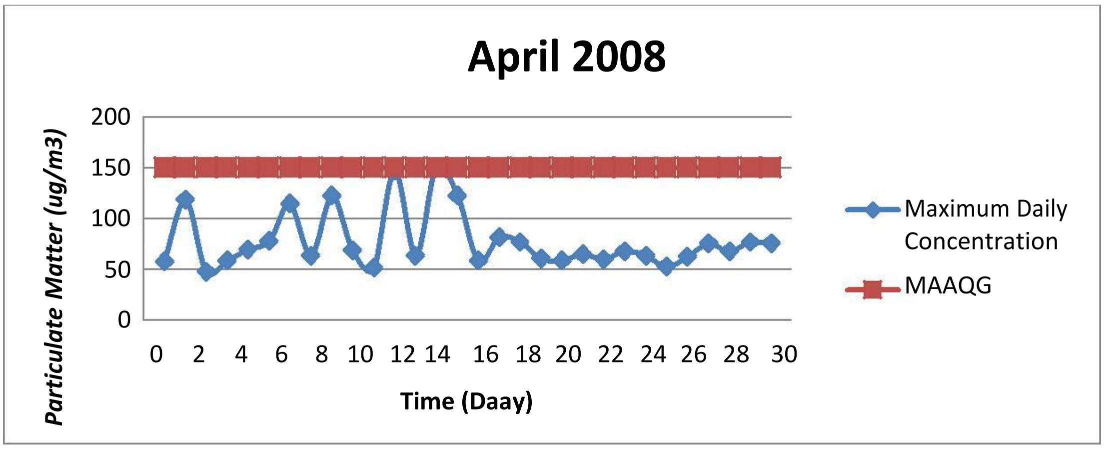

Figure A-6: The Maximum Daily Concentration for PM10

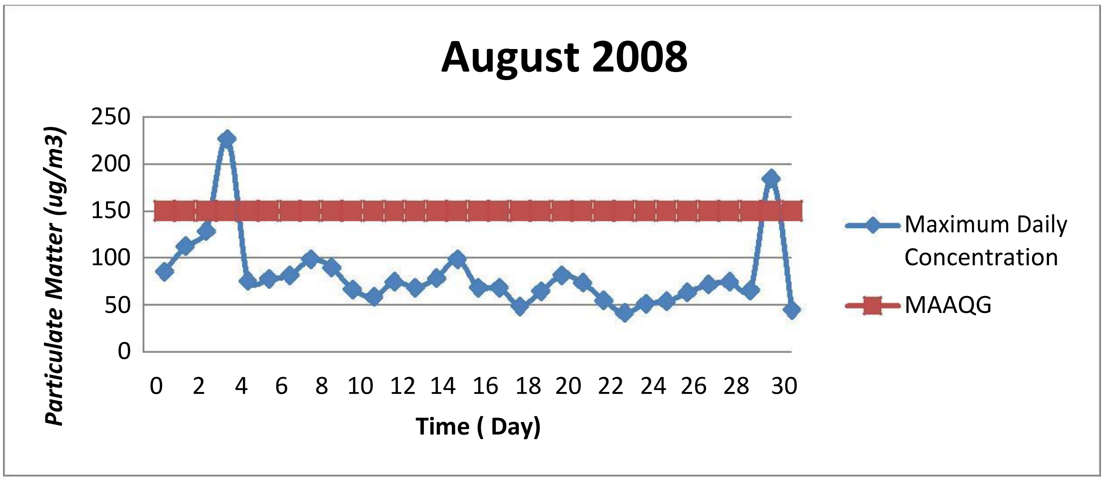

Figure A-7: The Maximum Daily Concentration for Sulphur PM10

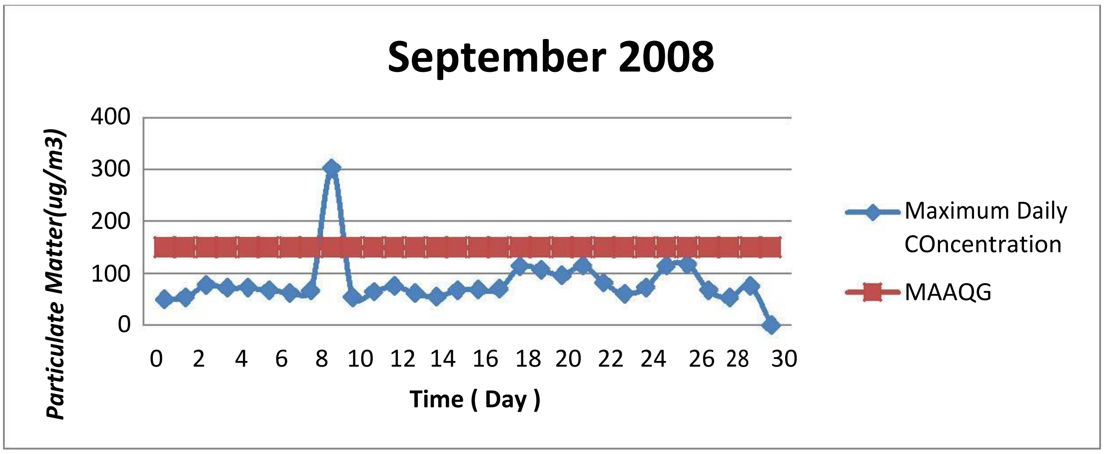

Figure A-8: The Maximum Daily Concentration for PM10

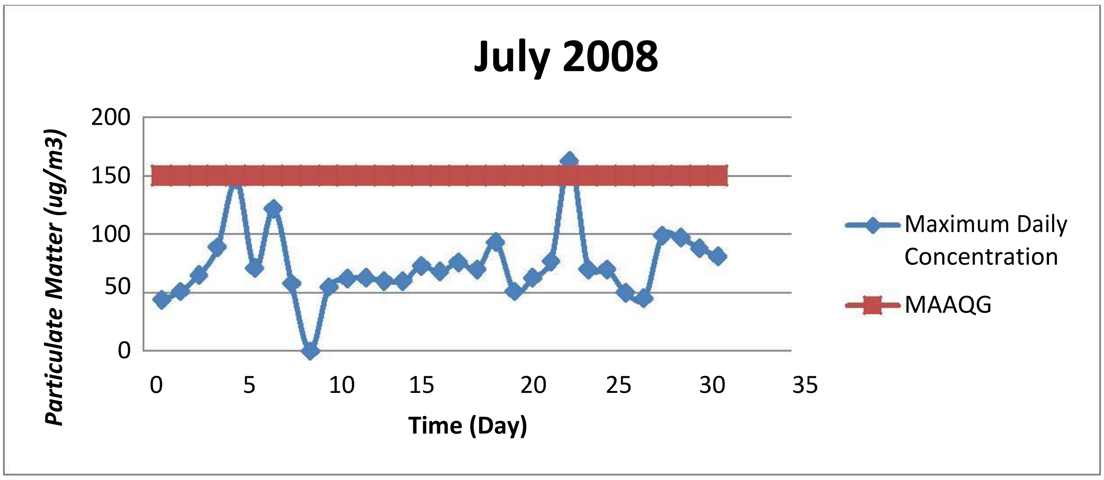

Figure A-9: The Maximum Daily Concentration for PM10

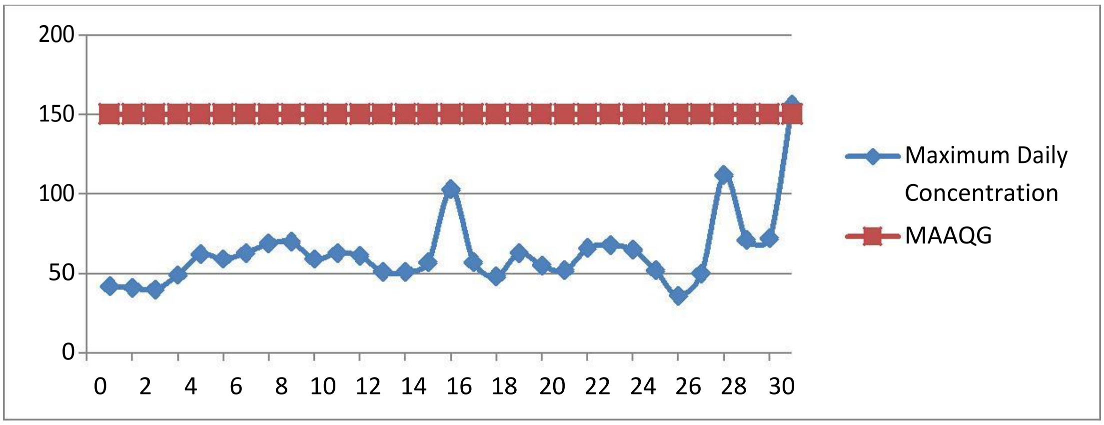

Figure A-10: The Maximum Daily Concentration for PM10

Figure A-11: The Maximum Daily Concentration for Sulphur Dioxide

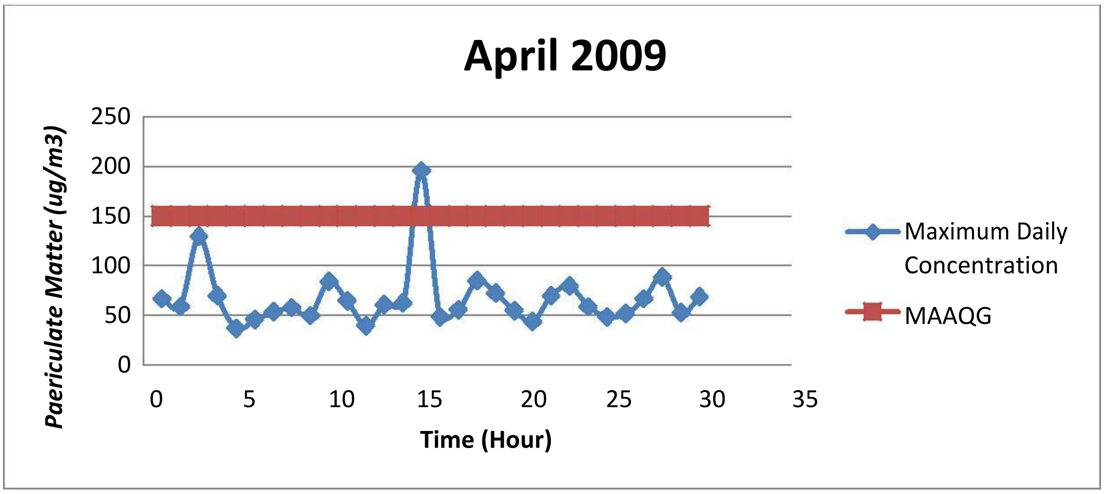

Figure A-11: The Maximum Daily Concentration for Sulphur Dioxide

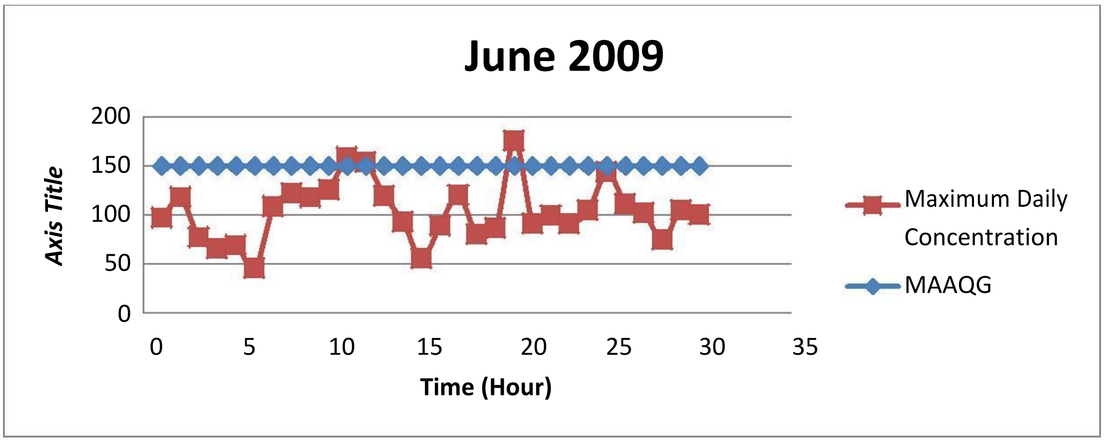

Figure A-12: The Maximum Daily Concentration for PM10

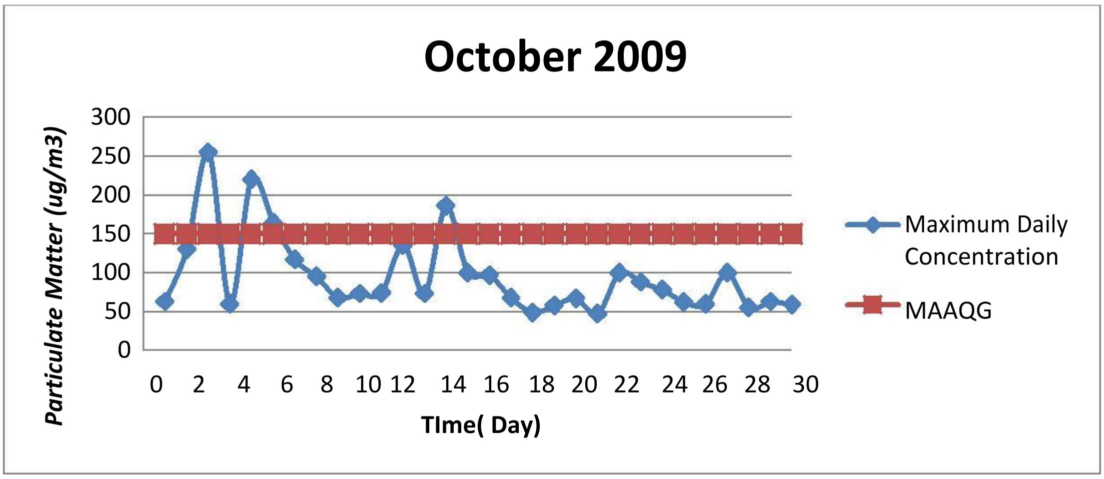

Figure A-13: The Maximum Daily Concentration for PM10

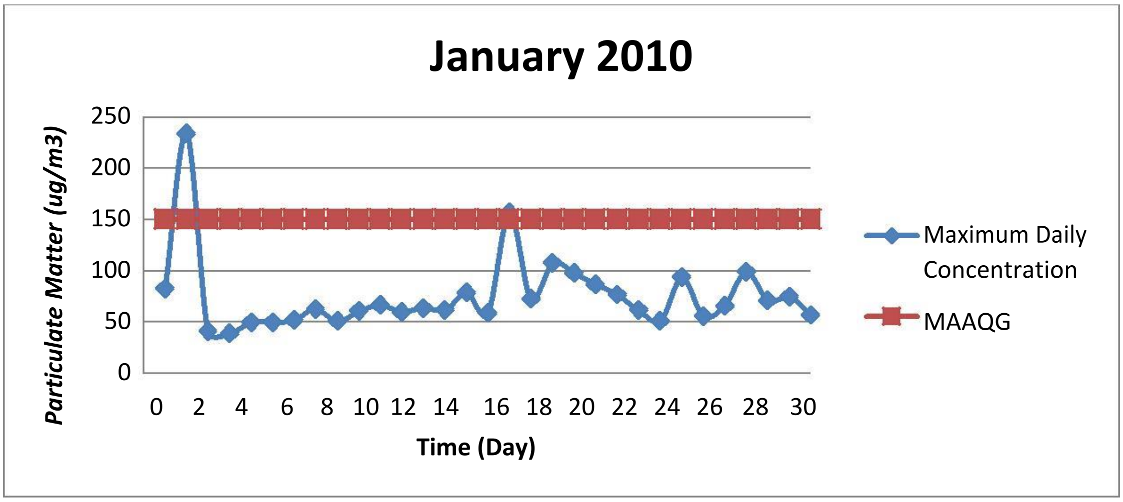

Figure A-14: The Maximum Daily Concentration for PM10

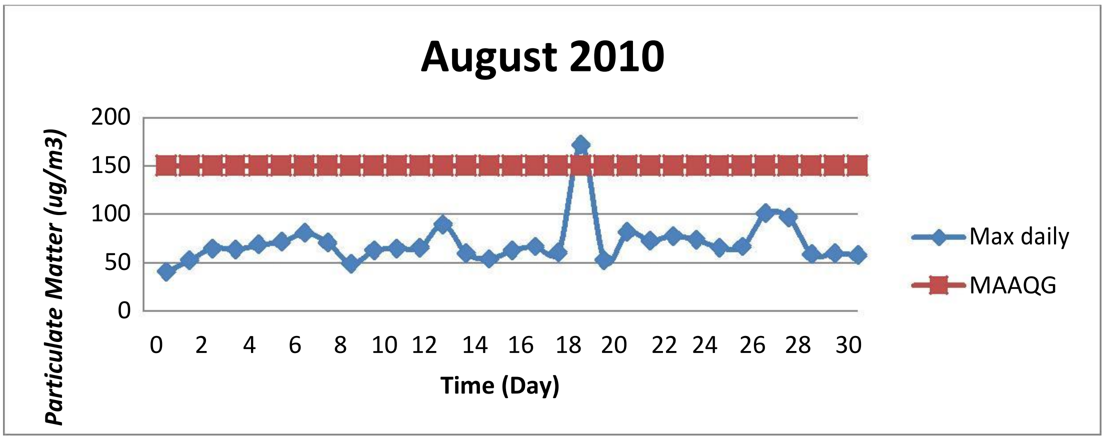

Figure A-15: The Maximum Daily Concentration for PM10

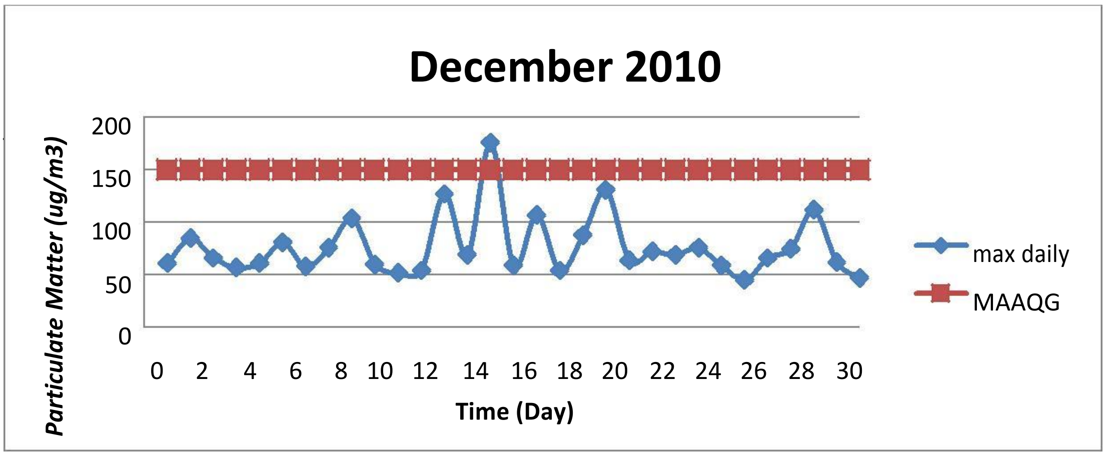

Figure A-16: The Maximum Daily Concentration for PM10