Effects of Sub-Urban Area Development in Selangor to the Air Pollution Index from 2012 to 2014

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***Abstract*— This study aims to explore the trend of ambient air pollution (i.e. PM10, CO, NO2, O3) within the two selected Malaysian air monitoring stations in Selangor of three years database from 2012 to 2014. The air pollution databases were compared to the recommended Malaysian Ambient Air Quality Guidelines (MAAQG) and the association between air pollutants and meteorological factors also assessed. In addition, data analysis has been carried out in the following developed sub-urban areas: Banting and Kuala Selangor. Hourly API from each air monitoring station was analysed where API was based on the average concentration of PM_{10}, $PM_{2.5}$, O_3, CO, SO_2, and NO_2. Based on the result, it can be said that the year 2014 was indeed the worst year for Banting and Kuala Selangor especially during the month of March, the highest reading recorded in Malaysia was in Banting and Kuala Selangor reaching hazardous level exceeding 300. The government has spent RM2.244 billion for environmental protection which increased by 0.3 percent compared to the previous years. Air quality trends for the criteria pollutants in these research generally continuing to show downward trends or stable trends well below the level of MAAQG except for particulate matter. However, PM_{10} and O_3 are the crucial pollutants in Selangor.**

Keywords—Ambient air pollution, API, sub-urban area

I. INTRODUCTION

Selangor Darul Ehsan is known to be one of the most successful states in Malaysia regarding to its socio-economic development. In order to expand its economic base and restore the confidence of local and foreign investors, Selangor has taken an initiative in achieving a developed by the year 2020 country by creating more developments. Infrastructure development has been stressed on, and by financing on public projects, Selangor as of now has been proved to be the best states with better transportation network system as well as port and airport facilities among all states in the country. All of this development processes emit air pollutants which is a substance in the air that can have adverse effects on humans and the ecosystem and adds a certain amount of pollution to the environment (Pereira, et.al, 2005). In western countries, the impact of air pollution on residents' health is higher in less wealthy communities according to a report done by World Health Organisation (WHO), the amount of deaths linked to air pollution is more than 90 per cent in a low- or middle-income countries especially in Asia and Africa (News, 2018; Sun & Gu, 2008). WHO's study found that "around seven million people die every year from exposure to fine particles in polluted air."

In order to view the level of pollution in the air, an air pollution index is used. Air Pollution Index (API) is a quantitative tool through which air pollution data can be reported uniformly (Swamee & Tyagi, 2011). An index for reporting daily air quality called API is established. It publicizes the cleanliness of the country, and what associated health effects might be a concern to the people in the country. The API helps to detect and gives information of health effects that be experienced within a few hours or days after breathing unhealthy air (Afroz et. al, 2003). The ambient air quality monitoring program has been initiated in 1977 followed by the introduction of the continuous automatic samplers in the 1980. A few years after that in 1989, ambient air quality standards have been developed in 1989 as a reference tools to help in air quality management. However, a new ambient air quality standard has replaced the older version of Malaysia Ambient Air

Quality Guideline in 1989. In the new ambient air quality standard, an additional of air pollutants criteria has been added to the previous 5 existing air pollutants which is particulate matter with the size less than 2.5 micron ($PM_{2.5}$) as well as the previous air pollutants criteria which are particulate with the size of less than 10 micron (PM_{10}), sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and ground level ozone (O_3).

Due to the increases in the population, numbers of vehicles, and traffic problems during peak time tend to effect the trend in the air pollution index when exposed for a long time. Area where there is a lot of human activities going on especially near school where there must be emission of motor-vehicle during school sessions from the parents' cars or motors for taking and sending children to school as well as school bus. Air pollutants from the emissions are trapped down in the surrounding and might contribute a stagnant contribution (Amir, 2007). The suspended air pollutants in the atmosphere may lead to various health effects to human no matter the age group such as respiratory effects, cardiovascular effects, cancer, reproductive and developmental effects, neurological effects, mortality, infection, and other health effects. Though most health effects involved children and elderly which linked to asthma and bronchitis due to outdoor activities when they are exposed to higher level of air pollutants. Even though the exposure to the pollution is short term such as getting stuck in traffic jam, the risk of getting a heart failure increases (Curtis, et.al, 2006).

This study aims to explore the hourly trend of ambient air pollution within the three selected Malaysian air monitoring stations in Selangor of three years database, from 2012 to 2014. The air pollution databases were compared to the recommended Malaysian Ambient Air Quality Guidelines (MAAQG) and the association between air pollutants and meteorological factors also assessed. In addition, data analysis has been carried out in the following developed sub-urban areas: Shah Alam, Banting and Kuala Selangor. Hourly API from each air monitoring station was analysed where API was based on the average concentration of PM_{10}, $PM_{2.5}$, O_3, CO, SO_2, and NO_2. Through this data, it is to be observed the whether level of pollution is due to the geography or climate, economy and industry, or population and urbanization.

II. METHODOLOGY

A. Materials and Methods

The study site was in Selangor, which is the most populated state in Malaysia according to the Department of Statistics Malaysia. The Malaysian population has grown by 1.3% reaching 32.4 million according to the statistics (DOS, 2018). Based on a report by The Star, the growth was recorded in the first quarter of this year, compared to the same period last year when there were 32 million Malaysians. Among these 32.4 million people, a total of 16.7 million are male while the rest are populated by female at 15.7 million people. The Selangor state is located at 3.0738° N, 101.5183° E categorized as urbanized region in Peninsular Malaysia. With the total are of 7931 km^2, it inhabits a total of 6.47 million population as of 2018 (DOS, 2018). It shows that Selangor in term of area represents only 2% of total area in Malaysia. However, the current population density in Selangor exceeded the level of national population about 13 times higher (Dominick, et.al, 2012).

Table 1: The air quality monitoring stations

Air quality station location	Area	Coordinates
Kolej MARA Banting	Banting	N 2.816971 E 101.623052
Sekolah Menengah Sains Kuala Selangor	Kuala Selangor	N 3.326548 E 101.258880

Source: Department of Environment (DOE)

Fig 1: Location of Experimental Study; Kuala Selangor

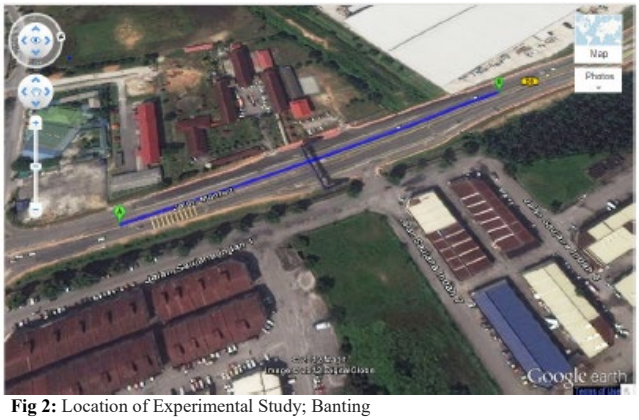

Fig 2: Location of Experimental Study; Banting

Table 1 shows the detail of the air quality monitoring stations that are all located in the sub-urban area. The Banting station resided near the roadside of a highway and surrounded by trees and oil palm plantations. This area is less populated by residents same goes to the station in Kuala Selangor which is in a location with low population density.

2.2. Data Collection

Before the research was done, a thorough finding has been carried out to collect information about air pollution in general and in Malaysia. A library research was done as a systematic study to investigate some aspect of information where conclusions are based on the analysis of data collected in accordance to the published research from previous researcher. Based on this method, a lot of information is gained such as the definition, measurement, sources, effects, etc. This library researching method helps to fulfil the objectives of this research to further prepare for site location study. It involves secondary data such as book, journal, article, news, and thesis. Previous research paper can further help to strengthen point to support findings in this research.

The dataset was obtained from Department of Malaysia (DOE) Malaysia in the Air Quality Division. In this study, dataset from the year 2012 to 2014 were used covering sub-urban areas Selangor with 2 sampling stations. Hourly Air Pollution Index (API) based on the average concentration of particulate matter (PM_{10}), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and ozone (O_3) at each air monitoring station. The API reading is based on the highest value among the air pollutant.

2.3. Data Analysis

Data collected from journals and articles are studied to be included in the literature review. The hourly readings were analyzed in Microsoft Excel and presented in graph. Each graph represents the weekly value for each pollutant for three years. The analysis consists of air pollutant data set of air quality monitoring stations that had been analyzed by ASMA.

III. RESULTS AND DISCUSSION

A. Air Quality Status

Fig 1 illustrates the weekly trends (1-week averaging time) of SO_2, NO_2, O_3 and CO and PM_{10} in Banting from 2012 to 2014. To determine API for a given time period, the sub-index values (sub-API) for five pollutants are calculated for the air quality data collected from the CAQM stations. The API value reported for given time period represents the highest API value among all the sub-APIs calculated during that particular time period. The following analysis are based on maximum daily measurement and weekly average. The air quality trend for the period of three years are received from DOE and computed by averaging direct measurements from the monitoring sites on a daily basis.

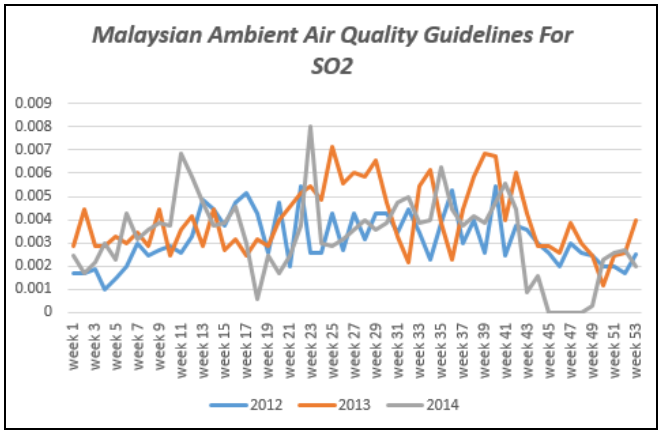

Fig. 3: Weekly trends of SO_2 (ppm) in the Banting from 2012 to 2014

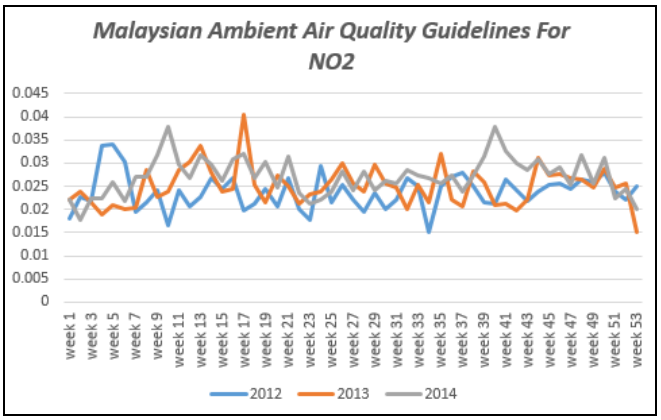

Fig. 4: Weekly trends of NO_2 (ppm) in the Banting from 2012 to 2014

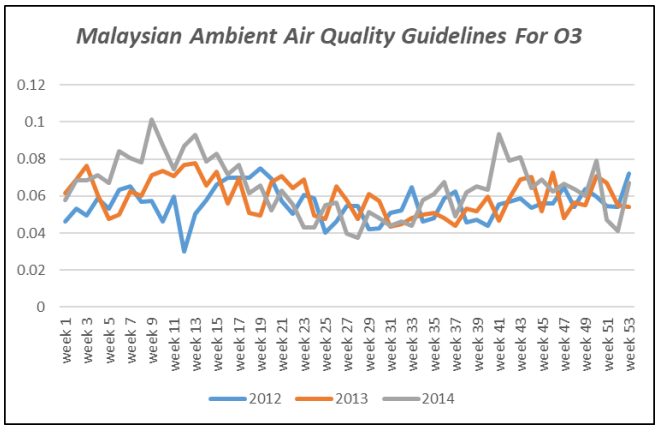

Fig. 5: Weekly trends of O_3(ppm) in the Banting from 2012 to 2014

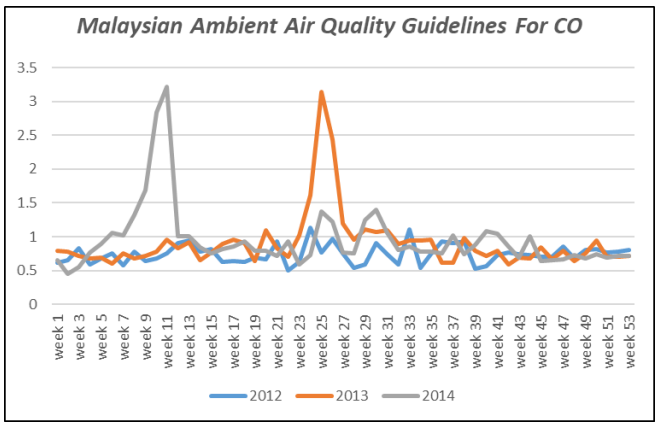

Fig. 6: Weekly trends of CO (ppm) in the Banting from 2012 to 2014

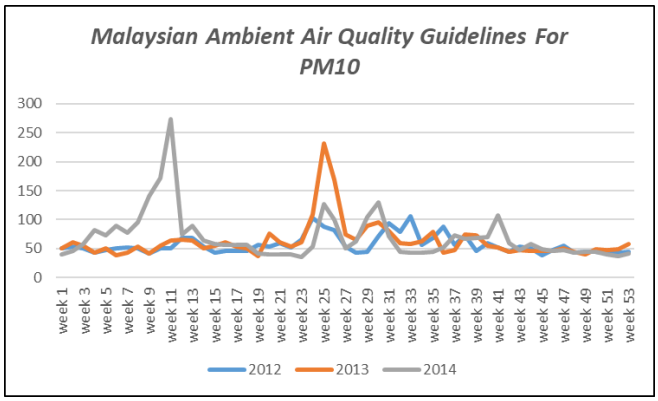

Fig. 7: Weekly trends of PM_{10} ($\mu g/m_3$),in the Banting from 2012 to 2014

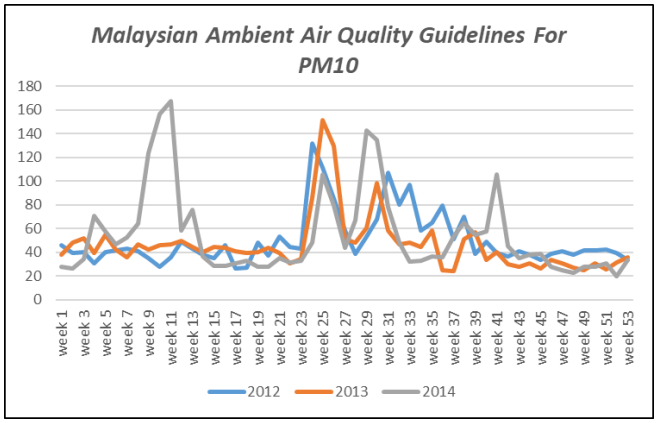

Fig. 8: Weekly trends of PM_{10} ($\mu g/m_3$),in the Kuala Selangor from 2012 to 2014

From the figures,, the concentrations of SO_2, NO_2, O_3 and CO are generally within the Malaysian Ambient Air Quality Guideline which is shown in Table 2. Values of pollutants concentration higher than stated in Table 2 were analyzed in this study (Rich, 2017) as unhealthy, very unhealthy, hazardous, and emergency levels likely to contribute significant damage to health, environment, and property. The first graph shows the weekly average reading of SO_2 in Banting for three years, indicating that the highest reading is measured in 2014. However, weekly data also indicate the readings for 2014 has the least concentration among three years especially from week 45 until week 49. Providing that Banting is largely populated areas if compared to Kuala Selangor. It might also due to the haze episodes experienced in Malaysia due to the transboundary pollution from Indonesian forest fires as SO_2 is one of the factors that made up haze. Meanwhile, data for the year 2013 shows a consistent high in readings compared to other years.

The second graph shows the relationship between the level concentration of NO_2 against the number of weeks. The result indicates a good measure which means that the level of concentration does not exceed the permitted level done by MAAQG. The weekly average data ranging from 0.015 to 0.04 throughout the year. In some cases, the weak blowing wind allowed the pollutants from moving vehicles to stay in the atmosphere for several weeks which to some extend contributed to the high level. Estimation on NO_2 emission load indicated that 65 was from industries while 27 percent from motor vehicles, 6 percent from power plants and 2 percent from other sources. The annual average concentration of NO_2 in the ambient air from 2012 to 2014 remains almost constant and well below the MAAQG.

Table 2: Ambient Air Quality Standard Guideline.

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

*mg/m^3, Source : (Department of Environment, 2013)

Similar trend is shown for other parameters except for CO and PM10, which has been proved by a study done by (How & Ling, 2006), where the result from their study shows that during the haze period, the concentration of PM10 is much higher compared to the non-haze period. There are certain data falls within dangerous level that on the 8th till 11th week of 2014, and the 24th till 28th week of 2013 where the concentration level peak at 273 and 231 respectively. This exceed the permitted level of PM10 at only 150 Besides, the study done by (Azid et al., 2015) shows that parameters such as O_3 and PM10 are responsible for air quality variations. Thus, presence of these pollutants has its own impact to air quality. Furthermore, it can be affected by the size of buildings that contributes to the recirculation of wind. The higher building might make a barrier for the resident area which impact the smoke from traffic to be trapped in the wind. Hence, the concentration of PM10 increases.

The trend of CO from 2012 to 2014 remains almost constant except for some weeks where the level rocketing. In 2013 and 2014 at some point, the concentration of CO was higher where the source of emission which is motor vehicles, which contributed to 95 percent of emission load. This might be due to the public holiday during the month of May and June for school children. However, the levels recorded were well in compliance to the Malaysian Ambient Air Quality Guidelines.

Besides PM10, ground level O_3 remained the pollutant of concern. The slightly high concentration of pollutants during May and September might be due to the increasing ozone concentrations resulting from the sunrise coinciding with increasing solar radiation. A study has done by (Tyagi et al., 2016) where they found that the concentration of O_3 gradually increase after sunrise especially during dry season as it experienced the southwest monsoon, which usually ran from May until September, thus lesser the number of rainfalls (A.Samy, 2012). During this hot and sunny day the formation of O_3 is enhanced especially since O_3 is made up chemical reaction between Volatile Organic Compounds (VOCs) and nitrogen oxides (NO_x) in the presence of sunlight. This condition led to a number of unhealthy days recorded in Banting especially places with heavy traffic volumes.

IV. Conclusion

Based on the statistics, it can be said that the year 2014 was indeed the worst year for Banting and Kuala Selangor especially during the month of March. There were also a lot of articles and newspapers published during this month reporting about the rise of API reading because of haze problem. In fact, according to the article by (Rozario, 2015), the highest reading recorded in Malaysia was in Banting and Kuala Selangor reaching hazardous level exceeding 300. Due to this, a survey has been done by the Department of Statistics Malaysia in 2015 reported that the Environmental Protection Expenditure (EPE) has spent RM2.244 billion for environmental protection which increased by 0.3 percent compared to the previous year. The same can be said for the year 2013 during June where there was an illegal burning of forests and other land in Indonesia pushing the air pollution index to be above the level considered hazardous. (Reuters, 2013) reported that Malaysia has declared a state of emergency on June 23 where we were affected greatly by this incident. There were no serious incidences of air pollution recorded in the period of 2012 to 2014 in Banting and Kuala Selangor. Air quality trends for the criteria pollutants in this research generally continue to show downward trends or stable levels well below the level of the Malaysian standards except for the particulate matter with size less than 10 micros. These values are important for determining the API level as well as determining the air quality on a certain day. The worst quality of air can bring harm not only on human health, but also to the environment and the economic growth. From the API level, the government as well as the public can take action to reduce the air pollutants. More knowledge and information should be acquired on local meteorological phenomenon, road condition, traffic volume and vehicle profile including the impact of weather elements such as wind, sunlight and temperature. On the bright side, Malaysian government has implemented necessary actions to diminish haze occurrence by restricting laws against open burning. Cloud seeding has also been introduced by the government to ensure API stays at a healthy level.

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