The Effects of Urban Area Development in Melaka to The Air Pollution Index from 2012 to 2014

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Abstract - Melaka has two air pollution monitoring stations which are located in SMK Bukit Rambai, Melaka and SMK Kota Tinggi Melaka, Melaka. The research would adhere the Air Pollution Index (API) scale provided by the Malaysian Department of Environment in order to promote a better understanding on the data as it would reflect the air quality levels associated with the urban development. The objective of this study includes identifying the urban air quality and gives recommendation based on the findings as well as to investigate the relationship between urban development to the air pollution index. This research includes the study of pollutants especially the five parameters used in Malaysia which are Sulphur Dioxide (SO_2), Nitrogen Dioxides (NO_2), Carbon Monoxide (CO), particulate matter with 10-micron (PM_{10}) size in diameter and ground-level ozone (O_3). The API trends in Melaka for year 2012 to 2014 are analysed and discussed to predict the trends for the following years. Various factors are taken into consideration in discussing the API readings that shows significant increase and decrease throughout the years. Based on the studies, the API readings in Melaka are predicted to increase by years as a result of continuous development in the region.

Keywords – Melaka, Air Pollution Index (API), Air pollution, urban development

I. INTRODUCTION

Currently, the most concerning natural issues facing our human progress is presumably air pollution. The significant contributor to this issue is the anthropogenic activities such as mining, transportation, development, mechanical work, agribusiness, and so forth. Natural phenomenon such as volcanic ejections and rapidly spreading fires may also causes air pollution, however their event is rare and they as a rule have a local impact, not at all like human exercises that are pervasive reasons for air pollution [1].

Air Pollution Index (API) is utilized to depict the surrounding air quality estimation in Malaysia. The API used simple ranges of values to describe the air quality rather than the use of the air pollutants actual concentrations. The impact of the air pollution to the human wellbeing can be reflected by the API, running from good to hazardous can be sorted by the action criteria as mentioned in the National Haze Action Plan. Pollutant Standard Index (PSI) created by the United States Environmental Protection Agency (US-EPA) is closely followed by The Malaysian API framework [2].

Malaysia's API includes five parameters which are Sulphur Dioxide (SO_2), Nitrogen Dioxides (NO_2), Carbon Monoxide (CO), particulate matter with 10-micron (PM_{10}) size in diameter and ground-level ozone (O_3).

The API scale and terms used in Malaysia to describe the air quality is shown in Table 1.

Table 1: Air Pollution Index Guidelines in Malaysia [2].

API	Status
0-50	Good
51-100	Moderate
101-200	Unhealthy
201-300	Very unhealthy
>301	Hazardous

If the API surpasses 500, the reporting zone is announced to be in an emergency state. Normally, this implies non-essential government services are suspended, and all ports in the affected zone are shut. There may also be a preclusion on private division business and industrial exercises in the announcing region barring the sustenance area [3].

SO_2 emission originates from the utilization of sulphur-fossil fuels such as fuel oil and coal, these emissions are mostly discharged to the air by petroleum refining, generation of power and heating systems [4]. The diesel motor vehicle division also contributes to the SO_2 discharges. NO_2 emission was contributed by diesel truck and additionally manufacturing, agriculture energy transformation, and forestry [4]. PM is a complex mixture of solid particles and liquid droplets suspended in the air that differ in size, composition, and concentration. PM_{10} can remain in atmosphere for quite a long time and can travel as far as 30 miles. Most O_3 originates from vehicular activity while CO is a gas that originates from incomplete combustion [4].

The air pollutant factors are taken into consideration in studying and predicting the API trend of the research areas.

II. METHODOLOGY

The research areas include SMK Bukit Rambai and Kota Melaka. Site visit to the research areas are conducted in order to study and observe the locations hence justifying the API data obtained. The air quality data used for this research were obtained from the Air Quality Division of the Department of Environment, Malaysia (DOE) through long-term monitoring by a private company, Alam Sekitar Sdn Bhd (ASMA). The five parameters studied in the research areas include SO_2, NO_2, CO, PM_{10} and O_3.

The following table shows the air pollution monitoring stations coordinate in the research areas, based on the Air Program Information Management System (APIMS) from the Malaysian Department of Environment official website [5].

Table 2: Air pollution monitoring stations coordinate of respective study area.

Location	Latitude (N)	Longitude (E)
SMK Bukit Rambai, Melaka	$02^0$15.510’	$102^0$10.396’
SMK Tinggi Melaka, Melaka	$02^0$12.789’	$102^0$14.055’

Graphs are plotted based on the API data obtained in order to study the API trends in respective areas. The API trend for year 2015 are then predicted for each area.

III. RESULTS AND DISCUSSION

The main pollutants recorded at the two air monitoring stations in Melaka are SO_2, NO_2, CO, PM_{10} size in diameter and O_3.

SMK Bukit Rambai

SO_2 concentration trend in Bukit Rambai throughout year 2012 to 2014 (Figure 1) shows the same patterns which are considered to correlate directly with the number of motor vehicles emissions, particularly from busses and vehicles near the monitoring station. However, the SO_2 concentration shows higher reading in year 2013 compared to year 2012 and 2014 due to haze events during that year. The reading shows a peak average concentration of 0.0126 ppm on July 2013 due to the heavy haze occurring during the month. The lower readings during the end of year for each year is believe to be correlated with the wet northeast monsoon (October to December) which brings more rainfall, hence decreases the amount of SO_2 pollutant in the air as they were trapped by the raindrops and eventually fell to the ground.

The trend of NO_2 (Figure 2) recorded at Bukit Rambai indicates a significant peak during January and fluctuation of NO_2 concentration during February and increase again the next month. This pattern continues throughout the year for the whole three years, probably due to the movement of motor vehicles. The NO_2 concentration in year 2014 rises during March due to a haze event [6]. This would be expected due to the composition of the sulphur compound, particularly from biomass burning [7].

O_3 is a secondary gas produced by the interaction of hydrocarbon, oxides of nitrogen and sunlight. Based on the result shown in Figure 3, the level of O_3 can be seen to be much more closely related to the intensity of sunlight and the contribution of other precursors rather than NO_2 and hydrocarbon from motor vehicles. A high concentration of NO is expected to be produced by motor vehicles around the monitoring area. NO has the capability to interact with O_3 to form NO_2 in the atmosphere [7]. The reading shows 0 ppm for O_3 concentration from week 3 to 9. This event might be due to the wind factor that prevented O_3 from floating at the ground level.

The CO concentration (Figure 4) shows the same yearly pattern. Although, the CO concentration in week 9 to 11 of year 2014 shows higher reading than that of year 2012 and 2013 Bukit Rambai recorded unhealthy API readings on March 2014 as a result of a haze event [6]. The concentration also shows a small peak during week 4 in year 2012 with an average concentration of 1.71 ppm. A major increase in CO concentration was recorded during week 25 (June) in year 2013 with an average concentration of 4.17 ppm. This phenomenon occurred due to the heavy haze event where the highest API reading recorded as of 19 June 2013 in Bukit Rambai was 118 ppm.

The PM_{10} readings indicate that the pollutant is in an allowable range as they did not exceed the Malaysian Air Quality Guidelines of 150 $\mu g/m^3$ daily, except for June 2013 where the reading surpasses the guideline. The peak average concentration of PM_{10} was recorded to be 348.71 $\mu g/m^3$ on week 25 in year 2013. This clearly shows that suspended particulate matter was the major air pollutant during the haze event in June 2013 and was transboundary in nature as a result of large-scale forest fires in parts of Sumatra [8].

Overall, the API trends in Bukit Rambai from year 2012-2014 are almost consistent. The API reading shows that the air pollutants concentrations are affected by the same factors each year. The major contributor of air pollution in Bukit Rambai from year 2012-2014 is believed to be from haze which are usually brought by the strong wind of southwest monsoon. This is because the API reading shows an increase of readings each year during the southwest monsoon season which is between June and September.

The API trend in Bukit Rambai for year 2015 is predicted to have the same trend as in year 2012-2014, where the SO_2 concentration would be consistent throughout the year and increase higher in October due to the dry season. NO_2 is believed to remain consistent throughout year 2015 as those in year 2012 to 2014. CO_2 trend in Bukit Rambai for year 2015 is predicted to be consistent throughout the year as the pollutant is affected by the constant vehicular activities at the research areas. O_3 is predicted to be inconstant throughout year 2015 as O_3 concentration is majorly affected by nature. The CO trend for year 2015 in Bukit Rambai is believed to have the same trend as those in year 2012 and 2013 where the concentration remains low throughout the year except in June, where the reading shows significant increase due to the haze event which usually occur during that month. PM_{10} in Bukit Rambai for year 2015 is predicted to have the same trend as CO where the concentration remains low throughout the year and increase higher in June.

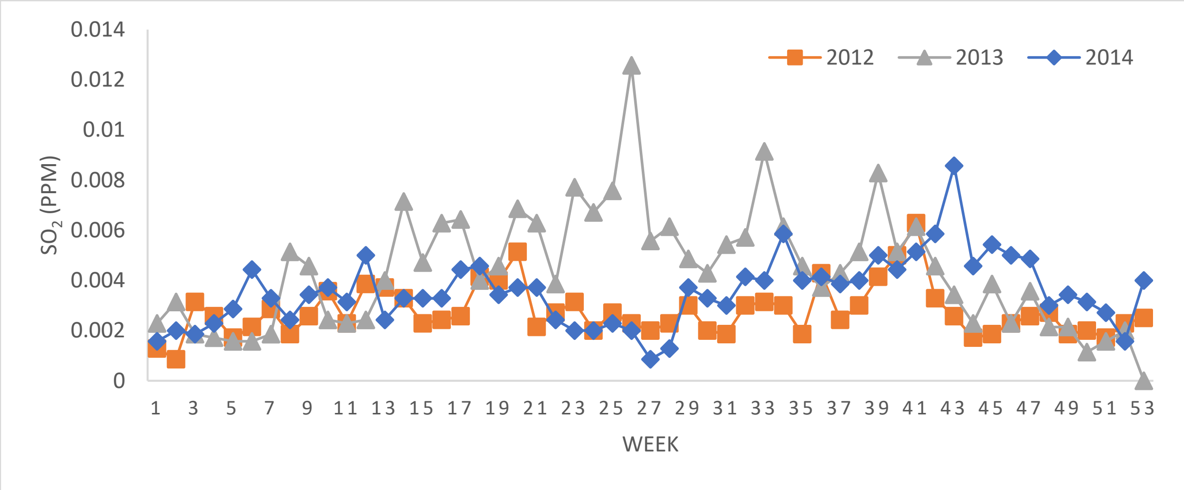

Figure 1: SO_2 Concentration Trend in Bukit Rambai For Year 2012-2014

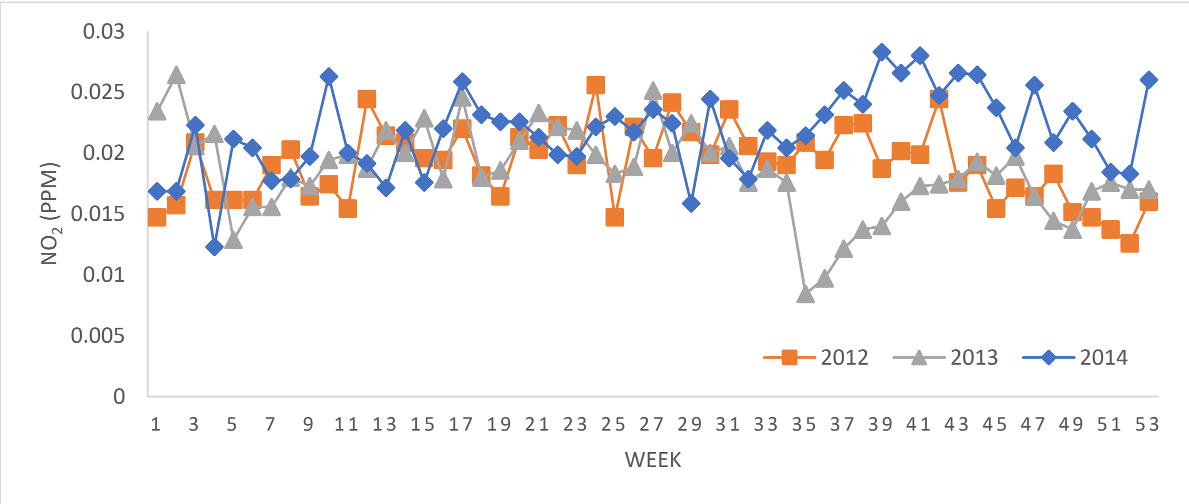

Figure 2: NO_2 Concentration Trend in Bukit Rambai For Year 2012-2014

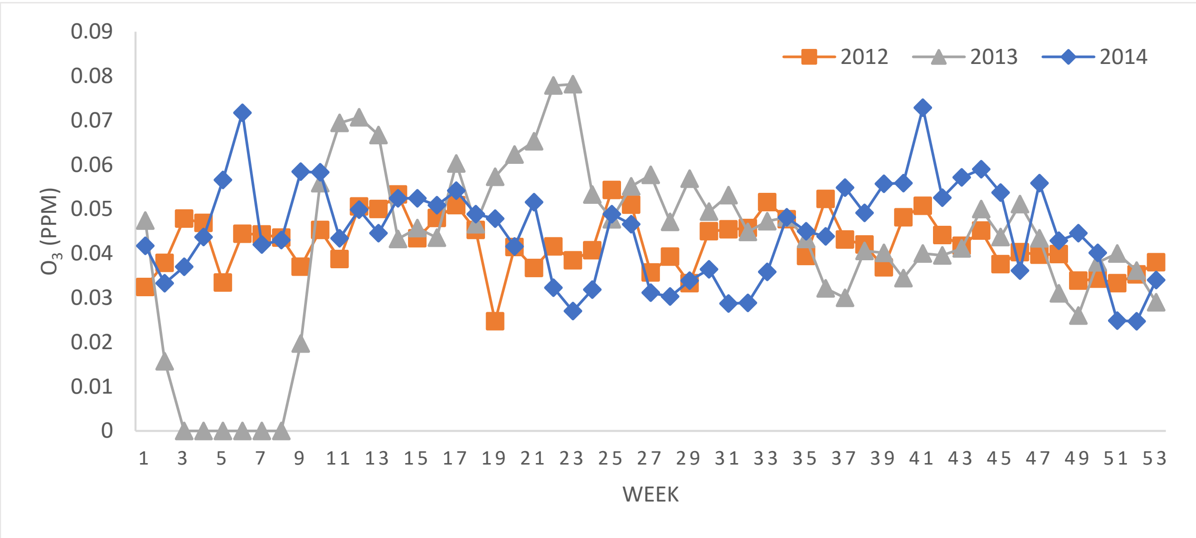

Figure 3: O_3 Concentration Trend in Bukit Rambai For Year 2012-2014

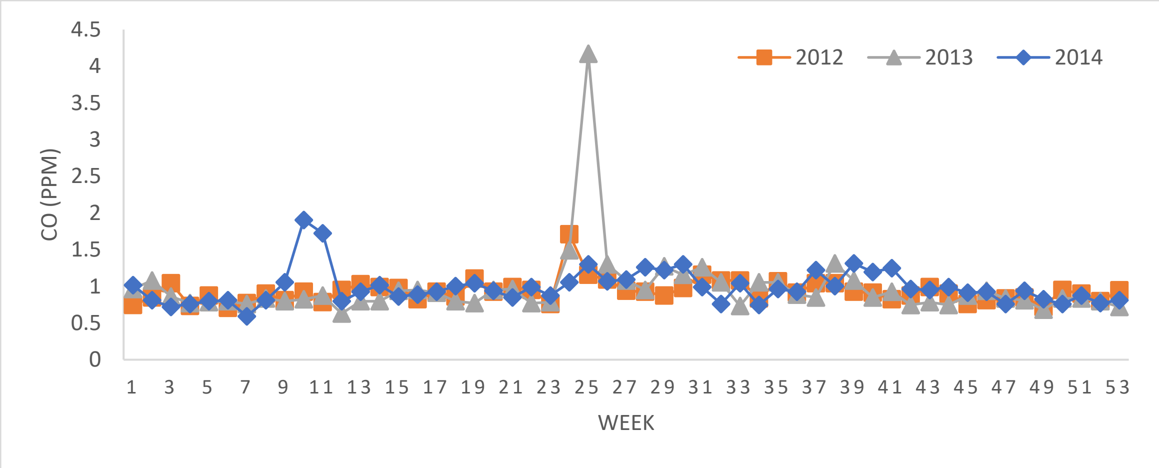

Figure 4: CO Concentration Trend in Bukit Rambai For Year 2012-2014

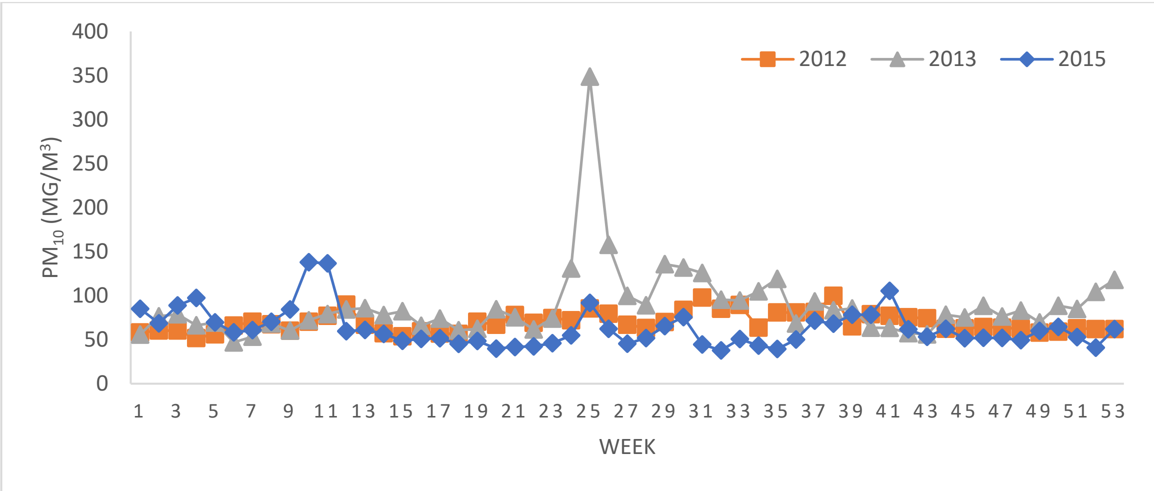

Figure 5: PM_{10} Concentration Trend in Bukit Rambai For Year 2012-2014

SMK Tinggi Melaka

The SO_2 concentration in Bandaraya Melaka (Figure 6) shows a significant high reading in year 2014. The peak average SO_2 concentration in that year is 0.009 ppm which is in week 6 (February). The air quality in Bandaraya Melaka fluctuated for few weeks before increased to unhealthy level during March 2014 [6]. The reading remained high until week 25 (June). The main source of this pollutant is expected to be from the haze episodes. The southwest monsoon occurs between June to September each year and is usually associated with the generation of haze episodes in the Malaysian Peninsular as a result of biomass burning from Sumatra, Indonesia [7]. The SO_2 concentration remained low at the end of year for each year due to the wet northeast monsoon (October to December).

Figure 7 shows that the NO_2 concentration in Bandaraya Melaka remains low from year 2012 to 2014, except in week 13 (March) of year 2014 where there is a significant peak with an average concentration of 0.113 ppm. This phenomenon occurred because of the haze event in March 2014 [6]. In the same year, the NO_2 reading fluctuate to 0 ppm in weeks 25 and 26 which might be due to the vehicular activities. It is believed to be a school holiday during that period, hence lesser vehicles are around the monitoring station as it is located inside a school area.

Figure 8 shows O_3 trends in Bandaraya Melaka and demonstrates that the formation of this gas is influenced by ultra-violet radiation from sunlight [7] as the readings differs significantly every week. The O_3 is also believed to be influence by the ambient temperature. The O_3 concentration is expected to be higher during sunny days and lower during rainy days. Besides, the high readings of O_3 is also expected to be the result of the massive vehicular activities around the monitoring area. The reading shows 0 ppm in week 45 to 49 of year 2013 which is expected to be caused by geographical factor. It was the wet northeast monsoon period thus increase in wind speed is expected, which resulted to O_3 floating away from ground level.

The CO concentration (Figure 9) are considerably low throughout year 2012 to 2014 except in few occasions. CO is correlated with the vehicular activities which explains the stable readings. However, the CO reading increases in week 11 and 12 (March) of year 2014 due to a haze event. The CO reading shows a significant increase in week 26 (June) of year 2013 with a peak average concentration of 4.05 ppm. This is expected due to the heavy haze occurring in Malaysia during that period. The reading has a sudden decrease the following week with an average concentration of 1.02 ppm.

Figure 10 shows the PM_{10} trend in Bandaraya Melaka for year 2012 to 2014. The trend is the same as CO as these pollutants are usually produced by the same factor, that is motor vehicles. Besides, PM_{10} is the major pollutant in haze. Hence, explaining the same pattern as CO. Heavy haze brought by the dry southwest monsoon in June 2013 results to high concentration of PM_{10} in the atmosphere. PM_{10} is also expected to be influenced by the meteorological factor such as sunlight and ambient temperature [7].

Based on the results, the API readings in Bandaraya Melaka from year 2012 to 2014 shows almost the same trend each year which may be due to the same factors affecting the air pollutant emissions every year. Vehicular activities are believed to be the greatest contributor of air pollutants in Bandaraya Melaka from year 2012 to 2014.

SO_2 readings in Bandaraya Melaka for 2015 is predicted to have the same pattern as those in 2012 to 2014. SO_2 is predicted to have higher readings during the first 6 months and proceed with lower readings for the next 6 months especially between October to December due to the wet northeast monsoon season. SO_2 is also believed to have higher readings in 2015 than 2014. As shown in Figure 6, the readings continue to increase by year. This may be due to the increasing amounts of vehicles in Bandaraya Melaka. NO_2 is predicted to remain consistent throughout year 2015 in Bandaraya Melaka if there is no heavy haze encounter as those occurred in year 2014. O_3 is believed to have lower readings in January and continue to increase until February. The O_3 concentration in Bandaraya Melaka is then predicted to have an inconsistent pattern from February to December 2015 similar to those in 2012 to 2014. CO in Bandaraya Melaka for year 2015 is predicted to have consistent readings throughout the year. PM_{10} in Bandaraya Melaka for year 2015 is predicted to have the same trend as CO as the contributing factors to these pollutants are the same.

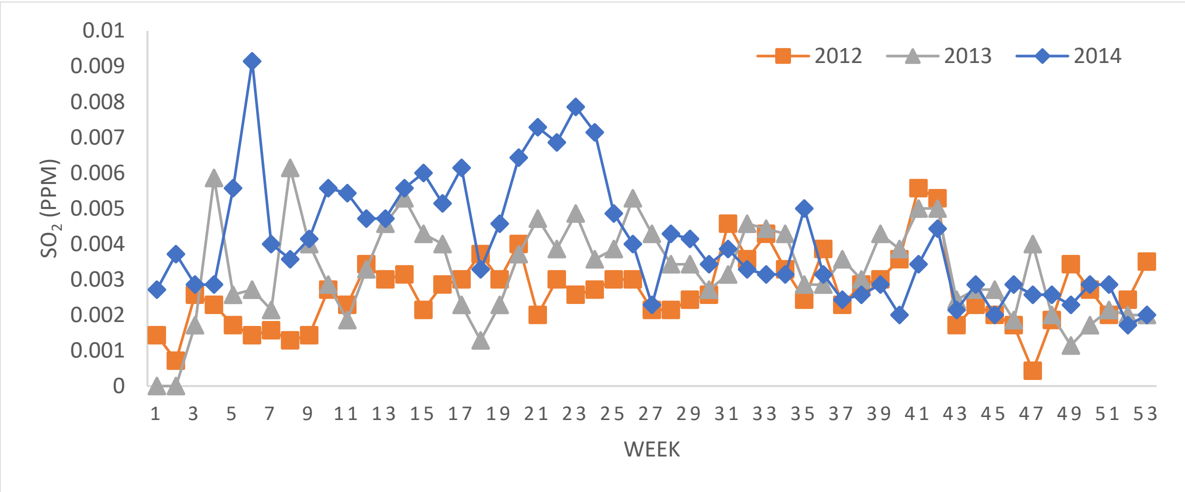

Figure 6: SO_2 Concentration Trend in Bandaraya Melaka For Year 2012-2014

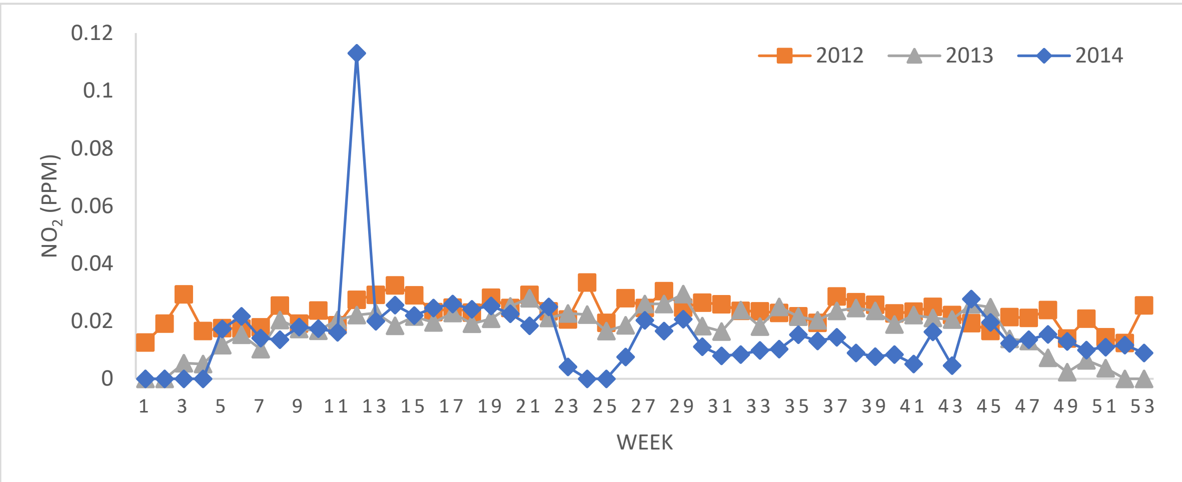

Figure 7: NO_2 Concentration Trend in Bandaraya Melaka For Year 2012-2014

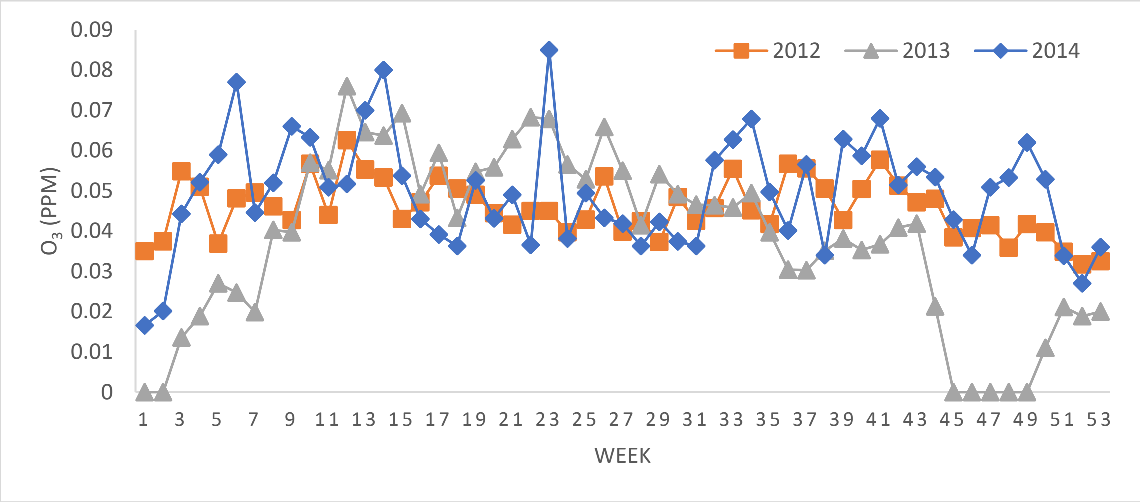

Figure 8: O_3 Concentration Trend in Bandaraya Melaka For Year 2012-2014

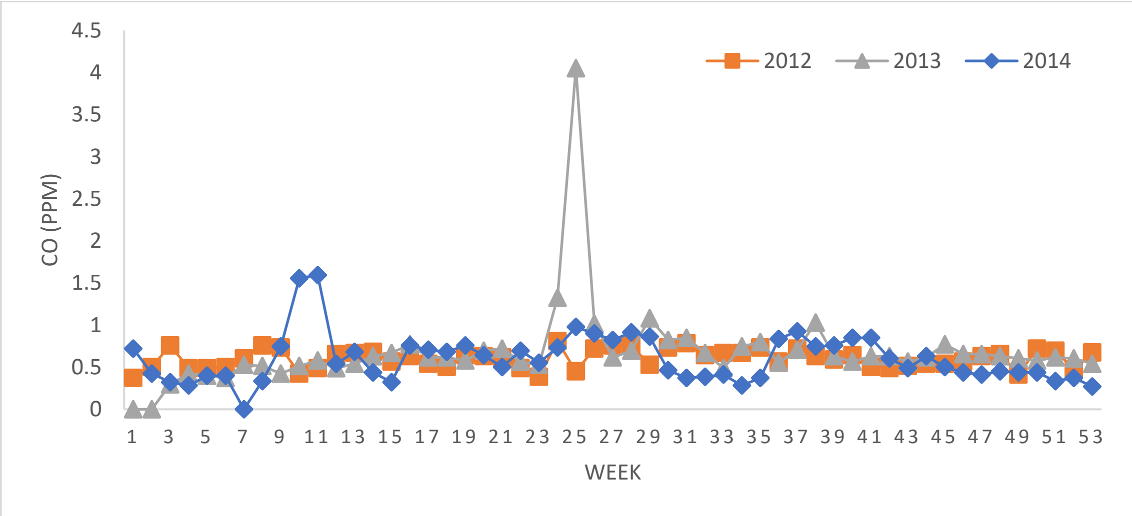

Figure 9: CO Concentration Trend in Bandaraya Melaka For Year 2012-2014

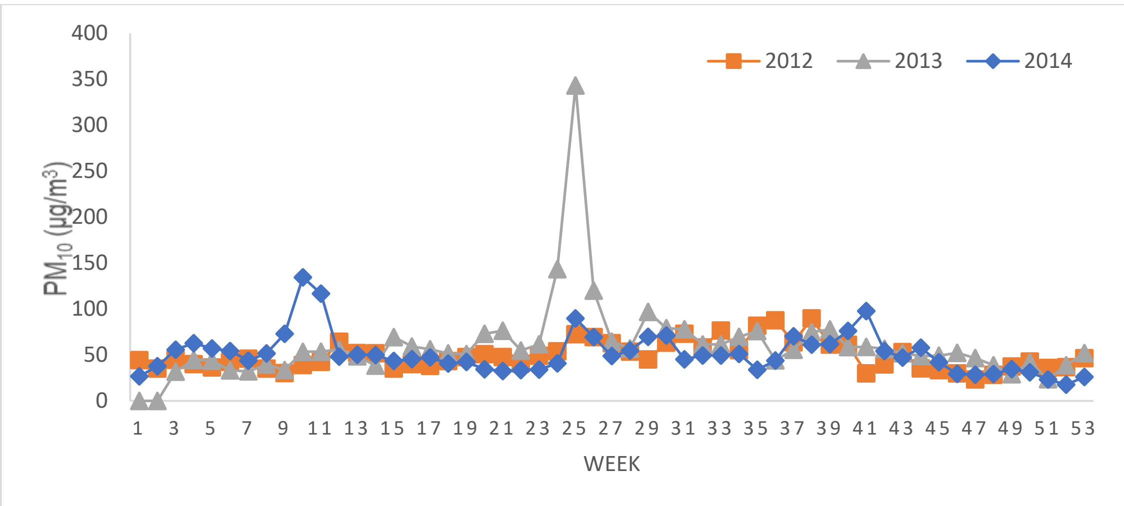

Figure 10: PM_{10} Concentration Trend in Bandaraya Melaka For Year 2012-2014

IV. CONCLUSION

The results from this study show that the averaged concentration of all atmospheric pollutants recorded at Bukit Rambai and Bandaraya Melaka are under the permissible value recommended by the Malaysian Department of Environment. However, certain pollution levels are distinctively higher during haze events, especially PM_{10}. The parameters observed are influenced more by the number of motor vehicles near the monitoring stations although the levels of PM_{10} and O_3 correlates more with the transboundary sources. Meteorological factors particularly sunlight and ambient temperature are expected to be associated with the concentration of O_3 and PM_{10}. The API readings in Melaka are predicted to increase in 2015 and the following years as the contributing factors are seen to worsen by years. The anthropogenic activities which are the biggest contributor to air pollution in Melaka are increasing each year due to the urban development, thus increases the amount of pollutants in air every year as seen by the API trend from year 2012 to 2014. In order to reduce these pollutants, several measurements can be taken such as reduce the usage of catalytic converter systems on vehicles to reduce NO_2 emissions. More mitigation plans should be conducted to overcome this air pollution issue such as using electric driven vehicles instead of fuel besides optimising the fuel consumption in Malaysia and increase in fuel qualities to have less emissions of pollutant.

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