

Effect of Urban Area Development in Selangor to the Air Pollution Index from 2012 to 2014

E. L. Suhaimi, S. Zainal

*Faculty of Chemical Engineering,
Universiti Teknologi Mara, Shah Alam, 40450 Selangor*

Abstract – Klang Valley's rapid urban development over the years has increased the risk of ambient air pollution. The pollutants may be in different forms such as solid particles, liquid droplets, gases or a mixture of these three forms. This study aims to analyse the air quality trends and their correlation with the anthropogenic and natural factors at three air monitoring stations in Klang Valley. The data of the five primary pollutants (SO_2 , NO_2 , O_3 , CO and PM_{10}) were continuously monitored daily by the Department of Environment Malaysia (DoE). The air quality trends and status could be observed by the data retrieved from DoE. It shows that the concentrations of PM_{10} , SO_2 and O_3 were high due to transboundary haze recorded at $275\mu\text{g}/\text{m}^3$, 0.013ppm and 0.094ppm respectively. This happened during the southwest monsoon where the country experience dry and hot weather. Meanwhile, the concentrations of NO_2 and CO were seen to be influenced more by the motor vehicles near the monitoring stations where the highest concentrations were recorded at 0.064ppm and 4.35ppm respectively. This shows that the source of air pollution from motor vehicles are dominant especially in urban areas. Besides that, industries, forest fires and urbanisation were also been found as the prime contributor to the decrease in air quality level in these three locations.

Keywords – Air pollution, urban area, air quality monitoring station, urbanisation

INTRODUCTION

The largest contributor to urbanisation is the general population growth (Montgomery, 2008). Today, the world's population that lives in urban areas is more than half (55%) and by 2050 the amount is expected to increase to 68% (UN (United Nations), 2018). Rapid growth of the human population in conjunction to the urban agglomeration are the driving force of global environmental changes, whether greenhouse gas-induced warming, deforestation, desertification, or loss in biodiversity (Grimmond, 2007). Also, one of the key environmental problems associated with urbanisation is air pollution. Urban and industrial areas are major sources of the potent greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), halocarbons, nitrogen oxides (NO_x) and SO_2 emissions.

Alam Sekitar Malaysia Sdn Bhd (ASMA) is a private company which operates and maintains Malaysia's air quality monitoring network (Country Synthesis Report on Urban Air Quality Management: Malaysia, 2006). In order to detect any significant change in the air quality which may be harmful to human health and the environment, these monitoring stations are strategically located in urban, sub-urban and industrial areas. The air quality monitoring network linked 66 monitoring stations via public telephone lines to EDC (Country Synthesis Report on Urban Air Quality Management: Malaysia, 2006). Malaysia's air pollution index (API) was adopted and closely follows the United States system known as pollutant standard index (PSI) (Sara Hsu, 2018). Like most countries, SO_2 , NO_2 , O_3 , CO and PM_{10} are the major pollutants recorded at the monitoring stations in Malaysia.

Apart from Kuala Lumpur and Putrajaya, Klang Valley consist of cities and towns in the state of Selangor such Shah Alam, Batu Muda, Petaling Jaya, Banting and Klang. Compared to other parts of the country, the Klang Valley is the most prone region to serious air pollution because of its rapid transformation into a wide urban area during the last decade of the twentieth century. This study focuses on the effects of urban developments in three main locations in Klang Valley which are Petaling Jaya, Shah Alam and Klang. It is required to explore the trend of ambient air pollution within these three locations of three years database from 2012 to 2014. The ambient air pollution to be analysed includes major parameters such as SO_2 , NO_2 , CO, O_3 , and PM_{10} .

METHODOLOGY

Department of Environment Malaysia (DoE) use their monitoring station network to continuously monitor the ambient air quality. The stations used in this study were located in Klang Valley which are Petaling Jaya, Shah Alam and Klang (Table 1). All of the monitoring stations listed are situated near the main roads of industrial and high density residential areas

Table 1: The air quality monitoring stations locations in Klang Valley

Air Monitoring Station Location	Area	Coordinates
Sek. Keb. TTDI Jaya	Shah Alam	3°06'17.0"N 101°33'22.4"E
Sek. Keb. Bandar Utama	Petaling Jaya	3°07'59.4"N 101°36'28.8"E
SMK (P) Raja Zarina	Klang	3°00'36.0"N 101°24'30.2"E

The air quality data used for this analysis was retrieved from DoE through long-term monitoring by a private company, ASMA. The air pollutant parameters used in these studies were PM_{10} , CO, SO_2 , NO_2 and O_3 . The overall air quality data used in this study was obtained from 1st January 2012 to 31st December 2014 at the three locations.

RESULTS AND DISCUSSION

The weekly trends of SO_2 , NO_2 , O_3 , CO and PM_{10} concentrations for each year in each place were plotted. Petaling Jaya, Shah Alam and Klang are urban area in Selangor with large population, high volume traffics, and industrial facilities surrounding them. The parameters that define the status of air quality in Malaysia is governed by the established Malaysian Ambient Air Quality Guidelines (MAAQG) 1989 issued by DoE. The maximum average values of SO_2 , NO_2 , O_3 , CO and PM_{10} concentrations observed must be within the MAAQG standard as shown in Table 2.

Air Quality Trends in Petaling Jaya

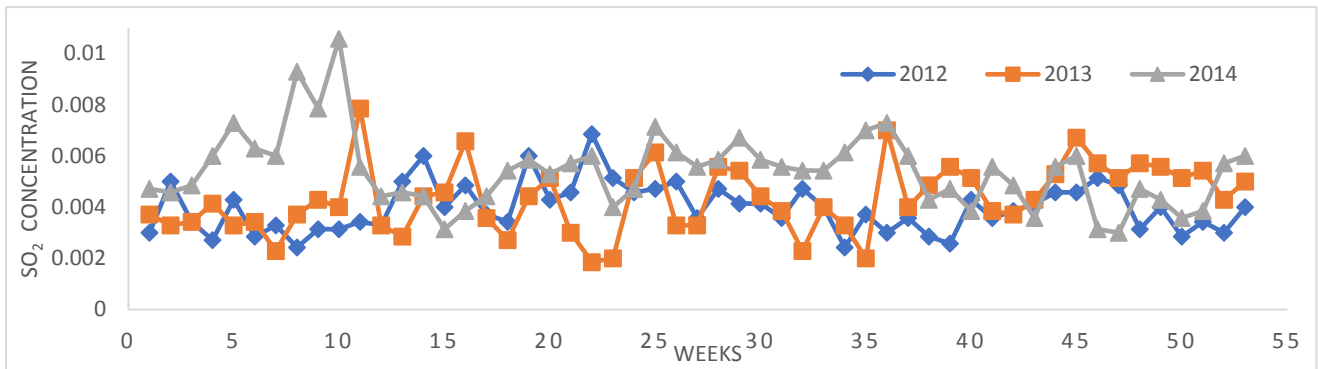


Figure 1: Average concentration of SO_2 monitored in Petaling Jaya by weekly

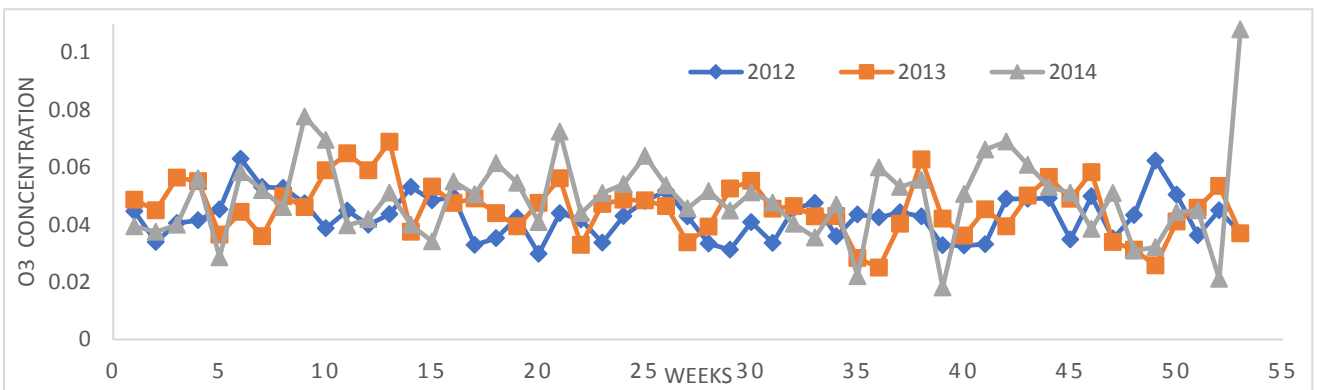


Figure 2: Average concentration of O_3 monitored in Petaling Jaya by weekly

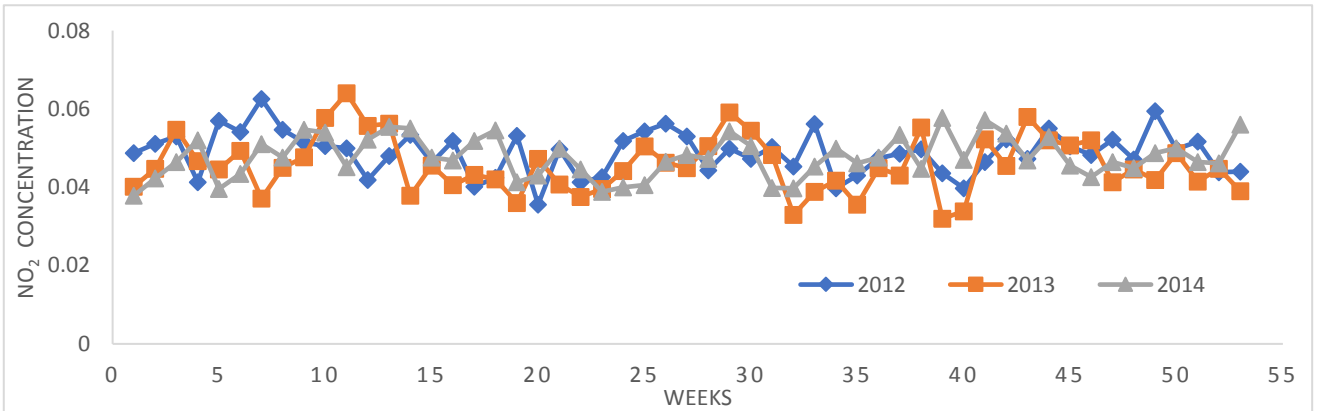


Figure 3: Average concentration of NO_2 monitored in Petaling Jaya by weekly

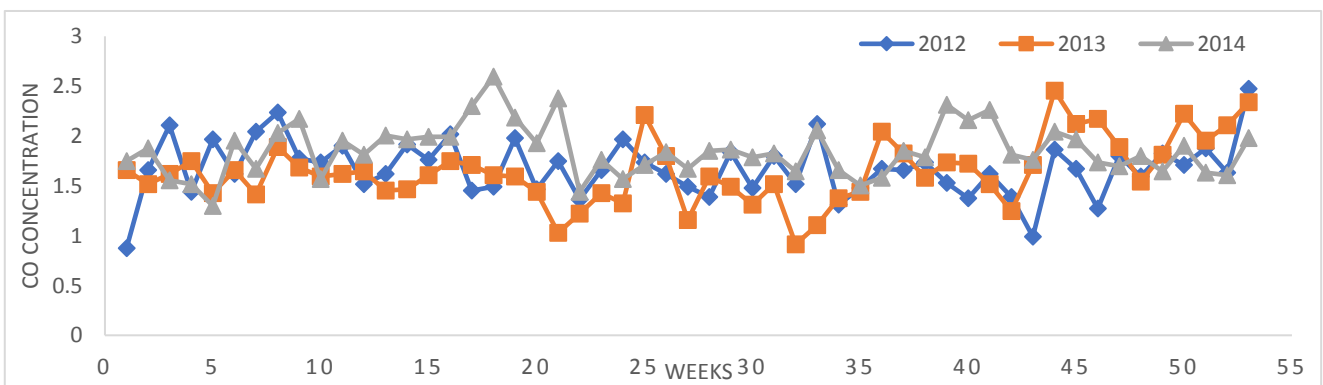


Figure 4: Average concentration of CO monitored in Petaling Jaya by weekly

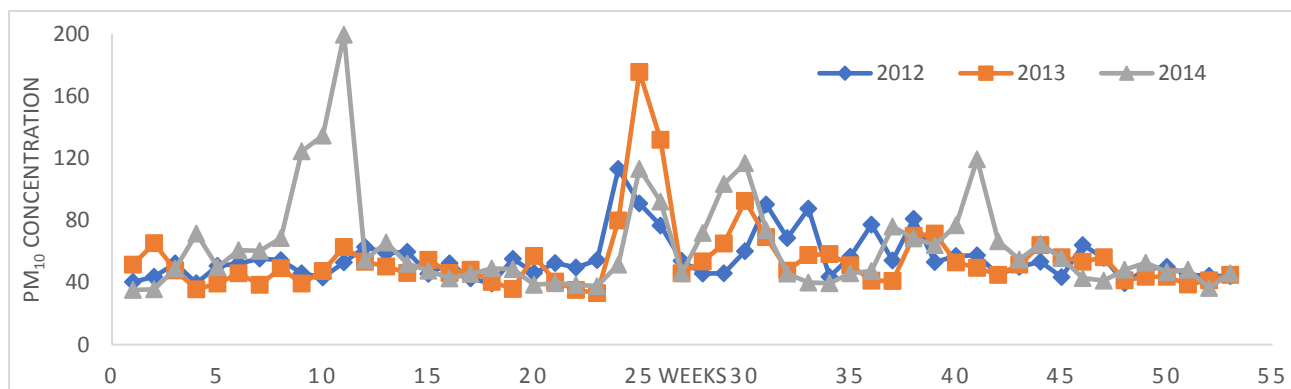


Figure 5: Average concentration of PM₁₀ monitored in Petaling Jaya by weekly

Table 2: Malaysian Ambient Air Quality Guidelines (MAAQG) (DoE (Department of Environment), 2000)

Parameter	Average time	Malaysia Guidelines
SO ₂	24h	0.04ppm
NO ₂	1h	0.17ppm
O ₃	8h	0.10ppm
CO	8h	9ppm
PM ₁₀	24h	150µg/m ³

It is observed from Figure 1, the SO₂ concentration were high in year 2014 followed by years 2013 and 2012. The highest SO₂ level was in the period of February 2014 to March 2014 at 0.011ppm. Supposedly, the northeast monsoon in Malaysia occurs from November to March where cold and wet season is to be expected (Chew et al., 2013). Any air pollutant would be brought to the Earth by the precipitation of rain during this wet season; lowering the pollutant concentration in the air (Odli, 2010). However, it was reported that an unexpected dry spell had hit the country which was expected to last until March (The Star Malaysia, 2014; Philomin et al., 2014). This was also stated by Muhammad Helmi Abdullah, director of the Meteorological Department National Weather Centre. The heatwave contributed to serious forest fires and peatland fires which had caused an episode of haze (New Straits Times, 2014).

Figure 2 shows that the O₃ concentration was the highest during the month of December 2014 where the O₃ level exceeded the emission limit at 0.108ppm. However, the O₃ overall trend showed a consistent trend and well below the MAAQG standard of 0.10ppm. Thus, the sudden increase of the O₃ concentration was probably due to a data error.

Figure 3 and Figure 4 show that the concentration of NO₂ and CO were always relatively high at 0.064ppm and 2.60ppm respectively throughout the 3 years. This could be strongly related to the large amount of industries, residential and commercial areas surrounding the location (Azmi et al., 2010). It was stated by Amis, 2007 that Petaling Jaya has the highest population in Klang Valley and motor vehicles were found to be the major source of air pollution which contributed to the high level of NO₂ and CO.

It can be observed from Figure 5 that the concentration of PM₁₀ was significantly high at 175.4µg/m³ in June 2013 due to the dry and short period of transboundary haze from peat fires in Riau province, Sumatera (The Star Malaysia, 2013). The transboundary haze was brought to the country by the southwest monsoon (News Straits Times, 2013). The PM₁₀ concentration was at its peak during the dry season recorded at 199.4µg/m³ in the period of February 2014 to March 2014. This result shows similar result with the previous SO₂ parameter in which the high PM₁₀ level during this period was due to the haze episodes caused by peatland fires and open burning activities (New Straits Times, 2014).

Air Quality Trends in Shah Alam

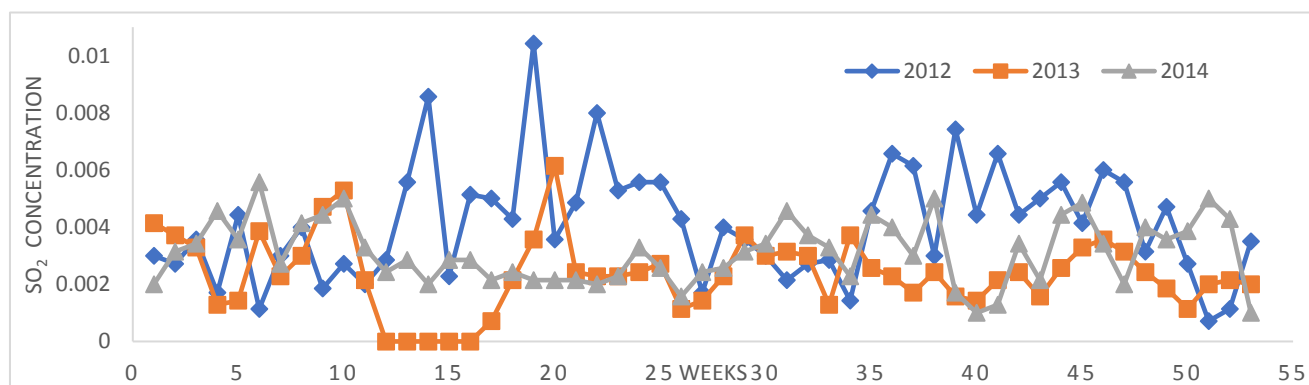


Figure 6: Average concentration of SO₂ monitored in Shah Alam by weekly

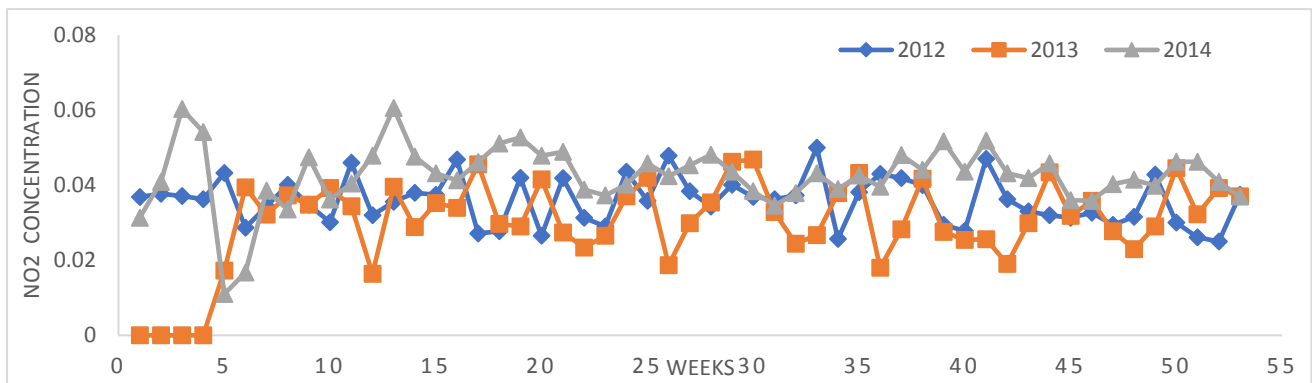


Figure 7: Average concentration of NO₂ monitored in Shah Alam by weekly

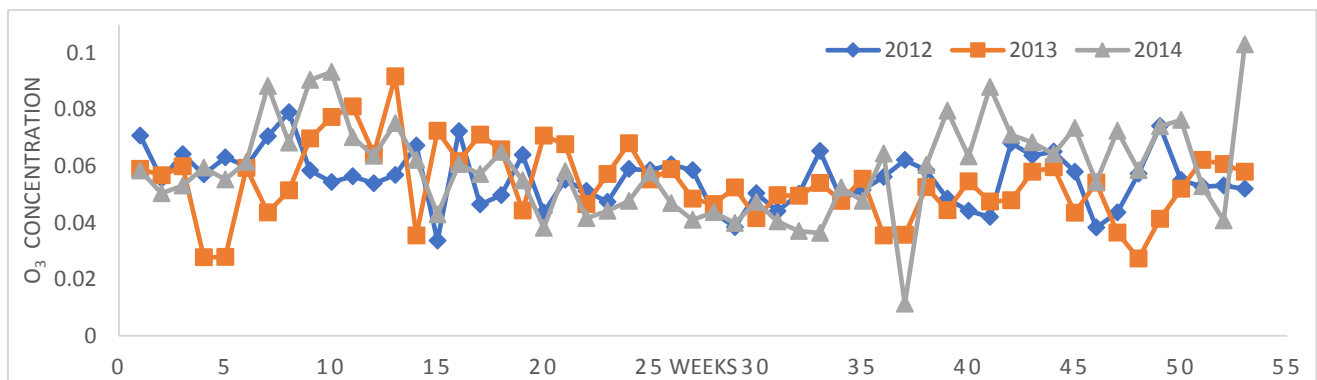


Figure 8: Average concentration of O₃ monitored in Shah Alam by weekly

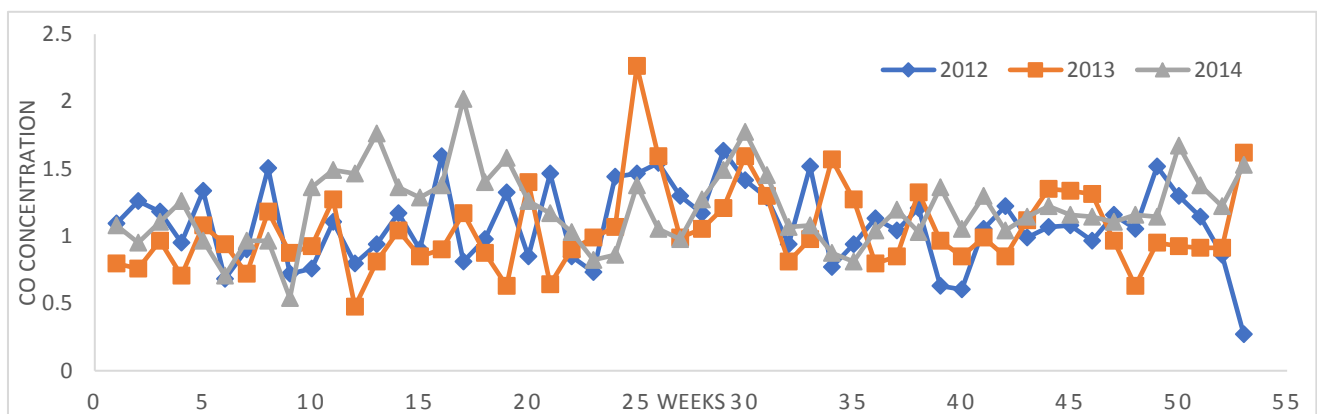


Figure 9: Average concentration of CO monitored in Shah Alam by weekly

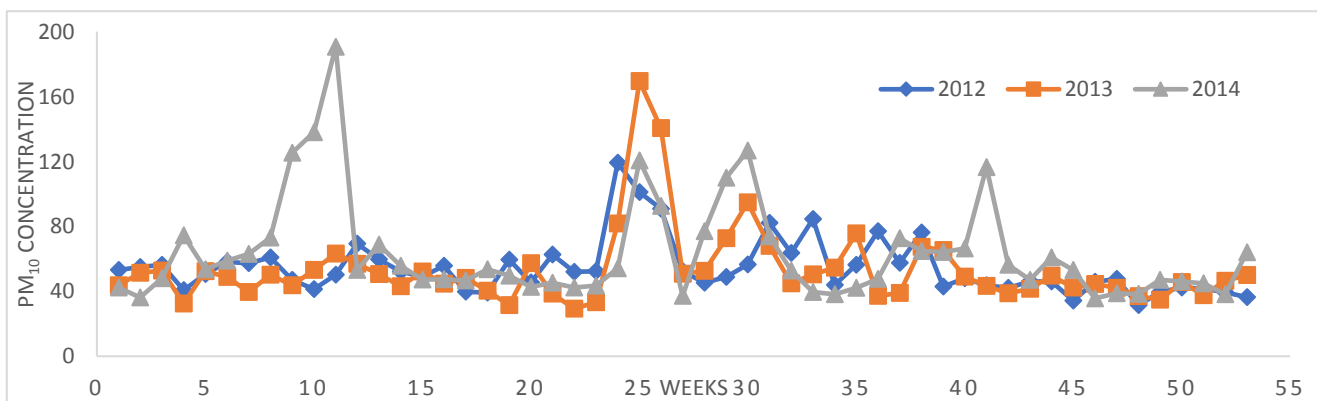


Figure 10: Average concentration of PM₁₀ monitored in Shah Alam by weekly

The concentration of SO₂ shown in Figure 6 was considerably high at 0.011ppm somewhere around May 2012 until Jun 2012 during the southwest monsoon. The southwest monsoon occurs from May to September where locals experience a drier season (Chew, 2013). During this period, there is little to no rainfall to dilute the SO₂, NO₂ and CO in air. Shah Alam is an area with many industrial facilities in which they contributed to the release of SO₂ (Pereira et al., 2007). Since the monitoring station is located near school area, the high SO₂ level would be from diesel-engined school buses and parents' vehicles (Rahman et al., 2015; Binyehmed et al., 2016). The increase of the number of vehicles will contribute to more SO₂ emissions. Also, the high SO₂ level during this period could be closely related to the haze episodes due to biomass burning (Clairac et al., 1988). Malaysia suffered with transboundary haze from the forest fires in Riau province, Sumatera in which the haze was transported by the southwest monsoon (The Star Malaysia, 2012; Berita Harian, 2012). It was also reported that the condition worsen with a peat fire in Banting, fire in Sabak Bernam plantation and a 108.44 hectare area peat fire near Perkampungan Orang Asli, Pulau Kempas, Kampung Seri Cheding (Utusan Malaysia, 2012).

It is observed in Figure 7 that the NO₂ concentration was substantially high at 0.061ppm from January 2014 to March 2014 in which haze occurred. It was reported that one of the prime cause of the haze episodes during that time of the year was open burning (New Straits Times, 2014). Besides industrial activities and domestic fuel sources, open burning can also contribute to the release of NO₂ in air (Andini et al., 2018).

Figure 8 shows relatively high concentration of O₃ throughout the 3 years especially somewhere around March and October. O₃ is known for being unstable which it is a secondary gas formed from the interaction of volatile organic compound (VOC), oxides of nitrogen (NO_x) and sunlight (Atkinson, 2000). Similar to the

previous result of SO₂ parameter, since it is located near school area, the number of vehicles increase during peak hours. Thus, releasing more NO_x to react with VOCs under sunlight. The highest concentration was recorded at 0.103ppm December 2014. However, the dramatic rise of the O₃ concentration may due to data error.

The high concentration of CO in Figure 9 was recorded in June 2013 and May 2014 at 2.26ppm and 2.02ppm respectively. This was during the hot and dry season in Malaysia where there are low precipitation and less cloud (Chenoli et al., 2018). Thus, similar to the previous result of SO₂ parameter where there were minimal to no rainfall to dilute the pollutant.

In Figure 10, the highest concentration of PM₁₀ was recorded in March 2014 at 190.7µg/m³. Likewise from the result of SO₂ in Petaling Jaya, an unexpected heatwave hit the country although the northeast monsoon is usually from November to March (The Star Malaysia, 2014; Philomin et al., 2014). The heatwave had cause peatland fires which occurred in several states and this contributed to the haze episodes that occurred (New Straits Times, 2014). It was also reported that local sources such as open burning, bush fires, motor vehicles and industrial gas emissions were the prime cause of haze during this time of the year (The Star Malaysia, 2014; New Straits Times, 2014). Although there was an eruption of Mount Sinabung in Indonesia, the debris from the eruption would not seriously affect Malaysia because the mild winds from Indonesia were not strong enough to transport the massive amount of ash to Malaysia (New Straits Times, 2014). From the results, although the PM₁₀ level was gradually declining, the concentration was still high some time around June until October 2014. This is because of the transboundary haze from forest fires in Sumatera and Kalimantan, Indonesia were transported by the Southwest Monsoon to the country (Harian Metro, 2014)

Air Quality Trends in Klang

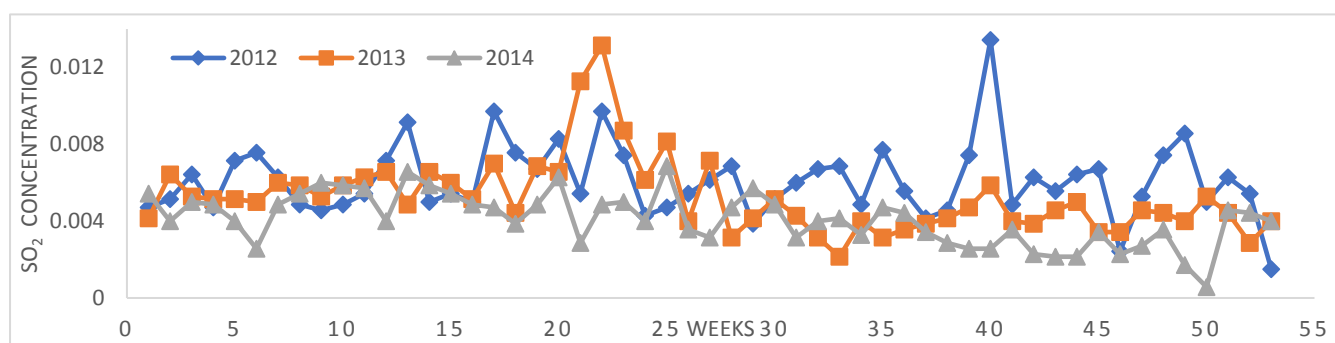


Figure 11: Average concentration of SO₂ monitored in Klang by weekly

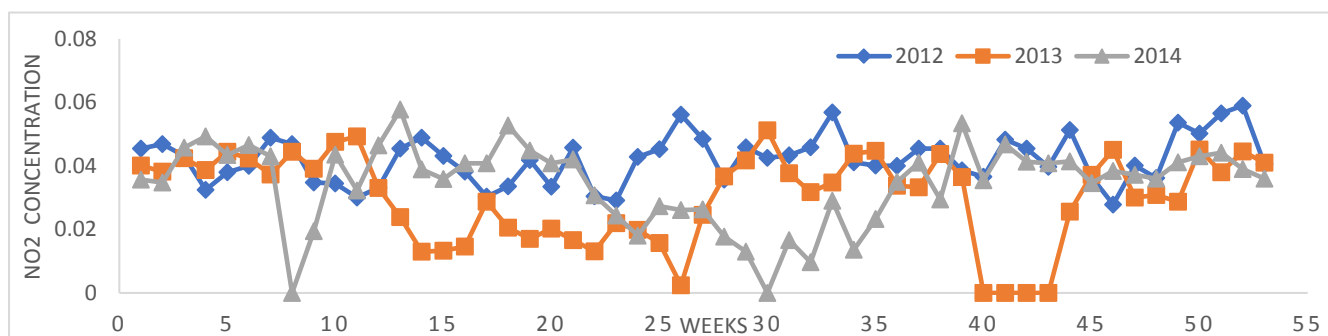


Figure 12: Average concentration of NO₂ monitored in Klang by weekly

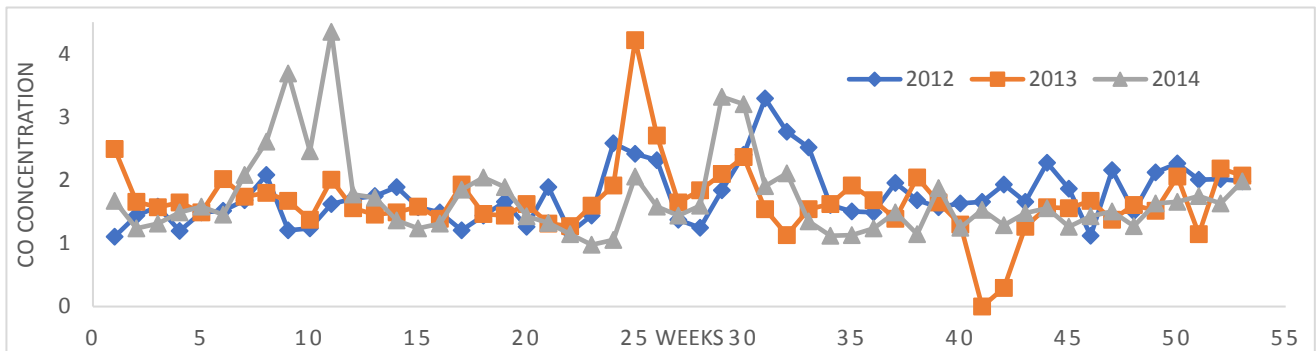


Figure 13: Average concentration of CO monitored in Klang by weekly

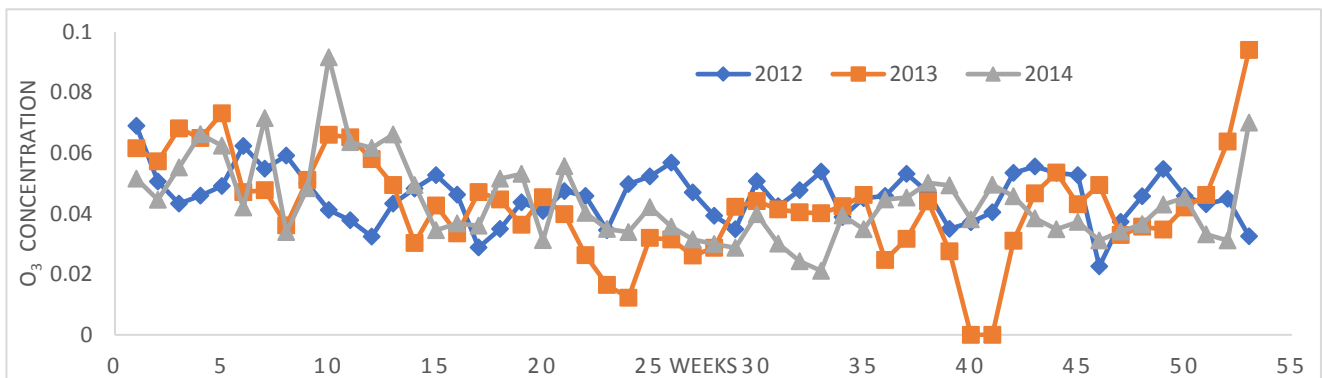


Figure 14: Average concentration of O₃ monitored in Klang by weekly

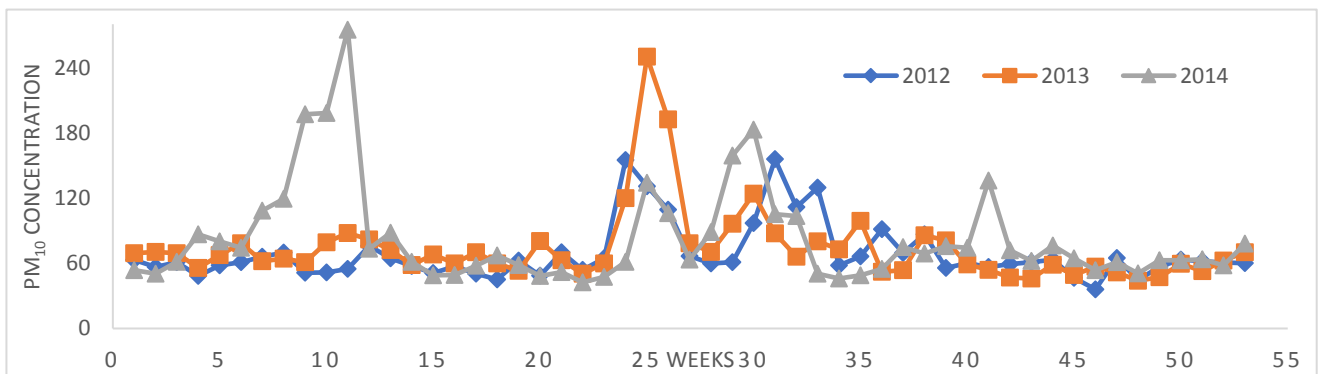


Figure 15: Average concentration of PM₁₀ monitored in Klang by weekly

It is observed in Figure 11 that the concentration of SO₂ was significantly high (0.013ppm) in October 2012 and April to June 2012. During this period of time, peatland fires and transboundary haze episodes occurred which deteriorated the air quality. October is the inter-monsoon month where heavy rainfall is to be expected (The Star, 2018). However, it was reported that the air quality was not improving despite the downpour (Utusan Malaysia, 2012). The high SO₂ concentration recorded in June 2013 was also due to haze episodes (Berita Harian, 2013).

Figure 12 and Figure 13 show that the concentration of NO₂ and CO were relatively high which were recorded 0.059ppm and 4.35ppm respectively. Port Klang is the largest port in Malaysia (The Malaysian Reverse, 2018). Heavy traffic from the port could have contributed to the high NO₂ and CO concentrations (Shah et al., 2010). It is observed that the concentrations of O₃ in Figure 14

were well within the MAAQG standard of 0.10ppm although high O₃ level was recorded in December 2013 and March 2014. Similar to previous results of O₃ in Petaling Jaya and Shah Alam, the sudden increase of O₃ level in December was probably due to data error.

Figure 15 indicated that the concentration of PM₁₀ was exceptionally high during the period of dry season from February 2014 to March 2014 recorded at 275µg/m³. It was reported that the extreme haze episodes, peatland fires and other local sources were the major contributor to the high PM₁₀ level (The Star Malaysia, 2014). Similar to the previous results PM₁₀ parameter, from June until October 2014, the transboundary haze from forest fires in Sumatera and Kalimantan, Indonesia had hit the country by the southwest monsoon (New Straits Times, 2014). It was reported

that the prolonged haze episode was because of the hotspots present in Kalimantan, Indonesia (New Straits Times , 2014).

CONCLUSION

Based on the results of this study, it can be observed that the SO₂, NO₂, O₃, CO and PM₁₀ concentrations show increment in each year especially during the dry and hot season. This specifically occur at the tail-end of the northeast monsoon from March to April and the southwest monsoon from May to September. However, an unexpected phenomenon may happen where the northeast monsoon could end early and the drought would be felt in February or the southwest monsoon could be prolonged until the month of October. During this period, haze from local sources and neighbouring country could be experienced due to the heatwave which would cause forest fires, peatland fires and bush fires. By referring to these trends, government and the people could expect similar trends for upcoming years and be more prepared to manage the situation.

Apart from the natural or climate factors, increment of the pollutants resulted from anthropogenic sources for instance motor vehicles, industries including power plants and open burning. In urban areas especially, motor vehicles remained the major source of air pollution (DoE (Department of Environment), 2014). It was reported by the Road Transport Department Malaysia that there was an overall increase of the number of registered vehicles in Malaysia compared to 2013 in which the number of registered passenger cars increased by 6.32%, motorcycles 4.88%, goods vehicles 3.92%, taxi 5.77% and buses 3.60% (DoE (Department of Environment), 2014). So, it is possible to predict the future air quality trends of these urban locations in Klang Valley in upcoming years since there is no stopping urbanisation. As the years come, the population will increase which leads to more development in industries to cater the needs of the population and more vehicle ownerships. These eventually contributes to more pollutant emissions and deteriorating the air quality.

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