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IMPACT OF URBAN LAND USES AND ACTIVITIES ON THE AMBIENT AIR QUALITY IN KLANG VALLEY, MALAYSIA FROM 2014 TO 2020

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Abstract

Ambient air in the urban area normally is more polluted than less developed areas. This is due to the concentration of urban activities, such as industrial, transportations and commercial or business activities. A study about the impact of urban land uses and activities on the levels of air pollutants in Malaysia's most urbanised and most developed region that is Klang Valley was conducted. Data of Air Pollutant Index (API) and average concentration of selected air pollutants were used to analyse the ambient air quality of the selected five (5) cities or towns in Klang Valley. The air quality condition of the five (5) cities or towns were related to the land use distributions of the cities or towns with a purpose to understand the impact of land uses on the ambient air quality. Furthermore, the changes of ambient air quality before and after Movement Control Order (MCO) were analysed to examine the impact of human activity changes on the ambient air quality. The study found that a city or a town with more industrial and transportation land uses with fewer greens was more polluted than the area with less industrial and transportation land uses with more greens. However, this finding did not apply to all areas due to effect of winds on the distribution of air pollutants. Besides that, because of MCO, most people stayed at home with the mode of "work from home" that caused air pollutant levels in urban areas to decrease due to less urban activities. Nevertheless, there was a risk of an increase in air pollution levels in residential areas due to the concentration of activities, especially driving motor vehicles in residential areas. A recommendation is given to encourage "work from home" and reduce dependency on auto-mobile in residential areas in order to improve the air quality in urban areas.

***Keywords**:* air pollutant index (API); COVID-19; health; lockdown; movement control order (MCO); urban land use

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INTRODUCTION

Clean air is one of the essential needs of human health and well-being. Nonetheless, urban development, energy consumption, transportation, industry activities, lacking green areas, and an increase in the urban population contribute to air pollution (Ling et al., 2014; Nurul Ashikin et al., 2015; Nurul Ashikin et al., 2018). In Malaysia, the region that consists of Selangor state and Kuala Lumpur city was commonly called as Klang Valley. It is the most rapidly grown, as well as the most urbanised region in Malaysia. Being the most developed region, Klang Valley is facing the issue of air pollution.

In Malaysia's most urbanised city that is Kuala Lumpur, there was a clear increasing trend in the number of unhealthy or hazardous days (based on API), which increased from 11 days in 2001 to 67 days in 2005 (Ling et al., 2010). Conversely, the unhealthy days in Kuala Lumpur decreased after 2005 and returned high again in 2010 and 2015 with 59 days and 52 days, respectively (DOE, 2015). For the most developed state in Malaysia that is Selangor, Nurul Ashikin (2017) analysed Air Pollutant Index (API) of the five urban areas from 2000 to 2014. Generally, the five urban areas showed a sudden increase in number of unhealthy days from 2001 to 2002 and from 2004 to 2005, and a sudden drop of unhealthy days in 2007 (Nurul Ashikin, 2017). Figure 1 shows the previous trend of unhealthy days in Klang Valley, Malaysia.

People who live in urban areas are facing the air pollution issue due to air emission (including particulate matter, PM) from various sources, such as auto-mobiles, industries, road and soil dust, household combustion (Shi et al, 2020), as well as energy generations. This will turn a safe city into a "toxic city" (Siti Nurazlina, 2011). Mobile sources (for example, automobiles) generally contribute at least 70 to 75 per cent of the total air pollution. Meanwhile, stationary sources (for example, industries and power generations) contribute around 20 to 25 per cent, and open burning and forest fires contribute around 3 to 5 per cent (Rafia et al., 2003).

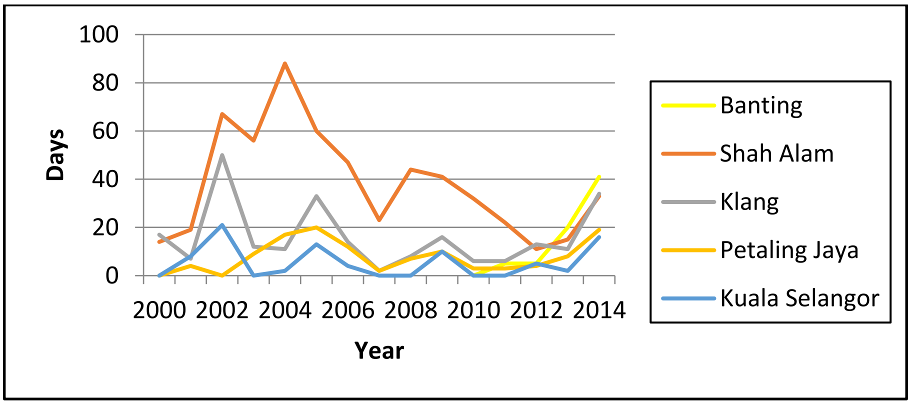


Figure 1: Number of Unhealthy Days in Klang Valley, 2000-2014 (*Source: Nurul Ashikin, 2017)*

LITERATURE REVIEW

Several studies had been carried out to relate air pollution with urban land use or activities. For instance, a study in an urban region of Petaling Jaya, Shah Alam and Klang (Ling et al., 2014) showed a relationship between city or local land use coverage and air quality. Besides that, a study in Kuala Lumpur city showed that an increase of "shopping floor space", "office floor space" or "industrial units" in the city was positively related with the number of unhealthy or hazardous days (as measured in API) (Ling et al., 2010).

Globally, most of the countries are also experiencing an increase in air pollution due to urbanisation or land-use changes. For instance, the urbanisation can cause the increase of ozone (O_3) concentration based on the study in Yangtze River Delta, China (Chen et al., 2020) and Selangor, Malaysia (Ooi et al., 2019). In contrast, urbanisation causes other pollutants, namely, particulate matter 2.5 ($PM_{2.5}$) and Nitrogen Oxides (NO_x) to decrease. A study at eight cities in China (Sun et al, 2016) displayed a correlation between particulate pollution and land use changes that was lower in coastal areas but higher in inland areas.

Moreover, a study at Ethiopia (Kasim et al, 2018) discovered that carbon dioxide (CO_2) emissions from the same land use were relatively similar. Kasim et al.'s (2018) study indicated that there were differences across different land uses. For instance, CO_2 emission was highest at commercial land-use, moderate at residential land use, and lowest at recreational land use in Bahir Dar. In Hawassa, industrial land use CO_2 concentration was the highest, followed moderately by circulation, residential and commercial, as well as lowest at recreational land use (Kasim et al., 2018). In general, the degree of urban land use mix, clustering, and concentration of development was significantly associated with better air quality (Kang et al., 2019).

Air pollution is a major environmental risk to health and affects urban public health (WHO, 2014). Exposure to ambient air pollution has been associated with a series of adverse health effects (Chen & Kan, 2008). Exposure to high concentration levels of ambient $PM_{2.5}$ increases the health risk of stroke mortality, cardiovascular disease, respiratory diseases, and lung cancer, as well as reduces a cognitive function of a person (Shi et al, 2020). In addition to the illnesses caused by pollution, loss of productivity, as well as missed educational and other opportunities in life happened (UN, 2001).

Apart from that, the effects of urban land use and activities on air quality can be observed during the implementation of Movement Control Order (MCO) to control the widespread of Corona Virus Disease 2019 (COVID-19). MCO was implemented in Malaysia starting 18 March 2020 until 12 May 2020. Because of that, most of the physical, economic and social activities, except those providing essential services and items in the country, including the Klang Valley were closed down (Khor et al., 2020; Tang, 2020). Most of the workers had changed from the mode of "work from office" to "work from home". Due to the lockdown of industry, tourism, recreational, social, sports, schooling, offices, and other non-essential activities, especially in urban areas (PMO, 2020; Tang, 2020), air quality was observed to be better than before with a reduction of air emission (Abdullah et al., 2020; DOE, 2020). A study by Abdullah et al. (2020) illustrated a high reduction of up to 58.4 per cent of $PM_{2.5}$ concentrations in Malaysia. The study was carried out by comparing the air quality between the period of 14 to 17 March 2020 and 18 March to 14 April 2020. Additionally, a study at Kuala Lumpur city (Suhaimi et al., 2020) observed a decrease of air pollutant concentrations, except for O_3 during MCO as compared to the same period in 2019, as well as to a period of 11 weeks before MCO in the year 2020.

In China, in which the first general lockdown established on 23 January 2020, the NO_2 and NO_x levels had reduced by about 50 per cent as compared to the previous year and time before as observed at Wuhan and East China (Kanniah et al., 2020). A different percentage of reduction of NO_2, PM_{10}, SO_2, $PM_{2.5}$ and CO concentrations were also reported in 44 cities in Northern China due to the lockdown. On the contrary, after the lockdown was over and most of the people resumed their daily working lives, the NO_x levels had gradually increased in some Chinese provinces. Reduction of air pollutants concentrations were also observed in other countries and cities, such as India and Barcelona during MCO or lockdown (Kanniah et al., 2020). The study by Kanniah et al. (2020) found the impacts of COVID-19 on the atmospheric environment in the Southeast Asia region.

Previous research showed a relationship between land use, activity and air quality. Urban activities and industry were related to the increase in air pollution. Meanwhile, the control of human activities improved the air quality in urban areas during MCO. However, there was insufficient specific study on the relationship between air quality and urban land use (and activities) in Malaysia's most developed region that is Klang Valley. Thus, this paper was aimed to analyse the impact of urban land use and activities on the ambient air quality in Klang Valley from January 2014 to April 2020.

METHODOLOGY AND CASE STUDY

The Klang Valley is considered to be the main focus of Malaysian property, industry and commerce developments. It is estimated as having a total population of 8.3 million in 2020 by combining the estimated population of Selangor and Kuala Lumpur (DOE, 2020c). Due to the geographical location as the central region of Peninsular Malaysia and the capital city of Malaysia, the rapid urbanisation, population growth, industrial activities, and high traffic volume had made the Klang Valley constantly exposed to the problem of air quality (Siti Zawiyah et al., 2010). Klang Valley had been chosen as a case study in this study with the focus on the five cities or towns, namely, Kuala Selangor town, Klang town, Shah Alam city, Petaling Jaya city, and Banting town.

These five urban areas are equipped with Continuous Air Quality Monitoring Stations (CAQM) by the Department of Environment, Malaysia (DOE). The locations of the CAQM stations are as shown below (see Figure 2):

a) Secondary School of Science Kuala Selangor, Kuala Selangor town,
b) National Secondary Girls School Raja Zarina, Port Klang town,
c) National Primary School Taman Tun Dr Ismail Jaya, Shah Alam city,
d) National Primary School Bandar Utama Damansara, Petaling Jaya city, and
e) College MARA Banting, Banting town, Selangor.

Data of ambient air quality and land uses had been collected from public departments and their documents. Land use data were collected from local authorities via maps and local plans. The data of ambient air quality were obtained through secondary sources as provided by DOE which consisted of API data and average air pollutant concentrations for the study areas.

API is an indicator of the air quality status at any particular area used by Government of Malaysia. The API value is calculated based on the average concentration of air pollutants, namely, SO_2, NO_2, CO, O_3, and PM_{10} before 2018. Since 2018, DOE added another type of pollutant into the calculation of API, which was $PM_{2.5}$. Apart from that, new standards (IT-2) were adopted starting from 2018 (see Table 1). The air pollutant with the highest concentration (dominant pollutant) would determine the API value. Normally, the concentration of PM is the highest among other pollutants and determines the API value in Malaysia based on an observation on the daily API values in DOE's website. Table 1 shows the six parameters used in API calculation and the previous (IT-1, before 2018) and new (IT-2, since 2018) ambient air quality standards. Table 2 shows the colour references of API to indicate different levels of API values and potential health effects.

Table 1: Malaysian Ambient Air Quality Standards

Parameter	Averaging time	Unit	Standards	
			IT-1	IT-2 (2018)
PM_{10}	24 hour	$\mu g/m^3$	150	120
$PM_{2.5}$	24 hour	$\mu g/m^3$	75	50
SO_2	24 hour	ppm	0.040	0.035
CO	8 hour	ppm	8.750	8.750
NO_2	1 hour	ppm	0.170	0.160
O_3	1 hour	ppm	0.100	0.100

Source: DOE (2018)

Table 2: Air Pollutant Index (API) and the Potential Health Effects

	Good: API 0 - 50 Low pollution without any bad effect on health.
	Moderate: API 51 – 100 Moderate pollution does not pose any bad effect on health.
	Unhealthy: API 101 – 200 Worsen the health condition of high-risk people with heart and lung complications.
	Very Unhealthy: API 201 – 300 Worsen the health condition and low tolerance of physical exercise to people with heart and lung complications. Affect public health.
	Hazardous: API more than 300 Hazardous to high-risk people and public health.

Source: DOE (2013); DOE (2018)

RESULTS AND DISCUSSION

Land uses, activity and air quality, 2014-2018

Based on API, it was found that Kuala Selangor had the best air quality level with the highest number of good days (see Figure 3) and lowest number of unhealthy days (see Figure 4). It was followed by Petaling Jaya and Shah Alam with a moderate number of good days among the five urban areas (see Figure 3). Nevertheless, based on the unhealthy days, Petaling Jaya and Klang had a moderate number among the five urban areas (see Figure 4). Banting had the least number of good days (see Figure 3) and the highest number of unhealthy days (see Figure 4).

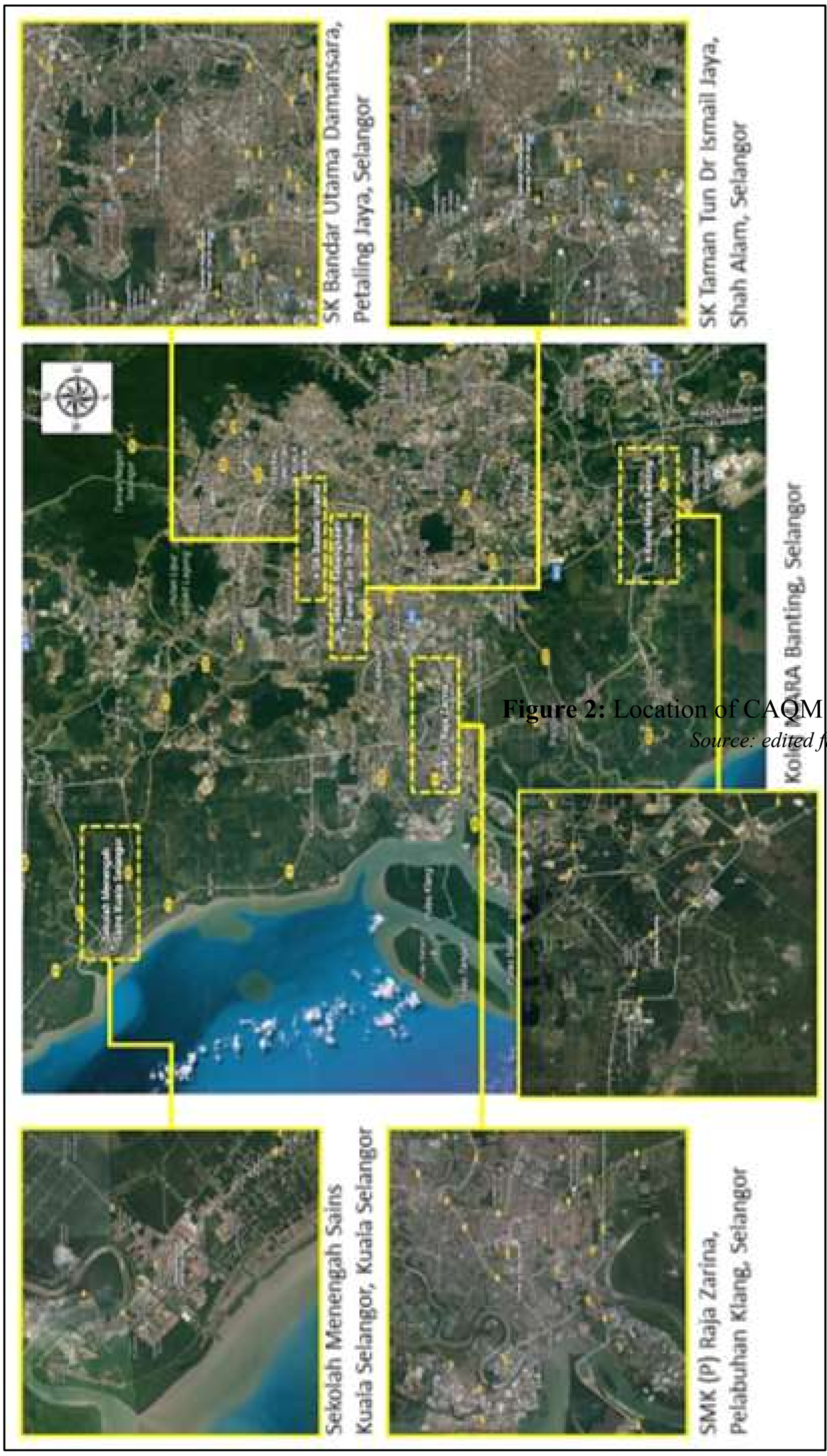


Figure 2: Location of CAQM stations in Klang Valley (study areas)
Source: edited from Google Earth (2015)

To rank the five urban areas from the best air quality to the most polluted area, the list of the five urban areas is shown as follows:

a. Kuala Selangor town (best air quality)
b. Petaling Jaya city
c. Shah Alam city and Klang town
d. Banting town (most polluted air)

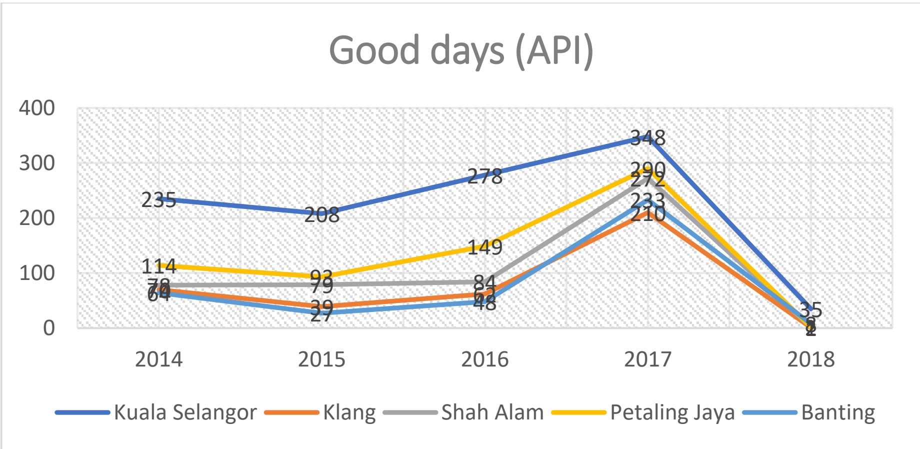


Figure 3: Number of Goods Days in Klang Valley, 2014-2018
Source: DOE (2014, 2015, 2016, 2017, 2018)

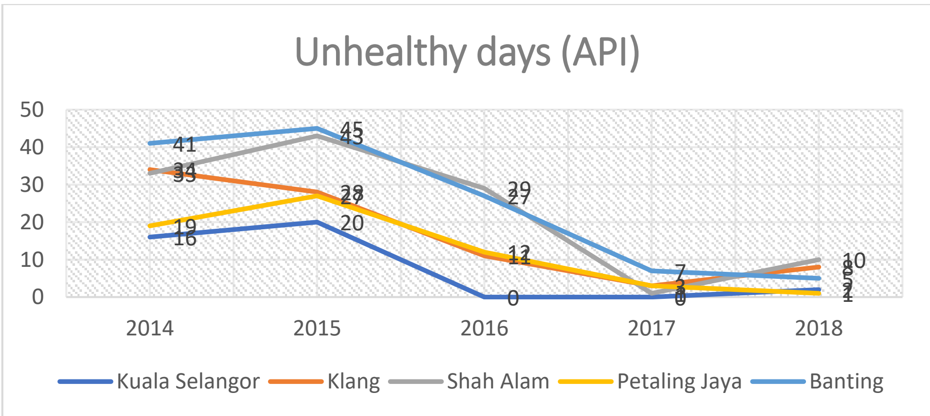


Figure 4: Number of Unhealthy/Very Unhealthy Days in Klang Valley, 2014-2018
Source: DOE (2014, 2015, 2016, 2017, 2018)

To relate the urban (city or town) land uses and activities to the air quality among the five areas, it was noticeable that Kuala Selangor had the least percentage of industrial and transportation land uses (see Table 3) and the highest percentage of green land use (including forest, agriculture, recreational, nature, and open areas) had best air quality from 2014 to 2018. Shah Alam with the least percentage of green land use and the highest percentage of industry or transportation land use was the second polluted area among the five study areas (see Table 3).

Table 3: **Land uses and the air quality of the study areas**

CAQM stations	Overall City/Town's land use (%)	Selected land use (%)	The rank of air quality based on Figure 3 and 4
Kuala Selangor	Open space & recreation: 4.86% Agriculture: 49.64% Forest: 33.74% Residential: 3.64% Industrial: 0.39% Commercial: 0.12% Institution & service: 0.59% Transportations: 4.19% Infrastructure & utilities: 0.38% Water reservoir: 2.44%	*Green = 88.24% Industry& transportations=4.58	1 (The best among the five areas)
Petaling Jaya	Open space & recreation: 7.62% Agriculture: 0.32% Green lung: 7.19% Residential: 34.34% Industrial: 12.79% Commercial: 3.92% Mix development: 1.16% Institution: 8.80% Transportations: 16.33% Infrastructure & utilities: 4.99% Water reservoir: 2.69%	*Green = 15.13% Industry& transportations=29.12	2
Klang	Open space & recreation: 2.21% Agriculture: 7.04% Natural ecology: 27.85% Housings: 28.91% Industrial: 10.98% Commercial & services: 2.07%	*Green = 37.1% Industry& transportations=22.73	3

	Institution & public facilities: 3.23% Transportations: 11.75% Infrastructure & utilities: 1.95% Water reservoir: 4.01%		
Shah Alam	Agriculture: 0.32% Open space & recreation: 7.55% Forest: 7.25% Residential: 33.81% Commercial & services: 4.04% Industrial: 12.67% Mixed development: 1.16% Institution & public amenities: 8.80% Transportations: 16.66% Infrastructure & utilities: 4.99% Water reservoir: 2.70%	*Green = 15.12% Industry & transportations=29.33	4
Banting	Open space & recreation: 1.14% Agriculture: 43.36% Forest: 6.85% Residential: 28.37% Industrial: 6.90% Commercial & services: 1.76% Institutions & public amenities: 1.20% Infrastructure & utilities: 0.99% Water reservoir: 4.40% Transportations: 4.78%	*Green = 51.35% Industry& transportations=11.68	5 (The most polluted among the five areas)

Notes: Percentage of unhealthy days based on the number of unhealthy, very unhealthy and hazardous API days.
*Percentage of green area based on the total percentage of agriculture, open space or recreation, agriculture, forests, green lung, natural ecology.
Source of land use data: Majlis Daerah Kuala Selangor (2015); Majlis Bandaraya Petaling Jaya (2011); Majlis Perbandaran Klang (2011); Majlis Bandaraya Shah Alam (2012); Majlis Daerah Kuala Langat (2011)

On a contrary, the air quality levels of Banting and Petaling Jaya were unable to be justified by green land uses and pollution sources land uses (industry or transportations). Banting with a high percentage of green land use and less industry or transportation land use was the most polluted or unhealthy area. Meanwhile, Petaling Jaya with a high industry or transportation land use and less green land use exhibited the second-best air quality among these five areas. This scenario could be related to the effect of wind. Sham (1988) elucidated that the effect of wind (sea breeze and land breeze) had "stored" air pollutants at the area located at the centre in between seashore and highland in Klang Valley (see Figure 5). Thus, Banting and Shah Alam which are located at the centre between seashore and highland were most polluted in Klang Valley. Meanwhile, Petaling Jaya is located just beside Kuala Lumpur which is near to the highland. This influenced the ambient air to be cleaned by the effect of wind that blew from the highland to the sea (land breeze).

Note: Shah Alam (SA) & Banting (B) received more air pollutants from Kuala Lumpur (KL) & Petaling Jaya (PJ)

Figure 5: Wind effects on air quality in Klang Valley
Source: edited from Google maps (2020)

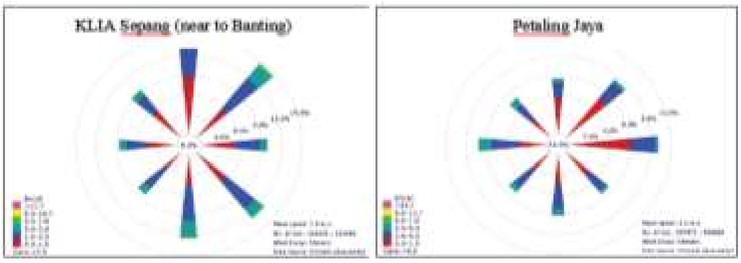


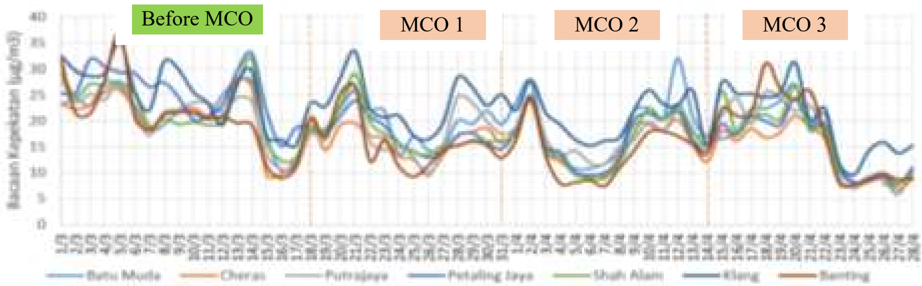
Figure 6: Wind rose diagrams for KLIA Sepang and Petaling Jaya (1999-2013)
Source: Malaysian Meteorological Department (2014)

Based on Figure 6, at Petaling Jaya, most of the winds were from the East, followed by the West direction. Hence, the wind transported the air pollutants away from Petaling Jaya and Kuala Lumpur areas to the West which is Shah Alam (see Figure 5). Due to the wind from the West (sea breeze), the air pollutants were "stored" at Shah Alam and not much was moved to the West (Klang). For Banting (see Figure 6), most of the winds blew from the North and the North-East, followed by the South and the South-East. Because of the wind effects, air pollutants from Petaling Jaya, Kuala Lumpur and the Eastern part of Selangor were transported to the South (Banting area). However, the air pollutants were "stored" at the Banting area due to the sea breeze from the South and the West that reduced the transmission of air pollutants farther to the South or the West (see Figure 5).

Air quality before and after MCO, 2019-2020

Most of the urban activities were on lockdown due to MCO. This caused the air emission from pollution sources to be expected to decrease which contributed to a better air quality. Figure 7 to Figure 10 showed the concentrations of $PM_{2.5}$, SO_2, NO_2, and CO that were decreased since the declaration of MCO on 18 March 2020 in Klang Valley (see Figure 7 to Figure 10). This displayed that the reduction of urban activities that were industrial, commercial, schooling, transportations, tourism, recreation, and other non-essential activities successfully improved the ambient air quality.

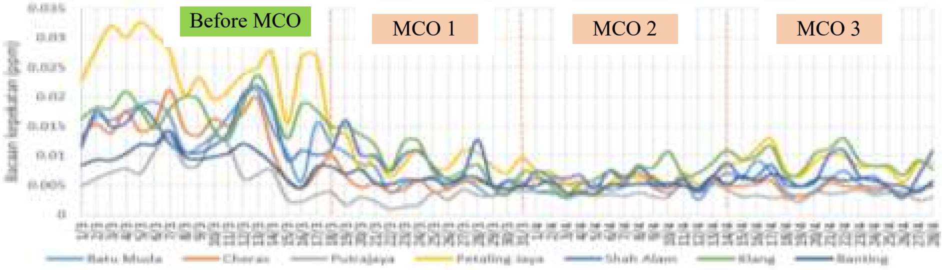
Figure 7: Average daily concentrations of $PM_{2.5}$ before and during MCO, Klang Valley, March-April 2020



Note: Reduction of 17% to 36% of the concentrations after the enforcement of MCO on 18 March 2020

Source: DOE (2020a)

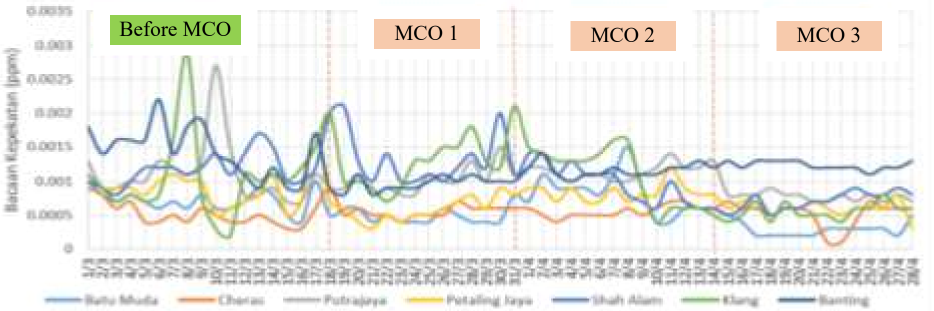
Figure 8: Average daily concentrations of NO_2 before and during MCO, KlangValley, March-April 2020



Note: Reduction of 49% to 68% of the concentrations after the enforcement of MCO on 18 March 2020

Source: DOE (2020a)

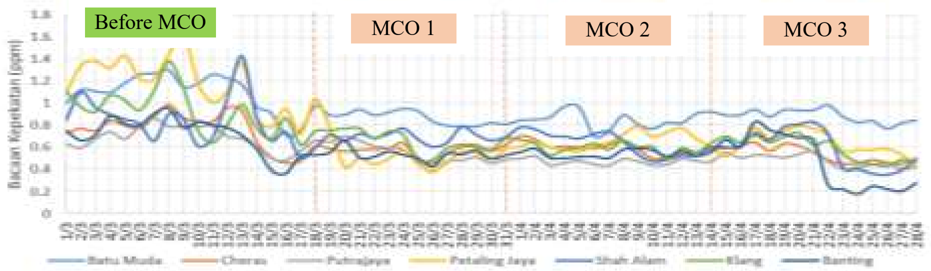
Figure 9: Average daily concentrations of SO_2 before and during MCO, Klang Valley, March-April 2020



Note: Reduction of 6% to 26% of the concentrations after the enforcement of MCO on 18 March 2020

Source: DOE (2020a)

Figure 10: Average daily concentrations of CO before and during MCO, Klang Valley, March-April 2020

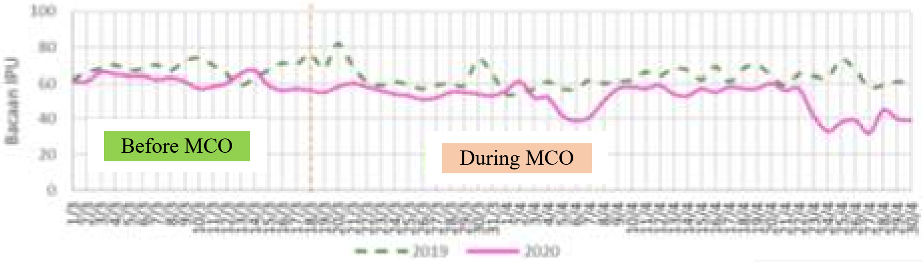


Note: Reduction of 21% to 48% of the concentrations after the enforcement of MCO on 18 March 2020

Source: DOE (2020a)

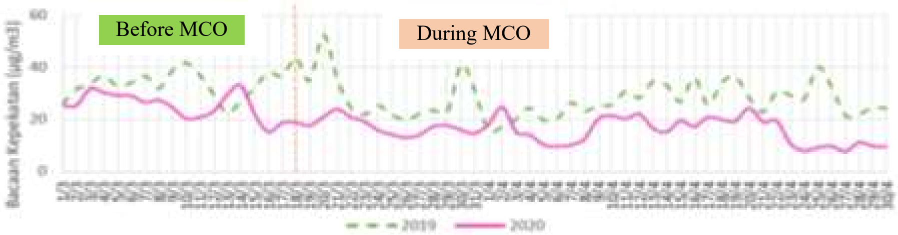
For the purpose to compare the air quality between 2019 and 2020 within the same period of March and April, Petaling Jaya city was only chosen for this analysis. This was due to the limitation of data available in the existing DOE's publication. Figure 11 to Figure 14 indicated reductions of API values, $PM_{2.5}$ concentration, NO_2 concentration, and CO concentration after 18 March 2020 were larger than the same period in 2019. Nonetheless, the trend of SO_2 concentration was similar between 2019 and 2020 for the period of March to April (see Figure 15).

Figure 11: API values in Petaling Jaya, March-April, 2019 and 2020



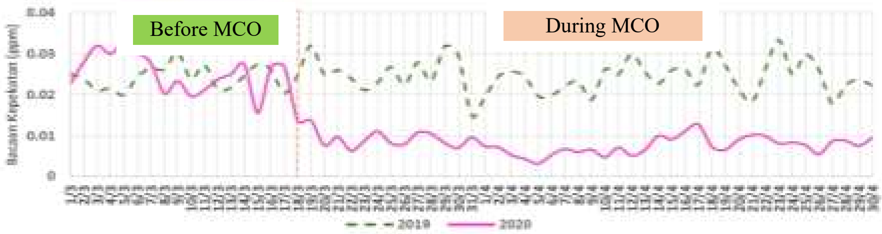
Source: DOE (2020b)

Figure 12: Average daily concentrations of $PM_{2.5}$ in Petaling Jaya, March-April, 2019 and 2020



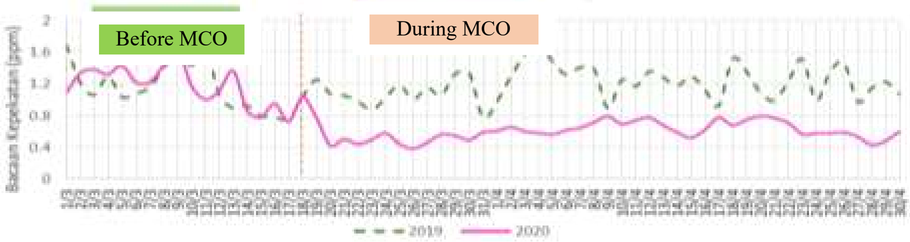
Source: DOE (2020b)

Figure 13: Average daily concentrations of NO_2 in Petaling Jaya, March-April, 2019 and 2020



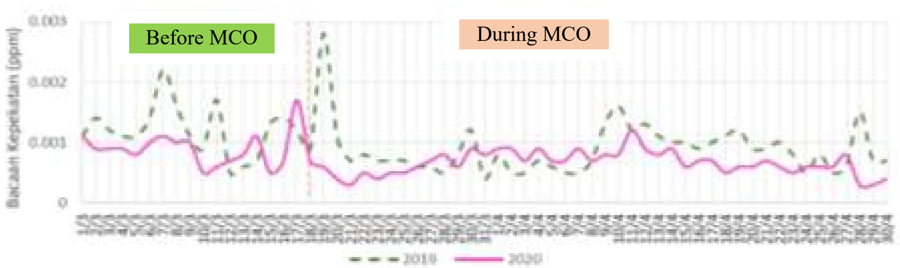
Source: DOE (2020b)

Figure 14: Average daily concentrations of CO in Petaling Jaya, March-April, 2019 and 2020



Source: DOE (2020b)

Figure 15: Average daily concentrations of SO_2 in Petaling Jaya, March-April, 2019 and 2020



Source: DOE (2020b)

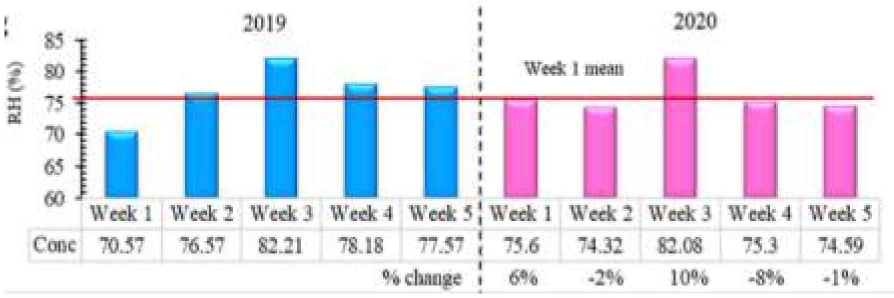


Figure 16: RH (%) in Kuala Lumpur city from 18 March to 21 April for both 2019 and 2020
Source: Suhaimi et al. (2020)

Again, the reduction of air pollution could be associated with the decreasing urban activities which contributed to the air emission. Based on the relative humidity (RH) data (see Figure 16 and Figure 17) in Kuala Lumpur (a city in Klang Valley and adjacent to Petaling Jaya), RH exhibited no apparent difference between the same period in those two years (2019 and 2020), as well as before and after MCO in 2020 (Suhaimi et al., 2020). Consequently, the improvement of air quality was affected by urban activities and not caused by the change of RH or precipitation.

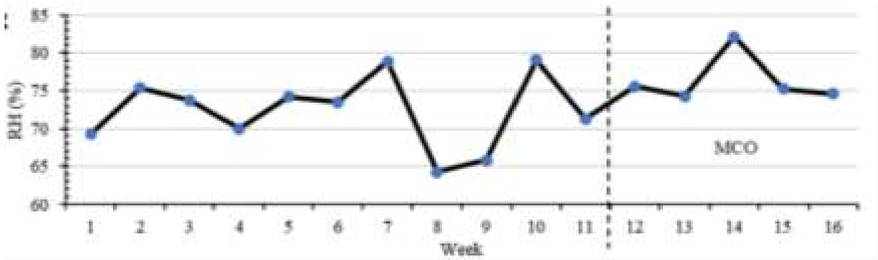


Figure 17: RH (%) in Kuala Lumpur city from 1 January to 21 April 2020
Source: Suhaimi et al. (2020)

Besides the data from DOE, air quality data from Mohd Nadzir et al. (2020) in five locations in Petaling Jaya city showed a relationship between land use, activities and air quality. After the enforcement of MCO, the concentrations of air pollutants were decreased but with a different rate among the five locations in Petaling Jaya (see Table 4 and Table 5).

Table 4: Daily average concentrations of CO, PM_{10} and $PM_{2.5}$ measured by AiRBOXSense at Bukit Gasing (BG), Kelana Jaya (KJ), Kota Damansara (KD), Petaling Jaya (PJ) and Uptown (UP)

Locations		Normal day			MCO		
		CO (ppm)	$PM_{2.5}$ ($\mu g\ m^{-3}$)	PM_{10} ($\mu g\ m^{-3}$)	CO (ppm)	$PM_{2.5}$ ($\mu g\ m^{-3}$)	PM_{10} ($\mu g\ m^{-3}$)
BG	Min	0.01	0.100	0.100	0.0100	0.100	0.100
	Max	8.88	1540	7110	1.94	477	2540
	Average	0.400	28.8	54.1	0.240	11.8	26.0
KJ	Min	0.0100	0.250	0.25	0.0100	0.34	0.34
	Max	12.8	193	2260	2.30	155	936
	Average	0.560	9.32	19.0	0.310	6.32	12.4
KD	Min	0.0100	0.250	0.250	0.0200	0.54	0.54
	Max	7.78	414	3460	5.11	213	3410
	Average	0.550	21.4	32.9	0.300	36.4	38.4
PJ City	Min	0.0100	0.140	0.140	0.0100	0.240	0.240
	Max	8.02	101	849	0.850	38.7	266
	Average	0.540	10.4	21.7	0.300	6.26	12.6
UP	Min	3.46	0.380	0.380	0.0100	0.360	0.360
	Max	8.59	300	1160	6.24	104	2010
	Average	0.680	11.1	22.2	0.360	8.78	15.8

Note: data during a normal day (20th November 2019–17th March 2020) and during the MCO (18th March 2020–12th April 2020)

Source: Mohd Nadzir et al (2020)

In Petaling Jaya, a car park at a recreation area (Bukit Gasing) experienced the largest reduction of air pollutant concentration, especially PM (see Table 5). Highway, town and industrial areas moderately improved the air quality. Areas with residential units (Uptown and Kota Damansara) faced the least reduction of air pollution or increased air pollution. This implied that urban land uses and human activities affected the air quality of the areas.

The car park at the recreational area (Bukit Gasing) normally had a higher concentration of PM (see Table 4) due to emission of motor vehicles; henceforth, it experienced the highest reduction of PM during MCO due to no or very less emission from motor vehicles for recreational activity (see Table 5).

Residential areas with a moderate concentration of PM (see Table 4) only experienced a small reduction of PM concentrations (at Uptown) or increased in the PM concentrations (at Kota Damansara) (see Table 5). This was because during MCO, most people stayed and only drove within their residential areas to obtain their basic daily goods, such as food. Thus, residential areas faced less reduction or even increased air pollution during MCO as measured by $PM_{2.5}$ and PM_{10}.

Meanwhile, highway, town and industrial areas (PJ city and Kelana Jaya) faced a moderate reduction of PM concentrations. This was because these areas had a lower concentration of PM in normal days (see Table 4). During MCO, these areas experienced less traffic due to the movement control which limited residents' activities within 20 kilometres only from residential areas. Therefore, there was a moderate reduction of PM concentrations as compared to other areas as listed in Table 4 and 5.

Table 5: Overall reduction of CO, $PM_{2.5}$ and PM_{10} recorded during MCO in Petaling Jaya

Station	Sensor deployment	Type of area	Air pollutants	Average reduction (%)
BG	Car park	Recreation area	CO	40.5
			$PM_{2.5}$	58.9
			PM_{10}	51.8
KJ	Facing highway	Main highway	CO	45.2
			$PM_{2.5}$	32.2
			PM_{10}	34.9
PJ City	Main road	Township and industrial	CO	44.1
			$PM_{2.5}$	39.8
			PM_{10}	42.0
UP	Main road	Residency, Mall, Shops and restaurant area	CO	47.5
			$PM_{2.5}$	20.8
			PM_{10}	28.8
KD	Main road	Residency and small industries	CO	44.7
			$PM_{2.5}$	+41.2
			PM_{10}	+14.2

Source: Mohd Nadzir et al (2020)

CONCLUSIONS

To conclude, this study successfully examined the impact of urban land use and activities on ambient air quality in selected five areas in Klang Valley. The wind also affected the distribution of air pollutants in Klang Valley. Some of the areas with fewer pollution sources land uses had a higher level of air pollution. In contrast, some areas with more pollution sources land uses had a better air quality due to the effect of winds. From the experiences during MCO, the study found that human behavioural change could reduce the level of air pollution. By reducing the industrial operations, transportation activities and other urban activities with more people choosing the mode of "work from home", the air pollutant levels in urban areas were reduced. Conversely, it was noticeable that the air pollution level in residential areas could be increased due to the concentration of human activities in the residential areas. Thus, it is recommended that urban managers should carry out a detailed urban management plan to reduce the concentration of activities in urban areas by enhancing development to other less developed areas as well as encouraging the culture of "work from home" even after the event of COVID-19 outspread in the human habitats. Besides that, residents should be encouraged to walk or bike more instead of driving to reduce air emission in residential areas.

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