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STATUS OF AIR QUALITY BEFORE AND DURING REINFORCEMENT OF MCO DUE TO COVID-19 OUTBREAK IN CENTRAL AND SOUTHERN REGIONS OF PENINSULAR MALAYSIA

(Status Kualiti Udara Sebelum dan Semasa Pelaksanaan Semula PKP disebabkan oleh COVID-19 di Daerah Tengah dan Selatan Semenanjung Malaysia)

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ABSTRACT

The first confirmed case of Coronavirus-19 (COVID-19) in Malaysia was reported on January 25, 2020, and the number of cases has been steadily increasing since March 2020. To minimize the spread of COVID-19, the Malaysian government implemented a Movement Control Order (MCO), effective on 18 March 2020. The MCO was extended multiple times and has, at times, switched to either the Conditional Movement Control Order (CMCO), the Recovery Movement Control Order (RMCO), or the Enhanced Movement Control Order (EMCO). As a result, there were fewer motor vehicles on the road, and industry operations were halted, resulting in lower hazardous emissions. Therefore, this study intends to investigate the air quality index (AQI) before and during MCO implementation. Air pollution has become a more worrisome problem in urban areas, especially from vehicle discharge. The data set of the daily average AQI in Kuala Lumpur, Petaling Jaya, Putrajaya, and Johor Bahru was analyzed using the paired t-test and independent t-test. The analysis showed that the AQI of the cities is normally distributed. The result showed a significant difference in daily AQI before and during the reimplementation of MCO in Kuala Lumpur. Apart from that, a comparison between urban areas with MCO and without MCO only shows a significant difference between Kuala Lumpur and Johor Bahru. The finding revealed that MCO is capable of reducing the AQI in Kuala Lumpur. Therefore, the government can plan strategies that are related to reducing the number of activities and carbon emissions such as increasing the utilization of public transport.

Keywords: air quality index; MCO; urban area

ABSTRAK

Kes Coronavirus-19 (COVID-19) yang pertama disahkan di Malaysia dilaporkan pada 25 Januari 2020, dan jumlah kes telah meningkat sejak Mac 2020. Bagi mengurangkan penularan COVID-19, kerajaan Malaysia melaksanakan Perintah Kawalan Pergerakan (PKP) berkuatkuasa pada 18 Mac 2020. PKP dilanjutkan beberapa kali dan beralih ke Perintah Kawalan Pergerakan Bersyarat (PKPB), Perintah Kawalan Pergerakan Pemulihan (PKPP), dan Perintah Kawalan Pergerakan Diperketatkan (PKPD). Ini mengakibatkan terdapat bilangan kenderaan yang sedikit di jalan raya, dan operasi industri dihentikan, mengkibatkan pengurangan pelepasan gas berbahaya. Oleh itu, kajian ini bertujuan untuk menyiasat indeks kualiti udara sebelum dan semasa pelaksanaan PKP. Pencemaran udara menjadi masalah yang membimbangkan di kawasan bandar, terutamanya dari pelepasan asap kenderaan. Purata harian indeks kualiti udara di Kuala Lumpur, Petaling Jaya, Putrajaya dan Johor Bahru dianalisis menggunakan ujian-t berpasangan dan ujian-t tak bersandar. Analisis menunjukkan bahawa indeks kualiti udara adalah tertabur secara normal. Hasil kajian mendapati bahawa terdapat perbezaan yang bererti dalam indeks kualiti udara harian sebelum dan semasa pelaksanaan PKP di Kuala Lumpur. Disamping itu, perbandingan di antara kawasan bandar yang dikenakan PKP dan tidak dikenakan PKP menunjukkan perbezaan yang bererti di antara

Kuala Lumpur dan Johor Bahru. Hasil kajian juga menunjukkan bahawa PKP dapat mengurangkan indeks kualiti udara di Kuala Lumpur. Sehubungan itu, kerajaan dapat merancang strategi yang berkaitan dengan pengurangan jumlah kegiatan dan pelepasan karbon seperti meningkatkan penggunaan pengangkutan awam.

Kata kunci: indeks kualiti udara; PKP; kawasan bandar

1. Introduction

The coronavirus (COVID-19) started in December 2019 as viral pneumonia in China. COVID-19 is a variant of the coronavirus family. Coronaviruses are positive-stranded RNA viruses surrounded by an envelope that belongs to the family Coronaviridae, a common type of virus that affects mammals, birds, and reptiles. Coronaviruses are divided into four generations, and they are Alpha-, Beta-, Gamma-, and Delta coronavirus, of which Alpha- and Beta- CoVs are known to infect humans (De Wilde *et al*. 2017). Coronavirus causes respiratory disease and it has been declared a pandemic status by the World Health Organization (Sauer 2020).

Based on an article published by The Star on April 8th, 2020, titled "Current Situation in Malaysia" (Pfordten & Ahmad 2020), Malaysia recorded its first COVID-19 affirmed case on the 25th of January 2020 that included three visitors from China that entered Malaysia through Johor from Singapore on January 23rd. The number of cases increased to 22 by February 16th that spike to the first influx of cases. Therefore, to reduce the number of new cases, it has been recommended for all Malaysians to practice social distancing and good hygiene, which included hand washing. The Malaysian government issued the Movement Control Order (MCO) on March 18th, 2020, to increase social distance and slow down the spread of the virus. The MCO order has been extended several times and has been renamed Conditional Movement Control Order (CMCO), Recovery Movement Control Order (RMCO), and Enhanced Movement Control Order (EMCO) at times as shown in Table 1 (Malaysian National Security Council 2020).

Table 1: Movement control order by phase in Malaysia

Type of MCO	Phase	Date
Movement Control Order (MCO)	Phase 1	18 March 2020 – 31 March 2020
	Phase 2	1 April 2020 – 14 April 2020
	Phase 3	15 April 2020 – 28 April 2020
	Phase 4	29 April 2020 – 3 May 2020
Conditional Movement Control Order (CMCO)	Phase 1	4 May 2020 – 12 May 2020
	Phase 2	13 May 2020 – 9 June 2020
Recovery Movement Control Order (RMCO)	Phase 1	10 June 2020 – 31 August 2020
	Phase 2	1 September 2020 – 31 December 2020
	Phase 3	1 January 2021 – 31 March 2021

Only a few vital service sectors, such as healthcare, logistics, the food supply system, and banking, are permitted to operate due to the restrictions on travel. As a result, there are fewer vehicles on the road, several flights have been cancelled, and construction and industrial operations have been reduced, resulting in lower levels of air pollution.

Air quality is a critical issue that any government must manage and regulate. Increased air pollution levels will have an impact on human health, producing respiratory and skin disorders. The World Health Organization estimates that air pollution and poor air quality cause 5.5 million avoidable deaths per year (World Health Organization 2016). The main sources of air pollution in urban areas are combustion from vehicles, power generation plants, landfill sites, wastewater treatment plants, and unsustainable farming (Nadzir *et al*. 2020). Air pollution in metropolitan zones is generally created from vehicle discharges, and the absence of interest in the public vehicle framework has prompted an expanding number of private vehicles in Malaysia (Brohi *et al*. 2018).

COVID-19-related air quality reductions have been widely debated around the world and discovered that lockdown did help to improve air quality (Collivignarelli *et al*. 2020; Sharma *et al*. 2020; Dantas *et al*. 2020; Chen *et al*. 2020). Considering Malaysia, many studies were conducted to investigate the effect of MCO on air quality such as studies by Abdullah *et al*. (2020), Ash'aari *et al*. (2020), and Nadzir *et al*. (2020).

This study was conducted to investigate the significant difference in air quality status during the implementation of the movement control order (MCO). Since some states are not under MCO, the objective is to distinguish between the air quality index between those states without MCO and the states with MCO. Accordingly, this paper investigates the air quality index (AQI) before and during MCO restriction in some selected urban areas in Malaysia. Air pollution has become a more worrisome problem in urban areas, especially from vehicle discharge and manufacturing firms. Thus, this study aims to investigate whether the subsequent implementation of the MCO affects the status of the air quality index.

The rest of this paper is organized as follows. A brief discussion on air pollution is reported in Section 2 while Section 3 explained the methodology. Results and analysis are presented in Section 4 while the conclusion follows in Section 5.

2. Air Pollution

Air pollution is physical or chemical changes brought about by natural cycles or human exercises that lead to air quality debasement (Cunningham *et al*. 2004). Criticalness association of pollution by Enger and Smith (2000) described air pollution as a state when human populaces turned out to be concentrated to the point that their wastage could not be reduced as quickly as they were created. The air will be polluted when the concentration of pollutants which are CO2, NO2, SO2, and other poisonous gases in nature is high (Ahluwalia & Malhotra 2008).

2.1. *Air pollution in urban area*

A researcher (Kemp 2004), expressed that air pollution was generally enormous in urban areas that had high occasional warming prerequisites, vigorously industrialized and high volumes of vehicular traffic, or encountered a blend of each of the three. In urban areas, the unbending detachment of lodging, work, business, and recreational exercises make reliance on a street-based vehicle, which adds to significant levels of metropolitan air contamination and nursery discharges (Yahaya & Yusoff 1999).

3. Methodology

3.1. *t-test*

Parametric and nonparametric approaches are the two types of statistical inference. The term "parametric techniques" refers to a statistical methodology in which the probability distribution of probability variables is defined, and inferences are made (Kim 2015). There is an assumption to be fulfilled when conducting a parametric test which implies that the data set must be normally distributed. Nonparametric methods are used in circumstances where the probability distribution cannot be determined. The t-test is a parametric procedure that can be employed when the samples are normal, have equal variance, and are independent. A t-test compares the means of two groups and it is one of the most extensively used statistical hypothesis tests (Ahad & Syed Yahaya 2014; Yim *et al*. 2010). The t-test consists of two categories: 1) independent and 2) dependent t-test (known as paired t-test). A t-test is also known as Student's t-test. It is a statistical analysis technique that was developed by William Sealy Gosset in 1908 as a means to control the quality of dark beers (Kim 2015). This test is used to compare two groups that are independent of each other, where one group is treated with A, and another group is treated with B. Paired t-test, on the other hand, is utilized in different experimental settings. Paired t-test is used when two groups are dependent. The experimental subjects, for example, are not divided into two groups and all of them are treated initially with A (Kim 2015).

The t statistic is calculated as shown in Equation (1) under the assumption that the two samples have a normal distribution and equal variance.

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{s_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \tag{1}$$

with a degree of freedom, df= $n_1 + n_2 - 2$

In Eq. (1), we denote $\bar{x}_1, \bar{x}_2$ = mean of sample i, i = 1, 2

s_1^2, s_2^2 = variance of sample i, i = 1, 2

n_1, n_2 = size of sample i, i = 1, 2

S_p is pooled variance and define as Eq. (2)

$$S_p = \frac{(n_1 - n_2)s_1^2 + (n_1 - 1)s_2^2}{n_1 + n_2 - 2} \tag{2}$$

However, if the population variance is not equal, the t statistic of the t-test would be calculated as shown in Eq. (3).

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \tag{3}$$

and the degree of freedom is calculated based on the Welch Satterthwaite equation.

$$df = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}} \tag{4}$$

The paired t-test can be considered as a type of t-test for a single sample because it tests the difference between two paired samples. Paired t-test is calculated as shown in Eq. (5).

$$t = \frac{\bar{D} - \mu_D}{s_D / \sqrt{n}} \quad (5)$$

where,

$\bar{D} = \frac{\sum_{i=1}^{n} D_i}{n_D}$, $D = X_{1i} - X_{2i}$, $s_D = \sqrt{\frac{\sum_{i=1}^{n}(D_i - \bar{D})^2}{n-1}}$ and degree of freedom, df = n-1.

3.2. *Data collection*

This study is exploratory research with quantitative analysis. The type of data used for this study is secondary data. A data set of the daily average air quality index (AQI) is retrieved from the official website of the Malaysia Department of Environment (DOE). The daily average of AQI for three states that were currently under MCO are collected from October 14th, 2020 to November 10th, 2020. As for the data set before MCO, the daily average of AQI for those stations are collected at the same period in 2019 which was before the COVID-19 pandemic and implementation of MCO. Besides, by focusing on the status of air quality in the urban area, the daily average AQI collected are from stations of the main city of each state which are Petaling Jaya in Selangor, Cheras in Kuala Lumpur, and Putrajaya. Apart from that, the city without MCO, the daily average AQI of Johor is also retrieved from 14th October 2020 until 10th November 2020.

3.3. *Method of data analysis*

The statistical analysis is performed by using SPSS version 25. Hypothesis testing was conducted to achieve the objective of the study. Firstly, to compare the different means of daily air quality index (AQI) of the stations mentioned in data collection for the period under review (before and during the implementation of MCO), a paired t-test is chosen to perform the analysis since the data are in the same group but comparing them in different years. Next, to evaluate the significant difference between the city with MCO reinforcement and without MCO, an independent t-test was used. Both analyses are conducted by performing a parametric test since the data fulfilled the normality assumption.

4. Results and Analysis

Table 2 to Table 4 and Fig. 1 to Fig. 3 show the daily average of AQI for Putrajaya (Putrajaya), Cheras (Kuala Lumpur), and Petaling Jaya (Selangor), respectively before and during MCO. There are increments and decrease in the air quality index in the cities before and during the reimplementation of MCO. Fig. 1 and Fig. 3 show that the air quality for the period under review was fluctuating and relatively stable in Fig. 2. The relatively low AQI stability in 2020 observed in Fig. 2 may be due to many dormant human activities during the MCO. Fig. 1 and Fig. 3 revealed a specific pattern of AQI for the period understudy. Nevertheless, Kuala Lumpur experienced a decrease during the reimplementation of MCO many times compared to Putrajaya and Petaling Jaya as shown in Table 4.

Table 2: Daily average of AQI for Putrajaya before and during MCO

AQI of Putrajaya					
Months	Date/Years	2019	2020	Variation	
				Index	%
OCTOBER	14	63	44	-19	-30.16
	15	69	62	-7	-10.14
	16	66	67	1	1.52
	17	64	57	-7	-10.94
	18	72	58	-14	-19.44
	19	58	61	3	5.17
	20	56	64	8	14.29
	21	56	65	9	16.07
	22	54	62	8	14.81
	23	54	55	1	1.85
	24	54	48	-6	-11.11
	25	61	54	-7	-11.48
	26	65	55	-10	-15.38
	27	62	44	-18	-29.03
	28	54	57	3	5.56
	29	51	66	15	29.41
	30	49	64	15	30.61
	31	53	66	13	24.53
NOVEMBER	1	59	62	3	5.08
	2	54	54	0	0.00
	3	55	48	-7	-12.73
	4	58	54	-4	-6.90
	5	60	51	-9	-15.00
	6	62	57	-5	-8.06
	7	64	61	-3	-4.69
	8	66	60	-6	-9.09
	9	62	60	-2	-3.23
	10	53	52	-1	-1.89

*negative values in variation indicate a decrement of AQI during the MCO

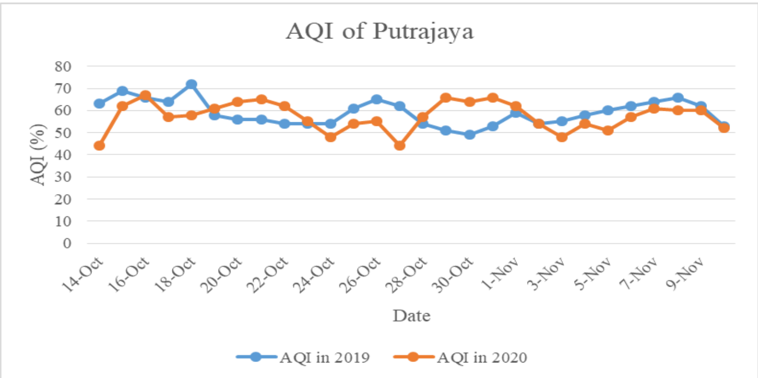

Figure 1: Time series plot of daily average AQI for Putrajaya

Table 3: Daily average of AQI for Cheras Station, Kuala Lumpur before and during MCO

AQI of Kuala Lumpur (Cheras)					
Months	Date/Years	2019	2020	Variation	
				Index	%
OCTOBER	14	62	34	-28	-45.16
	15	69	56	-13	-18.84
	16	66	58	-8	-12.12
	17	65	51	-14	-21.54
	18	75	48	-27	-36.00
	19	59	50	-9	-15.25
	20	56	51	-5	-8.93
	21	53	58	5	9.43
	22	55	59	4	7.27
	23	54	51	-3	-5.56
	24	54	44	-10	-18.52
	25	64	47	-17	-26.56
	26	67	59	-8	-11.94
	27	59	40	-19	-32.20
	28	52	53	1	1.92
	29	53	56	3	5.66
	30	51	56	5	9.80
	31	51	60	9	17.65
NOVEMBER	1	58	58	0	0.00
	2	57	48	-9	-15.79
	3	61	45	-16	-26.23
	4	64	48	-16	-25.00
	5	68	42	-26	-38.24
	6	70	48	-22	-31.43
	7	60	62	2	3.33
	8	54	56	2	3.70
	9	63	52	-11	-17.46
	10	57	45	-12	-21.05

*negative values in variation indicate a decrement of AQI during the MCO

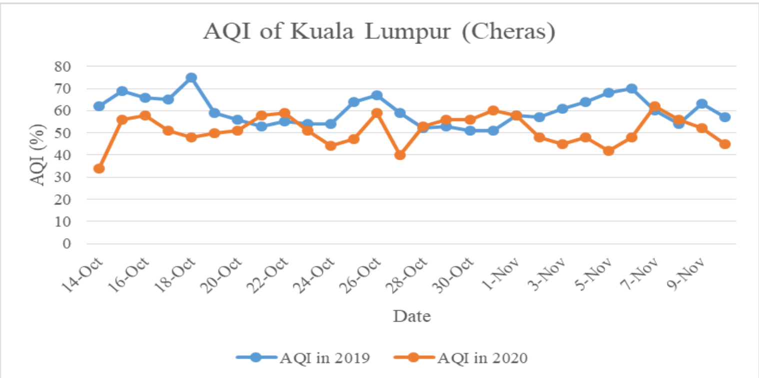

Figure 2: Time series plot of daily average AQI for Cheras

Table 4: Daily average of AQI for Petaling Jaya, Selangor before and during MCO

AQI of Petaling Jaya					
Months	Date/Years	2019	2020	Variation	
				Index	%
OCTOBER	14	64	40	-24	-37.50
	15	71	56	-15	-21.13
	16	68	61	-7	-10.29
	17	67	56	-11	-16.42
	18	72	56	-16	-22.22
	19	60	57	-3	-5.00
	20	59	58	-1	-1.69
	21	55	66	11	20.00
	22	58	60	2	3.45
	23	57	54	-3	-5.26
	24	55	51	-4	-7.27
	25	62	53	-9	-14.52
	26	63	57	-6	-9.52
	27	63	50	-13	-20.63
	28	60	68	8	13.33
	29	52	63	11	21.15
	30	52	69	17	32.69
	31	59	74	15	25.42
NOVEMBER	1	61	71	10	16.39
	2	54	58	4	7.41
	3	56	52	-4	-7.14
	4	59	60	1	1.69
	5	56	62	6	10.71
	6	60	67	7	11.67
	7	61	68	7	11.48
	8	66	68	2	3.03
	9	63	60	-3	-4.76
	10	57	57	0	0.00

*negative values in variation indicate a decrement of AQI during the MCO

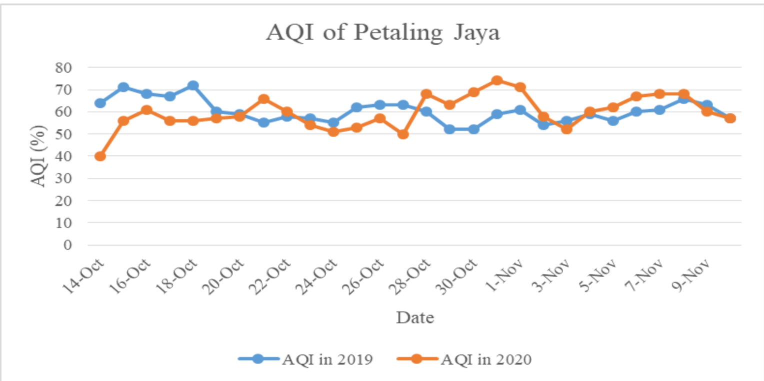

Figure 3: Time series plot of daily average AQI for Petaling Jaya

As explained in the methodology, it is vital to assess the assumptions of normality before proceeding with the parametric tests. Based on Table 5, the p-values for Kolmogorov-Smirnov and Shapiro-Wilk tests are greater than 0.05 for all cities. This concludes that they are not significant. The AQI data for the cities is normally distributed.

Table 5: Result for normality test

Test of Normality								
	Cities	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
AQI	KL	.151	28	0.103	.960	28	0.342
	PTJ	.118	28	0.200*	.951	28	0.210
	PJ	.095	28	0.200*	.970	28	0.575
	JB	.113	28	0.200*	.976	28	0.746

*. This is a lower bound of the true significance.

In this study, the null and alternative hypotheses can be stated as

H_0: The is no difference in the average daily air quality index in the cities before and during the reimplementation of MCO.

H_1: There is a difference in the average daily air quality index in the cities before and during the reimplementation of MCO.

Based on the output in Table 6, we have enough evidence to reject the null hypothesis of no difference in the average daily air quality index in the cities of Kuala Lumpur before and during the reimplementation of MCO. Only Kuala Lumpur has a significant p-value (0.000<0.05). The other two pairs which are Putrajaya and Petaling Jaya are not significant since the p-value for both pairs is 0.340 and 0.734, respectively. Thus, the average difference of AQI in both cities before and during MCO is 0.0 which had statistically proven that there are no differences in the average of AQI in Putrajaya and Petaling Jaya before and during the reimplementation of MCO.

To extend the discussion, by referring to Table 6, on average, Kuala Lumpur has the highest mean differences of daily AQI with 8.643 which points out that daily AQI in Kuala Lumpur before MCO is 8.643 higher compared to during MCO averagely. The mean differences of daily AQI in Putrajaya on average are only 1.643 and 0.643 for Petaling Jaya that shows a slight difference value. Significantly, the reinforcement of MCO in these three states does not affect the air quality in Putrajaya and Petaling Jaya as shown during the first and second phases of the MCO. The implementation of the MCO indirectly reduced air pollution in the study area and Malaysia in general.

Table 6: Result of paired samples test

Paired Samples Test									
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Putrajaya	2019 - 2020	1.643	8.958	1.693	-1.831	5.116	0.970	27	0.340
Kuala Lumpur	2019 - 2020	8.643	10.475	1.980	4.581	12.705	4.366	27	0.000
Petaling Jaya	2019 - 2020	.643	9.889	1.869	-3.192	4.477	0.344	27	0.734

Next, to statistically determine either reinforcement of MCO in several states will significantly differentiate the status of air quality from the states without the order, hypothesis testing is conducted using an independent t-test.

H_0: The is no difference in the average daily air quality index between the city with MCO and without MCO is the same.

H_1: There is a difference in the average daily air quality index between the city with MCO and without MCO.

The performed analysis is illustrated in Table 7. From the table, the dependent variable which is the daily average AQI is homoscedasticity since the p-value from Levene's test is 0.755 which is larger than the significance value of 0.05 hence not significant. Thus, by referring to the p-value with equal variance assumption, we can conclude that the average AQI between Kuala Lumpur that is under the reinforcement of MCO, and Johor Bahru with MCO free is different. Therefore, enough evidence to reject the null hypothesis because the p-value (0.001) computed is smaller than the significance level (0.05). There might be a significant difference in the average of AQI in both cities since MCO has significantly reduced the AQI in Kuala Lumpur during the reinforcement based on the result in Table 7. Moreover, from the mean difference, it can be seen that air quality in Kuala Lumpur during MCO reimplementation is 6.5(µg/m3) better than the AQI in Johor Bahru.

Table 7: Result of independent t-test (Kuala Lumpur-Johor Bahru)

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
AQI	Equal variances assumed	.098	.755	-3.392	54	.001	-6.50	1.916	-10.342	-2.658
	Equal variances not assumed			-3.392	53.43	.001	-6.50	1.916	-10.343	-2.657

Since reinforcement of the MCO in Putrajaya does not significantly affect the status of air quality before and during its reinforcement, the computed p-value of independent t-test for daily average AQI in Putrajaya during MCO and Johor Bahru with the same timeline in Table 8 revealed that the p-value is greater than the significant value which is 0.865. Hence, we do not have enough evidence to reject the null hypothesis which directly concludes that there is no difference in the average AQI between both cities. This statement also can be supported by referring to Table 8, there is only a slight difference in means of AQI in both cities which is 0.32.

Based on Table 9 that displayed the output of the independent t-test for Petaling Jaya and Johor Bahru, we do not have enough evidence to support the claim that the average of AQI between Petaling Jaya and Johor Bahru is different. This is because it is not significant at the 5% significance level since the *p*-value (0.331) is greater than the significant value. Based on Table 9, the mean of daily average AQI in Petaling Jaya during the reinforcement of MCO is 1.96(µg/m3) higher than the mean of daily average AQI in Johor Bahru during the same period.

Table 8: Result of independent t-test (Putrajaya-Johor Bahru)

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
AQI	Equal variances assumed	.248	.621	-.171	54	.865	-.321	1.880	-4.091	3.448
	Equal variances not assumed			-.171	52.87	.865	-.321	1.880	-4.093	3.450

Table 9: Result of independent t-test (Petaling Jaya-Johor Bahru)

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
AQI	Equal variances assumed	.002	.965	.981	54	.331	1.964	2.002	-2.050	5.979
	Equal variances not assumed			.981	53.99	.331	1.964	2.002	-2.050	5.979

5. Discussion

This study mainly focused on the status of air quality in urban areas when the reinforcement of Movement Control Order (MCO) was implemented to assess the daily average air quality index. The MCO has significantly affected the air quality index in Kuala Lumpur. Meanwhile, no significant difference could be observed in the other two urban areas which have implemented MCO. On the other hand, Kuala Lumpur has a significant difference in the AQI before and during the reinforcement of MCO. This may be due to most of the restricted activities are held here before and has consequently reduced the number of vehicles in Kuala Lumpur since those activities are not allowed to operate during the MCO. Besides, during the MCO, most employers must work from home and thus, less carbon emission could be produced in the air because they do not have to go out to work.

Furthermore, urban areas are also known as polluted areas in Malaysia. From this study, by comparing the urban areas with MCO and without MCO, only Kuala Lumpur and Johor Bahru show a significant difference in AQI. Thus, MCO does significantly affect the air quality in urban places when fewer people are going outside with their cars, this will significantly reduce the carbon emission to the air.

Air pollution has become one of the main issues in the urban areas in Malaysia. Air pollution can affect our health and the environment. Accordingly, this study could give a brief insight into the status of air quality in urban areas in Malaysia. The government could implement strategies to reduce or maintain the air quality index that relates to reducing carbon emission since this action has significantly affected the AQI in Kuala Lumpur during the reinforcement of MCO. Moreover, the government could also investigate the industries and activities in Petaling Jaya and Putrajaya because this reinforcement of MCO is not capable of reducing the AQI in both cities.

To study the significant difference in air quality before and during the implementation of MCO, it is recommended to be more specific by testing on the concentration of air pollutants instead of testing the air quality index generally. However, this has become a limitation to this study since the authors could not test air pollutants. The data on the concentration of the air pollutants are not provided. The authors could be more precise and know which air pollutants significantly affect the air quality index if MCO has statistically affected the air quality index generally. Therefore, the government can focus on implementing strategies that relate to reducing the concentration of air pollutants in the air. The authors should also consider factors such as traffic density, weather conditions, industrial activities, and biomass burning for future investigation. Next, the authors could also compare the urban areas with a low air quality index with Kuala Lumpur that has significant effects on AQI before and during MCO. Consequently, the authors could also know if the air quality indexes are significantly different. Moreover, for future studies, regressing the air quality index by using the concentration of the air pollutants as the independent variables will be more beneficial.

6. Conclusion

The MCO significantly affected the air quality index in Kuala Lumpur and otherwise for both cities, Petaling Jaya and Putrajaya. The previous study by Abdullah *et al*. (2020) has statistically proven that MCO had significantly reduced the air pollution in Petaling Jaya and Putrajaya during the second phase of MCO in April which was a week after the first MCO was implemented in Malaysia by the government. Nevertheless, the research specifically analyzes the air pollutants which was PM2.5 at that time. The finding affirmed that MCO could only significantly reduce the concentration of the air pollutants but not generally reducing the air quality index since other air pollutants also exist in the air. Besides, the MCO during the first and second phases is stricter compared to the reinforcement on the third MCO in these three states since several industries are allowed to operate

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