Impact of National Movement Control Orders toward Ground Level Ozone Concentrations in Shah Alam

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Impact of National Movement Control Orders toward Ground Level Ozone Concentrations in Shah Alam

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Abstract. Malaysia is currently facing the COVID-19 pandemic which has claimed hundreds of innocent lives. Because of the health problems impose by the pandemic, the government has ordered to implement the movement control order (MCO) starting March 18, 2020. With this movement control order in place, people are not allowed to leave the house. Therefore, movement on the road can also be reduced. This study was conducted to investigate the emission concentrations of ground-level ozone into the air during MCOs in an urbanized area of Shah Alam. This secondary data of ground-level ozone (O_3) was acquired from the Department of Environment in 2020 and interpreted using the methods of box and whisker plot, time series analysis, and diurnal variation plot. The results found that the concentrations of air pollutants in each type of MCOs implemented were different in terms of trends. During the early implementations of MCOs, results showed that there was a slight decrement in O3 concentrations and as MCOs periods continued, there higher decrements in O_3 concentrations were observed. During the MCOs period, non-exceedance episodes were recorded which show the level of ground-level ozone was significantly improved result of the implementation of MCOs. Results also suggested there is a shift in the peak concentration time as the plot showed peak concentrations were reached between 4 to 6 p.m. which is quite later as normally peaks O_3 concentrations were reported normally reached from 12 noon to 2 p.m. [13]

1. Introduction

On 31st December 2019, the World Health Organization (WHO) announced the discovery of a new virus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This virus was firstly identified in Wuhan City, China [1]. Therefore, the WHO has decided to announce the global pandemic on 11th March 2020 [2]. All the countries in this world took an initiative to reduce the spread of COVID-19 including Malaysia. Malaysia's government has implemented various types of Movement Control Order (MCO) by the National Security Council (NSC) of Malaysia in response to the COVID-19 crisis which is Movement Control Orders (MCO) are divided into MCO1, MCO2, MCO3, MCO4, then the Conditional Movement Control Order (CMCO), and finally the Recovery Movement Control Order (RMCO) based on their enforcement periods.

All colleges, schools, religious institutions, and non-essential sectors were closed during MCO. Interstate travel was prohibited unless there were compelling reasons to do so. All movements were restricted within a 10 km radius with only the head of the family permitted to go out to purchase groceries. The Malaysian National Security Council (NSC) has ordered police officers and the army to cooperate to monitor the movement of civilians [3]. The traffic jams, smoke emissions from vehicles, and industrial activities which are major sources of air pollution have been decreasing during MCO

implementation. Because of that, the air quality status was becoming better [2]. The possibility of increasing air pollutants was very low because of the closure of factories, shopping centres, travel operations, and businesses during MCO [4]. Similar situations were expected to occur around the world including in Malaysia. In Malaysia, major air pollution problems were normally reported at urbanized locations such as Klang Valley including Shah Alam, with sources from industrial establishments and heavy transport [5]. The restriction orders had tremendously affected the daily economic sectors as employees were advised to work from home. Currently, the terms 'Work from Home' and 'Online Learning' become normal words used in society and becoming a new norm. This research aims to study the impact of national movement restriction orders on air quality in Shah Alam and how the MCO initiatives were capable to curb the spreading of COVID-19 as well as mitigating the air pollution problems.

2. Materials and Methods

2.1 Study Area

Shah Alam was chosen as the study area for this study (Figure. 1). Shah Alam is strategically located in the Klang Valley which is known as an area that has a larger population in Malaysia which consists of 7.2 million population in 2021 [6]. The variability of climatic parameters in Shah Alam are around 24-27 ℃ during nighttime and during the day 33-38 ℃, high humidity, and considerable rainfall with two major monsoon seasons, like the rest of the Peninsula's west coast (southeast and northeast monsoon). The climate of Shah Alam and all the Klang Valley is the warm tropical rainforest and sunshine. The average annual rainfall in the project region could range from 1800 to 2400 mm [7].

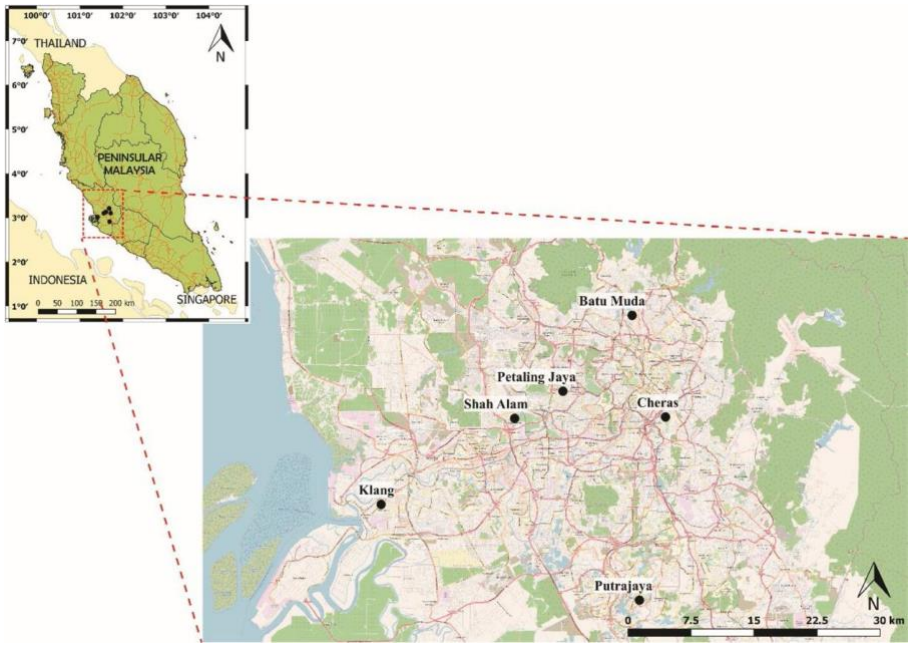

Figure.1 Location of Shah Alam in Klang Valley, Malaysia [8]

2.2 Data Acquisition

In this study, continuous hourly ground level ozone monitoring records in Shah Alam from 1st January 2020 to 31st December 2020 were obtained from the Malaysia Department of Environment (DoE). The hourly concentrations of O3 were measured using UV photometric Thermo Scientific Ozone Analyzer (Model 49i) [9]. The Thermo Scientific Model 49i is designated by the United States Environmental Protection Agency (USEPA) as an Equivalent Method for the measurement of ambient concentrations of ozone pursuant to the requirements defined in the Code of Federal Regulations, Title 40, Part 53. Model 49i operates on the principle that ozone (O_3) molecules absorb UV light at a wavelength of 254

nm. The degree to which the UV light is absorbed is directly related to the ozone concentration as described by the Beer-Lambert Law.

2.3 Data Analysis

The box and whisker plot was used to determine the concentration of O_3 during the MCO in Shah Alam [10]. A box plot also known as a whisker plot, can be used to identify outliers and compare distributions. A box plot shows the basic characteristics of a distribution which can graphically represent a set of numerical data in terms of quartiles. When there was enough data to generate statistics, the box plot graph works well [11]. The input data set was divided into quartiles using the boxplot approach. A boxplot had a maximum value, lower quartile, median, upper quartile, and minimum value. The fluctuations of the ground level ozone during various MCO were studied using a time series plot. A diurnal variation plot was used to differentiate between air pollutants concentrations during the various type of MCOs in Shah Alam. The hourly ozone concentrations were taken to form the graph and see the temporal variations of diurnal. The diurnal variations illustrate the trends in 24 hours on the first date of all types of MCOs [12]. All the data analyses were carried out using Origin Pro 10 analysis software.

3. Results and Discussion

3.1 Box and whisker plot

The following box and whisker plot showed the variations of ground level ozone during six different MCOs that were implemented in Shah Alam. Results suggested there were significant variations and differences in O_3 concentrations during the different MCOs with the lowest concentration was 0.2 ppb that were recorded during RCMO. Meanwhile, the lowest mean concentration was observed during MCO4 with 16.07 ppb, while during RCMO is 16.15 ppb. During all periods of MCOs, non-exceedances of Malaysia Ambient Air Quality Standard limit of 100 ppb for 1-hour averaging time were recorded. This clearly indicates that, due to restrictions of movement that were enforced during MCOs, the O_3 concentrations in Shah Alam are significantly reduced and air quality over the area is getting better [5]. The result suggested the lowest average concentrations were recorded during RCMO with concentrations around 10 ppb, while mean concentrations for the first three MCOs, MCO1, MCO2 and MCO3 are slightly above 20 ppb. The variations in O_3 concentrations also clearly reflected the type of MCOs as during more restricted MCOs such as RMCOs, the O_3 concentrations were much lower compared to MCO1, MCO2 and MCO3 which still allowed a few essential sectors to be continuously operated.

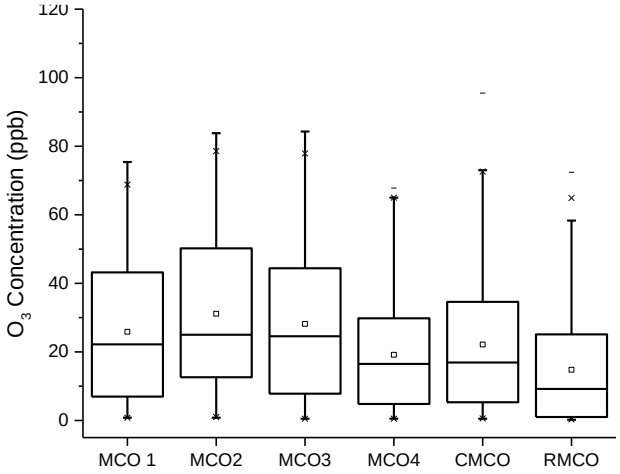

Figure 2. Box and whisker plot of ground level ozone concentration during various periods

3.2 Time series Analysis

Figure 3 showed the time series during the various type of MCOs implementation in Shah Alam. The plot clearly showed that there are quite small variations in hourly O_3 concentrations during the MCOs with the lowest variations detected during RCMO that were shown after 18th June 2020. The result suggested that Shah Alam still had some economic activities operated during MCOs since some essential sectors were allowed to be operated. However, the concentrations were reduced profoundly due to reductions of its precursors as has been reported by [5] The O_3 main precursors such as nitrogen oxides (NOx) and volatile organic compounds (VOCs) are mainly emitted from anthropogenic emissions such as vehicular and power generations [13]. The vehicular or traffic emissions is known to be more profound during congested areas, thus the implementation of MCOs was capable in reducing the O3 main precursors such as NOx and VOC emissions from vehicular as the change for congestion traffic is reduced during the periods.

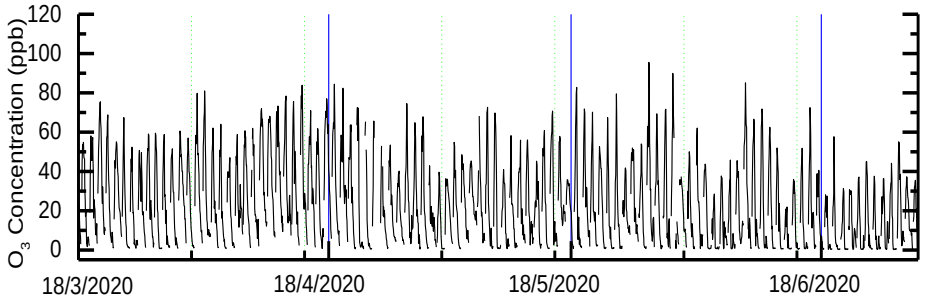

Figure 3. Time series during MCO1, MCO2, MCO3, MCO4, CMCO, and RMCO implementation in Shah Alam, Selangor.

3.3 Diurnal Variations

The diurnal variations of O_3 during all MCOs periods were depicted in Figure 4. The result suggested that O_3 diurnal variations during the MCOs periods still follow the O_3 typical unimodal diurnal trends. The unimodal O_3 trends were characterized by a single peak during afternoon or early evening while O_3 showed significantly high concentration during daytime compared to nighttime. Since O_3 is a secondary air pollutant which has been produced by photochemical reactions with sunlight acts as its main catalyst. So, O_3 only can be produced during daytime in presence of its precursors and sunlight. Results showed the minimum daily concentrations were observed at around 9 a.m. before they began to increase due to intense photochemical reactions. Results clearly showed that the highest peak concentration was observed during MCO2 slightly above 80 ppb. The lowest diurnal trends were observed during CMCO as their peak concentration was around 50 ppb. Results also suggested there are shifts in the peak concentration time as the plot showed peaks concentrations were reached between 4 to 6 p.m. which is quite later as normally peaks O_3 concentrations were reported normally reached from 12 noon to 2 p.m. [13]. The shift may be due to lower precursors concentrations due to limited emissions, thus lowering the rate of O_3 photochemical reactions. During nighttime, O_3 concentrations for CMCO and RMCO is consistently showed values that were less than 10 ppb indicating very minimal O_3 concentrations present in the air during the periods. Similar trends have also been reported by Awang et al. [14] when investigating the influence of particulate matter (PM) on O_3 formation during high particulate events. The study reported that the are shift in O_3 critical conversion time due to the screening effect of a PM that promotes attenuation of sunlight. Similar shifting might also contribute to changes in precursors concentrations [14].

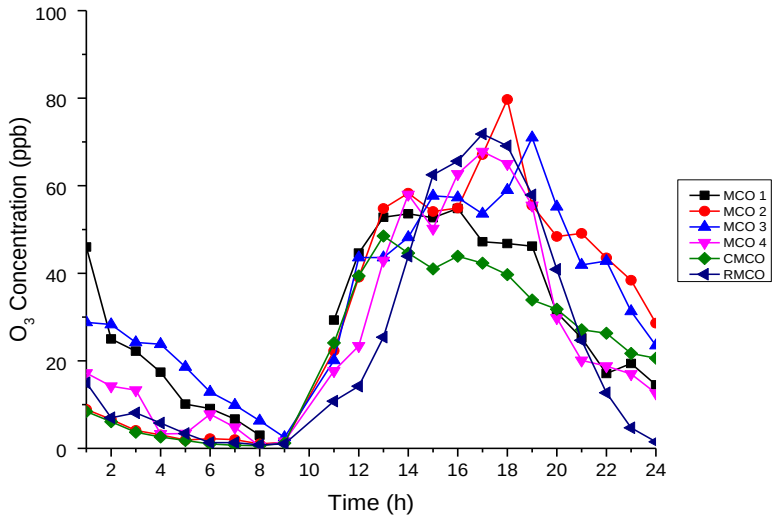

Figure 4. Diurnal variation of six major air pollutants during MCO1, MCO2, MCO3, MCO4, CMCO, and RMCO in Shah Alam, Selangor

4. Conclusion

This study evaluated the impact of the implementations of MCOs towards variations of ground level ozone concentrations in Sham Alam. Result clearly showed that the O_3 concentrations is significantly reduced during the MCOs periods. In addition, result of this study also indicating the O_3 variations is directly response to restrictions applied during various MCOs, with more restriction implemented, the more reductions in O_3 concentrations were observed. The findings also clearly showed that O_3 and other air pollutions in Malaysia could be remedied and control when their source of the pollutants is reduced as have been proved by MCOs periods.

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