ESTEEM Academic Journal
Vol. 18, March 2022, 150-159

Evaluation of Air Quality Assessment in Seberang Jaya, Penang During Movement Control Order (MCO) 1.0

Mohamed Syazwan Osman[1 *], Tengku Shamim Amelin Tengku Zahidi[2], Khairunnisa Khairudin[3], Muhammad Ikhwan Nizam[1], Ahmad Zia ul-Saufie[4]
[1]EMZI-UiTM Nanoparticles Colloids & Interface Industrial Research Laboratory (NANO-CORE), School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA, Cawangan Pulau Pinang, Jalan Permatang Pauh, 13500, Permatang Pauh, Pulau Pinang, Malaysia.
[2]School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA Cawangan Johor, Kampus Pasir Gudang, Jalan Purnama, Bandar Seri Alam, 81750 Masai, Johor, Malaysia.
[3]School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor Darul Ehsan, Malaysia.
[4]Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
**corresponding author: [1]syazwan.osman@uitm.edu.my*

ARTICLE HISTORY

Received
13 January 2022

Accepted
22 March 2022

Available online
31 March 2022

ABSTRACT

Due to the recent global threat of COVID-19, World Health Organization (WHO) announced a Public Health Emergency of International Concern (PHEIC). The Malaysian government has taken several measures to combat the outbreak, with the goal of finally ceasing it. One of the major initiatives taken by the government was the implementation of the Movement Control Order (MCO). The Malaysian government's enforcement of MCO, which was intended to control the COVID-19 transmission throughout the country was believed to have an impact on the quantity of air pollutants emitted [1]. Several rules were implemented under MCO that greatly limited individuals' activities outside of their homes, such as only permitting critical industries to operate and suspending non-essential ones, which significantly decreased traffic density and the emission of industrial pollutants [2]. This study involved obtaining databases from the Department of Environment Malaysia (DOE), which were then utilised to perform various statistical analyses in OpenAir software to observe the quality of air pollutants emitted across the Seberang Jaya, Penang area. Simultaneously, a statistical analysis was employed using an R-package open-source software to analyse pollutants that were related to meteorological conditions. The main goal of this study was to analyse the overall quality of major air pollutants such as PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and O_3 during MCO 1.0 which began on the 18th of March 2020 to the 31st of May 2020. The data on wind direction and speed from DOE were critical to accomplish this study. In summary, the main pollutants emitted in Seberang Jaya were PM_{10} and $PM_{2.5}$, and the locations where the greatest concentration of all pollutants detected were business areas. In the end, this study provided statistical analysis using the OpenAir software tool able to analyse the amounts of various types of air contaminants in this densely populated area of Seberang Jaya.

Keywords: *OpenAir, air pollution, wind rose, pollution rose, bivariate polar plot, calendar plot.*

p-ISSN 1675-7939; e-ISSN 2289-934

1. INTRODUCTION

Air pollution can be described as the contamination of the air, whether it originates from the outside or from within. It is caused by physical, biological and chemical entities such as harmful gases, dust, smoke caused by mainly human daily activities which enter the atmosphere [3]. As the air grows dirtier, significant health consequences for all living creatures worsen and the chances of having and sustaining good health deteriorate. According to research, the average adult breathes 15,000 litres of air every day, making it much easier for dangerous pollutants to enter the bloodstream from the lungs and eventually reach internal organs [4]. As a result, severe health issues such as asthma, cardiovascular disease and cancer develop and reduce health quality and longevity [5]. Air pollution might also damage the surrounding ecosystem because of the immediate changes induced by global warming which raises global temperatures and causes sea levels to rise as ice melts in cooler regions of the planet. Acid rain is created by pollutants in the atmosphere such as nitrogen oxides and sulfur oxides released by the combustion of fossil fuels, which subsequently harms other aspects of the ecosystem. The rapid development of green-coloured algae in lakes and ponds as a result of increasing nitrogen in the atmosphere and poisonous chemicals deposited on the water's surface will have an impact on animals in their natural environment. Because of the increased emission of chlorofluorocarbons and hydrochlorofluorocarbons into the atmosphere, the ozone layer is depleting at an alarming rate [6]. Sources of pollutants can be divided into two categories namely natural sources and man-made sources. Natural sources of air pollution are released from body processes of living things, and it could also transpire from natural events in the environment such as the release of smoke accompanied by polluted gases from active volcanic eruptions. Man-made sources contributing to air pollution are further divided into outdoor pollution sources and indoor pollution sources. Nevertheless, the majority of air pollution originates from outdoor pollution sources such as power generation, vehicles, agriculture or waste incineration, industry, and building heating systems. The evaluation of air quality must be based on the Air Pollutant Index (API) of 6 main criteria pollutants whereby the major pollutant in Malaysia would be fine particulate matter ($PM_{2.5}$) [7].

The most recent global pandemic, coronavirus disease (COVID-19) has significantly shifted the level of air pollution globally. COVID-19 is a recently discovered infectious disease that is currently the main focused struggle of all humanity now. COVID-19 mainly affects the human respiratory system that is caused by novel Cov, severe acute respiratory syndrome coronavirus 2. This virus can readily spread by droplets of saliva or a discharge from another person's nose transmitted through coughing or sneezing. To avoid this, specific precautions must be taken while going out into the public and even when undergoing quarantine [8,9]. This outbreak started in December 2019 in Wuhan, Hubei Province, People's Republic of China. Because it is rapidly spreading around the globe, the World Health Organization (WHO) has declared a Public Health Emergency of International Concern (PHEIC). COVID-19 case was initially found in Malaysia on January 25, 2020, and have subsequently increased. Several measures have been taken, with one of the most important measures being the implementation of a Movement Control Order (MCO) to stop the spread. Many human everyday activities are dramatically reduced or must have come to a halt during MCO, leading to some positive effects, particularly on atmospheric air quality. The implementation of lockdown around the globe has helped effectively reduce severe air pollution levels that can be seen in several of the world's biggest cities, according to many studies conducted with the assistance of satellite technology [10]. Moreover, recent studies over Southeast Asia including Malaysia reported significant reductions of PM_{10}, $PM_{2.5}$, NO_2, SO_2, and CO during MCO based on aerosol optical depth

p-ISSN 1675-7939; e-ISSN 2289-934

(AOD) observations from Himawari-8 satellite, column density from Aura-OMI and ground-level continuous air pollutant measurements. About 63% reduction for $PM_{2.5}$ and CO were recorded across different Malaysian Department of Environment stations and other stations display a significant reduction of NO_2 concentration while MCO is in operation [11].

MCO shows drastic positive changes in urban areas throughout Malaysia, particularly in "red zones" areas. MCO not only broke the COVID-19 chain but also indirectly reduced environmental pollution, including air pollution, due to the reduction of toxic substances released from human activities. Experts and researchers must collaborate to keep these improvements prevail in the long run, which might improve people's lives and the environment [12]. All in all, this study evaluated the recent condition of air quality at Seberang Jaya, Penang, Malaysia during MCO from 18th of March to 31st of May using data recorded continuously by the Department of Environment (DOE), Malaysia which aimed to prove potential meteorological influences.

2. METHODOLOGY

2.1 Study Area

Seberang Jaya, Penang, Malaysia was chosen as the study location. Historically, the Penang Development Corporation (PDC) developed the southern bank of the Perai River, which was the east of Perai, in the 1970s to develop residential areas that are suitable for growing industries in Perai as well as to eliminate social and economic inequalities in urban and rural parts of Seberang Jaya. Years later, Seberang Jaya has developed into a thriving district with a variety of businesses and retails [13] as well as becoming a suburb with a significant volume of traffic. Thus, air pollution becomes a concern among the residents here. According to Figure 1, the nearest industrial areas to Seberang Jaya are the Mak Mandin Industrial Area and Perai Industrial Area, both of which are 2.63 km and 3.70 km away. Furthermore, the residential and commercial sectors of Seberang Jaya are densely crowded.

2.2 Department of Environment Malaysia (DOE) Data

This study required the official Department of Environment Malaysia (DOE) data used during the investigation. The air pollution data required included sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), particulate matter (PM_{10} and $PM_{2.5}$) wind direction (wd), and wind speed (ws). All units were in the International System of Units (SI units) and air pollutants data from all existing stations in the chosen area were used. These data were obtained from the start of MCO, which was from the 18th of March to the 31st of May hourly.

2.3 OpenAir

The quality of the air was monitored and assessed using OpenAir, a set of open-source tools for analysing air pollution data. OpenAir is a software tool for analysing air pollution data that is developed in the statistical programming language "R." This software was created to enable effective analysis using a range of instructions in the form of code included in the package. OpenAir has several advantages, including providing a free, open-source set of tools that anyone can use, a wide range of techniques and the development of new ones, statistical/data analysis software that uses an ideal programming language, quick responses and the ability to carry out advanced analysis in a timely manner, and allowing the air quality community to contribute to the software's further development. Furthermore, this software has developed

p-ISSN 1675-7939; e-ISSN 2289-934

seven unique characteristics that may be utilised in a variety of ways, and it continues to evolve as more developer input is received [14].

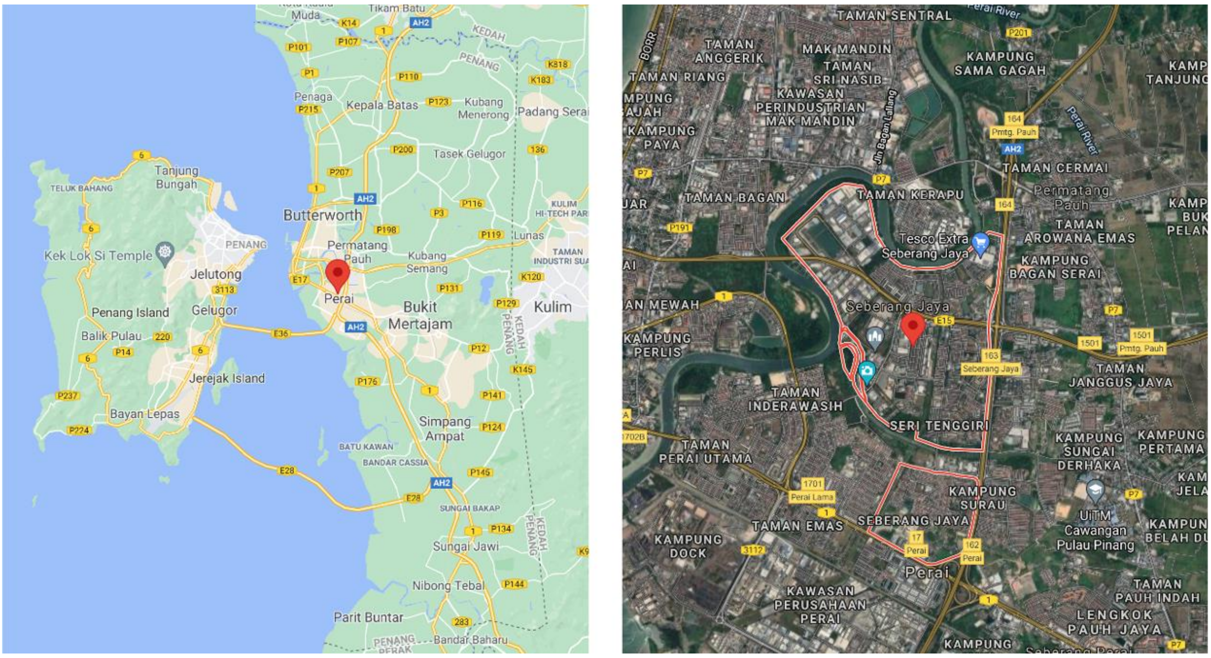


Figure 1: Map of Seberang Jaya, Penang, Malaysia

2.4 Statistical Analysis

The wind rose plot, pollution rose plot, calendar plot, and bivariate polar plot were some of the expected forms of air quality information and figures generated from the OpenAir software application. The statistics provided information about the average air quality for the period specified.

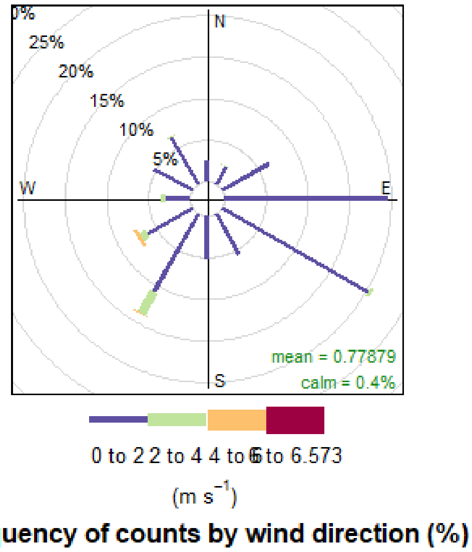
3. RESULTS AND DISCUSSION

Figure 2 shows a data representation that aids understanding of the condition of the wind direction, wind speed, and count frequency (%). This statistic is crucial since it is used to assess the weather and climate, whereas wind direction impacts air quality [15]. Wind rose depicts the basic wind direction and speed created by the wind, with colour coding supplied just beneath the wind rose figure estimates the ranges of speed it travels in different regions of the area. The frequency, or the number of times the wind blew in that direction, is indicated by the length of each "spoke" [16]. The wind movement is characterised as being greater than typical values on a broad scale. The wind rose displays that during this sampling period, the highest frequency of wind blowing comes from around the east to south direction 20% of the time with the maximum wind speed reached of about 2 to 4 ms^{-1}. The fastest wind speed reached about 4 to 6 ms^{-1} in the direction from west to south alongside 10-15% frequency at the time. The lowest frequency of the wind is located around the north to the west area as the highest frequency reached approximately around 5-10% with a maximum wind speed reached of about 2 to 4 ms^{-1}. The mean value of the wind speed is 0.77879 ms^{-1} with an overall calmness of about 0.4%. According to the findings, there are linear connections with another study that reveals that wind speeds show direct changes in speed that are significantly quicker than the average wind speed prior to MCO. The wind speed during MCO, which begins in March, is slightly greater than in other months, although calm breezes in other months are all quite low. During MCO, the wind

p-ISSN 1675-7939; e-ISSN 2289-934

begins to blow more strongly on the West, South, and East sides of the area, with higher wind speeds than in previous months [17].

Figure 2: Wind rose plot of Seberang Jaya Area



Pollution rose can help conjure up a picture of a wind pattern for six different types of pollutants. Pollution surged in another type of wind; this time focused on pollutant concentrations as a function of wind direction. It may also be used to estimate the level or snapping point for a certain pollutant using a data set that has been provided to it. Figure 3 shows some of the fascinating outcomes that are influenced by day-to-day timing and conditions [18]. According to Figure 3, the general form of all six pollution roses of various types of pollutants is quite similar. As indicated in Figure 3, the highest source of air pollution from all six pollutants comes from roughly the east to south of the entire region. It was identified that PM_{10} pollutant was the major source of air pollution around the area of Seberang Jaya, Penang, Malaysia with a maximum concentration of 83.016 ppm. Secondarily, $PM_{2.5}$ was recognised to hold a maximum concentration of 82.999 ppm followed by CO with a 2 ppm concentration. Ultimately, SO_2, NO_2, and O_3 were at the lowest concentration in the atmosphere that curbs with only around 0 ppm to 1 ppm of its concentration. The mean value listed revealed to be 0.0077632 ppm (NO_2), 21.674 ppm (PM_{10}), 0.018825 ppm (O_3), 0.58235 ppm (CO), 15.267 ppm ($PM_{2.5}$), and 0.00104 ppm (SO_2) during MCO. For all six contaminants present, the proportion of calmness was 0.4 per cent. According to research, the overall percentage decline in air pollution during MCO was roughly 20-60% in most areas throughout Malaysia [19]. From the pollution rose results acquired, it can be concluded that the level of pollutants had dropped drastically as shown by a lower average value of pollutants compared with an average value of pollutants months before the COVID-19 pandemic.

Figures 2 and Figure 3 show that the most common pollution emissions originated from the east to the south side of Seberang Jaya, accompanied by low wind speeds, primarily about 0-2 ms^{-1}. As a result, the residential and industrial regions in Seberang Jaya are the areas with the highest frequency of pollutants. This is because MCO has shifted the main source of air pollution from the industrial area to residential area as a result of Malaysian government

p-ISSN 1675-7939; e-ISSN 2289-934

policies and regulations that require some industrial enterprises to cease or reduce their operations [2]. In Figure 3, Seberang Jaya recorded PM_{10} and $PM_{2.5}$ as the major pollutants in addition to the other four main pollutants namely NO_2, SO_2, CO, and O_3 where the latter was significantly low and almost negligible as compared with PM_{10} and $PM_{2.5}$. There is no direct knowledge of different sources of certain activities that contributed to the release of PM_{10} and $PM_{2.5}$.

Figure 3: Pollution rose for (a) NO_2, (b) SO_2, (c) O_3, (d) CO, (e) $PM_{2.5}$ and (f) PM_{10}

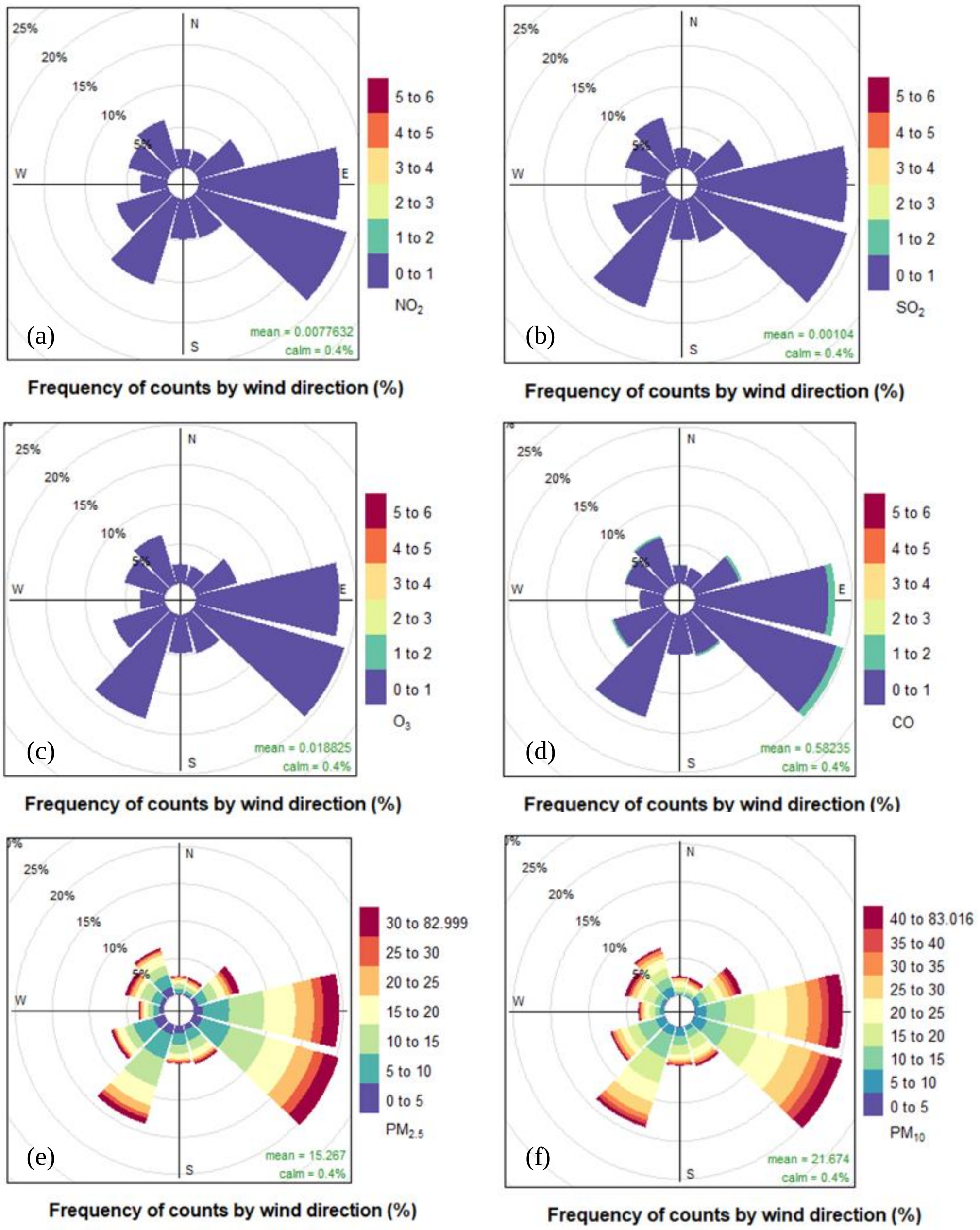


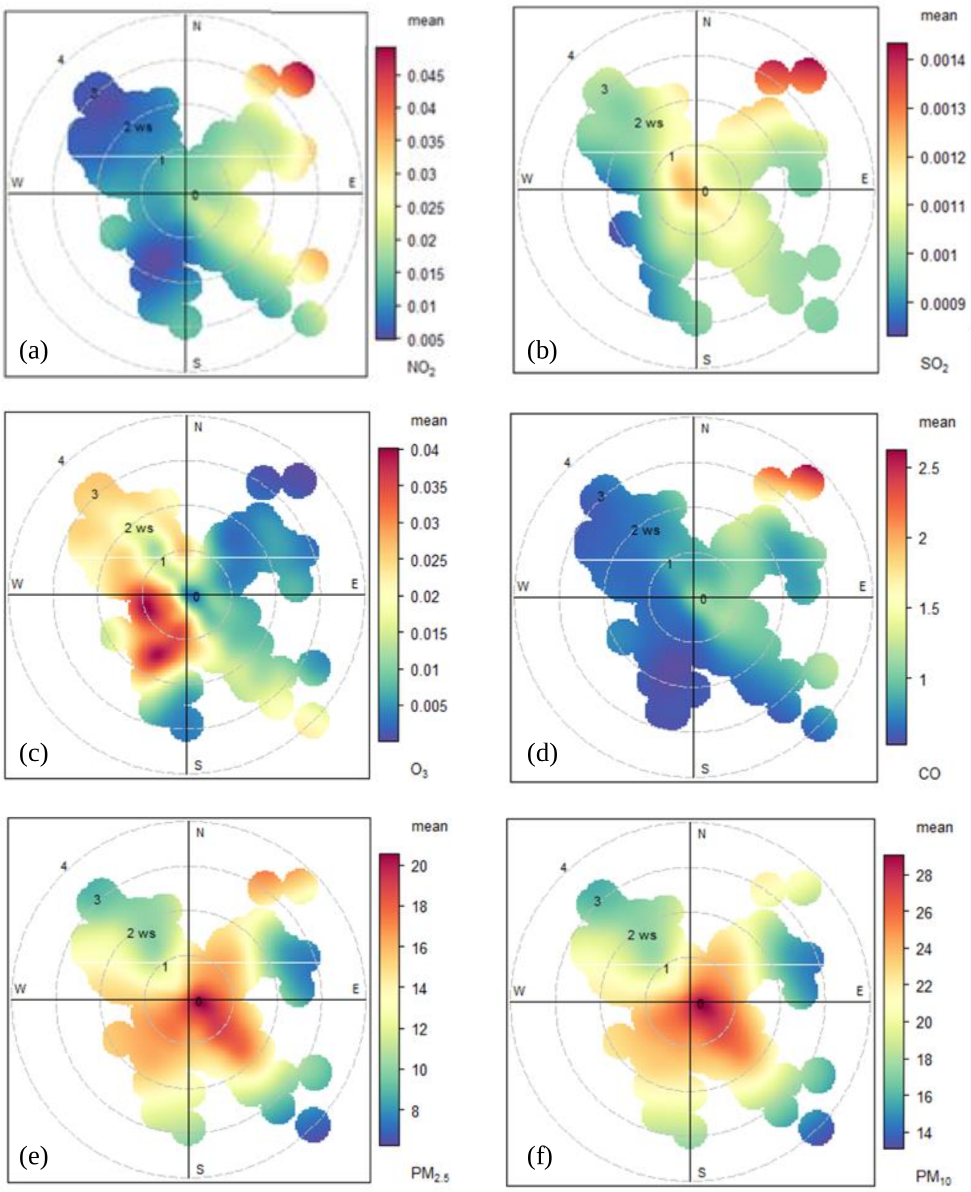
Figure 4 statistics were used to investigate contaminants using correlation and regression techniques. Polar plots are created by calculating the mean concentration for wind speed as well as wind direction bins, demonstrating multiple sources from all six pollutants displayed in Seberang Jaya, Penang, Malaysia from the 18th of March 2020 to the 31st of May 2020 [20]. Colours ranging from red (highest) to blue (lowest) suggest that increased concentration in

p-ISSN 1675-7939; e-ISSN 2289-934

ESTEEM Academic Journal
Vol. 18, March 2022, 150-159

particular regions of Seberang Jaya is accompanied by low wind speeds. On the right side of the polar plot, Figure 4 shows the region of the highest to lowest production of each type of pollution based on its mean value. The highest source of pollutants is in the area from west to south with mean value 0.04 ppm (O_3), north to east with mean value 0.0014 ppm (SO_2), north to east with mean value 2.5 ppm (CO), the middle region with mean value 20 ppm ($PM_{2.5}$), north to south with mean value 0.045 ppm (NO_2), and middle region with a mean value 28 ppm (PM_{10}). The correlation polar plot in Figure 4 demonstrates that $PM_{2.5}$ and PM_{10} occupy the biggest area of its highest source of pollutants highlighted accompanied by O_2, followed by SO_2, NO_2 as well as CO. From the overall perspective, $PM_{10,}$ as well as $PM_{2.5,}$ is an expected major pollutant in the Seberang Jaya region as Malaysia is known to contain PM_{10} and $PM_{2.5}$ the most in comparison with other types of pollutants [2].

Figure 4: Bivariate polar plot for (a) NO_2, (b) SO_2, (c) O_3, (d) CO, (e) $PM_{2.5}$ and (f) PM_{10}



p-ISSN 1675-7939; e-ISSN 2289-934

Statistic to show pollutants concentration for each day from 18th of March to 31st of May is shown in Figure 5 calendar plot of PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and O_3. The information gathered aids in the construction of some sort of understanding of the meteorological conditions on each day, as well as highlighting specific values more clearly. The daily mean concentration value for each pollutant is located on the right side, alongside the colour coding that represents different values of concentration, each containing different shades of the colour [18]. From the overall perspective, the highest concentration reached is on the 21st of March 2020 with mean value 45 ppm (PM_{10}), on the 22nd of May 2020 with mean value 0.9 ppm (CO), 27th of April 4th, 12th, 14th of May with mean value 0.0014 ppm (SO_2), 20th of May 2020 with mean value 0.016 ppm (NO_2), 19th of May 2020 with mean value 0.03 ppm (O_3), and 21st of March 2020 with mean value 35 ppm ($PM_{2.5}$). Pollutant SO_2 is considered to release its maximum concentration value the most often as it contains the highest amount of darker shade in its calendar plot followed by the release of O_3, CO, NO_2, $PM_{2.5}$ as well as PM_{10}. The average daily mean calendar plot on all pollutants is lowered from before MCO to after MCO, according to the findings in Figure 5. Since the MCO, daily vehicle travel has been significantly decreased, with weekday numbers of approximately 20-30% assessed in early March [21].

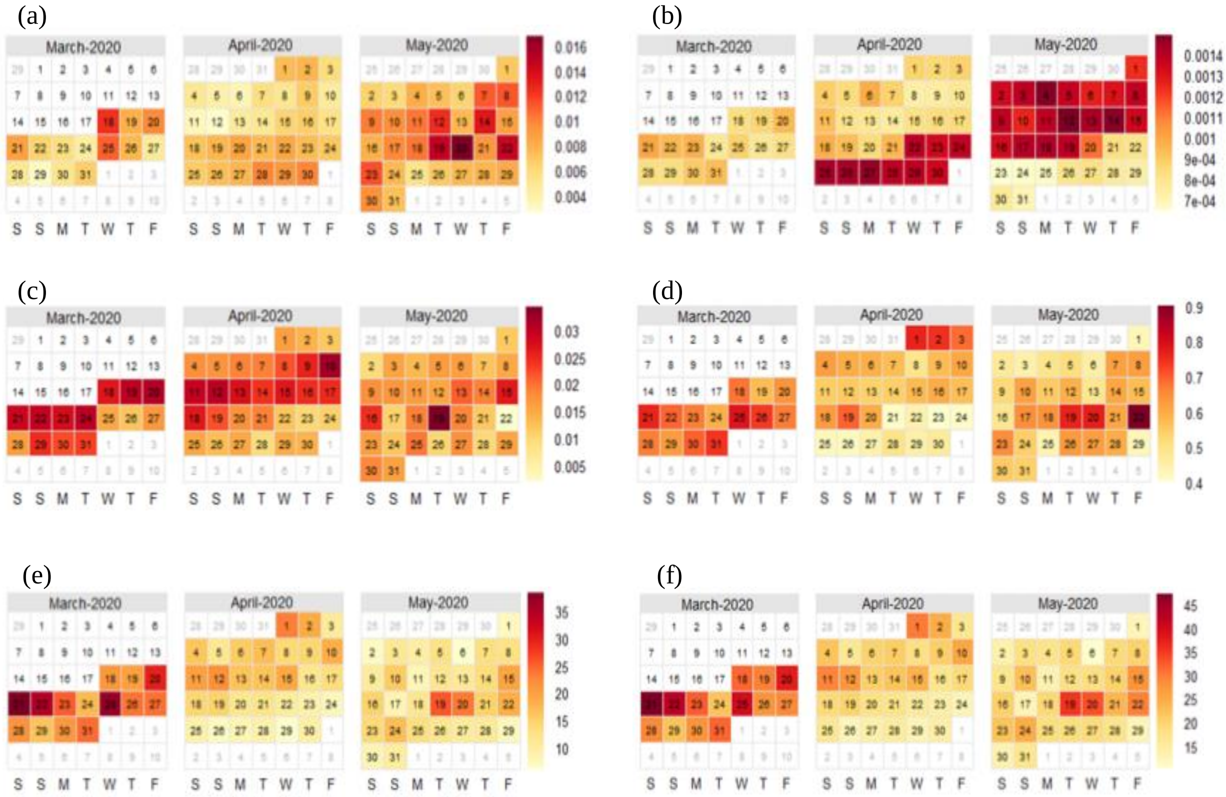


Figure 5: Calendar plot of (a) NO_2, (b) SO_2, (c) O_3, (d) CO, (e) $PM_{2.5}$ and (f) PM_{10}

Figure 4 indicates the location of multiple sources of PM_{10} and $PM_{2.5}$ that focused on the middle region of Seberang Jaya. Knowingly, the middle parts of Seberang Jaya are predominantly a commercial district where high traffics take place. Long-distance transportation with high traffic density might have been the primary source of PM_{10} and $PM_{2.5}$ emissions from vehicles. Maximum contribution occurs only when the wind speed is low, and the maximum concentration occurs when local traffic pollutants affect the monitoring location [20]. A comprehensive view of Figure 4 demonstrates that the middle region and north to east region consist of high concentrations of pollutants. This gives an indication of which Seberang Jaya

p-ISSN 1675-7939; e-ISSN 2289-934

commercial region generates the most pollution when compared to Seberang Jaya's residential and industrial regions. In comparison to the other pollutants, SO_2 releases the largest concentration most regularly and is notably around the end of April and early May, according to the daily concentrations of all six pollutants shown in Figure 5. The overall calendar plot in Figure 5 shows that weekend days tend to emit more pollutants than weekdays.

4.0 CONCLUSION

Seberang Jaya is mostly a residential district with coverage in the north, south, and east of the total region, with a little coverage of industrial areas on the west side and commercial areas in the centre. Due to low wind speed, the number of counts for pollutants is the highest frequency in the south to the east region of Seberang Jaya. According to the data obtained, six different types of pollutants recorded, show that in the residential area located on the south-east side of Seberang Jaya, PM_{10} and $PM_{2.5}$ are the major pollutants while the other four are NO_2, SO_2, CO, and O_3 are significantly low and almost negligible relative to the former, as shown in Figure 2 and 3. However, Figure 4 shows that the concentration of PM_{10} and $PM_{2.5}$ are the highest in the commercial area located in the middle region of Seberang Jaya. According to Figure 5 overall, pollutants are emitted more on the weekends rather than weekdays with SO_2 being the most consistent around the end of April and early May.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Universiti Teknologi MARA Cawangan Pulau Pinang for the financial support and facilities provided to carry out this research work, especially the technical and academic staff from the School of Chemical Engineering.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

REFERENCES

[1] N.A. Aziz, J. Othman, H. Lugova, A. Suleiman, “Malaysia’s approach in handling COVID-19 onslaught: Report on the Movement Control Order (MCO) and targeted screening to reduce community infection rate and impact on public health and economy” *Journal of Infection and Public Health*, vol. 13, pp.1823–1829, 2020.

[2] S. Abdullah, M. Ismail, A.N. Ahmed, A.M. Abdullah, “Forecasting Particulate Matter Concentration Using Linear and Non-Linear Approaches for Air Quality Decision Support” *Atmosphere*, vol. 10, p.667, 2019.

[3] L. Sanlad, Air Pollution Awareness in the Philippines. Its Practical Measure for Prevention, 2020.

[4] National Jewish, Our Lungs, Our Air, Our Health, (n.d.). https://www.nationaljewish.org/NJH/media/pdf/pdf-CECH_Our-Lungs_Our Ai_Our_Health.pdf (accessed December 30, 2021).

[5] M. Balali-Mood, A. Ghorani-Azam, B. Riahi-Zanjani, “Effects of air pollution on human health and practical measures for prevention in Iran” *J Res Med Sci.* vol. 2, p. 65, 2016.

[6] R. P. Zawar, S. R. Spronken, Encyclopedia of world climatology. Choice Reviews Online, p. 43, 2006.

[7] J. Barnes, “Natural and man-made selection for air pollution resistance” *Journal of Experimental Botany*. p. 50, 1999.

p-ISSN 1675-7939; e-ISSN 2289-934

[8] M.T. Latif, D. Dominick, N.S.S.L. Hawari, A.A.A. Mohtar, M. Othman, "The concentration of major air pollutants during the movement control order due to the COVID-19 pandemic in the Klang Valley, Malaysia" *Sustainable Cities and Society*. p. 66, 2021.
[9] M. Othman, M.T. Latif, "Air pollution impacts from COVID-19 pandemic control strategies in Malaysia" *Journal of Cleaner Production.* p. 291, 2021.
[10] S. Abdullah, M. Ismail, A.N. Ahmed, A.M. Abdullah, "Forecasting Particulate Matter Concentration Using Linear and Non-Linear Approaches for Air Quality Decision Support," *Atmosphere.* p. 10, 2019.
[11] K.D. Kanniah, N.A.F. Kamarul Zaman, D.G. Kaskaoutis, M.T. Latif, "COVID-19's impact on the atmospheric environment in the Southeast Asia region," *Science of The Total Environment.* p. 736, 2020.
[12] Y. Yusup, N.K. Ramli, J.S. Kayode, C.S. Yin, S. Hisham, H. Mohamad Isa, M.I. Ahmad, "Atmospheric Carbon Dioxide and Electricity Production Due to Lockdown," *Sustainability*, p. 12, 2020.
[13] Wikipedia, Seberang Jaya, Wikipedia. (2021). https://en.wikipedia.org/wiki/Seberang_Jaya (accessed December 30, 2021).
[14] V. Leong, Introduction to OPENAIR - Open-source Tools for Air, 2021.
[15] Chakrabarti, Wind Rose: The Beginners Guide - Perfect Pollucon Services, Perfect Pollucon Sevices Environmental Consultant. (n.d.). https://www.ppsthane.com/blog/wind-rose-beginners-guide (accessed December 30, 2021).
[16] How To: Interpret A Wind Rose Diagram, Wind Rose Diagrams Using Excel. (n.d.). https://windroseexcel.com/guides/how-to-interpret-a-wind-rose-diagram/ (accessed December 30, 2021).
[17] M. Rendana, "Impact of the wind conditions on COVID-19 pandemic: A new insight for direction of the spread of the virus," *Urban Climate.* p. 34, 2020.
[18] D. Carslaw, The openair manual open-source, tools for analysing air pollution data, 2019.
[19] M.S. Mohd Nadzir, M.C.G. Ooi, K.M. Alhasa, M.A.A. Bakar, A.A.A. Mohtar, M.F.F.M. Nor, M.T. Latif, H.H.A. Hamid, S.H.M. Ali, N.M. Ariff, "The Impact of Movement Control Order (MCO) during Pandemic COVID-19 on Local Air Quality in an Urban Area of Klang Valley, Malaysia," *Aerosol Air Qual. Res.* p. 20, 2020.
[20] S.K. Grange, A.C. Lewis, D.C. Carslaw, "Source apportionment advances using polar plots of bivariate correlation and regression statistics," *Atmospheric Environment*, vol. 145, pp. 128–134, 2016.
[21] D. Carslaw, A. Lewin, "2020 COVID-19 lockdown period - Air Quality Analysis," *Ricardo Energy & Environment*, 2020.

p-ISSN 1675-7939; e-ISSN 2289-934