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Analysis The Effect of Large-Scale Social Restrictions on Air Quality in DKI Jakarta

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Abstract

The Covid-19 pandemic has caused all countries to implement strategies to suppress its spread, one of which is Indonesia, especially DKI Jakarta, which has implemented Large-Scale Social Restrictions (PSBB) since April 10 2020. Apart from being able to suppress the spread of the Covid-19 virus, PSBB is thought to have an impact on the environment, especially air quality in DKI Jakarta. According to research from the BMKG, Jakarta's air quality has improved over the last 5 years with the implementation of the PSBB. Besides analyzing the effect of the PSBB on air quality in DKI Jakarta, this research also aims to help governments in every region of Indonesia that do not have air quality monitoring stations. The method used in this study is to utilize Imagery from Sentinel-5P to measure concentrations of NO2, CO and SO2 gases validated using field data and utilize the NOAA Satellite acquired with Ventusky to analyze the effect of wind on the distribution of air pollution due to the PSBB. The results showed that the ratio of the average concentrations of NO2, CO and SO2 gases in DKI Jakarta decreased respectively to 27.70%; 10.20%; 42.06%. This shows an increase in air quality in DKI Jakarta due to the implementation of the PSBB. Comparison of the average concentrations of NO2, CO and SO2 gases in DKI Jakarta during the PSBB and after the PSBB increased slightly respectively to 11.92%; 1.89%; 35.84%. This shows that there is a decrease in air quality in DKI Jakarta which was caused after the implementation of the PSBB. Wind also affects the concentration of NO2, CO and SO2 gases. This is evidenced by the results of the correlation where the gas concentration is low when the wind speed is high, and vice versa. It was concluded that during the COVID-19 pandemic the concentrations of NO2, CO and SO2 in DKI Jakarta decreased and slightly increased after the PSBB, and wind could affect the distribution of these gases.

Keywords: DKI Jakarta, PSBB, Air Quality, Sentinel-5P, Wind, Ventusky

1. Introduction

The World Health Organization (WHO) first declared Covid-19 a pandemic in February 2020, and it has spread worldwide to approximately 124 countries negara (Emanuel, dkk, 2020). Lockdown is a strategy several countries use by implementing activity restrictions and strictly keeping distance between citizens to reduce the spread of the Covid-19 virus 19 (Yunus, 2020). According to Government Regulation Number 21 of 2020, lockdown is termed Large-Scale Social Restrictions (PSBB). Apart from being able to suppress the spread of the Covid-19 virb us, this lockdown or PSBB is expected to have an impact on the environment, especially air quality in DKI Jakarta. Restrictions on human activities, such as reducing passing vehicles, will certainly impact the spread of air pollution.

Several studies have proven air pollution directly affects human health, especially respiratory disorders (Dominici, 2006). According to WHO, air pollution is a serious environmental threat that kills

around seven million people yearly (WHO, 2020). Air pollution is the result of incomplete combustion in vehicles (CO and NO_2) and waste gases produced by industrial activities (SO_2) harm the human respiratory system (EPA, 2016). Air quality monitoring carried out by DLH DKI Jakarta in 2018 and 2019 before the PSBB, air quality in the DKI Jakarta area was very bad. However, according to BMKG (2020), Jakarta's air quality has improved over the last 5 years with the implementation of the PSBB. The research was conducted using air monitoring stations scattered in Jakarta. However, air monitoring stations are not evenly distributed in Indonesia. Jakarta and Surabaya are areas that have air monitoring stations. Limitations in air quality monitoring terms do not represent the coverage of air quality in Indonesia.

This study's purpose was to analyze air quality changes in Jakarta before, during and after the PSBB was implemented at every level using Sentinel-5P TROPOMI. This study collected data on the distribution of CO, NO2 and SO2 gases before, during and after the PSBB where the data collection during the PSBB will be adjusted according to the predetermined PSBB levels as well as research on wind direction and speed to determine the effect of wind on the distribution of CO, NO2 gases. and SO2. This is an update on previous research. Sentinel-5P data is processed using cloud-based computing on the Google Earth Engine in this study. Pollution gas information is extracted by utilizing JavaScript syntax in the Google Earth Engine Code Editor. Wind direction and speed data are also needed because they are one of the factors in the distribution of air pollution (Rahmawati, 1999).

This research hopes to use it as a reference in visual form so that it can be used for air pollution prevention in Jakarta and other areas.

2. Material and Methods

2.1 Study Area

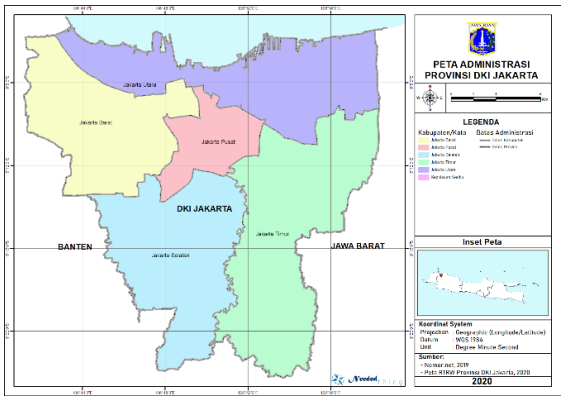


Figure 1. Study Area

The research area is located in DKI Jakarta with coordinates of 5° 19' 12" - 6° 23' 54" South Latitude and 106° 22' 42" - 106° 58' 18" East Longitude. DKI Jakarta is the national capital and the largest city in Indonesia, which has an area of 664.01 km². The population of DKI Jakarta Province is 9.041 million people, with a population density of 13,667.01 people per square kilometer. Jakarta has a tropical climate with an annual average temperature of 27°C and 80-90% humidity. The average rainfall is 2000 mm, with the highest rainfall in January and the lowest in September. Jakarta is the only city in Indonesia with provincial status. DKI Jakarta has 5 Air Quality Monitoring Stations.

2.2 Data

This study used several datasets for processing air pollution gases, wind data, and result validation. The data used in this study are shown in Table 1.

Table 1. Data Requirement

Data	Source
Sentinel 5P imagery January 2020 – March 2021	Copernicus
Wind Data	Ventusky and BMKG
DKI Jakarta Air Quality Data 2020 and 2021	DLH DKI Jakarta
Field Data	Literature Study and Questionnaires
DKI Jakarta Administrative Map	InaGeoportal

2.3 Flow Chart

The flow chart in this study can be seen in Figure 2.

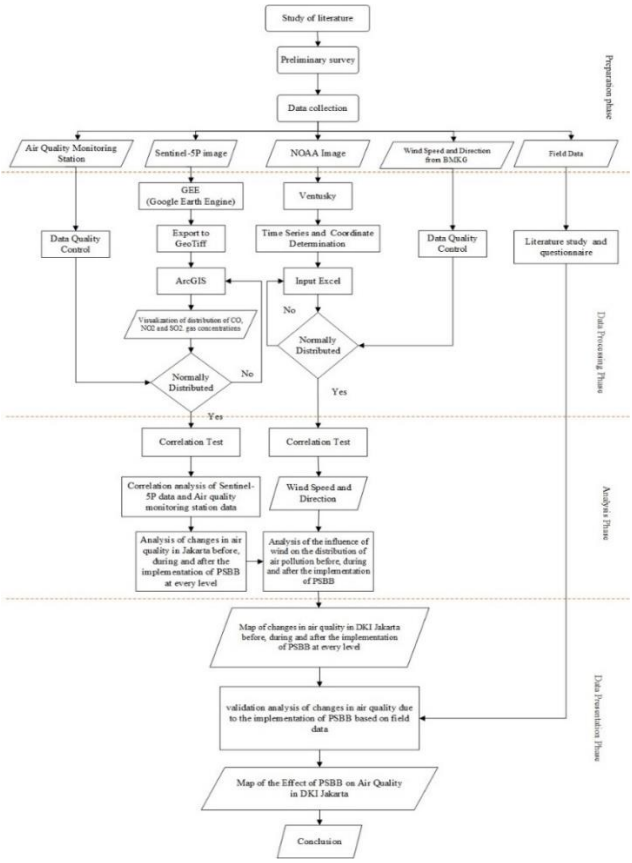


Figure 2. Study Flowchart

2.4 Large-Scale Social Restrictions (PSBB)

The Special Capital Region of Jakarta became the first province to implement Large-Scale Social Restrictions (PSBB), the Provincial Government of DKI Jakarta proposed on April 6, 2020 and implemented four days later. This PSBB is valid for two weeks until April 23, according to conditions. During the implementation of this policy, all public transportation such as KRL Commuter Line, MRT Jakarta and Transjakarta are limited to 50%. Online motorcycle taxis are not allowed to carry passengers, while it is done from home in the education sector. On the other hand, Jakarta's sky looks unusually bright. Based on the statement by the Head of the BMKG Climate Change Information Center Dodo Gunawan, regarding the blue sky in Jakarta it is the impact of Large-Scale Social Restrictions, this does have an effect **(Permana, 2020)**.

2.5 Air Pollution

Natural sources or human activities can cause air pollution. The narrower the green land or trees in an area can also worsen the air quality in that place. The more motorized vehicles that can emit carbon monoxide (CO) and nitrogen dioxide (NO2) gases and industrial equipment that emits waste gases such as sulfur dioxide (SO2) which pollute the environment, the more severe the air pollution will be. These elements can be said to be pollution or types of air pollutant **(Disperkimta, 2019)**.

2.6 Wind

The wind is one of the causes of weather dynamics that affect climate **(Habibie, 2011)**. The wind is an air mass that moves from low to high-pressure air, and is one of the weather elements that can affect the environment directly or indirectly. Broadly the wind will affect other weather elements such as temperature, air humidity and the distribution of pollution. Wind can help in dispersing pollutants. When pollutants linger in an area, wind can spread them out of the area and reduce the more intense concentration of pollutants in one area **(IQAir, 2022)**.

2.7 Kriging Interpolation

The Kriging method is a stochastic estimate similar to Inverse Distance Weighted (IDW) which uses a linear combination of weights to estimate values between data samples **(Yao, 2019)**. This method was invented by D.L. Krige to estimate the value of the mined materials. This method assumes that the distance and orientation between data samples shows an important spatial correlation in the interpolation results. Kriging provides a measure of error and confidence. This method uses a semivariogram representing the spatial differences and values between all data samples. The semivariogram also shows the weights used in the interpolation. The stages in using this method are statistical analysis of data samples, variogram modelling, making interpolation results and analyzing variance values. This method is very appropriate to use when we know the spatial correlation of distance and orientation of the data. Therefore, the kriging interpolation method is very suitable when used for irregular data **(Tania dkk, 2020)**.

2.8 Linier Regression

The regression test studies the relationship between one variable, namely the variable explained by one or more variables, namely the explanatory variable **(Yuliara, 2016)**. Simple multiple regression means that there is only one independent variable and multiple linear regression with more than one independent variable. It is said to be multiple because several independent variables affect the dependent variable. Regression test is widely used in calculating the final results for writing scientific papers or research. The results of the regression test are in the form of a regression equation. This regression equation is a predictive function of variables that affect other variables. The equation formula for calculating linear regression is as follows:

$$Y = a + bX \quad (1)$$

Where:

Y = Variabel Dependent
X = Variabel Independent
a = Slope
b = Intercept

3. Result and Discussion

3.1 Results and Analysis of DKI Jakarta Nitrogen Dioxide (NO_2) Gas

1. NO_2 Gas Analysis Before PSBB

Based on the results of air quality data processing in Figure 3, it can be seen from the visualization and concentration values of NO_2 gas distribution in the DKI Jakarta area before the PSBB was almost the same. January and February 2020 had the highest concentrations of 0.000215 mol/m^2 and 0.000216 mol/m^2 respectively. Slightly different from March 2020, whose distribution almost covered DKI Jakarta but with a slightly lower concentration of 0.000211 mol/m^2. Increased activity and mobility were caused by panic buying by the people of DKI Jakarta to prepare for the Lockdown (Laksono, 2020). This resulted in the expansion of NO_2 gas in DKI Jakarta.

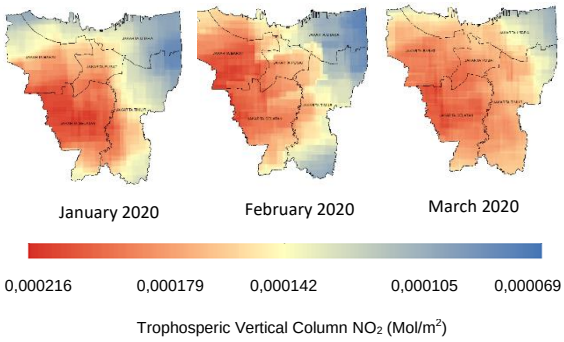


Figure 3. Visualization of NO_2 Gas Distribution Before PSBB

2. NO_2 Gas Analysis during PSBB

Based on the results of air quality data processing in Figure 4, it can be seen from the visualization and concentration values that there is spatial and temporal variability that follows the regulations for each stage of the PSBB on the

distribution of NO_2 gas concentrations in the DKI Jakarta area during the PSBB.

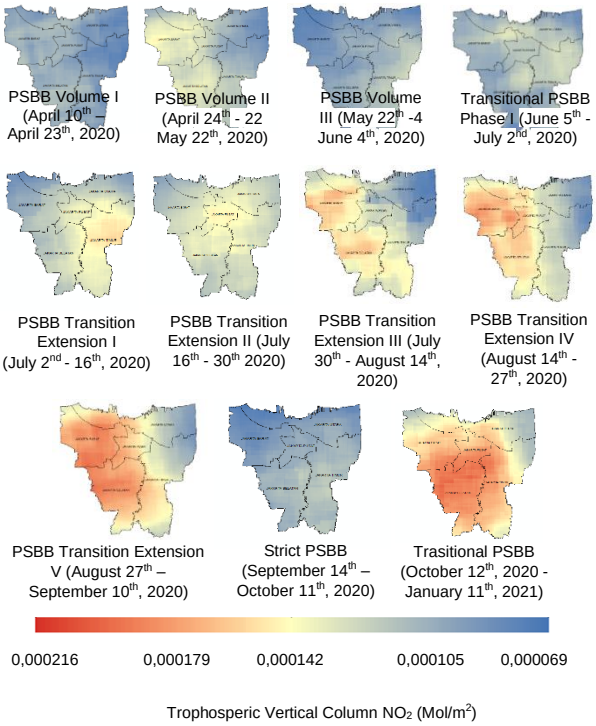


Figure 4. Visualization of NO_2 Gas Distribution During PSBB

Significant differences in visualization and concentration values can be seen, especially in March 2020 and PSBB Volume I. The highest concentration value was in PSBB Volume I, 0.000118 mol/m^2. The low concentration of NO_2 gas is caused by the DKI Jakarta Government Regulation regarding implementing Large-Scale Social Restrictions (PSBB) caused by the Covid-19 pandemic. The government stopped office and school activities, online motorcycle taxis were limited, private and public transportation capacity was limited. Residents were not allowed to gather and had to keep their distance. This greatly affects the distribution of NO_2 polluting Gas.

During the Transitional PSBB, you can visually see that the distribution of NO_2 gas is getting thicker. The value of NO_2 gas concentration also increased. The highest concentration value in the PSBB Transition was in the PSBB Transition Extension stage V, 0.000193 mol/m^2. This is because the DKI Jakarta Government relaxed PSBB regulations. Places of worship, offices, tourism spots, sports facilities, shopping centers and public transportation have resumed operations with a maximum capacity of 50%. Online motorbike taxis can carry passengers with the provisions of providing insulation and wearing masks.

Experiencing an increase in the positive number of Covid-19 in DKI Jakarta after the Transitional PSBB, the Government of DKI Jakarta re-imposed stricter PSBB regulations, namely by stopping office activities, tourism places and places of worship were closed again, online motorcycle taxis were limited, private and public transportation capacity was limited until residents may not gather and must maintain their distance (Putri, 2020). Therefore, there is a decrease in concentration values at this stage. The highest value of NO_2 gas concentration at this stage was 0.000121 mol/m^2, a decrease of around 43.98% from the previous stage. After successfully suppressing the positive number of Covid-19, the DKI Jakarta government re-imposed the Transitional PSBB with the same regulations as the previous Transitional PSBB. This resulted in a further increase in the distribution of NO_2 gas. The highest value of NO_2 gas concentration at this stage was 0.000198 mol/m^2.

3. NO_2 Gas Analysis After PSBB

Based on the results of air quality data processing in Figure 5, it can be seen from the visualization and concentration values that there is spatial and temporal variability in the distribution of NO2 gas concentrations in the DKI Jakarta area after the PSBB.

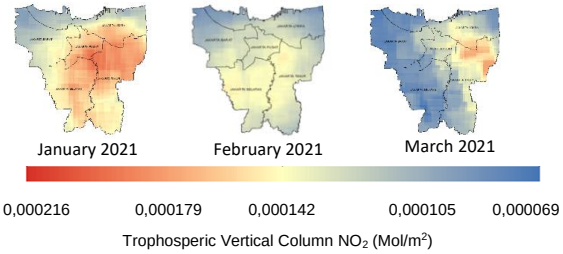


Figure 5. Visualization of NO_2 Gas Distribution After PSBB

January 2021 is the final stage of the PSBB and continues with the Implementation of Restricting Community Activities (PPKM) which is still in the experimental stage and the people of DKI Jakarta are still ignoring the regulations. Instead of suppressing the positive growth of Covid-19, it has increased at this stage. The highest value of NO_2 gas concentration is 0.000198 mol/m^2, the same as in the previous step. In February 2020 the highest concentration value was 0.000151 mol/m^2. This month's value of NO_2 gas concentration decreased by around 23.74% and NO_2 gas levels were thinner than the previous month. This is because in February 2021 the Government of Jakarta conducted Micro PPKM by implementing regulations down to the RT/RW. March 2021 has the highest gas concentration value of 0.000178 mol/m^2. The value of NO2 gas concentration this month increased by around 17.88%. However, only a few areas have NO_2 gas. This is due to the extension of Micro PPKM to RT and RW. The DKI Jakarta government also stated that this month it experienced a decrease in positive Covid-19.

3.2 Results and Analysis of DKI Jakarta Carbon Monoxide (CO) Gas

1. CO Gas Analysis Before PSBB

Based on the results of air quality data processing in Figure 6, it can be seen from the visualization and concentration values of the distribution of CO gas in the DKI Jakarta area before the PSBB was almost the same. January and February 2020 had the highest concentrations of 0.0343701 mol/m^2 and 0.0386819 mol/m^2, respectively. Slightly different from March 2020, where the concentration value was higher than in the previous two months, namely 0.0400683 mol/m^2. The increase in activity and mobility was due to panic buying by the people of DKI Jakarta to prepare for the Lockdown. This resulted in the expansion of CO gas in DKI Jakarta.

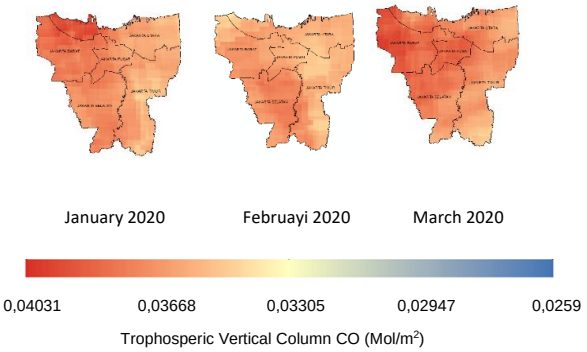
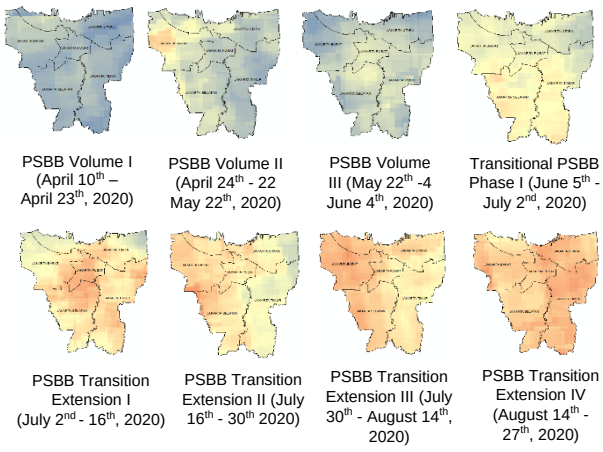


Figure 6. Visualization of CO Gas Distribution After PSBB

2. CO Gas Analysis Before PSBB

Based on the results of air quality data processing in Figure 6, it can be seen from the visualization and concentration values that there is spatial and temporal variability that follows the regulations for each stage of the PSBB on the distribution of CO gas concentrations in the DKI Jakarta area during the PSBB.



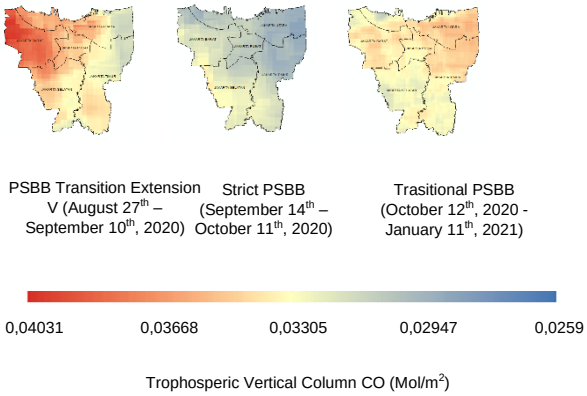


Figure 7. Visualization of CO Gas Distribution During PSBB

A significant difference can be seen in the visualization and concentration values, especially in March 2020 and PSBB Volume I. The highest CO gas concentration value was in PSBB Volume I, which was 0.0323039 mol/m^2. The low concentration of CO Gas is due to the DKI Jakarta Government Regulation regarding the implementation of Large-Scale Social Restrictions (PSBB) caused by the Covid-19 pandemic. The government stopped office and school activities, online motorcycle taxis were limited, private and public transportation capacity was limited. Residents were not allowed to gather and had to keep their distance. This greatly affects the distribution of CO pollution gas.

During the Transitional PSBB, you can see that CO gas distribution is getting thicker. The value of CO gas concentration also increased. The highest concentration value in the Transitional PSBB was in the Transitional PSBB Stage Extended V, 0.0403155 mol/m^2. This is because the DKI Jakarta Government relaxed PSBB regulations. Places of worship, offices, tourism spots, sports facilities, shopping centers and public transportation have resumed operations with a maximum capacity of 50%. Online motorbike taxis can carry passengers by providing insulation and wearing masks.

Experiencing a positive increase in Covid-19 in DKI Jakarta after the Transitional PSBB, the DKI Jakarta Government re-enacted the Strict PSBB regulations, namely by stopping office activities, tourism places and places of worship closed again, online motorcycle taxis were limited, private and public transportation capacity was limited, so that residents were not allowed to gather and must keep their distance (Putri, 2020). Therefore, there is a decrease in concentration values at this stage. The highest value of CO gas concentration at this stage was 0.0338888 mol/m^2, a decrease of around 15.94% from the previous stage. After successfully suppressing the positive number of Covid-19, the DKI Jakarta government re-imposed the Transitional PSBB with the same regulations as the previous Transitional PSBB. This resulted in a

further increase in the distribution of NO2 gas. The highest value of CO gas concentration at this stage was 0.0360099 mol/m^2.

3. CO Gas Analysis After PSBB

Based on the results of air quality data processing in Figure 8, it can be seen from the visualization and concentration values that there is spatial and temporal variability in the distribution of CO gas concentrations in the DKI Jakarta area after the PSBB.

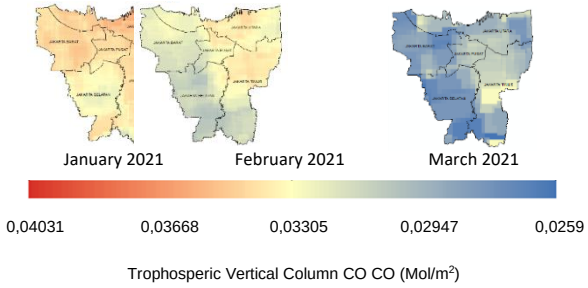


Figure 8. Visualization of CO Gas Distribution After PSBB

January 2021 is the final stage of the PSBB and continues with the Implementation of Restricting Community Activities (PPKM) which is still in the experimental stage and the people of DKI Jakarta are still ignoring the regulations. Instead of suppressing the positive growth of Covid-19, it has increased at this stage. The highest value of CO gas concentration is 0.0370494 mol/m^2. In February 2020 the highest concentration value was 0.0346161 mol/m^2. The value of CO gas concentration this month decreased by around 6.57% and CO gas levels were thinner than the previous month. This is because in February 2021 the Government of Jakarta conducted Micro PPKM by implementing regulations down to the RT/RW. March 2021 has the highest CO gas concentration value of 0.0338848 mol/m^2. The value of CO gas concentration this month decreased by around 2.11% and only a few areas contained CO gas. This is due to the extension of Micro PPKM to RT and RW. The DKI Jakarta government also stated that this month it experienced a decrease in positive Covid-19.

3.3 Results and Analysis of DKI Jakarta Sulfur Dioxide (SO_2) Gas

1. SO_2 Gas Analysis Before PSBB

Based on the results of air quality data processing in Figure 9, it can be seen from the visualization and concentration values that there is spatial and temporal variability in the distribution of SO_2 gas concentrations in the DKI Jakarta area before the PSBB. January and February 2020 had the highest concentrations of 0.000698286 mol/m^2 and 0.000698286 mol/m^2, respectively. In contrast to March 2020, whose distribution almost covered DKI Jakarta and the concentration was higher, namely 0.00126094 mol/m^2. The increase in activity and mobility was due to panic buying by the people of DKI Jakarta to prepare for the Lockdown. The halt resulted in the expansion of SO_2 gas in DKI Jakarta.

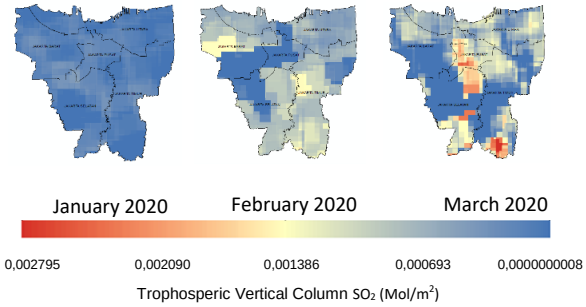


Figure 9. Visualization of SO_2 Gas Distribution After PSBB

2. SO_2 Gas Analysis During PSBB

Based on the results of air quality data processing in Figure 10, it can be seen from the visualization and concentration values that there is spatial and temporal variability that follows the regulations for each stage of the PSBB on the distribution of SO_2 gas concentrations in the DKI Jakarta area during the PSBB.

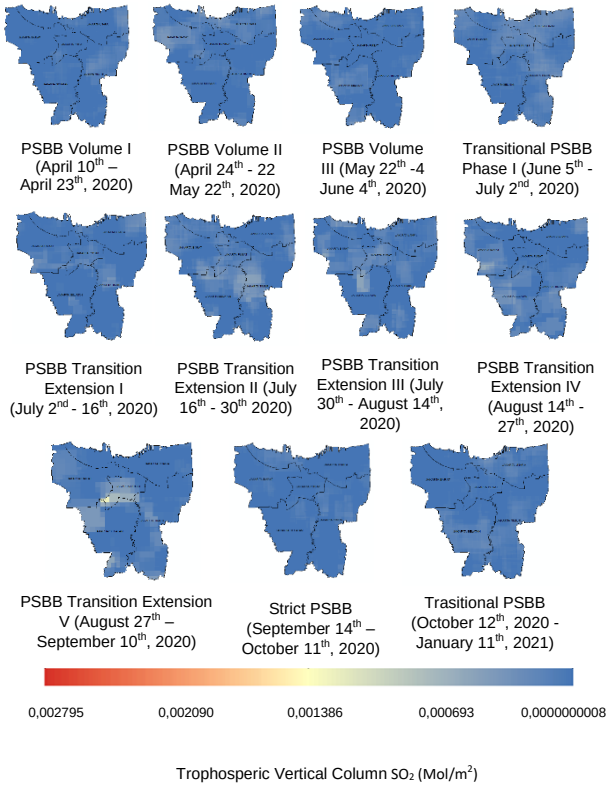


Figure 10. Visualization of SO_2 Gas Distribution After PSBB

A significant difference can be seen in the visualization and concentration values, especially in March 2020 and PSBB Volume I. The highest SO_2 gas concentration value was in PSBB Volume I, 0.000328505 mol/m^2. The low concentration of SO_2 gas is due to the DKI Jakarta Government Regulation regarding implementing Large-Scale Social Restrictions (PSBB) caused by the Covid-19 pandemic. The government stopped office and

school activities, online motorcycle taxis were limited, private and public transportation capacity was limited, so residents were not allowed to gather and had to keep their distance. This greatly affects the distribution of SO_2 polluting gas.

During the Transitional PSBB, you can visually see that the distribution of SO_2 gas is getting thicker. SO_2 gas concentration value also increased. The highest concentration value in Transitional PSBB was in Phase V of Transitional PSBB, 0.00126094 mol/m^2. This is because the DKI Jakarta Government relaxed PSBB regulations. Places of worship, offices, tourism spots, sports facilities, shopping centers and public transportation have resumed operations with a maximum capacity of 50%. Online motorbike taxis can carry passengers by providing insulation and wearing masks.

The increase in the positive number of Covid-19 in DKI Jakarta after the Transitional PSBB, the DKI Jakarta Government re-enacted the Strict PSBB regulations, namely by stopping office activities, tourism places and places of worship closed again, online motorcycle taxis were limited, private and public transportation capacity was limited, so that residents were not allowed to assemble and must keep their distance. Therefore, there is a decrease in concentration values at this stage. The highest value of SO_2 gas concentration at this stage was 0.000236643 mol/m^2, a decrease of around 66.11% from the previous stage. After successfully suppressing the positive number of Covid-19, the DKI Jakarta government re-imposed the Transitional PSBB with the same regulations as the previous Transitional PSBB. This increased the distribution of SO2 gas. The highest value of SO_2 gas concentration at this stage was 0.000330628 mol/m^2.

3. SO_2 Gas Analysis After PSBB

Based on the results of air quality data processing in Figure 11, it can be seen from the visualization and concentration values that there is spatial and temporal variability in the distribution of CO gas concentrations in the DKI Jakarta area after the PSBB.

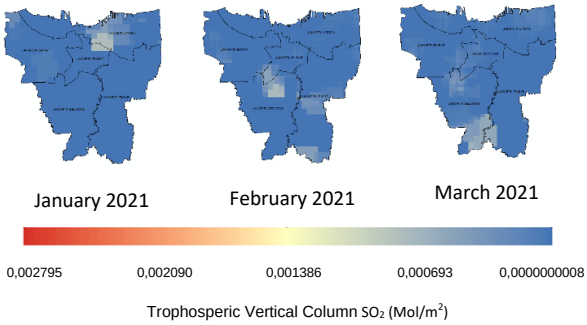


Figure 11. Visualization of SO_2 Gas Distribution After PSBB

January has the highest SO2 gas concentration value of 0.00099478 mol/m2 and only a few areas have SO2 gas, especially in North Jakarta. This is because there is a port with coal activity in that area. February 2020 has the highest SO2 gas concentration value of 0.000755645 mol/m2. This month's value of SO2 gas concentration decreased by around 24.04%, and several areas of DKI Jakarta have concentrated SO2 gas, especially in the South Jakarta area. This is because, in February 2021 there was a fire in a densely populated area in South Jakarta. March 2021 has the highest SO2 gas concentration value of 0.000649439 mol/m2. This month's value of SO2 gas concentration has decreased by around 14.06%, and CO gas levels in March 2021 are thinner than in February 2021. This is because in March 2021 the Jakarta Government carried out Micro PPKM by implementing regulations down to RT and RW.

3.4 Correlation Analysis of Sentinel 5P Air Quality Data with SPKU data

The validation in this study examines the correlation between the concentrations of NO_2, CO and SO_2 gas obtained from the Sentinel 5P satellite and measurements in the field taken from Air Quality Monitoring Station (SPKU) data spread across the DKI Jakarta area. The regression analysis results can be seen in Figure 12, Figure 13 and Figure 14.

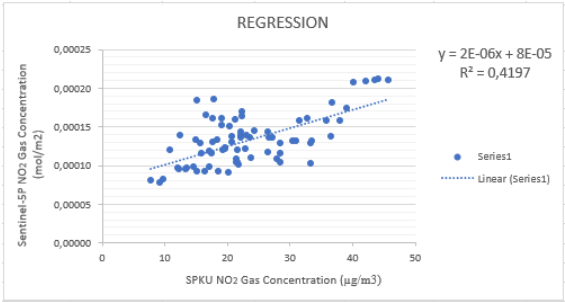


Figure 12. Regression Graph of Sentinel-5P NO_2 Gas Concentration and SPKU NO_2 Gas Concentration

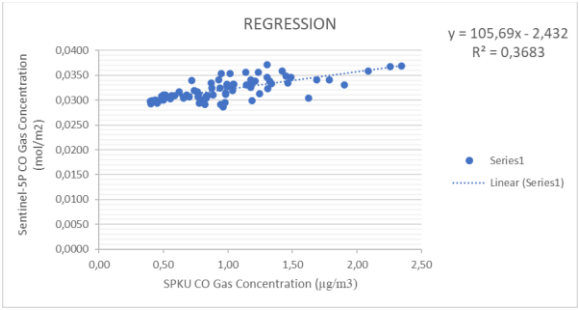


Figure 13. Regression Graph of Sentinel-5P CO Gas Concentration and SPKU CO Gas Concentration

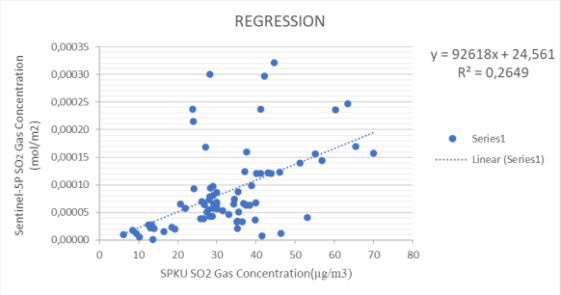


Figure 14. Regression Graph of Sentinel-5P NO2 Gas Concentration and SPKU NO2 Gas Concentration

Figure 12 shows that the coefficient of determination (R^2) is 0.4197 or 41.97%. Based on these values, it can be seen that the correlation value (R) between NO_2 Sentinel 5P and NO_2 SPKU is 0.648, which is a strong correlation. Figure 13 shows that the coefficient of determination (R^2) is 0.3683 or 36.83%. Based on these values, it can be seen that the correlation value (R) between CO Sentinel 5P and NO_2 SPKU is 0.607 which indicates a strong correlation. Figure 14 shows that the coefficient of determination (R^2) is 0.265 or 26.50%. Based on these values, it can be seen that the correlation value (R) between SO_2 Sentinel 5P and SO_2 SPKU is 0.515 which indicates a moderate correlation. Based on the results of the three correlations, Sentinel-5P can be used to estimate pollution in an area that does not have an Air Quality Observation Station and can be used to assess a government policy related to the distribution of pollution.

3.5 Analysis of the Effect of Wind on Spatial Distribution of NO_2, CO and SO_2 gases

This study assessed the climatological characteristics of near-surface winds in DKI Jakarta before the PSBB, during the PSBB and after the PSBB to be precise from January 2020 - March 2021. The method for determining the effect of wind on NO_2, CO and SO_2 gases uses the correlation between polluting gases and wind speed. The regression analysis results can be seen in Figure 15, Figure IV 16 and Figure 17.

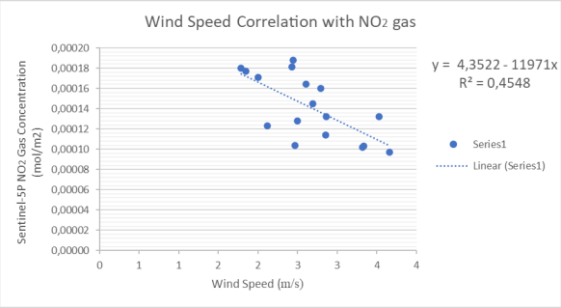


Figure 15. Scatter Plot of Wind Speed to NO_2 Gas Concentration

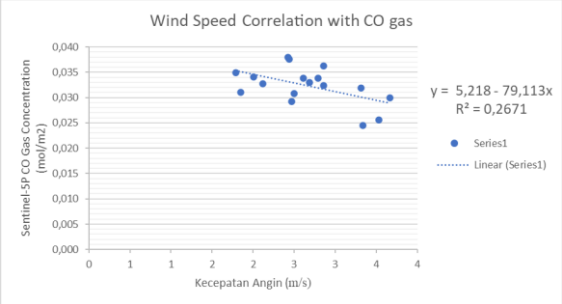


Figure 16. Scatter Plot of Wind Speed to CO Gas Concentration

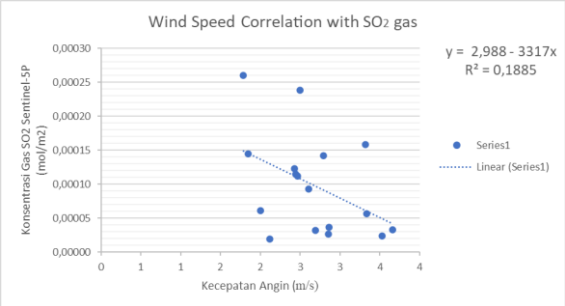


Figure 17. Scatter Plot of Wind Speed to SO_2 Gas Concentration

Based on Figure 15, a correlation value of 0.674 shows a strong correlation result. It can be seen that the concentration of NO_2 gas is higher when the wind speed decreases, and otherwise when the wind speed is higher the concentration of NO_2 gas is lower. Based on Figure 16, a correlation value of 0.517 shows a strong correlation result. It can be seen that the concentration of CO gas is higher when the wind speed decreases, and otherwise when the wind speed is higher the concentration of CO gas is lower. Based on Figure 17, getting a correlation value of 0.434 shows a moderate correlation result. It can be seen that the concentration of SO_2 gas is higher when the wind speed decreases, and otherwise when the wind speed is higher the concentration of SO_2 gas is lower.

3.6 Result Validation

Results Validation was carried out to prove the agreement between the results of this study and the actual field conditions. Two data were used to validate this study, namely research from DLH DKI Jakarta and BMKG DKI Jakarta agencies and questionnaires from the people of DKI Jakarta.

1. Agency validation

Based on research conducted by the DKI Jakarta Environmental Service and DKI Jakarta BMKG, which was recorded as an Air Quality Monitoring Final Report and the results of the study concluded that DKI Jakarta has experienced an increase in air quality by showing decreased gas parameters PM_{10}, $PM_{2.5}$, CO, O_3, SO_2 and NO_2. This can be caused by the Large-Scale Social Restrictions (PSBB) that occurred during the pandemic, where there was a decrease in activities outside the home, which in turn had an impact on

decreasing traffic activities in DKI Jakarta. This proves that this research is following what was researched by the DKI Jakarta Environmental Service and BMKG DKI Jakarta, namely DKI Jakarta has experienced an increase in air quality as indicated by a decrease in the levels or concentrations of polluting gases during the PSBB.

2. Validation of the Questionnaire

Questionnaires were distributed to several DKI Jakarta residents by answering several questions posed by researchers according to the topic in this study, namely regarding differences in air quality before, during and after the PSBB. The total number of respondents to the research questionnaire was 18 respondents, almost all of whom are students and have represented all over the city of DKI Jakarta.

Based on the results of the questionnaire that the researchers submitted, the results are in line with this study, namely before the PSBB and during the PSBB experienced visual differences and gas concentrations, where before the PSBB visually appeared to be more concentrated and the number of concentrations was high whereas, during the PSBB visually it appeared thinner and low concentration of polluting gases. Apart from that, the difference was also felt during the PSBB and after the PSBB where after the PSBB, visually it appeared to return to its original state, namely it looked thicker and the concentration of polluting gases increased.

4. Conclusion

From the research that has been carried out, it can be concluded that:

1. The results showed differences in the visualization and concentration levels of NO_2, CO and SO_2 gases in the DKI Jakarta area before, during and after the PSBB. Factors that influence differences in air quality in DKI Jakarta are the regulations at each stage of the PSBB. This is evidenced by the rise and fall in NO_2, CO and SO_2 gas concentrations at each stage of the PSBB. Before the PSBB, the average concentrations of NO_2, CO and SO_2 were 0.000214 mol/m^2; 0.039584 mol/m^2 ; 0.000886 mol/m^2. During the PSBB the average concentrations of NO^2, CO and SO^2 gases were 0.000155 mol/m^2; 0.035545 mol/m^2 ; 0.000513 mol/m^2. There was a decrease in NO_2, CO and SO_2 gas concentration respectively by 27.70%; 10.20% ; 42.06%. This shows an increase in air quality in DKI Jakarta due to the implementation of the PSBB in DKI Jakarta. After the PSBB, the average concentrations of NO2, CO and SO2 were 0.000176 mol/m2; 0.035850 mol/m2 ; 0.000799 mol/m2. There was an increase in the number of concentrations of NO2, CO and SO2 respectively by 11.92%; 1.89% ; 35.84%. %. This shows a decrease in air quality in DKI Jakarta due to the return of the normal activities of the people of DKI Jakarta.
2. The results showed an influence of wind speed and direction on the concentration and distribution of NO2, CO and SO2 gases. The higher the wind speed, the lower the concentration of NO2, CO and SO2 gases. The strong correlation between wind speed and the gas concentrations of NO2, CO and SO2 evidences this. Wind direction also affects the distribution of NO2, CO and SO2 gases. This is evidenced by the visualization results listed in the research results.
3. The results of the study show a match between the results of this study and what is in the field. This is evidenced by the suitability of the results of this study with research conducted by DLH DKI Jakarta and BMKG DKI Jakarta, as well as the results of the questionnaire distributed to the people of DKI Jakarta.

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