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Changes in the Distribution of Air Pollutants (Carbon Monoxide) during the Control of the COVID-19 Pandemic in Jakarta, Surabaya, and Yogyakarta, Indonesia

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ABSTRACT

The condition of the Coronavirus Disease 2019 (COVID-19) pandemic in 2020 characterizing DKI Jakarta, Surabaya, and Yogyakarta Provinces which have a high population density in 2019, necessitates implementing Large-Scale Social Restrictions (LSSR) to control or break the chain of the spread of COVID-19. The LSSR policy that limits community activities, be it business activities, transportation, and the industrial sector, will impact social activities and the environment due to the reduced intensity of community activities. Therefore, this study aimed to determine changes in the carbon monoxide (CO) levels in Jakarta, Surabaya and Yogyakarta during the pre-pandemic and during the pandemic. The method used is the tropospheric CO concentration extracted from the Sentinel-5P satellite data. The CO data were retrieved and calculated using Google Earth Engine. The COVID-19 pandemic reduced CO level by 19.7%, 14.9%, and 21%, respectively. The paired t-test shows no significant difference from before the COVID-19 pandemic, with a significance of 0.05. The highest pre-pandemic average and total CO concentration levels were 0.042 and 1.0198 mol/m^2 in Yogyakarta, respectively, whereas the lowest during the pandemic were 0.02845 and 0.6828 mol/m^2 in Surabaya. Overall, the three cities have a weak relationship between CO level and precipitation as well as temperatures and CO level.

Keywords: COVID-19 pandemic, carbon monoxide, Sentinel-5p, LSSR.

INTRODUCTION

The outbreak of the COVID-19-coronavirus has been known as an infectious disease since it occurred in Wuhan, China. This virus can spread from animal reservoirs and transmit through respiratory droplets (Whitworth, 2020). The disease from the COVID-19 virus quickly spread to 210 countries and, in less than six months, has killed more than 100,000 people worldwide. Several other countries attend public gatherings when cases and deaths increase. The government has been urged to implement the measures to control public health since it was discovered that COVID-19 cases had increased significantly since March 15, 2020. Among them were re-screening of people severely affected by the state, providing 14-day self-quarantine for at-risk groups, providing recommendations to the community to work from home, and minimizing congregational crowds.

Some pollutants, such as methane (CH_4), sulfur dioxide (SO_2), non-CO_2 nitrogen oxides (NO_x), and volatile organic compounds (VOC) in urban areas generally arise due to exposure to transportation activities (Karner et al., 2010). The possible impact is a decrease in the quality of the air environment, an increase in disease vectors, and a negative impact on health (Septiariva & Suryawan, 2021). Carbon monoxide is one of the most widespread pollutants.Carbon monoxide has the characteristics of no odor, no color, and is difficult to dissolve in water. In addition, compared to air, it has a lower density. This gas easily reacts with hemoglobin in the human body to form carboxyhemoglobin. The global background concentration of carbon monoxide ranges between 0.05 mg/m^3 or 0.05 ppm to 0.14 mg/m^3 or 0.12 ppm. The concentrations measured in ambient air are lower than those measured in motor vehicle activity in the traffic sector. The average concentration is 2 to 5 times greater when measured in a private car than measured on the streets or on the subway. In addition, an activity that can increase the average carbon monoxide concentration of 23–46 mg/m^3 for 8 hours, such as smoking, emits smoke in vehicles, homes, offices, and restaurants(Whitworth, 2020). Wind conditions greatly affect the spread of pollutants in the air and horizontal transportation (Suradi et al., 2021). The impact of wind generated by industrial emission sources in urban and transportation areas and natural conditions, such as fires are significant for spreading air pollutants (Fan et al., 2021).

Metropolitan cities face the challenges of population density, many motorized vehicles, and unplanned industrial development. These factors improve the environment both regionally and internationally. Environmental pollutants are mainly composed of "dust, smoke, smoke, carbon dioxide, carbon monoxide, nitrogen oxides", particulate matter, and other organic compounds. For example, largecities in Indonesia, namely Surabaya, Yogyakarta, and Jakarta are three metropolitan cities.

Large-Scale Social Restrictions (LSSR) constitutes one of the policies implemented as an outcome of the COVID-19 pandemic outbreak. This policy regulates the limitation of population activities in an area to prevent the potential for the spread of the virus from being controlled. DKI Jakarta, Yogyakarta, and Surabaya are Indonesia's regions implementing the LSSR policy. The application of this policy indirectly impacts the economic sector and positively impacts environmental quality (Sari et al., 2022, 2023; Suryawan et al., 2021). Concerning their function as the three cities as provincial capitals, DKI Jakarta, Surabaya, and Yogyakarta are included in areas with very dense population activities (Indriyaningtyas et al., 2021). The high population density followed by the dynamics of existing activities can impact the air quality of the area concerned. Throughout 2019, the air quality of DKI Jakarta, according to data from the Environment Agency, was mainly classified into moderate (ISPU 51-100) to unhealthy (ISPU 101-199) classes. This poses a significant risk to human health and increases mortality in the surrounding community.

Generally, carbon dioxide is one of the most prevalent pollutant parameters resulting from the incomplete combustion of carbon-containing fuels (Wu & Wang, 2005). The high CO concentrations are also insufficient for the health and environment. The presence of excess carbon monoxide in the troposphere is one of the causes of the greenhouse effect, which can trigger global warming. CO gas is a gas released due to incomplete fuel oil combustion. CO gas has a stronger affinity for hemoglobin than oxygen. Thus, if inhaled, a person will experience dizziness; at a certain point,they can be poisoned, and have heart problems until death. Large-Scale Social Restrictions limit the activities related to mass mobilization and transportation as well as companies and industries. The enactment of these policies has the potential to positively impact air quality due to reduced activities that have been sources of pollutants.

Remote sensing can play a role in monitoring CO emissions multitemporal, and this is supported by the ability to detect spectral characteristics for observing atmospheric attributes (Dede et al., 2020). According to (S. Lin et al., 2020), remote sensing satellite imagery can play a role in estimating air quality on a multi-time basis. It can be integrated with field measurements to ensure the accuracy of the data obtained. Therefore, this study was conducted to determine changes in tropospheric CO concentrations to analyze how air quality has affected the COVID-19 outbreak. CO levels on a large scale have become a link between local air pollution and emissions from the transportation sector. Therefore, the authors intended to find out the changes in spatial CO levels before the pandemic, work from home, and lockdown in Indonesia, and study cases in Surabaya, Jakarta and Yogyakarta.

Lower energy consumption, lockdowns due to the COVID-19 outbreak, and lesser use of oil have significantly affected transportation activities. Improvements in air quality can quickly be investigated due to the lockdown. The National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) have recently released information regarding improvements in environmental quality (Gautam, 2020). In addition, climatology from the MOPITT satellite (measurement of pollution in the troposphere) compared to the CO levels from TROPOMI were later recorded, showing that during the first phase of lockdown in India CO levels were lower but in the second phase higher (Pathakoti et al., 2021). This may indicate a longer lifetime of CO in the atmosphere and long-distance transport of CO from multiple global sources. Overall, CO and NO_2 subtraction in near-surface air masses due to COVID-19 lockdown conditions ranged from 20% to 80% for 50% CO and 20% for NO2 for all globally reported observations (Gkatzelis et al., 2021).

MATERIALSANDMETHODS

The research was conducted in DKI Jakarta, Surabaya, and Yogyakarta provinces. DKI Jakarta Province is a lowland province with an average height of 7 meters above sea level and 17 rivers or canals passing through the DKI Jakarta area. DKI Jakarta consists of 6 districts with a population of 10,557.810 people in 2019 and a total area of 662.33 km^2 (BPS, 2021). The average temperature of DKI Jakarta is around 28.7 °C, and annual rainfall is around 121.65 mm^{2,} according to the data from the Kemayoran Observation Station. Surabaya has an area of approximately ±326.81 km² and 2,970.843 inhabitants. Surabaya has lowlands in most of its territory, which is 80.72%. Its height above sea level is between 3–8 m or -0.5–5 m SHVP. Like major cities in Indonesia, Surabaya also has a tropical climate. The average rainfall in Surabaya is 165.3 mm. In January-March and November-December, the highest rainfall is above 200 mm, with the average air temperature in Surabaya ranging from 23.6 °C to 33.8 °C (BPS, 2021 b). Yogyakarta has a height of about 112 m above sea level. Yogyakarta has the same climate as other regions in Indonesia, namely a tropical climate. The average rainfall in the Yogyakarta city area is ± 2012 millimeters per year, with the number of rainy days ranging from 100–150 rainy days per year. The average humidity level per year in this area is ±77%. The total population of Yogyakarta amounts to 388,088 people (BPS, 2020c). In this study, the object of research is determining the dynamics of changes in CO concentration before and after the COVID-19 pandemic.

In this study, TROPOMI was launched by the European Space Agency on October 13, 2017, with the primary objective of monitoring air quality with several parameters, one of which is carbon monoxide (CO). Several atmospheric gases, aerosols, and cloud distributions that impact air quality and climate have been effectively tracked by the Sentinel-5P satellite. The satellite is equipped with a single sensor known as the TROPOspheric Monitoring Instrument (TROPOMI), which can deliver accurate and timely observations of important atmospheric species. TROPOMI is a multispectral imaging spectrometer that detects solar energy reflected or scattered back into space by the atmosphere and the earth's surface. Each atmospheric trace of the target gas spectral fingerprint, enables to detect each concentration using the distinct fingerprints of components in various sections of the electromagnetic spectrum. This study makes use of NRTI data to accommodate a comprehensive working period spanning September 2019 to August 2020.

In addition, TROPOMI has additional spectral bands compared toits predecessors: UV and visible (270–500 nm), near-infrared (675–77 nm), and short infrared (270–500 nm) (2305–2385 nm). This enables TROPOMI to monitor a broader variety of trace gases in the atmosphere, including NO_2, O_3, SO_2, CH_4, and CO. TROPOMI already has a high spatial resolution (3.57 km^2 for all trace gases except CO and CH4, i.e. 77 km^2); hence, it is expected that estimating pollutant concentrations and emissions at the size of small cities would be crucial (Oo et al., 2021).

The Google Earth Engine exports CO raster data, downloads Sentinel-5P data as well asorganizes and analyzes changes over different periods. The authors also extracted precipitation and land surface temperature values using the same method with MODIS and CHIRPS satellite images.To discover significant variations in the CO levels before and during the epidemic, a statistical t-test was used. A paired t-test was used to compare the CO levels during the COVID-19 pandemic in 2020 to the same period in 2019 (without the CO-VID-19 pandemic). SPSS Version 25.0 was used for all statistical analyses.The carbon monoxide (CO) informationwere extracted using Javascript syntax in the Google Earth Engine Code Editor. Some of the Javascript syntax wasused and visualization of raster data was performed. The algorithm was compiled to obtain CO column density information representing the CO content in the atmosphere. The visualization graph wasdone in a side-by-side mode according to the time period, intended to facilitate visually identifying spatial distribution patterns.

RESULTS AND DISCUSSION

According to the regression analysis, there is a positive linear relationship between CO levels and temperature in each province, namely Jakarta, Surabaya, and Yogyakarta, with an R^2 value of 0.3839 for the period September-February 2019 and 0.0141 for the period March-August 2020 for Jakarta, respectively (During the Pandemic). Table 1 shows the linear regression findings, while Table 2 shows the correlation criterion recommendations.

Table 1 shows the correlation between carbon monoxide concentration and temperature and the relationship between carbon monoxide concentration and precipitation and then compared with the standard correlation in Table 2. Then, each city compared the relationship of carbon monoxide concentration with temperature and precipitation. It can be seen in Table 1 that CO concentration sufficiently affects the air temperature by showing a positive relationship between air temperature and CO concentration. The increase in air temperature in Jakarta, Yogyakarta, and Surabaya may not only be caused by the concentration of CO, but by other factors, such as heat absorption by paved roads, poor air circulation, or other factors.

CO levels differ from national perspectives before and during the pandemic (Fig. 1 and Fig. 2). The authors observeda significant difference in the mean value of CO VCD between the two previous periods (before and during the pandemic), with values of 0.03544 and 0.02845 mol/m^2 respectively, which reduced 19.7% compared to before pandemic.

In October, November, and December of 2019, the CO VCD values ranged between 0.03 mol/m^2 and 0.04 mol/m^2. In March and April of 2020, a gentle fall in CO level was notable; the CO VCD values ranged from 0.02 mol/m^{2}on most days of these two months. CO concentrations were close to 0.04 mol/m^2 before to the epidemic. CO level and temperature have a positive linear connection; however, there is a weak link during the pandemic, with levels of 0.0141 mol/m^2. Precipitation also influences CO levels. The regression study revealed that CO level was moderately associated to precipitation before the pandemic, with values of 0.4264. In the period before the

Table 1. Correlation value of Weather Variables (temperature and precipitation)

r (before and during pandemic Covid 19)	Weather variabels
0.3839 and 0.0141	CO concentration with temperature (Jakarta)
0.3989 and 0.1933	CO concentration with temperature (Surabaya)
0.1369 and 0.049	CO concentration with temperature (Yogyakarta)
0.5257 and 0.0277	CO concentration with precipitation (Jakarta)
0.4264 and 0.1145	CO concentration with precipitation (Surabaya)
0.3589 and 0.1917	CO concentration with precipitation (Yogyakarta)

Table 2. Correlation criteria guidelines

r value	Relationship criteria
0	No correlation
0–0.5	Weak correlation
0.5–0.8	Medium correlation
0.8–1	Strong correlation
1	Perfect correlation

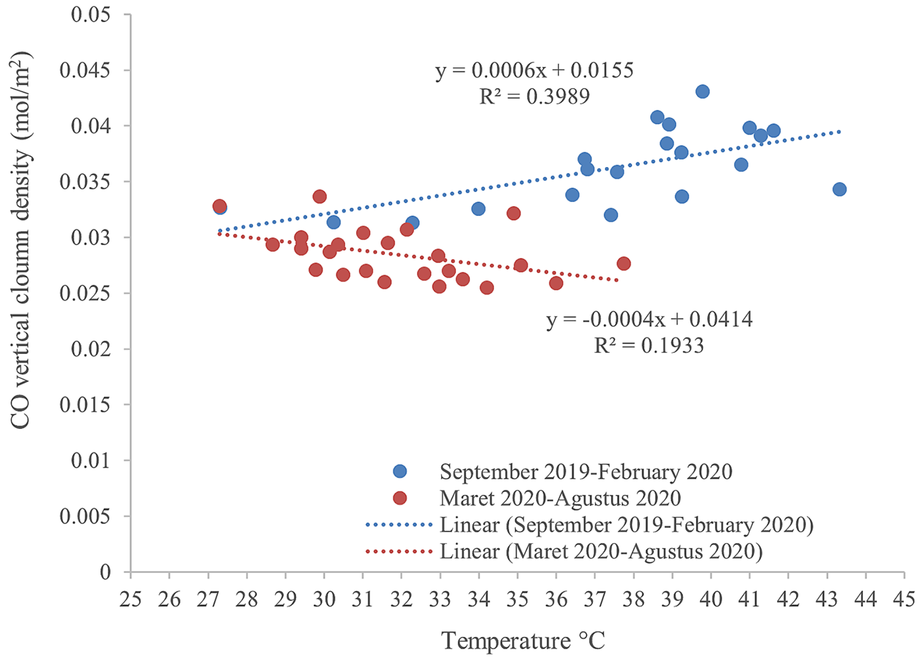

Figure 1. The correlation between daily CO levels and precipitation in the Surabaya

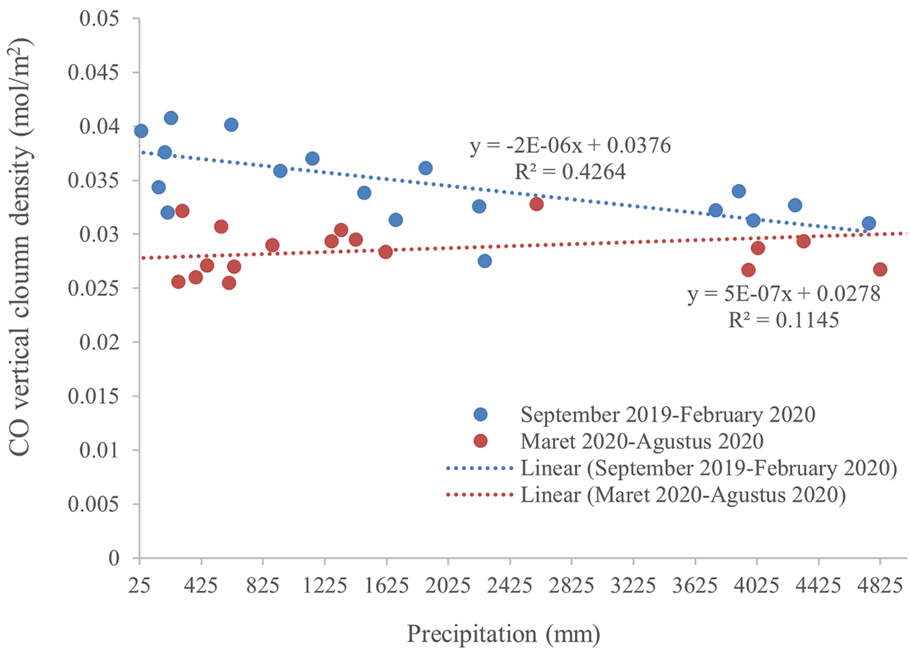

Figure 2. The correlation between CO levels and temperature in the Surabaya

implementation of the large-scale area restriction policy, namely from January 3 to April 9, 2020, the average and total CO had high values, which were around 0.0828 mol/m^2 and 21.205 mol, respectively. Then, there was a decrease in the average and total CO concentration when the social distance policy was implemented in DKI Jakarta on April 10 – June 4, 2020, with an average of 0.0769 mol/m^2 and a total concentration of 19,673 mol. However, the concentration of carbon monoxide increased again during the transitional LSSR period (5 June-13 September), namely 0.0826 mol/m^2 and 21.136 mol (Indriyaningtyas et al., 2021).

A significant change in the average CO VCD values was detected between the two periods before (0.03504 mol/m^2) and during the pandemic (0.0298 mol/m^2) in the Yogyakarta metropolitan area. During the epidemic, CO levels fell by 14.9%. As a result, it is known that the CO

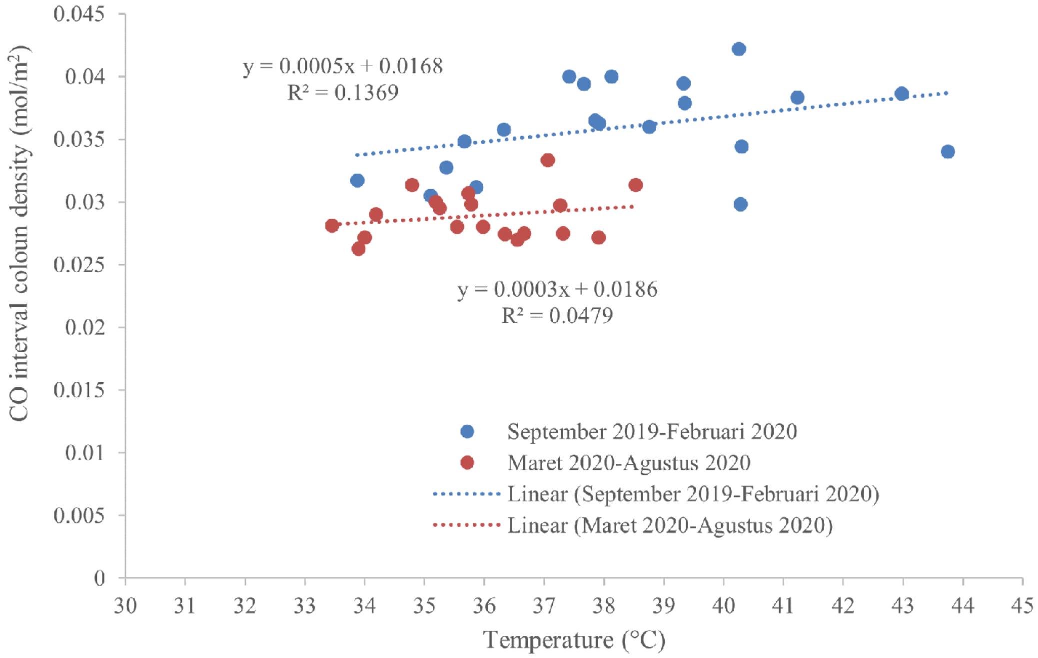

Figure 3. The correlation between daily CO levels and precipitation in Yogyakarta

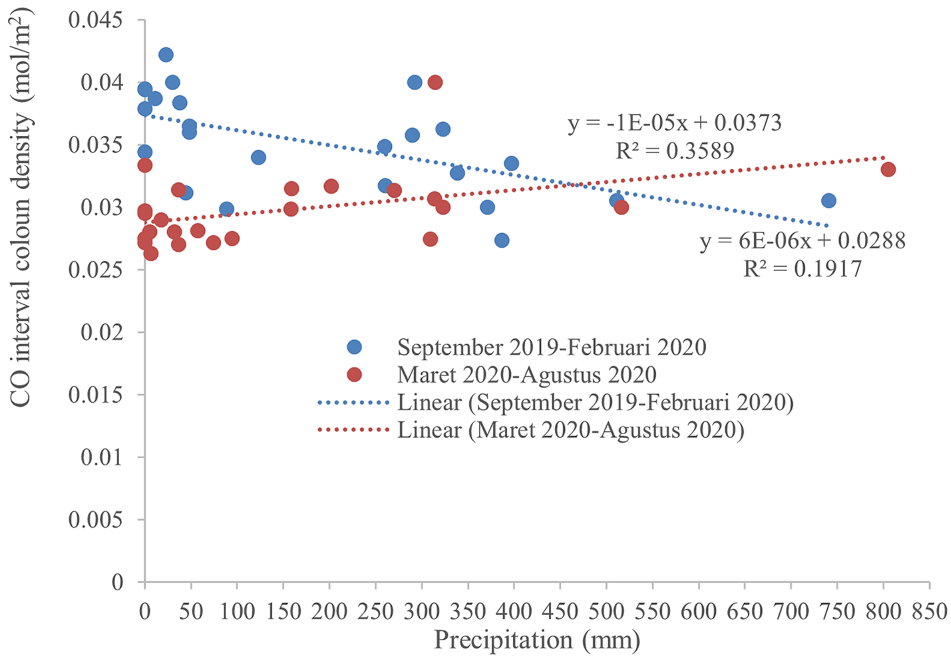

Figure 4. The correlation between daily CO levels and temperature in Yogyakarta

levels in Yogyakarta differ from national viewpoints before and throughout the epidemic (Fig. 3 and Fig. 4). Tropospheric CO VCD was 0.039 and 0.042 mol/m² in the latter two weeks of September 2019, according to Figures 3 and 4. The maximum CO VCD in October 2019 was 0.04 mo/m², and the lowest was 0.037 mol/m². In November 2019, the highest vertical column density was 0.038 mol/m², while the lowest was 0.034 mol/m². The range VCD reported in Yogyakarta throughout December was 0.032–0.035 mol/m², with the greatest value obtained on December 2, 2019. In January 2020, the CO level began to fall for the most of the month. However, CO concentrations began to riseagain in February 2020, indicating that the COVID-19 epidemic had no effect on CO levels when it first arrived in Indonesia.The results of observing the amount of CO concentration compared to the weathers parameter, namely temperature, and precipitation, is in Figure 5 and 6.

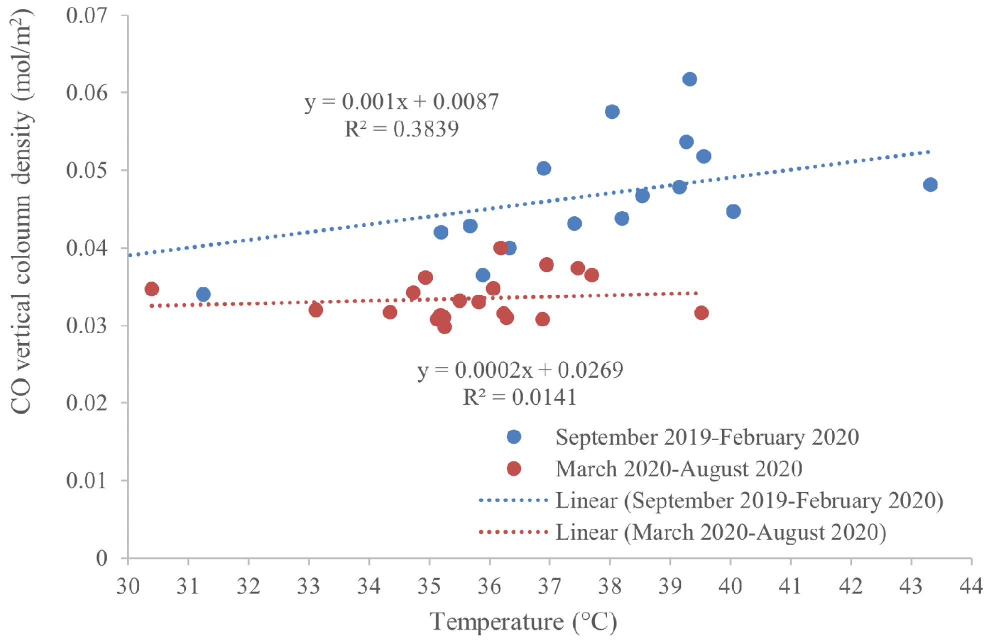

Figure 5. The correlation between daily CO levels and precipitation in the DKI Jakarta

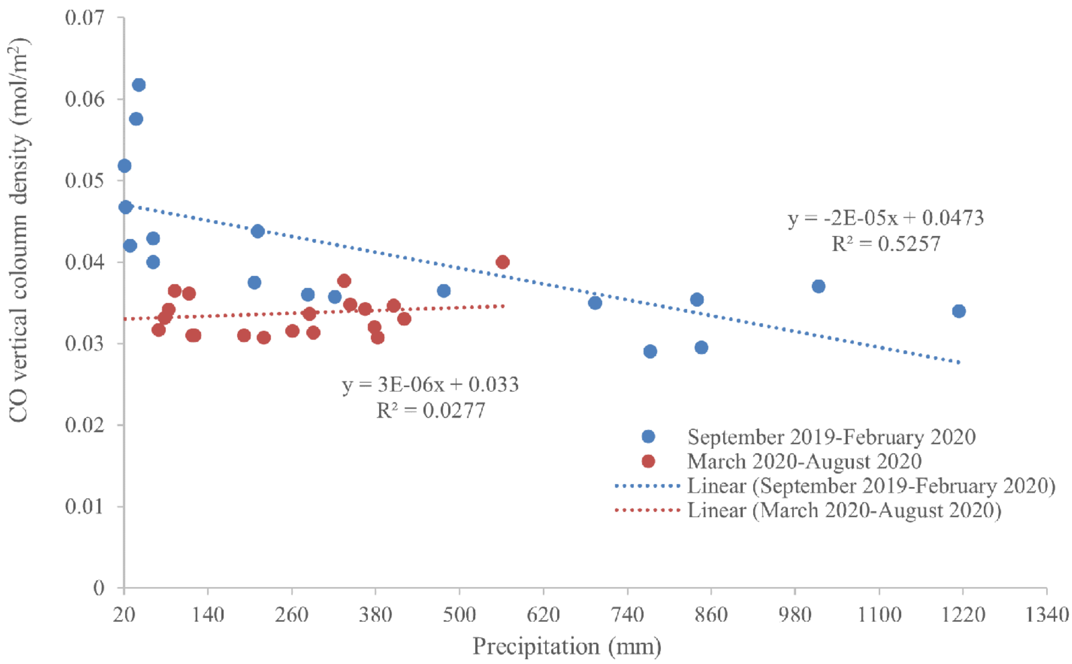

Figure 6. The correlationbetween CO levels and temperature in the DKI Jakarta

A substantial difference in the average CO VCD values before and during the pandemic was discovered, with values of 0.042 mol/m² and 0.0335, respectively, which was 21% lower than before the epidemic. In the Jakarta metropolitan region, the regression model produced a higher determination coefficient (R^2) of 0.3839 in the September 2019 - February 2020 (before) period compared to the March 2020 – August 2020 period (R^2 = 0.0141). However, because the R^2 values for "During Pandemic" are 0.0141 and 0.0277, respectively, and are near to zero in the regression analysis for both CO-precipitation and CO-temperature comparison, they are stated to have little or no association. Overall, the association between CO level and temperature and CO level and precipitation in DKI Jakarta is low.

The results of the scatterplot between CO concentration and precipitation are shown in Figure 3 – Figure 5, indicating a positive correlation. This can be seen from the distribution pattern and trend, which shows a positive value. The greater the value of the precipitation intensity, the greater the concentration of $CH_4$is. The humidity factor also affects the concentration of CO. Therefore, the increase in CO concentration is influenced by precipitation and humidity factors, and other factors influence others. (Nakada & Urban, 2020) also conducted research similar to the impact of the partial implementation of lockdown on air quality in São Paulo, Brazil. Significant air quality improvement was observed during the partial lockdown period in São Paulo. The result is that the partial policy Lockdown is proven to positively contributeto improving air quality. Furthermore, a study by (Ghude et al., 2009) indicated that NO2 levels are falling due to changes in human activity under large-scale social restrictions, working from home, and curfew measures during the COVID-19 pandemic.

The highest concentration of CO pollutants in DKI Jakarta province and the lowest in Surabaya can be seen in Figure 7. Motor vehicles in the Jakarta metropolitan area, which are one of the greatestcontributors to the presence of carbon monoxide gas emissions in the air, are also a major factor causing congestion if the volume of vehicles at a point is not proportional to the road area.

In the boxplot of the concentration of CO at Jakarta, 75% concentration data CO is between the values of 0.03 – 0.04 $mol/m^{2,}$ and the remaining 25% is between 0.04–0.06 mol/m^2, which in this season period CO concentration is still relatively safe for Jakarta area. On the boxplot CO concentration in the Yogyakarta, 75% of the CO concentration data is between value 0.027–0.035 mol/m^2, and the remaining 25% is between 0.036–0.042 $mol/m^{2,}$ which in this season period the concentration of CO still relatively safe for the Yogyakarta area. The same case is also seen in the Surabaya, where CO levels are still relatively safer than others. It is possible to control pollution from factories and motor vehicles before the pandemic has been minimized. Improved air quality can be considered a benefit of temporary restrictions, as economic revitalization can reverse this trend. This will offer a basis for future mitigation plans for regulatory agencies to monitor air quality levels closely (Kumar et al., 2020).

Comparison of CO levels in Jakarta, Yogyakarta, and Surabaya (before pandemic: September 2019 – February 2020) and during the pandemic can be seen in Figure 8 and Figure 9. On the basis of the paired sample t-test on SPSS 25 software for each city, a summary of the results is obtained, as shown in Table 3. As with the Chinese study, the relationship between CO2 concentration and temperature varies widely across China. Positive correlation coefficients are found in the northern and eastern China, but negative ones are found in the northwest and southern China (J. Lin et al., 2021). CO is often used as a tracer of other air pollutants, because it is less affected by wet scavenging and can identify transport efficiency (Garrett et al., 2010). High pollutant concentrations are associated with stagnant air, usually characterized by weak winds, anticyclonic synoptic conditions, high temperatures, and limited rainfall (Tai et al., 2010).

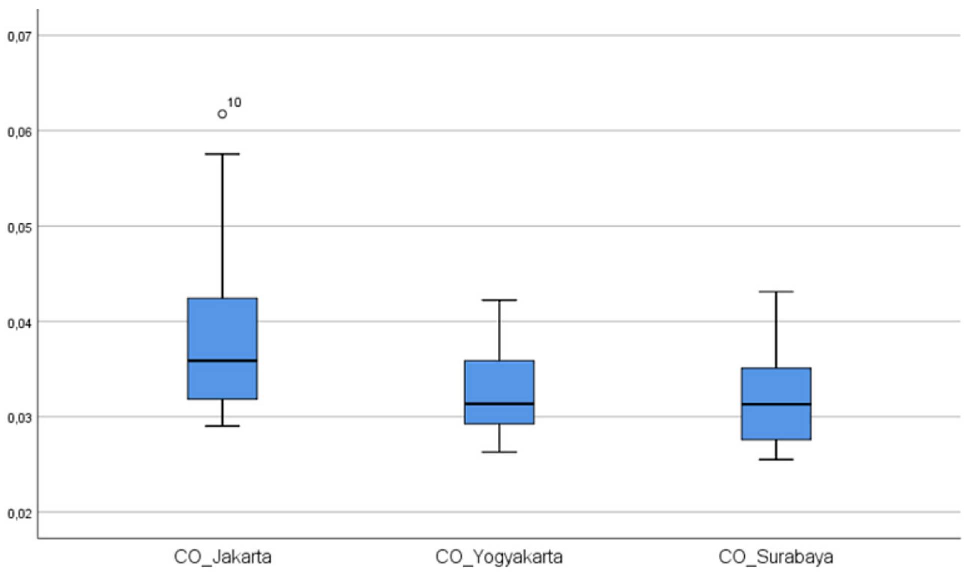

Figure 7. Boxplot comparison of CO concentration in Jakarta, Yogyakarta & Surabaya

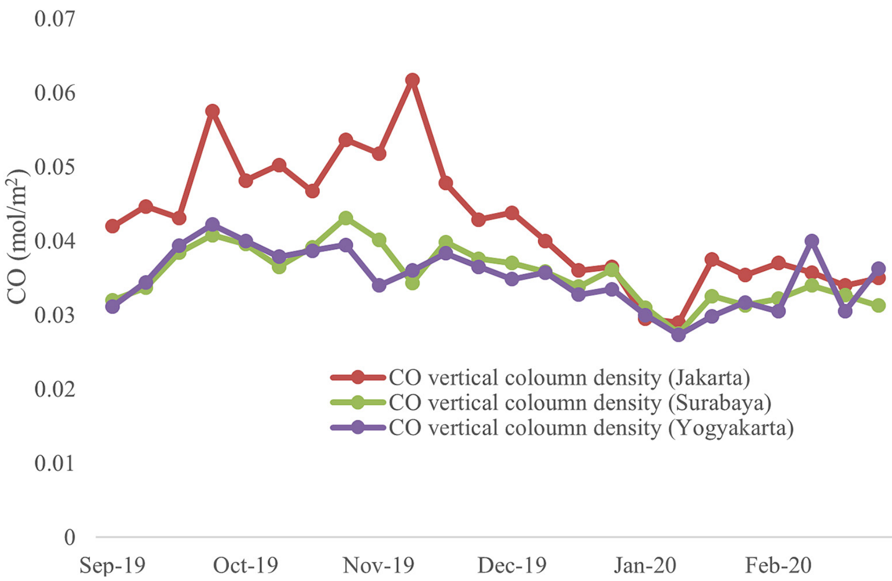

Figure 8. Comparison of CO levels in the Jakarta, Yogyakarta and Surabaya (before pandemic: september 2019 – February 2020)

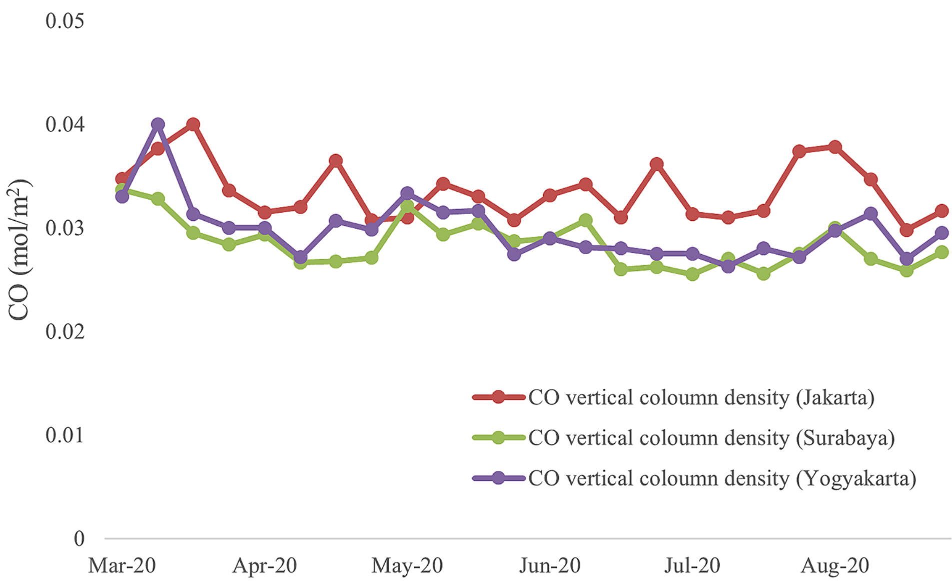

Figure 9. Comparison of CO levels in the Jakarta, Yogyakarta and Surabaya (during pandemic: March 2020 – February 2020)

Paired sample statistics show average carbon monoxide concentrations before and after the pandemic. Before the pandemic, the average concentration of CO in the atmosphere for the Jakarta area with 48 data was 0.4249, while after the pandemic, the average concentration dropped to 0.3356. Besides, from paired samples correlation, the correlation between the two variables in Yogyakarta is 0.263 with a sig of 0.214. This shows a weak correlation between the two average CO concentrations before and after the increase. The calculated t value is 8.296 in Surabaya with a sig of 0.00. Because sig < 0.05, it can be concluded that H1 is accepted, meaning that

Table 3. Summary of paired t test results

Variables	Mean	Paired samples correlation	Paired sampled test
Jakarta: before and after pandemic	0.42492 and 0.33566	Correlation 0.029 and sig 0.893	t = 4.92 and sig = 0.00
Yogyakarta: before and after pandemic	0.350 and 0.297	Correlation 0.263 and sig 0.214	t = 6.002 and sig = 0.00
Surabaya: before and after pandemic	0.354 and and 0.284	Correlation 0.177 and sig 0.408	t = 8.296 and sig = 0.00

the average concentration of C before and after the pandemic is different. Thus, it can be stated that the pandemic period affects the concentration of carbon monoxide in large cities like Jakarta, Surabaya, and Yogjakarta. To avoid the spread of COVID-19, lockdown measures such as reducing air quality and water pollution in some heavily polluted cities have aided the environment's self-recovery (Paital et al., 2020).

When considering Figure 5 and Figure 6, there was a significant decrease in the concentration of CO in the atmosphere before the pandemic, which was from around September 2019 until February 2020. In February 2020, some news of the emergence of this covid outbreak began. However, from March to August 2020, the CO concentration decreased slightly until it finally experienced a constant and dropped again. This is because, at that time, the regional restriction program was still in transition, so there were still some office, transportation, and industrial activities. In Figure 5, Jakarta, the capital city of Indonesia, shows that the distribution of CO pollutants is greater than in the cities of Surabaya and Yogyakarta. This centering is supported by the high level of human activity in the area before the enactment of thesocial distancing policy in the DKI Jakarta area. Duringthe social distancing period, the distribution pattern of CO contentbecomes more varied. In addition, the large-scale restriction policy has not yet been fully implemented in the cities of Yogyakarta and Surabaya.

The next test is with one-way ANOVA. The descriptive output results show that the standard deviation of each group is 0.00436 (Jakarta & Yogyakarta) and 0.00472 for Surabaya. Each value is becomingcloser to the average. Output Test of Homogeneity of Variances shows that the probability or significance is 0.874 which means greater than 0.05. It can be concluded that the null hypothesis (Ho) is accepted, which means the assumption that the three population variants are the same (homogeneous) is acceptable. After the five variances were proven the same, the ANOVA test was then carried out to test whether the five samples had the same average. OutputANOVA is the end of the calculation used to determine the hypothesis analysis that will be accepted or rejected.

On the basis ofthe results obtained in the ANOVA test, it is seen that F count = < F table = 0.179, which means Ho is rejected and Ha is accepted. As for the probability value, it can be seen that the probability value is 0.837 >.05. Thus, the null hypothesis (H_0) is accepted. This shows no differences in CO concentrations for the three largecities, namely Surabaya, Jakarta, and Yogyakarta, during the non-pandemic period (September 2019 – February 2020) and during the pandemic (March 2020 – August 2020). A Post Hoc test with Tukey and Bonferroni test was conducted to determine which groups were different and which were not. This can be done if the calculated F shows there is a difference. If the calculated F shows no difference, the analysis after the ANOVA does not need to be carried out.

CONCLUSIONS

TROPOMI Sentinel-5P Image Processing with Google Earth Engine JavaScript API on carbon monoxide (CO) data extraction shows the effect of the implementation of large-scale social restriction policies on the concentration of carbon monoxide (CO) gas emissions in DKI Jakarta, Yogyakarta, and Surabaya. In the three cities, the average CO VCD (Vertical Column Density) values reduced by 19.7%; 14.9%; and 21%, respectively,during the COVID-19 pandemic but based on the paired t-test, and there is no significant difference compared to before the COVID-19 pandemic with a significance of < 0.05. This is because at that time (March-August 2020), the regional restriction program was still in a transition process, so some office, transportation, and industrial activities were still there. The highest concentration of CO pollutants is in Jakarta. It was found that 75% of the concentration data CO is between the values of 0.03–0.04 mol/$m^{2,}$ and the remaining 25% is between 0.04–0.06 mol/$m^{2.}$ Therefore,CO concentration is still relatively safe for the Jakarta area. The correlation test shows the effect of weathers variable in producing the average CO concentration. The concentration of CO sufficiently affects the air temperature and precipitation by showing a positive relationship between air temperature and CO concentration. However, the relationship is still weak because the value of r is below 0.5 or a range of 0.5. The increase in air temperature and precipitation in Jakarta, Yogyakarta, and Surabaya may not only be caused by the concentration of CO, but by other factors such as heat absorption by paved roads, poor air circulation, or other factors with an R-valueof 0.3839 and 0.4264.

Besides, from paired samples correlation, the correlation between the two variables in Yogyakarta is 0.263 with a sig of 0.214. This shows a weak correlation between the two average CO concentrations before and after the increase. The calculated t value is 8.296 in Surabaya with a significance of 0.00. Thus, it can be stated that the pandemic period affects the concentration of carbon monoxide in large cities like Jakarta, Surabaya, and Yogyakarta. On the basis of the results obtained in the ANOVA test, it is seen that F count = < F table = 0.179. As for the probability value, the probability value is 0.837 >.05. This shows that there are no differences in CO concentrations for the three large cities, namely Surabaya, Jakarta, and Yogyakarta during the non-pandemic period (September 2019-February 2020) and during the pandemic (March 2020-August 2020).

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