The Effect of the COVID-19 Pandemic on Nitrogen Dioxide (NO_2) Gas Concentration in Yogyakarta Special Province

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***Abstract*—COVID-19 has plagued the world, one of which is Indonesia. During the COVID-19 pandemic, all anthropogenic activities are limited, including activities that cause air pollution, such as transportation and industrial activities. Nitrogen Dioxide (NO_2) is one of the parameters of air pollution which has the main source of human activity. Therefore, this study aims to analyze the effect of the COVID-19 pandemic on changes in NO_2 gas concentrations in the Yogyakarta Special Province. This study uses Sentinel 5-P satellite imagery data obtained through cloud computing on Google Earth Engine (GEE) to obtain NO_2 gas concentration values. The results showed that there was a 3.7% decrease in the concentration of NO_2 gas before and after the COVID-19 pandemic. The correlation result between the number of COVID-19 cases and the concentration of NO_2 gas is 0.39, which means it has a weak correlation.**

Keywords—COVID-19, pandemic, Nitrogen Dioxide, correlation

I. INTRODUCTION

Currently, the world is facing a global disaster, namely the COVID-19 pandemic which is caused by the SARS-CoV-2 virus and attacks the respiratory system in humans. Indonesia is one of the countries with a high number of positive cases of COVID-19. Government policies in dealing with COVID-19 cases such as lockdown, PSBB (Large-Scaled Social Restrictions), and PPKM (Restrictions on Community Activities) affect hum an activities. Transportation, social and industrial activities were limited to suppress the spread of the COVID-19 virus.

Restrictions on human activities affect air quality, one of the air quality parameters is Nitrogen Dioxide (NO_2) gas [1]. Nitrogen Dioxide is one of the causes of air pollution deriving from human activities such as transportation, household, and industrial activities [2]. The number of vehicles operating indicates the high level of public transportation activities. The transportation sector contributes 60% to air pollution [3]. Land use in an area affects the concentration of NO_2 gas. Land use with dense vegetation cover has lower NO_2 gas compared to areas with low vegetation cover such as urban and industrial areas [4].

The cities of Madrid and Barcelona (Spain) experienced a decrease in Nitrogen Dioxide (NO_2) gas during the lockdown in March 2020 [5]. Apart from Spain, the decline in NO2 gas during the lockdown was also experienced by several European urban areas such as Milan and Paris and US urban areas such as New York and Boston [6]. The countries of Cairo, Egypt and Riyadh, Saudi Arabia also experienced a decrease in NO_2 gas during the lockdown [7].

The decrease in the concentration of Nitrogen Dioxide (NO_2) also occurred in Indonesia. The concentration of NO_2 gas during the pandemic in Palembang City, Semarang City and West Java has decreased [8, 9, 10]. Based on research the concentration of NO2 gas with positive cases of COVID-19 has a correlation of 0.82513 which indicates that Nitrogen Dioxide (NO_2) gas and positive cases of COVID-19 in East Java Province have direct correlation [11].

One area that has a high number of COVID-19 cases is the Yogyakarta Special Province. It is important to conduct a study on the effect of the pandemic on the concentration of Nitrogen Dioxide (NO_2) gas in the Yogyakarta Special Province, due to the increasing trend of COVID-19 cases and was ranked as the 4th largest case in Indonesia. Therefore, this study was conducted to provide information on the effect of the COVID-19 pandemic on the dynamics of NO_2 gas in the Yogyakarta Special Province and to map its spatial temporal distribution.

II. METODOLOGY

A. Research Framework

This study uses a quantitative descriptive approach, namely descriptive analysis to explain the dynamics of the concentration of Nitrogen Dioxide (NO_2) gas temporally (2019 - 2021) in the Yogyakarta Special Province and hot spot analysis to determine the spatial pattern of NO_2 gas concentration based on land use (Fig. 1). The spatial and temporal distribution of NO_2 gas concentrations is sourced from the TROPOMI Sentinel-5P satellite imagery obtained through monthly average calculations, from February 2019 to January 2020 as the time before the pandemic and March 2020 to December 2021 as the time during the pandemic, via the cloud computing on *Google Earth Engine* (GEE).

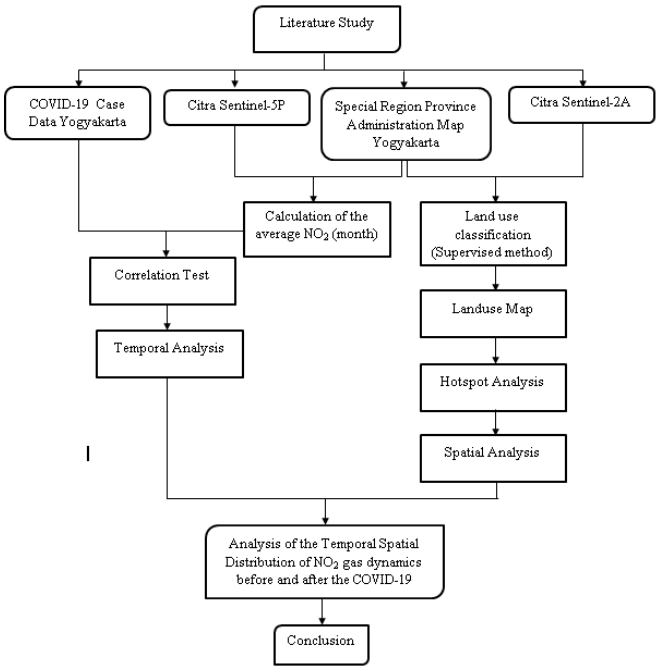


Fig. 1 Research Framework

B. *Data Anaysis*

The data analysis used is descriptive quantitative. To analyze the spatial pattern of nitrogen dioxide (NO_2) gas concentration using hot spot analysis. Areas with high levels of NO_2 gas concentration were analyzed in relation to land use. Land use can identify areas that are sources of NO_2 gas emissions.

Temporal analysis of nitrogen dioxide (NO_2) gas concentration in February 2019-December 2021, using descriptive analysis. Time series data on NO_2 gas concentrations in the form of numbers are processed spatially and temporally to describe changes before (February 2019-January 2020) and after the COVID-19 pandemic (March 2020-December 2021). The change in the concentration of NO_2 gas is associated with the number of COVID-19 cases in the Yogyakarta Special Province. The correlation test between the concentration of NO_2 gas and the number of COVID-19 cases in the Yogyakarta Special Province to determine the strength of the relationship between the two variables.

TABLE 1. Class Classification [12]

Correlation coefficient	correlation relationship
0,00	No correlation
0,01 – 0,20	Very weak correlation
0,21 – 0,40	Weak correlation
0,41 – 0,70	Medium correlation
0,71 – 0,99	High correlation
1,00	Perfect correlation

III. RESULT AND DISCUSSION

A. *Spatial and Temporal Distribution of Nitrogen Dioxide (NO_2) Gas Concentration in Yogyakarta Special Region*

Covid-19 pandemic changed the concentration of NO_2 gas. Before the COVID-19 pandemic, from February 2019 to January 2020, the NO_2 gas concentration was 18.1 x 10^{-6} mol/m^2, while after COVID-19, March 2020-December 2021, the NO_2 gas concentration was 17.5 x 10^{-6} mol/m^2. Fig. 3 shows a decrease in the graph. The decrease in NO_2 gas concentration before and after COVID-19 was 3.7%. The decrease in the concentration of NO_2 gas was due to the decrease in community activities outside the home during COVID-19. The same thing also happened in Palembang City, where the concentration of NO_2 gas decreased by 24.5% [8]. Apart from Indonesia, the same thing also happened in Madrid and Barcelona by experiencing a decrease in NO_2 gas by 62% and 50% [5].

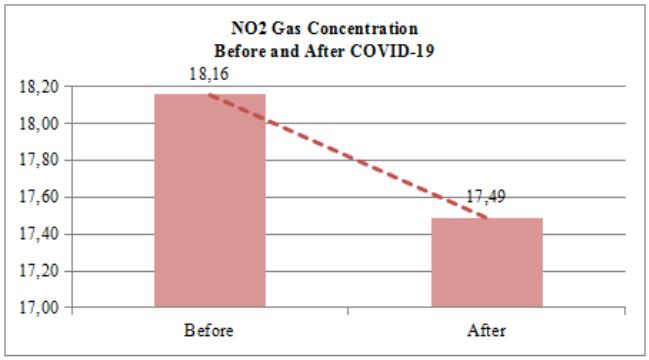


Fig. 2. NO_2 Gas Concentration Diagram

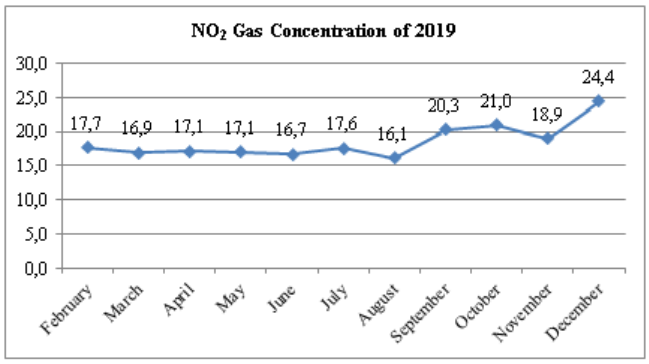


Fig. 3 NO_2 Gas Concentration of 2019

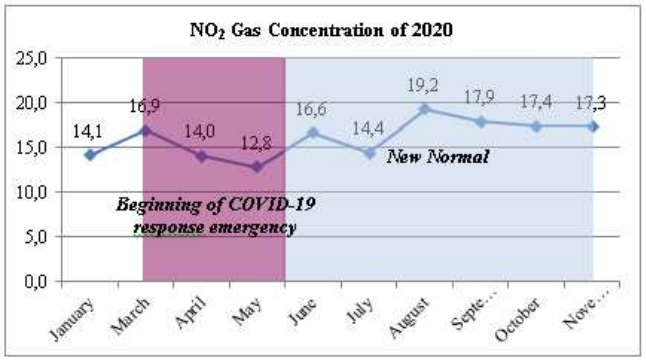


Fig. 4 NO_2 Gas Concentration of 2020

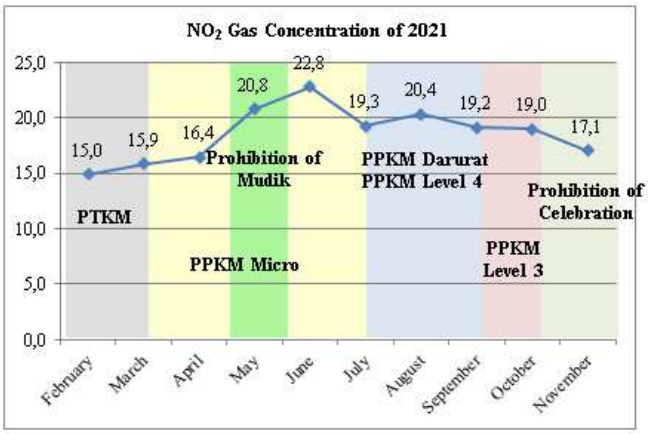
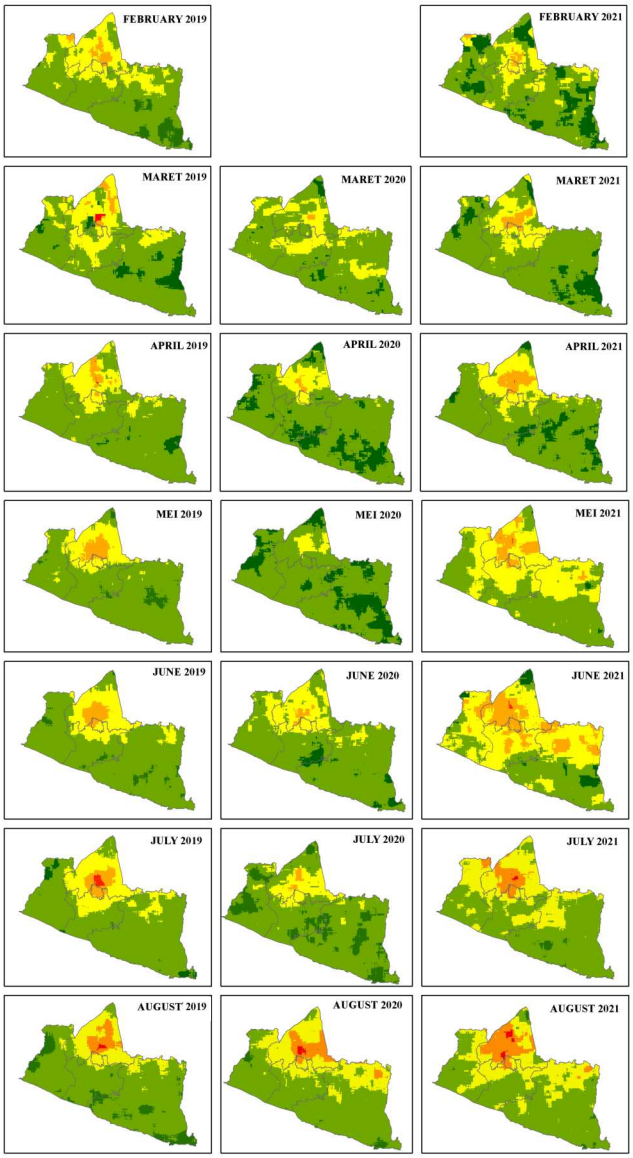


Fig. 5. NO_2 Gas Concentration of 2021

In February 2021, areas with NO_2 gas concentrations of 20-41 x 10^{-6} mol/m^2 have a smaller area and areas with NO_2 gas concentrations <10 x 10^{-6} mol/m^2 are wider than in February 2019. February 2020 has incomplete data, so it cannot be analyzed with February 2019 and 2021 (Fig. 6)



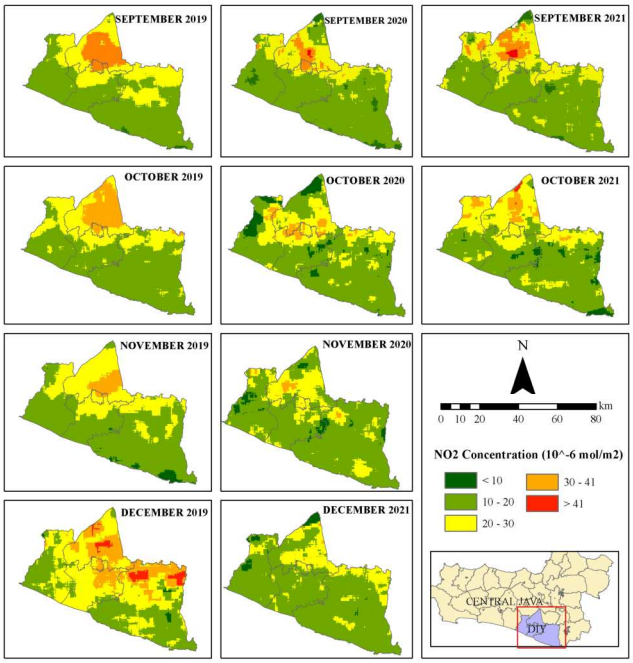


Fig. 6. Temporal Spatial Distribution of NO_2 . Gas Concentration

The concentration of gas NO_2 in March-April 2020 at Yogyakarta Special Province decreased by 2.9 x 10^{-6} mol/m^2 (17%). This can be caused because in April 2020, the Yogyakarta Special Province government began to implement the COVID-19 emergency response, namely by reducing all activities outside the home. The same thing also happened in Salé Morocco, during the lockdown in March-April 2020, there was a decrease NO_2 by 96% [13].

In May 2020, the concentration of NO_2 gas was dominated by green color, namely the concentration of NO_2 gas <20 x 10^{-6} mol/m^2 (Figure 6). This month is the month of Ramadan before the holiday, so it is possible for people to carry out homecoming. Several regions in Indonesia have implemented PSBB (Large-Scale Social Restrictions) to suppress the spread of COVID-19, one of which is DKI Jakarta which applies PSBB in three stages, from April 10 - June 4 2020. Apart from DKI Jakarta, other areas such as Central Java, Java West and East Java also implemented the PSBB policy from April to June [14]. The implementation of PSBB in Palembang City on June 1-15 2020 resulted in a decrease in NO_2 gas concentration by 24.5% [8]. In addition to Indonesia, urban areas in Europe and the USA also implemented a policy of limiting community activities with regional quarantine or lockdown from March to May 2020 which caused a decrease in NO_2 gas concentration by 18-40% [6]. However, the Yogyakarta Special Province does not implement PSBB (Large-Scale Social Restrictions). Even so, community participation in complying with government regulations is very large [14]. This is what causes the least community activity, so that the concentration of NO_2 gas decreases.

In June-August 2020, the concentration of Nitrogen Dioxide (NO_2) gas increased markedly by increasing the size of the yellow and orange colored areas, namely areas with NO_2 gas concentrations of 20-41 x 10^{-6} mol/m^2 (Fig. 6). This is because in that month the Yogyakarta Special

Province began to implement the New Normal policy, so that community activities increased. The peak is in August with an average concentration of NO_2 gas of 19.25 x 10^{-6} mol/m^2. The same thing also happened in East Java Province. In 2020, the highest concentration of NO_2 gas occurred in August at 20.99 x 10^{-6} mol/m^2 [11].

In June-October 2021, the concentration of NO_2 in the Yogyakarta Special Province actually had a downward trend. This could be due to the PPKM Emergency and PPKM level 4 policies in July and August 2021. These policies reduced transportation activities, marked by the lack of vehicles on several roads which are usually crowded with vehicles. Reduced transportation activities can reduce the concentration of NO_2 gas.

December 2019 is the holiday season before Christmas and the new year, people do a lot of activities, the concentration of Nitrogen Dioxide Gas (NO_2) is dominated by yellow to red colors, namely the concentration of NO_2 gas is >20 x 10^{-6} mol/m^2 (Fig. 6). This shows high community activity, then in December 2021, there will be a spatial change in the concentration of NO_2 gas in the Yogyakarta Special Province. The Yogyakarta Special Province area is dominated by green and slightly yellow (NO_2 gas concentration <30 x 10^{-6} mol/m^2), which means a decrease in activity. The Yogyakarta Special Province local government forbids its citizens from celebrating Christmas and New Year. The Yogyakarta Special Province government also tightens and supervises places that have the potential to cause crowds. This has caused a decrease in community activity when compared to before the COVID-19 pandemic in December 2019.

B. The Relationship of Land Use to the Concentration of Nitrogen Dioxide (NO_2)

Residential land use has the highest concentration of NO_2 gas. This is because settlements are the household sector which is one of the sources of NO_2 gas emissions. Sources of NO_2 emission come from household activities such as burning waste and using fuel to process food [15]. Residential land use has the largest distribution in the city of Yogyakarta.

TABLE 2. NO_2 Gas Concentration Based on Land Use

Landuse	Average NO_2 Gas Concentration (10^{-6} mol/m^2)			
	2019	2020	2021	Average
Water body	16,22	14,97	17,39	16,19
Ricefield	19,82	17,19	19,83	18,95
Vegetation	17,43	15,15	17,57	16,72
Settlement	22,85	19,28	22,34	21,49
Industry	20,34	17,72	20,24	19,43
Open field	19,12	16,66	18,94	18,24

Industrial activities are one of the sources of air pollution in urban areas. The use of fuel to support industrial activities produces air pollutant gas emissions, one of which is NO_2 gas [15]. This is the cause of the high concentration of NO_2 gas in the industrial area of the Yogyakarta Special Province.

C. The Relationship between COVID-19 Cases and NO_2 Concentrations in the Yogyakarta Special Province

The high level of human activity outside the home can increase the possibility of direct contact and contamination of COVID-19. This causes the concentration of Nitrogen Dioxide (NO_2) is also high. The increase in NO_2 gas concentration is directly proportional to the increase in the number of COVID-19 cases, so the higher the NO_2 gas concentration, the higher the increase in the number of positive COVID-19 cases in East Java [11].

The relationship between COVID-19 cases and the concentration of Nitrogen Dioxide (NO_2) in the Yogyakarta Special Province was calculated using the Pearson correlation method. The correlation between the number of COVID-19 cases and the concentration of NO_2 gas is 0.39, which is included in the weak correlation category, meaning that the relationship between the variable COVID-19 cases and the concentration of NO_2 gas is weak (Fig. 7). Weak correlation indicates that variable x can affect variable y, but the effect is still weak/doubtful. The concentration of NO_2gas can contribute to the increase in COVID cases in Yogyakarta Special Province by 39%.

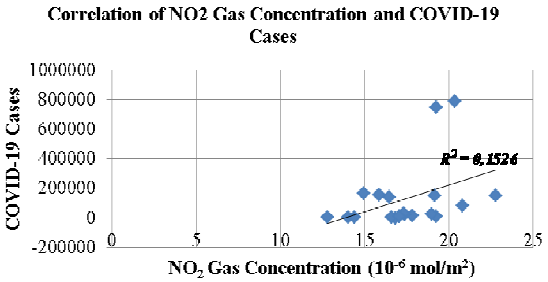


Fig. 7. Graph of Correlation of NO_2 Gas and COVID-19 Cases

IV. CONCLUSSION

The temporal distribution of Nitrogen Dioxide (NO_2) gas concentration before and after the COVID-19 pandemic experienced a decrease in NO_2 gas concentration by 3.7%. Before the COVID-19 pandemic, from February 2019 to January 2020, the NO_2 gas concentration was 18.1 x 10^{-6} mol/m^2, while after COVID-19, March 2020-December 2021, the NO_2 gas concentration was 17.5 x 10^{-6} moles/m^2. The decrease in NO_2 gas concentration was due to the decrease in community activities outside the home during COVID-19. Spatially changes in NO_2 gas concentrations before and after COVID-19 can be seen in the City of Yogyakarta and the southern part of Sleman Regency.

Based on land use, residential and industrial areas have the highest concentration of NO_2 gas compared to other land uses. Residential and industrial areas have the highest spatial distribution in the city of Yogyakarta and its surroundings, such as the southern part of Sleman district and northern part of Bantul district. The number of COVID-19 cases and the concentration of NO_2 gas in the Yogyakarta Special Provincehave a correlation of 0.39 or 39%. The correlation value shows that the relationship between the number of COVID-19 cases and the value of NO_2 gas concentration in Yogyakarta Special Province has a weak relationship.

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