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Abstract. Resilient and sustainable infrastructure development is necessary to support innovative industries. Batang Regency is one of the regencies on the island of Java that is currently intensively building infrastructure to prepare the Batang Integrated Industrial Estate (*KITB*). Therefore, the government also supports this Presidential Regulation Number 79 of 2019 and Presidential Regulation No. 109 of 2020, which observes the development of the Batang Regency Integrated Industrial Estate. When the Covid-19 pandemic hit Indonesia in early March 2020, many changes occurred in the infrastructure development process. Some infrastructure has been temporarily suspended due to the Covid-19 pandemic. Of course, this will be followed by a decrease in emissions due to limited movement and infrastructure development there. This study wants to analyze how the air changes from the beginning of the pandemic until 2022. The air changes will be seen by monitoring NO_2 formed from emissions from cars, trucks, buses, and industry. This is intended to measure/identify how the pattern of air changes considering the Batang District is passed by the *Pantura* road so that there is a high intensity of movement. The method used is spatial analysis with google earth engine Sentinel 5P images. The result of this study can provide input monitoring emissions related to technological advances in the era of open data.

Keywords: air quality, covid-19, emissions

1. Introduction

Covid-19 was first identified in Wuhan at the end of 2019 and spread worldwide at the end of January 2021. The very rapid spread of the virus throughout the world indicates that this is a pandemic behavior [1]. Until March 11, 2020, the World Health Organization (WHO) announced that Covid-19 was a pandemic [2]. Covid-19 entered Indonesia on March 2, 2020, confirmed two positive cases infected by Japanese citizens who had come to Indonesia in February 2020 [3]. To minimize the spread of the virus, many countries have imposed strict restrictions on all regions and access to and from other countries. This regional restriction will undoubtedly positively impact the environment, such as air conditions, one of which is nitrogen dioxide (NO_2) [4][5][6]. Nitrogen dioxide (NO_2) is closely related to burning fossil fuels such as land, sea, and air transportation modes. Indonesia is one of the developing countries where the manufacturing and home industries are the pillars of one of the economies. This is also, of course, related to the fuel for the manufacturing and home industries, which contribute to nitrogen dioxide (NO_2) [7].

Nitrogen dioxide (NO_2) has been reported to cause the formation of atmospheric particulates such as ammonia nitrate [8]. As a result, it can cause cardiovascular diseases such as hypertension, coronary heart disease, and stroke. A significant reduction in NO_2 will undoubtedly reduce the number of deaths

from the disease [6][9]. Recent reports suggest that 8,911 deaths in China could be saved due to NO_2 reduction [6][9]. Several studies also mention the role of pollutants in reducing viral diffusion or increasing the severity after infection with Covid-19 [10][11][12]. Covid-19 has indeed caused damage on all fronts in every country, especially the economy and health, but there is a positive side, one of which is from the environmental aspect [5][13].

Remote sensing undoubtedly offers a tool that facilitates the retrieval of various information and images on the earth's surface [14]. The resulting data varies from high, medium, and low resolution with an extensive scope. In the current conditions and ease of using remote sensing, many researchers use Google Earth Engine to support their research related to air quality [15][16]. Google Earth Engine is an online, open-source platform that allows users to run algorithms on an updated basis in all locations globally. The data used is geographically referenced and stored in Google's infrastructure [16]. This research will utilize remote sensing using Google Earth Engine for monitoring air conditions, especially NO_2.

Batang Regency is one of the regencies on the island of Java that is currently intensively building infrastructure to prepare the Batang Integrated Industrial Estate (*KITB*). The mobility of goods and services in Batang Regency is also relatively high because it is passed by the north coast of Java that connects Jakarta to Semarang City. Of course, with infrastructure development and increased mobility, Batang Regency has the potential to become a contributor to the vehicle and industrial exhaust emissions that can cause various diseases. When the Covid-19 pandemic hit Indonesia in early March 2020, of course, many changes occurred in infrastructure development and the mobility of goods and services. However, infrastructure development is hampered due to regional restrictions, which inhibit the supply of raw materials and the limited mobility of goods and services. This should make the air conditions in Batang Regency better because of the regional restrictions. The reduction in exhaust emissions will be followed by better environmental conditions to support the development of resilient and sustainable infrastructure. This study will show how the air changes, especially NO_2, from the beginning of the pandemic until the face of 2022. This is intended to find out how the pattern of air changes so that later it can be known whether there is a decrease in air quality or not. The processing will use the google earth engine using Sentinel 5P.

With this research, it will be known how the pattern of air changes temporally to be compared to whether there is a significant decrease. Of course, being an innovative industry requires solid and sustainable development. This is a challenge for Batang Regency to support Sustainable Development Goals (SDGs), especially in sustainable infrastructure. The result of this study can provide input monitoring emissions related to technological advances in the era of open data.

2. Data & Methods

2.1. Study Area

Batang Regency is one of the regencies located in Central Java Province and is located on the northern coast of Java Island. Batang Regency stretches from the coastal area to the highlands approaching the Dieng area. Batang Regency is bordered to the west by Pekalongan Regency and City, to the south by Wonosobo Regency and Banjarnegara Regency, to the east by Kendal Regency, to the north by the Java Sea. Geographically, Batang Regency is located between 6^0 51' 46" dan 7^0 11' 47" south latitude and 109^0 40' 19" dan 110^0 03' 06" east longitude. Batang Regency consists of 15 sub-districts with an area of 78,864.16 Ha composed of 81.06% of agricultural land and 18.94% of non-agricultural land. For more details, the following is a study area that can be seen in Figure 1.

Figure 1. Study Area Display in Google Earth Engine

2.2. Data & Proccesing

The data used is Sentinel 5P which aims to monitor the atmosphere, weather, air quality, and the ozone layer. Sentinel 5P used in this study spans the end of 2019 to early 2022. The end of 2019 will start in December to early 2022, starting in March 2022. Sentinel 5P results from a collaboration between ESA, the European Commission, the Netherlands Space Office, industry, data users, and scientists. In addition to this data for the base map, the Batang Regency RTRW data for 2019-2039 will be used. In this study, remote sensing will be operated using the Google Earth Engine for monitoring air conditions, especially NO_2. The NO_2 value used is the mean per month to reduce the data.

Table 1. Monthly Data NO_2 Proccesing

Month	Days	Years			
		2019	2020	2021	2022
January	31		√	√	√
February	28		√	√	√
March	31		√	√	√
April	30		√	√	
May	31		√	√	
June	30		√	√	
July	31		√	√	
August	31		√	√	
September	30		√	√	
October	31		√	√	
November	30		√	√	
December	31	√	√	√	

3. Result and Analysis

This discussion will be divided into four categories: before, during, and transition. Before the pandemic, identification will be carried out for four months; for the time of the pandemic, it will be identified for two years, while the transition will be recognized for three months. The total observation of the distribution of NO_2 will be carried out for 28 months. The analysis results show a decrease in NO_2 in Batang Regency from late December to March 2020. If you look closely, the end of December is when Covid-19 was detected in Wuhan, China. There was a decline in January and February, but there was an increase in March. Early March was the first time Covid19 entered Indonesia. More details regarding the distribution of NO_2 distribution in each month in period one can be seen in Figure 2.

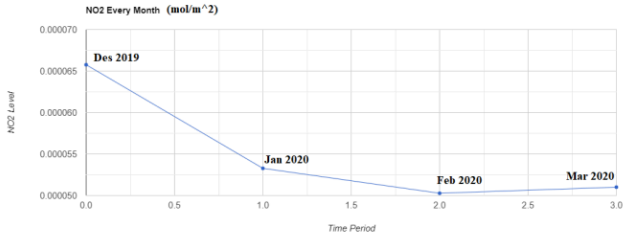

Figure 2. Period 1 Distribution NO2 (Analysis, 2022)

In period 2 in 2020, it is known that there is a fluctuation in the distribution of NO_2. There was a decrease at the beginning, namely from January to May, but there was a significant increase in June. The reduction in NO_2 in March was due to government policies that implemented large-scale restrictions that also affected the mobility of goods and services from Jakarta to Semarang City. The decline occurred in July, but it still fluctuated after that. If seen from these data, infrastructure development and exhaust emissions will not significantly impact Covid-19 in 2020. However, NO_2 can affect susceptibility to Covid-19; this is evidenced by the literature that acknowledges the relationship between cytotoxicity, genotoxicity, and oxidative stress factors [17]. The study [18] also explained the relationship between PM2.5, NO_2 in air, and ACE-2 expression with the severity of SARS-CoV-2 infections. Further literature highlights that environmental conditions may be related to the spread and incidence of Covid-19 [19]. [20] his study also reported that the rise in PM2.5, PM10, and NO_2 was related to 37.8%, 32.3%, and 14.2% of COVID-19 cases, respectively. This certainly strengthens the justification that atmospheric pollutants have a relationship with people's susceptibility to Covid-19 infection. In December, there was a decline because Indonesia entered the 1st wave of Covid-19 from November 2020 to January 2021, so mobility is strictly limited. More details regarding the NO_2 distribution in each month in period two can be seen in Figure 3.

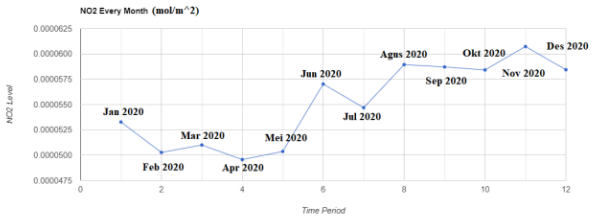

Figure 3. Period 2 Distribution NO2 (Analysis, 2022)

Data NO_2 in 2020 is still moderately fluctuating; there is a decrease from January to February but an increase again in March. There was an increase in May, then a slight decline in June, after which the curve sloped downwards to August. This is due to the 2nd wave of Covid-19 starting in May 2021. The curve tends to rise every month due to the vaccination program that has started to run both stages 1 and 2 so that people are more courageous and feel safe in their mobility. The problem is when you feel safe but forget about health protocols; Covid-19 can spread. As in the study [21], it was explained that population mobility played an essential role during this pandemic.

There was a decline from November to December because Indonesia entered the 3rd wave of Covid, namely the entry of the Omicron variant. If seen, the decrease is quite significant and significantly affects mobility and industries that produce NO_2. A significant reduction in NO_2 is undoubtedly good for the environment and can also reduce the vulnerability impact of Covid-19. Based on research, it is known that air pollution is one of the early causes of human death [22]. In 2014, around seven million people died from diseases related to air pollution [23]. For more details regarding the NO_2 distribution in each month in period three can be seen in Figure 4.

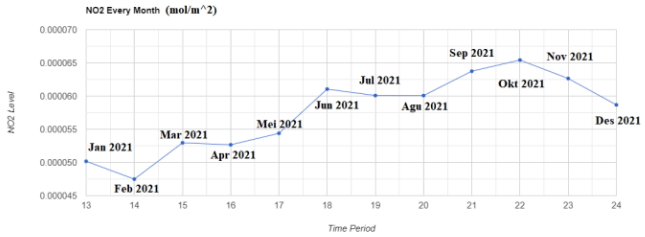

Figure 4. Period 3 Distribution NO_2

In period 3 in 2022, there is still a decrease in NO_2 due to the 3rd wave of Covid-19, but there is a significant increase in March. A downward trend followed this increase in Covid-19 since wave 3 hit Indonesia. If viewed in more detail, in March, the vaccination rate in Indonesia had reached 93.54% for the first dose and 74.15% for the second dose, while for the booster, it was 7.87% [24]. More details regarding the NO_2 distribution in each month in period four can be seen in Figure 5.

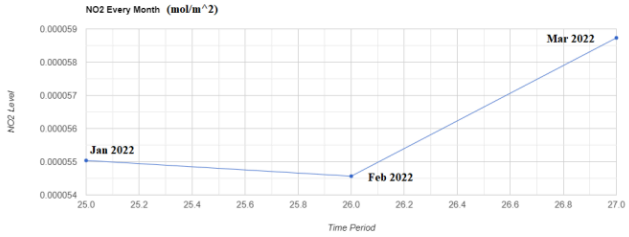

Figure 5. Period 4 Distribution NO2

NO_2 distribution in figure 6, there are only two color classifications, namely blue and purple. The blue level is lower than the purple color, which means NO_2 has a lower level. In the distribution of NO_2 colors entered into the google earth engine script consists of ['black', 'blue', 'purple', 'cyan', 'green', 'yellow',

'red']. The lowest level is black, and the highest is red. If there is no color, then the NO_2 content is in the normal category. In period 1, with an observation time of 4 months, it is known that there are two color variations, namely purple and blue. The distribution of NO_2 is known to be concentrated in the south, namely Wonotunggal, Bandar, Blado, Reban, and Bawang Districts. If you look closely, this area is passed by provincial roads which have high mobility in addition to the northern coast of Java (Pantura). Seen in Bandar District, there is a concentration of NO_2 in the area of the city health center, Bandar market, and tourist attractions (Water Boom Bina Garut, Bandar EcoPark, and Curug Sidangkong). In period 1, the NO_2 data was mainly in December 2019, while in 2020, the NO_2 level had dropped. For period 2, which was observed for 12 months, it is known that there was a significant decrease from 2019. Therefore, the distribution of NO_2 is only found in 2 sub-districts, namely Wonotunggal District and Bandar District, with a distribution that is not too wide. With a significant reduction in NO_2 in 2020, the mobility of goods and services and industries that produce NO_2 will decrease or stop temporarily. In period 3, there was an increase in NO_2 because the vaccination rate continued to rise, and people felt safer and moved and worked in the industry. In period 4, NO_2 is still in the normal category from January to March 2022. More details regarding the Distribution Temporal NO_2 19 December 2019 – 31 March 2022 can be seen in Figure 6.

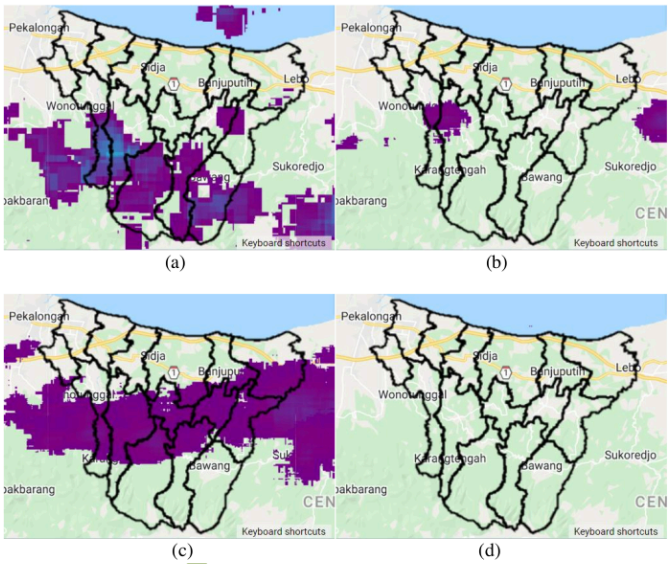

Figure 6. (a) Period 1, (b) Period 2, (c) Period 3, (d) Period 4

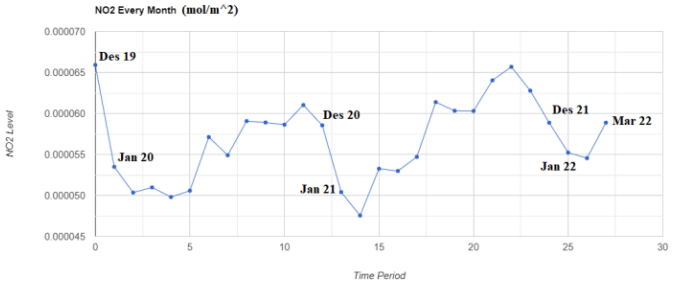

Figure 7. Distribution Temporal NO2 19 December 2019 – 31 March 2022

4. Conclusion

The conclusion that can be drawn from this research is that there will be a decrease in NO_2 levels in Batang Regency in 2020, but in 2021 there will be another increase. This is because people feel safe in mobility after vaccination. Therefore, NO_2 level monitoring needs to be carried out continuously to support a healthy environment and the SDG program. Sentinel 5P in NO_2 monitoring can be used and is very helpful with the availability of real-time data. Furthermore, in this era of data disclosure, the Google Earth Engine platform can assist remote sensing analysis, especially monitoring NO_2 as in this study.

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