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Air Pollution Changes of Jakarta, Banten, and West Java, Indonesia During the First Month of COVID-19 Pandemic

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Abstract

Purpose: This research aims to explore the level of air pollution in Jakarta, the epicenter of COVID-19 Pandemic in Indonesia and its surrounding provinces during the first month of the Pandemic. **Research design, data and methodology:** This study uses data, which have been obtained real time from API (Application Programming Interfaces) of air quality website. The measurements of Air Quality Index (AQI), temperature, humidity, and other factors from several cities and regencies in Indonesia were obtained eight times a day. The data collected have been analyzed using descriptive statistics and mapped using QGIS. **Results:** The finding of this study indicates that The Greater Jakarta Area experienced a decrease in pollutant levels, especially in the Bogor area. Nevertheless, some areas, such as the north Jakarta, have exhibited slow reduction. Furthermore, the regions with high COVID-19 confirmed cases have experienced a decline in AQI. **Conclusions:** The study concludes that the air quality of three provinces, Jakarta, Banten, and West Java, especially in cities located in the Jakarta Metropolitan Area during COVID-19 pandemic and large-scale social restrictions, is getting better. However, in some regions, the reduction of pollutant concentrations requires a longer time, as it was very high before the pandemic.

Keywords : Air Quality Index, COVID-19, Air Pollution, Big Data

JEL Classification Code: I18, Q53, R12

1. Introduction

Pandemic COVID-19 has led to the disruption of worldwide activities. Many countries have been forced to keep their citizen home. The lockdown policies to decrease the spread of COVID-19 have led to almost no social activities.

Globally, researchers have shown the declining air pollution and witnessed a massive reduction ~~on~~ in air pollution all over the world during the pandemic. All of China, especially Wuhan, the city where the novel Coronavirus originated, shows biggest air pollution reduction (BBC, 2020). Other countries, such as France, also have had a drastic reduction. Air pollution in Paris has dropped to an astonishing 50% (Bartels, 2020). Furthermore, China's CO_2 emissions have fallen by a quarter after quarantine period (Dutheil, Frédéric, Baker, Julien. S., & Navel, 2020).

The IQAir's scientists have investigated ten major cities (Delhi, London, Los Angeles, Milan, Mumbai, New York City, Rome, São Paulo, Seoul and Wuhan), which have quite a high number of COVID-19 cases and lockdown regulation or halted activities in regencies around the world in response to the COVID-19 pandemic. They report that due to the limitation of economic activities and lockdowns, air pollution can diminish fine particulates ($PM_{2.5}$) of up to 60% as compared to 2019 condition (IQAir, 2020).

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In addition, some studies have also investigated the relationship between the risks of getting COVID-19 with the high level of air pollution (Martelletti & Martelletti, 2020). Other studies have observed the correlation between COVID-19 infections and outdoor air pollution concentrations using regression model in Wuhan and other provincial capitals in China (Han, Lam, Li, Guo, Zhang, and et al, 2020). A study in the United State has also investigated the association death rate of COVID-19 with $PM_{2.5}$ level (Wu, Nethery, Sabath, Braun, and Dominici, 2020).

Unlike China, France, and other countries that did an intensive lockdown, Indonesia has only issued a social distancing regulation. In the beginning of March 2020, the government has announced the first confirmed cases in the capital, Jakarta. To prevent the spreading of the Coronavirus while keeping the economy running, the Indonesian government has decided not to apply a full lockdown but to regulate physical distancing and work from home regulations. Hence, the activities in Jakarta which is not as strict as in other countries, makes the improvement of air quality in Jakarta is less drastic. Still, people have stayed home and limited their mobility that would emit air pollution.

In the age of Big Data, massive and real-time data of different structures can be used for policy making (Pramana, Setia ; Yuniarto, Budi ; Kurniawan, Robert ; Lee, Jonggun ; Putu, Ni Luh; Amin, 2017). One of the big data sources measuring air pollution is AQI, which obtains almost hourly combining from different stations all over the world.

The goal of this research is to explore the level of air pollution in Jakarta, the epicenter of COVID-19 Pandemic in Indonesia and its surrounding provinces, Banten and West Jakarta. This study also focusses on air pollution of Jakarta Metropolitan Area (known as Jabodetabek), which refers to Jakarta and the regencies which have direct border with Jakarta, including Jakarta, Bogor, Depok, Tangerang and Bekasi.

2. Literature Review

Air pollution is defined as the occurrence of materials which contain toxic chemicals or composites in the air, having an effect of health risk for livings beings. World Health Organization (WHO, 2010) determines the limits of the concentration of air pollution for outdoor and indoor pollution from buildings or homes that are harmful to the health. The indoor pollutants contain benzene, carbon monoxide, formaldehyde, naphthalene, nitrogen dioxide, polycyclic aromatic hydrocarbons, radon, trichlorethylene and tetrachloroethylene. Ambient air pollution is measured mostly by the concentration of PM_{10} and $PM_{2.5}$ (WHO, 2016). The Air quality guidelines for Europe had been produced since 1958 and constantly being ratified and improved (Maynard et al., 2017).

The U.S Environmental Protection Agency (EPA), on the other hand, established six criteria of air pollutants for the National Ambient Air Quality Standard (NAAQS) that can endanger environment and human health. These pollutants are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO_2), ozone, PM_{10}, $PM_{2.5}$ and sulfur dioxide (SO_2) (EPA, 2017). Air pollution can be measured by Air Quality Index (AQI) value and the level of Air Quality Index is explained in Table 1.

Table 1: Level of Air Quality Index

Levels of Air Quality Index	Value	Meaning
Good	0 to 50	Air quality is satisfactory and poses little or no risk
Moderate	51 to 100	Air quality is moderate health
Unhealthy for sensitive group	101 to 150	Sensitive group may experience health effects, but others may not be affected
Unhealthy	151 to 200	Everyone may experience health effects, and for sensitive groups may have serious health effects
Very Unhealthy	201 to 300	Everybody may experience more serious health effects
Hazardous	301 to 500	Emergency conditions.

Source: NASA space, 2020

AQI AirVisual aggregates and validates air quality data from governments, private individuals, and non-governmental organizations. The site reports median air quality data of several ground stations of that city for which public data is available. For Jakarta, there are 37 ground level stations, most of which are Indonesian government stations that report data publicly.

For Indonesia, there are two approaches for the AQI calculations, US and Indonesian AQI. The US AQI is globally well established and closely aligned with the air quality guidelines of the World Health Organization (WHO). Indonesian AQI has not yet included $PM_{2.5}$ pollutant data. For regions with no $PM_{2.5}$ monitoring, air visual applies AI to estimate $PM_{2.5}$ based on PM_{10} measurements. For this study, we use the US AQI.

3. Research Methods and Materials

The AQI data of several cities and region in Indonesia is obtained from www.airvisual.com. The information, such as AQI, temperature, humidity, etc., is obtained eight times a day from API (Application Programming Interfaces) (https://website-api.airvisual.com/v1/cities/location_id). Python modules Requests and Beautifulsoup are used to render and parse the HTML to gather all specified locations. Around 2000 locations have been compiled daily throughout Indonesia during January, March, and April of 2020. This study investigated the AQI of 45 cities and regencies of three provinces in Indonesia, e.g., Jakarta, Banten, and West Java. Furthermore, the focus is at Jakarta and its surrounding regions (Jakarta Metropolitan Area) which is the epicenter of COVID-19 pandemic in Indonesia. The number of COVID-19 cases is obtained from the government's official COVID-19 website, COVID-19.go.id. The data collected is analyzed using descriptive statistics and mapped using QGIS.

AQI average

AQI average is the average AQI value over a certain time span in the *i*-th region. The formulation of the calculation is as follows:

$$AvgAQI_i = \sum_{t=0}^{n} \frac{AQI_{it}}{n}, \qquad (1)$$

t = date,
n = number of observations.

Change in AQI average

The change in average AQI is the difference in value from the average AQI in the *i*-th region between n_2 periods and n_1 periods. The formulation is as follows:

$$ChangeAQI_i = \sum_{t1=0}^{n1} \frac{AQI_{it1}}{n1} - \sum_{t2=0}^{n2} \frac{AQI_{it2}}{n2} \qquad (2)$$

t1 =date of period 1,
n1 = number of observations period 1,
t2 = date of period 2,
n2 = number of observations period 2.

4. Results and Discussion

Monthly average of Air Quality Index of January to April, in 45 cities of Jakarta, Banten and West Java, varies from 51 to 187. It shows that, in general, some region has moderate quality, while some have unhealthy air.

Figure 1 shows the heatmap of daily AQI from 45 cities, from January, March and April 2020. It shows that some regencies such as Bogor and West Bogor have high AQI in the beginning of the year but then get lower AQI during March and April. However, some region tends to have similar AQI.

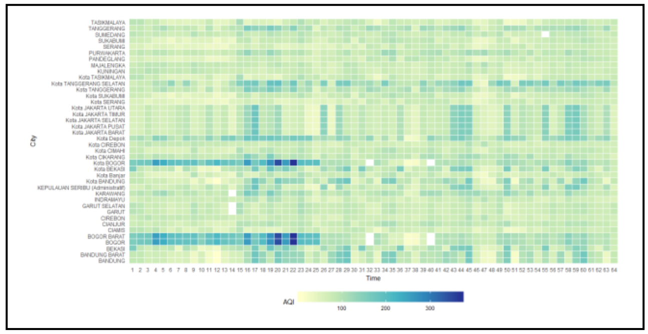

Figure 1: Heatmap of AQI from 45 cities and regencies in Jakarta, Banten and West Java.

Figure 2 shows the map of AQI average for January, March and April 2020. Jakarta, the capital, tends to have moderate air quality during the period, while some regions tend to vary over the period.

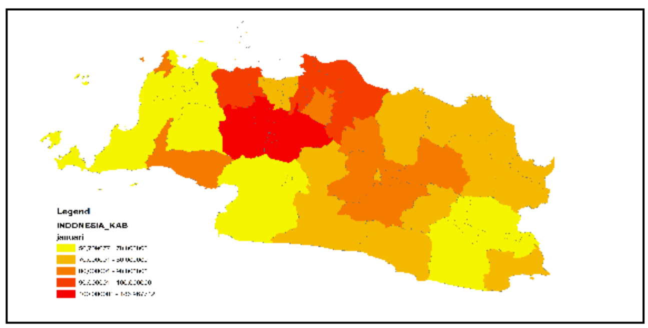

Figure 2.a: AQI average of January 2020 in Jakarta, Banten and West Java

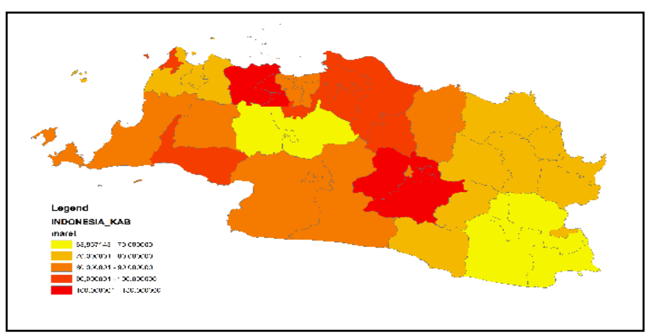

Figure 2.b: AQI average of March 2020 in Jakarta, Banten and West Java

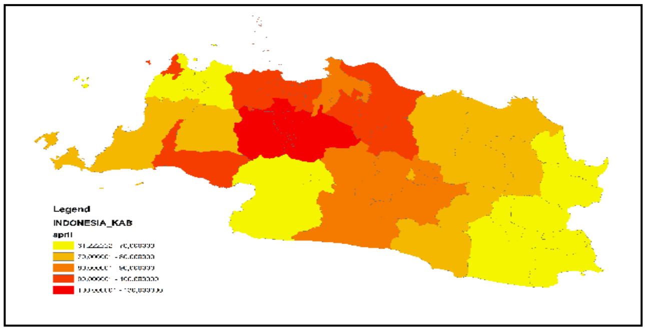

Figure 2.c: AQI average of April 2020 in Jakarta, Banten and West Java

The condition of AQI also indirectly provides an overview of people mobility within an area. In addition, it can also indicate productivity and activities of industries with dominant pollutants in the form of $PM_{2.5}$. Conditions in the Tangerang region, which is also located in the Soekarno-Hatta International Airport, lead to high levels of pollutants.

Indonesia announced its first COVID-19 case on the 2nd of March. Two weeks after that, in mid-March, the Jakarta local government announced work from home policy for all civil servants in Jakarta and private companies as well. In the beginning of April, large-scale social restrictions (PSBB) in Jakarta were implemented. This restricted much more activities with stricter law enforcement. The moderate air quality in Jakarta during the COVID-19 outbreak period shows how Jakarta has been dominated by commuters, despite the pandemic situation.

One area of interest is the southern area around Lebak and Cilangkahan regencies. In contrast to the surrounding area, it appears that the two regions have high levels of pollutants. This may be due to the dense start of the area. Jakarta commuting seems to come from surrounding areas, such as Bekasi, Bogor, Depok and Tangerang. Figure 3 indicates that, in general, the Jakarta Metropolitan Area experienced a decrease in pollutant levels, especially in the Bogor area.

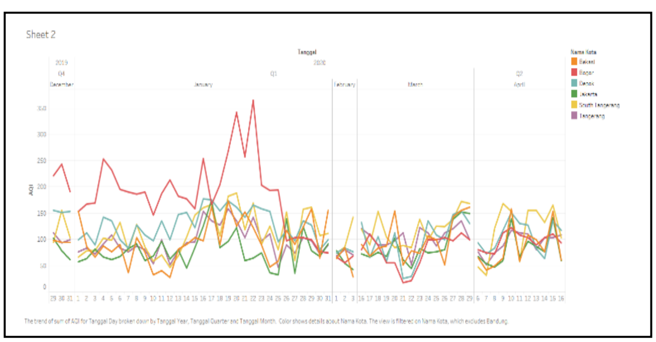

Figure 3: Daily AQI The Jakarta Metropolitan Area

The AQI of Bogor has significantly decreased from 350 (very unhealthy) to below 100, which is moderate. This may be due to mobility restrictions, so areas that are usually crowded throughout the week for both commuting and tourism have decreased levels of pollutants. Although other regions tend to be constant, on average, there is also a slight decrease in pollutant levels.

The map of COVID-19 confirmed case distribution that occurred around Jakarta, West Java, and Banten, can be seen in Figure 4; the distribution seems to be concentrated and dense in the Jakarta area. The condition of high population density on normal days before the virus struck shows Jakarta's vulnerability to the quick spread of the virus. Coupled with the condition of Jakarta on a normal day that is quite dense with tourists, Jakarta's vulnerability to the danger of the COVID-19 outbreak is also strengthened.

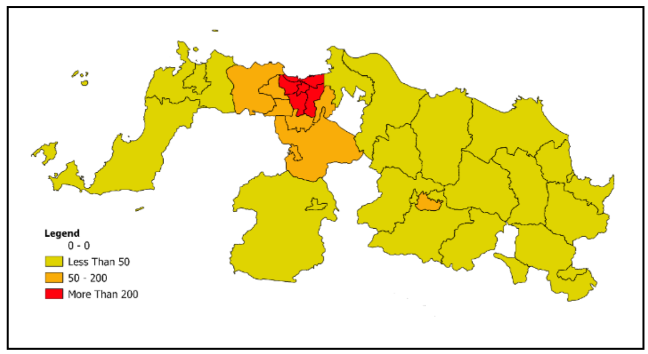

Figure 4: Number of Positive COVID-19 Cases in Jakarta, West Java and Banten Provinces

By the 17th of April 2020, there have been 5,923 confirmed cases in Indonesia, with 2,815 cases (47.5%) in Jakarta, 632 cases (10.7%) in West Java province, and 311 cases (5.2%) in Banten province. These cases account for almost 64% of all cases in Indonesia. The number of confirmed cases of metropolitan Jakarta cities are 174 in Bekasi, 147 in Depok, 85 in Tangerang, and 58 in Bogor, (See Table 2 and Figure 5).

Table 2: Number of Positive COVID-19 Cases in Indonesia, Jakarta, West Java, and Banten Regions until 17th April 2020

Regency	Number of Positive COVID-19 Cases	Number of COVID-19 Death
Indonesia	5923	520
Jakarta	2815	194
West Java	632	96
Banten	311	36

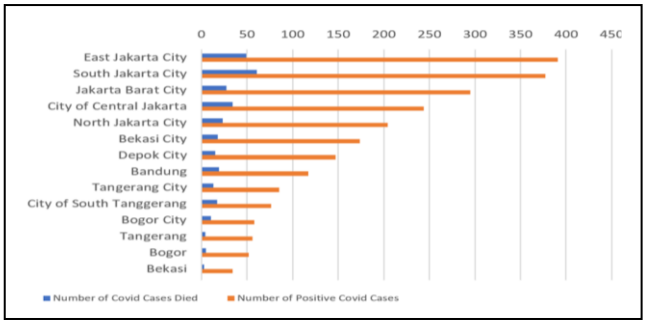

Figure 5: Bar plot of Number of Confirmed and death cases of COVID-19 Cases in Jakarta and surrounding cities and regencies by 17th April 2020

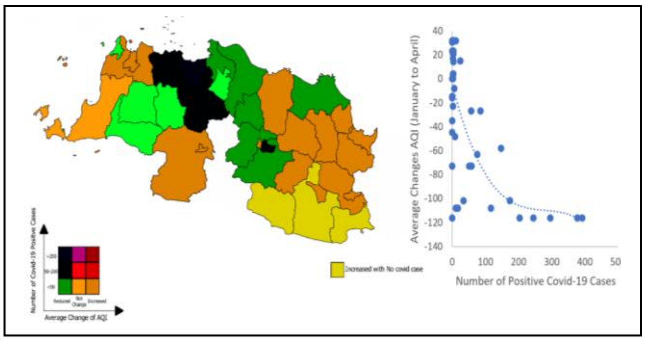

Figure 6: Overlay Average Change AQI (Jan-Apr) with Positive Cases of COVID-19 and Scatter plot with three degree of polynomial line

It can be seen from Figure 6 that regions with high confirmed cases like Jakarta and Bogor experienced a decline in the value of AQI. On the other hand, regions with low cases or even no cases have experienced an increase in AQI. This supports the belief that population mobility within districts during COVID-19 quarantine tend to reduce the pollutant produced leading to better air quality.

Furthermore, from the scatter plot of number of cases against the AQI change in Figure 6, a declining trend with a polynomial pattern can be seen. The correlation value of -0.66, shows a moderate correlation. The change in AQI in the Jakarta metropolitan was associated by the COVID-19 outbreak.

5. Conclusions

The air quality of three provinces, Jakarta, Banten, and West Java, especially cities located in the Jakarta Metropolitan Area during COVID-19 outbreak and large-scale social restrictions is better. It was found that the areas with high confirmed cases have higher reduction in pollutants. However, in some areas, the reduction is slow, which may be due to some factories and power plants still operating in business and factory areas. The pollutants concentrations need longer time to reduce as it was very high before the pandemic.

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