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Analysis of Air Pollution (SO2) at Some Point of Congestion in DKI Jakarta

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ABSTRACT

Background: Air pollution is the entry or inclusion of energy substances from other components into the air by humans so that air quality drops to a certain level which causes the air to not meet the requirements. This study aims to determine concentration levels of particulates (PM10, PM25), sulfur dioxide (SO2), carbon monoxide (CO), ozone (O3), and nitrogen dioxide (NO2) at several congestion points in *Daerah Khusus Ibukota* (DKI) Jakarta. **Method**: The research location based on the purposive sampling method was carried out at 5 congestion points in DKI Jakarta namely Bundaran Hotel Indonesia (HI), Kelapa Gading, Jagakarsa, Lubang Buaya, and Kebon Jeruk. The data used in the process of forming the model using the Box-Jenkins method and analyzed manually, so this process can be done using ARIMA Forecasting. **Results**: Based on the time series of hourly data, which was calculated on average into daily data, the concentration of PM10, PM25, SO2, CO, O3, and NO2 from January to October 2021 has decreased from the previous months at several congestion points in DKI. **Conclusion**: The conclusion of this study is the decreased concentration of PM10, PM25, SO2, CO, O3, and NO2 at several points in DKI Jakarta, so it is recommended to the Government and the Community make efforts/activities to maintain the healthy air quality in DKI Jakarta.

Introduction

Jakarta, the country's capital, has been declared the capital city with the highest degree of air pollution in the world. The air pollution is measured in this case using the PM10 and PM25 concentration indicator values [1]. This is inextricably linked to a number of other elements that contribute to pollution, such as emissions from motor vehicles and industrial operations. With a population of more than 10 million people and a land area of only 699.5 square kilometers, it has an impact on urban inequality as the seat of government, business, and industry, as well as the symbol for the concentration of all community activities [2].

Air is essential for the existence of all living things, including humans. Air, Air is a mixture of gases found in the earth's strata [3]. It is made up of 78% nitrogen, 21.94% oxygen, 0.93% argon, 0.032% carbon dioxide, and other noble gases in the atmosphere [4]. We need to breathe air on a daily basis. Humans and other species are unable to live without the presence of air.

The need for air for humans is prioritized over the need for food and water. An adult's average daily air need is 15 kg, whereas their daily food and water requirements are 1.5 kg and 2.5 kg, respectively [5]. The atmosphere is a collection of gases that surrounds the earth with a chemical composition that is not always constant due to the existence of gases emitted into the air by objects. Air can contain both organic (benzene, naphthalene, formaldehyde) and non-organic (smoke and dust) particles in addition to chemical substances [6].

Excessive usage of motorized vehicles, according to the Ministry of Environment and Forestry (KLHK), is the largest source of air pollution in major cities, including DKI Jakarta [7]. As a result, Jakarta residents must modify their mode of mobility by actively adopting public transit to improve air quality. In addition, the odd-even license plate policy and Car Free Day in DKI Jakarta can help to clean up the air. CO2 emissions have decreased by 28% since the regulation was adopted [8]. If the situation differs from normal due to excessive quantities of contaminants that cause environmental harm and human health problems, the air is said to be polluted [9]. Air pollution can be generated by emissions from a variety of sources, including natural processes and human activities that emit toxins into the atmosphere [10].

Here are some sources of pollution caused by natural processes and human activities so-called Natural Process such as Volcanic Eruption. Because Indonesia is a country with many volcanoes, natural disasters caused by volcanic eruptions are common. Lead, copper, zinc, iron chromium, and silica are all found in volcanic ash [11]. CO2 is one of the main causes of air pollution caused by volcanic eruptions, among the numerous gases generated by volcanic eruptions [12]. All volcanoes in the world are estimated to emit 0.13 - 0.44 billion tons of CO2/per year [13]. Drought can cause forest fires over the long dry season. The heat generated by the stone with other things that can store and conduct heat causes the dry twigs and leaves to burn naturally. Because woods are naturally a location to absorb CO2, forest fires will release CO2 gas into the sky [14]. In addition to CO2, forest fires emit hydrocarbons, CO, SO, NO, and NO2, as well as smog in the form of tiny particles mixed with dust, all of which contribute to air pollution.

The other cases are caused by human activities like transportation. There is 70% of city people have inhaled polluted air as a result of motor vehicle emissions [15]. Every year, the number of automobiles on the road in Indonesia grows, generating traffic congestion and perhaps increasing air pollution. The proportion of motor vehicle exhaust emissions as a source of air pollution is 60–70% [16]. Diesel or gasoline is commonly used in motorized vehicles to generate energy for operation. Hydrocarbon molecules are present in the fuel, which are then burned to produce CO2. In actuality, the engine cannot entirely burn hydrocarbons, and the vehicle exhaust contains toxic compounds that pollute the air. CO, NO2, and VOCs are produced as a result of incomplete combustion. As the industry expands, particularly in metropolitan areas, numerous toxins are emitted into the air as a result of industrial waste. Industrial garbage or industrial waste is residual residue from a manufacturing process that contains harmful and dangerous compounds. Chemical and food industrial waste, as well as metal and electronics industrial waste, have different consequences on air pollution [17-18].

According to the study's findings, the contribution of industrial waste in the form of gas is responsible for more than 90% of air pollution in industry. Hazardous pollutants such as CO, CO2, SO2, NO, hydrocarbons, and organic compounds are produced by a number of industrial businesses. CO2 is emitted into the atmosphere by industrial activities that burn fossil fuels. However, some operations, such as the cement industry, the metal sector, such as iron and steel, and chemical manufacture, produce CO2 through chemical reactions that do not entail burning [19]. The cement industry produces CO2 in the production process through a number of activities [20], including the utilization of electrical energy, the process of burning fossil fuels for energy or transportation, and chemical reactions in the clinker calcination process. The more clinker creates, the more CO2 is emitted into the atmosphere.

The issue of air pollution has recently become one of the key issues of discussion among numerous parties, particularly the state of air quality in Jakarta, Indonesia's capital. This has gotten quite hot as a result of the AirVisual application's air quality data, which demonstrates that Jakarta has poor air quality when compared to other cities across the world. Furthermore, the inhabitants of

Jakarta as a whole complain about the poor air quality, which is thought to be harmful to their health. Several air quality indicators are offered to the public in this regard. PM10 and PM2.5 are two of them. Thus, Particulate Matter (PM) is a type of air pollution that consists of a mixture of solid and liquid particles trapped in free air. Typically, this PM indicator refers to the mass concentration of particles with a diameter of less than 10 μm (PM10) and less than 2.5 μm (PM2.5) that have a negative impact on health (PM2.5). PMs with sizes ranging from 0.1 μm to 10 μm can last for days or weeks in the atmosphere. It has the potential to spread across regional and national borders.

According to data from AirVisual, a website that publishes daily online pollution maps of major cities across the world, Jakarta is the city with the worst air quality, especially as the dry season approaches in July 2019. The Air Quality Index (AQI) places Jakarta's air quality in the very unhealthy category. Jakarta has a population of 240 people. Basic ozone, particle matter, carbon monoxide, sulfur dioxide, and nitrogen dioxide are the five main air pollutants used to calculate the AQI.

Materials and Method

The data used in this study is data on air pollution by PM10, PM25, SO2, CO, O3, and NO2 in the Special Capital Region (DKI) including the HI Roundabout, Kelapa Gading, Jagakarsa, Lubang Buaya, and Kebon Jeruk obtained from the Environment Agency [21]. DKI. This data is daily air pollution data for PM10, PM25, SO2, CO, O3, and NO2. The data used ranges from January 1, 2021, to October 31, 2021, with a total of 1,519 records.

The research procedure has special rules for entering data for analysis, which is referred to as a simulation procedure as shown in Figure 1. The data used in the process of forming the model using the Box-Jenkins method is too large and difficult to analyze manually, so this process can be done using ARIMA Forecasting.

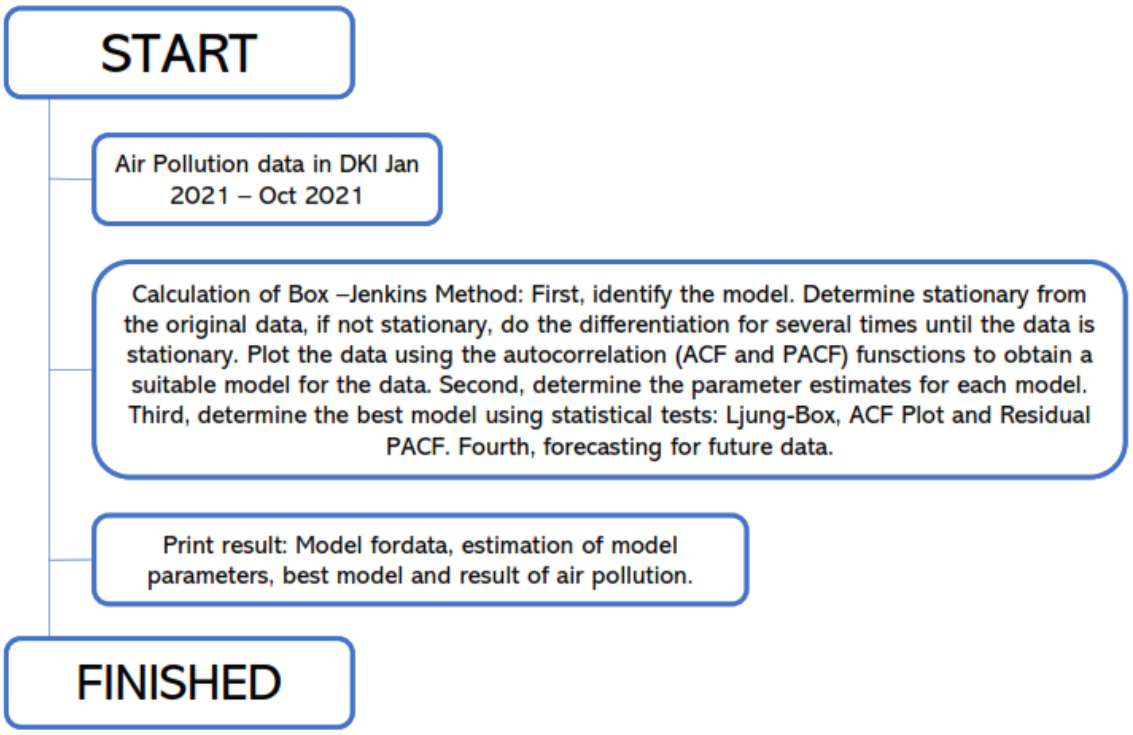

Figure 1. The Flowchart of Research Method

This research comes up with some references provided in Table 1 giving elaboration on data Air Pollutant. The Air Pollutant Standard index is a number without units that describes the state of ambient air quality at a certain location and time based on human health, aesthetic value, and other living things.

The data for the Air Pollutant Standard Index comes from the Automatic Ambient Air Quality Monitoring Station's operation. Particulate matter (PM10), carbon dioxide (CO), sulfur dioxide (SO2), nitrogen dioxide (NO2), and ozone are among the Air Pollutant Standard Index parameters (O3). In the Attachment to the Decree of the Head of the Environmental Impact Management Agency No. 107 of 1997 concerning the Calculation and Reporting and Information on Air Pollution Standards Index, the criteria used in obtaining the SPU value are outlined in further depth shown in Table 2.

Table 1. National Ambient Air Quality Standard

Parameter	Time	Quality Standard (µg/m^3)
Aerosol (PM_{10})	24 hour	150
Carbon monoxide (CO)	1 hour	30000
	24 hour	10000
Ozon (O_3)	1 hour	235
	1 year	50
Sulfur dioxide(SO_2)	24 hour	365
	1 year	80
Nitrogen dioxide (NO_2)	1 hour	0.25
	1 year	100

Table 2. SPU measurement basic parameters and measurement time period

Parameter	Measurement Time (average)
Particulate (PM_{10})	24 hour
Sulfur dioxide(SO_2)	24 hour
Carbon monoxide (CO)	8 hour
Ozonei(O_3)	1 hour
Nitrogen dioxide (NO_2)	1 hour

The SPU value is used to categorize the air quality conditions in a location as a result of this calculation. The qualification is based on the principal pollutant parameter's SPU value shown in Table 3.

Table 3. Category Air Quality based on SPU Value

SPU Value	Category
0 – 50	Good
51 – 100	Medium
101 – 199	Unhealthy
200 – 299	Very Unhealthy
> 300	Dangerous

Results and Discussion

Results

The effect of carbon monoxide (CO) gas concentration on human and animal health is as follows: the SPU index is categorized as excellent (0-50), meaning it has no effect on humans or animals (Figure 2). The SPU value of 51-100 falls into the moderate category, indicating that CO gas exposure causes changes in blood chemistry, even if these are not observed. CO gas exposure begins to exacerbate cardiovascular disease in smokers with heart disease in the range of 101-199, which is considered harmful. Exposure to CO gas will aggravate cardiovascular illness in nonsmokers with heart disease, and there will be some obvious weaknesses, in the range of 200-299, which is regarded as highly unhealthy.

The concentration of PM10, PM25, SO2, CO, O3, and NO2 from January to October 2021 has reduced from prior months at many congestion points in DKI, as shown in the Figure 2, based on hourly time series data that is averaged into daily data following. The following is the plot of the ISPU SPKU per congestion point area of every month.

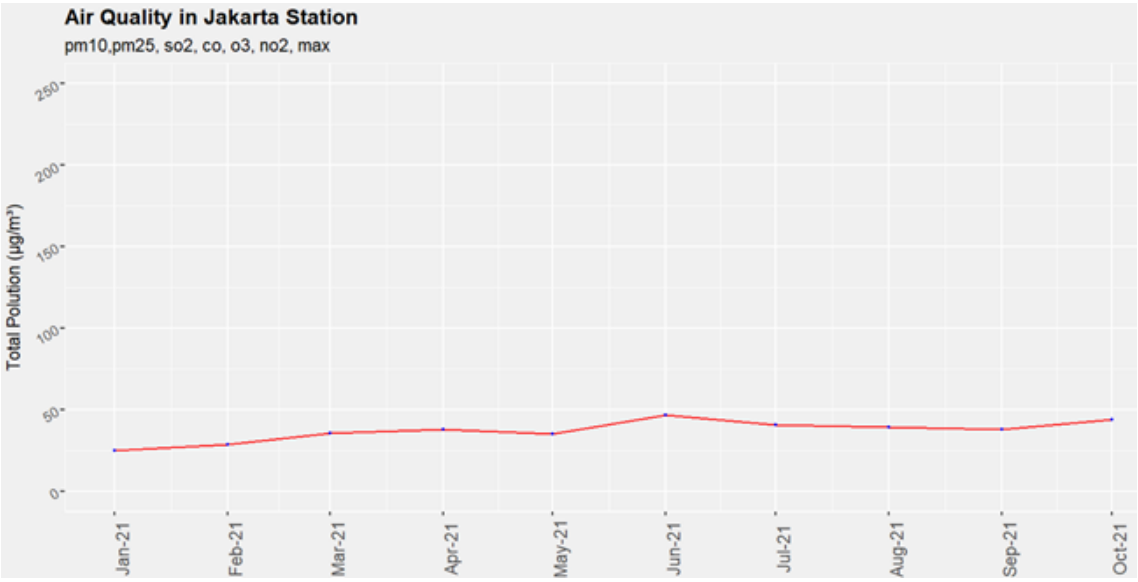

Figure 2. Monthly ISPU in 5 AQMS

In addition to the addition of parameters, there is an increase in the frequency of delivering ISPU information to the public. The results of the PM2.5 ISPU calculation are submitted to the public every hour for 24 hours. Meanwhile, the results of ISPU calculations for PM10, NO2, SO2, CO, O3, and HC parameters are submitted to the public at least 2 (two) times in 1 (one) day at 09.00 and 15.00. ISPU calculation is done based on the upper limit ISPU value, lower ISPU limit, upper limit ambient, lower ambient, and ambient concentration measurement results.

This dataset contains the Air Pollution Standard Index (ISPU) measured from 8 air quality monitoring stations (SPKU) in DKI Jakarta Province in 2021 (Figure 3).

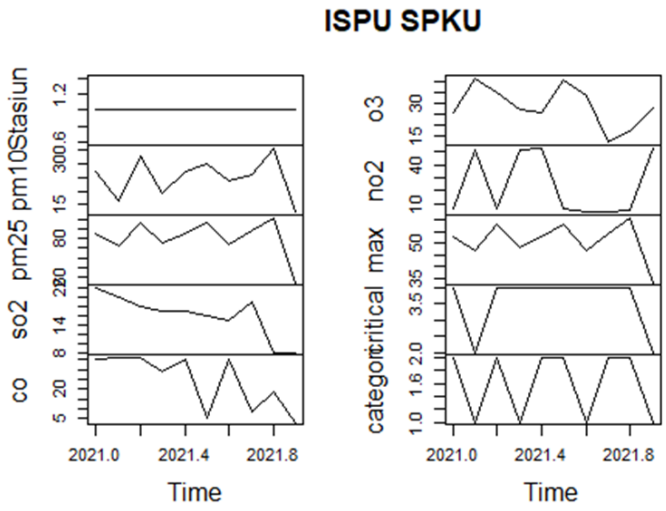

Figure 3. The plot of DKI SPKU SPU

The following is the plot of the Air Pollutant Standard Index or *Indeks Standar Pencemaran Udara* (ISPU) AQMS per congestion point area (Appendix). On the sets of Air Pollution standard index that reported on DKI Jakarta are directly showed the ISPU calculation are submitted to the public at least 2 (two) times in 1 (one) day. The measurements that shown the values of parametres on 300,6 and the critical max are or upper 40. This indicating the index of air pollution are not dangerous and enable the good air for the environment.This is directly different as the estimation of index on HI cycles stations, which are belonged on below (Appendix, Figure 5).

Where the set air pollution standard index has shown the values of pm01 station are on 15 and the critical max are upper than 1,0. This directly indicated the pollution air are still safe for the environment. This also connected with the plot of ISPU on Kelapa Gading stations where the values on the parametres significantly not really higher and the critical max are not moved (Appendix, Figure 6). While, on the plot that shown on the Jagakarsa stations above currently improved to 70 values and this is indicating the air pollution on there still on the medium and this is currently need the efforts for the people to keep the healthy air without any healing of the air (Appendix, Figure 7). Conditions on Lubang Buaya are higher than Kebon Jeruk situations. Which are the values on station of Lubang Buaya are on 40 (Appendix, Figure 8) while on the parametres values of Kebon Jeruk are on the 20 (Appendix, Figure 9). Even though, this is not directly dangerous but it could be one of aspect that should obey by the people on the all round of the environment. Beside, preventing the air polllution. It should currently know how to prevent from the factors such as the wasting the smoke on all round of the environment.

This dataset contains the ISPU measured from 5 Air Quality Monitoring Stations (AQMS) in DKI Jakarta Province in 2021. The explanation of the variables from the data is as follows: 1. date: Date of air quality measurement 2. pm10: Particulate one of the measured parameters 3. pm25: Particulate one of the measured parameters 4. so2: Sulfide (in the form of SO2) one of the measured parameters 5. co: Carbon Monoxide one of the measured parameters 6. o3: Ozone one of the parameters 7. no2: Nitrogen dioxide one of the measured parameters 8. The following is ISPU in 5 AQMS areas (Figure 4)

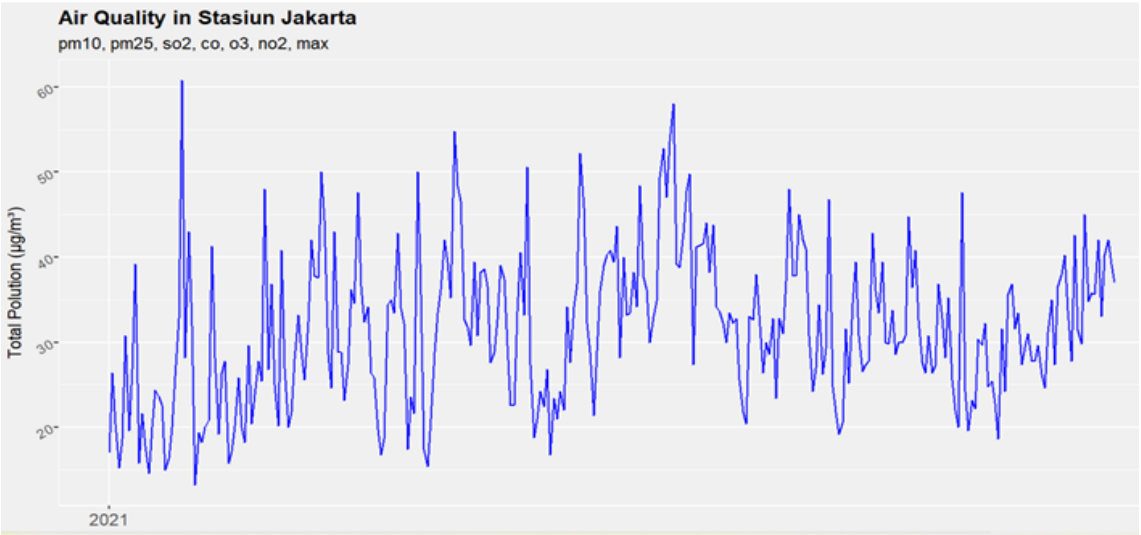

Figure 4. Daily ISPU in 5 AQMS

Discussion

The Ministry of Environment and Forestry (KLHK) is committed to providing precise and accurate air quality information to the public in order to control air pollution. This is evidenced by the continued increase in the number of continuous automatic monitoring stations owned by the Ministry of Environment and Forestry, which is targeted to reach 38 stations by 2020. In order for information on air quality to be easily understood by the public, the results of air quality monitoring from continuous automatic monitoring stations are submitted in the form of the ISPU.

Air Pollutant Standard Index is a number without units, used to describe the condition of ambient air quality in a certain location and is based on the impact on human health, aesthetic value, and other living things [22]. Especially for areas prone to forest and land fires, this information can be used as an early warning system or an early warning system for the surrounding community. The purpose of the ISPU is to provide the convenience of uniformity of ambient air quality information to the public at a certain location and time and as a material consideration in carrying out air pollution control efforts for both the central government and local governments [23].

In 2020, the Ministry of Environment and Forestry issued Regulation of the Minister of Environment and Forestry number 14 of 2020 concerning the Air Pollutant Standard Index which is a replacement for the Decree of the Minister of the Environment No. 45 of 1997 concerning Calculation and Reporting and Information on Air Pollution Standards Index. In this replacement regulation, it is stated that the ISPU calculation is carried out on 7 (seven) parameters, namely PM10, PM2.5, NO2, SO2, CO, O3, and HC. There are additional 2 (two) parameters, namely HC and PM2.5 from the previous regulation. The addition of these parameters is based on the magnitude of the risk of HC and PM2.5 to human health.

Coal, gas, and oil are still used to generate electricity in some power plants. Imperfect combustion in power plants produces a variety of hazardous gases that pollute the air, including SO2, NO, CO2, and PM. CO2 emissions will vary depending on the type of fossil fuel used to generate power. This activity releases up to 11 billion tons of CO2 into the atmosphere every year. Coal combustion produces more CO2 than oil or natural gas combustion [24].

PM is made up of a mix of physical and chemical elements that vary in character depending on where they are found. Sulfate, nitrate, ammonium, inorganic ions such as sodium, potassium, calcium, magnesium, and chloride, organic and carbon elements, solid components, water particles, and metals are all found in PM (including copper, nickel, cadmium, etc.), polycyclic aromatic hydrocarbons, and vanadium and zinc. Biological components such as allergens and bacterial compounds are also present. PM can be found in the air or generated in the atmosphere as a result of gases like SO2, NO, NH3, and volatile organic chemicals (second particles). Human activities or natural sources produce basic PM and gases. In addition, soil and dust can both contribute to PM levels. Jakarta's air quality, which was declared to be in poor condition, attracted public attention.

In addition to the addition of parameters, there is an increase in the frequency of delivering ISPU information to the public. The results of the PM2.5 ISPU calculation are submitted to the public every hour for 24 hours. Meanwhile, the results of ISPU calculations for PM10, NO2, SO2, CO, O3, and HC parameters are submitted to the public at least 2 (two) times in 1 (one) day at 09.00 and 15.00. ISPU calculation is done based on the upper limit ISPU value, lower ISPU limit, upper limit ambient, lower ambient, and ambient concentration measurement results.

Air quality, stratospheric ozone depletion, and climate change are closely related, all with the potential to affect human well-being. For any comprehensive and realistic assessment of the changes in atmospheric composition, it is crucial to have information not only on the concentration of PM but also on the chemical constituents of precipitation. The rain chemistry information could imply the history or the source of the air pollution.

The volume of ambient air is the amount of substance, energy, or other components that exist in free air [25]. The state of ambient air quality in a location at the time an inventory is taken is known as the ambient air quality state. Humans benefit from clean air since it includes numerous nutrients. Clean air is free of all kinds of things that humans don't need, whether they're solid substances or particles like dust, dirt, or other particles, or gases like carbon dioxide, carbon monoxide, and other harmful gases that aren't needed because of their harmful properties. This clean and healthy air has certain qualities that set it apart from the air that is contaminated or has a terrible odor [26]. Colorless, odorless, tasteless, not mixed with foreign objects, feels fresh when inhaled, feels cool, and can be utilized for therapy are some of the properties of clean and healthy air [27].

Air quality refers to the status of the air around us, whether it is clean or contaminated [28]. Good air quality is crucial not just for humans, but also for animals, plants, water, and soil [29]. The concentration of air pollution parameters that are measured to be higher or lower than the value of the National Ambient Air Quality Standard is used to assess air quality. The limit or level of air pollution elements that can be tolerated in the ambient air is measured by an air quality standard. Ambient air is free air on the earth's surface in the troposphere (a layer of air 16 km thick from the earth's surface) that is needed and impacts the health of humans, living creatures, and other parts of the environment and is within the jurisdiction of the Republic of Indonesia. The national ambient air quality standard, as attached in PP no. 41 of 1999, is set as the highest limit for ambient air quality to prevent air pollution. To preserve public health and comfort, the government has established the National Ambient Air Quality Standard. The spread of pollutants in the air is influenced by a variety

of factors, including location, sources of pollutants from various activities, pollutants, as well as meteorology and topography [30].

Air pollution can occur both outside and within the home. Outdoor air pollution can spread from the home to urban areas, eventually becoming a global problem. Outdoor air pollution is the world's second most important air pollution problem, behind indoor air pollution, according to the Blacksmith Institute's World's Worst Polluted Places report from 2008 [12]. Pollution in the air can occur everywhere. The improper location will have an impact on the quality of the outdoor air. The level of outdoor CO2 concentration is determined by location, such as traffic-heavy areas, industrial areas, and residential areas in metropolitan areas [13]

To address urban air pollution, there has been a growing concern about the monitoring of acid deposition and particulate matter in recent years. In Indonesia, however, information on the concentration of fine particles in the ambient air and chemical constituents is still rare. Therefore, assessment of air quality both acid deposition and particulate matter in Jakarta is scarce to find.

Conclusion

The finding shows that based on the time series of hourly data which is calculated on average into daily data, the concentration of PM10, PM25, SO2, CO, O3, and NO2 from January to October 2021 has decreased from the previous months at several congestion points in DKI. As a result of the high concentrations of PM10, PM25, SO2, CO, O3, and NO2 in DKI, it is advised that the government and community make efforts/activities to ensure the healthy air quality in DKI Jakarta and that the public use masks when participating in outdoor activities.

Declaration

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Conflicts of Interest: No conflict of interest

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Appendix

The following is the plot of the ISPU AQMS per congestion point area:

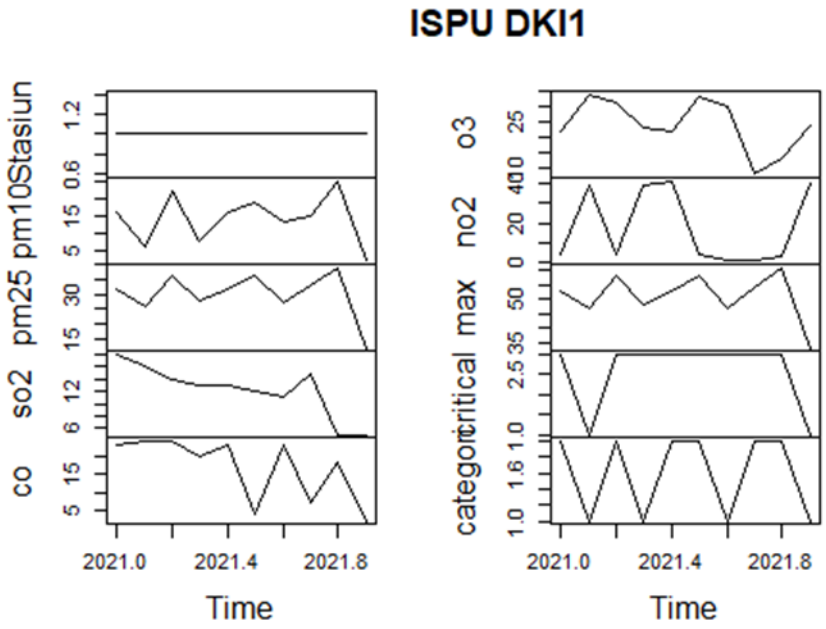

Figure 5. Plot ISPU SPKU DKI1 (Bundaran HI)

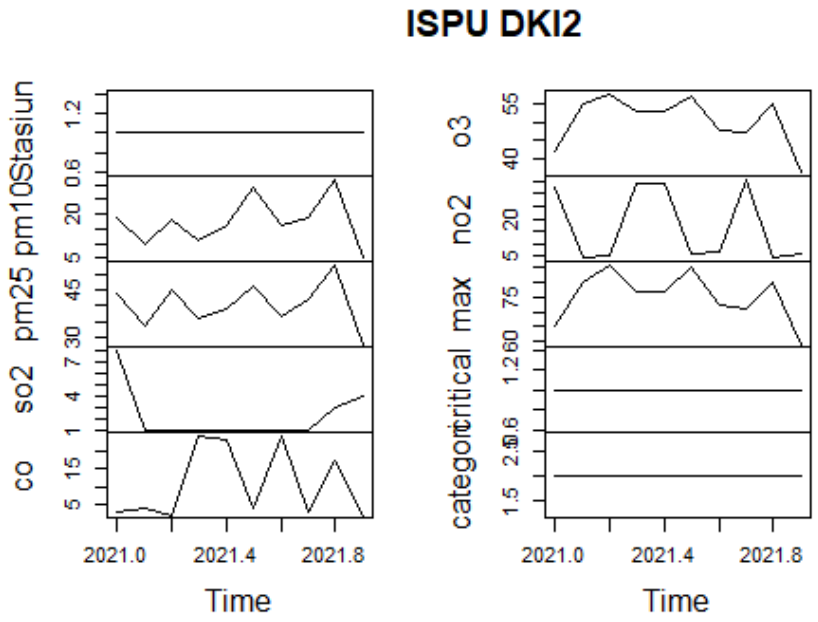

Figure 6. Plot ISPU SPKU DKI2 (Kelapa Gading)

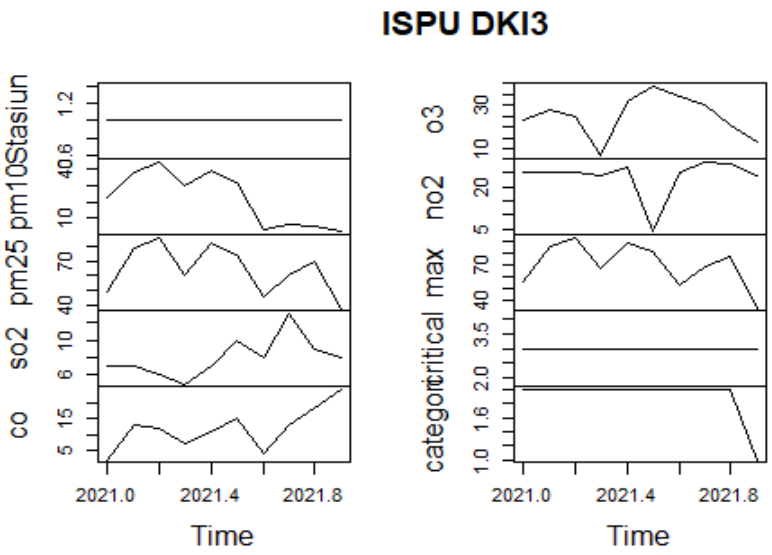

Figure 7. Plot ISPU SPKU DKI3 (Jagakarsa)

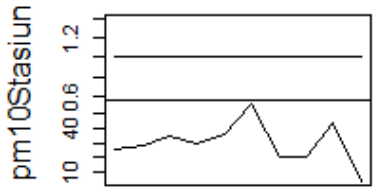

Figure 8. Plot ISPU SPKU DKI4 (Lubang Buaya)

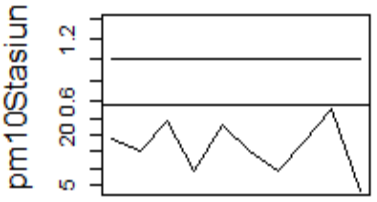

Figure 9. Plot ISPU SPKU DKI5 (Kebon Jeruk)