RESEARCH PAPER

THE INFLUENCE OF METEOROLOGICAL FACTORS ON SULFUR DIOXIDE (SO_2) AND NITROGEN DIOXIDE (NO_2) AND PREDICTION MODEL FOR RAINWATER ACIDITY BASED ON THEIR CONCENTRATIONS IN JAKARTA CITY

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ABSTRACT. In the last few decades, rapid industrial growth and increasing urban traffic density have caused air quality problems, including in Jakarta. One indicator of air pollution is acid rain. Acid rain occurs due to pollutants in the form of SO_2 and NO_2 reacting with water (H_2O). The impact of acid rain, among other things, can damage soil fertility, affect the quality of human life, and damage objects and infrastructure. This research aims to analyze the distribution of SO_2 and NO_2 spatially and temporally and create a rainwater acidity model based on the distribution of SO_2 and NO_2 in Jakarta. The distribution of SO_2 and NO_2 was obtained using remote sensing techniques using Sentinel 5P Satellite imagery. Processing is carried out using GEE. From the results of the bivariate analysis, it is known that the spatial distribution of SO_2 is influenced by rainfall and is not influenced by wind speed. Meanwhile, the distribution of NO_2 is significantly influenced by rainfall and wind speed. Temporally, the distribution of SO_2 in 2023 has the highest value in June, and the distribution of NO_2 has the highest value in August. The prediction model for rainwater acidity levels was obtained based on the distribution of SO_2 and NO_2 in 2023 in Jakarta. The results of multiple linear regression show a correlation between rainwater acidity and the distribution of SO_2 and NO_2. The correlation coefficient is (-) 0.7305, which means the correlation is in the strong category. The negative correlation explains that the higher the levels of SO_2 and NO_2, the more acidic the rainwater will be. A value of 13% was obtained in the MAPE calculation, which means the prediction model is included in the good category and can be used to predict rainwater acidity in Jakarta.

KEYWORDS: air pollution, rain acidity, SO_2, NO_2, Sentinel 5P, bivariate analysis

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INTRODUCTION

Air pollution is a condition of the atmosphere in which the concentration of a particular substance has adverse effects on human health and the environment, including global warming, acid rain, and ozone layer depletion [1],[2]. The World Health Organization (WHO) states that air pollution kills millions of people worldwide every year [3]. Research results show that most of the world's population faces this problem, especially in big cities [4]. In Southeast Asia, air pollution is the biggest cause of non-communicable diseases [5]. In recent decades, rapid industrial growth and increasing urban traffic density have become serious air quality problems [6]. The decline in air quality is one of the consequences of the growth and development of a city [7]. Air mixed with hazardous components at certain levels can be categorized as air pollution. In 2020, the government of the Republic of Indonesia determined that air quality is measured from the concentration of seven parameters, namely carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), PM 10, PM 2.5, sulfur dioxide (SO_2), and hydrocarbons (HC) [5].

As a pollutant, SO_2 has a significant impact on the environment and global climate [8]. SO_2 is a toxic gas that is colorless and has an odor if its concentration is more than 5 ppm [9]. The effect of SO_2 on humans is to cause respiratory disorders such as asthma and throat irritation. Even high levels of SO_2 inhaled by humans for a long time can cause lung cancer [10]. NO_2 is a reaction between nitrogen oxide and oxygen. NO_2 is a grayish-red substance that can cause eye irritation and even with high exposure can cause lung disease in humans [11]. In clean air, NO_2 cannot be found [12], therefore, if NO_2 is found in the air at a certain level, it can be ascertained that the area is polluted. In urban areas, the concentration of NO is usually 10-100 times greater than in rural areas [13]. SO_2 and NO_2

gases in the air are the cause of acid rain. Rainwater plays a role in washing pollutants in the air and carrying them from the atmosphere to the soil or water below [14], [15]. Acid rain can harm the environment and also the health of living things [16]. One indicator of air pollution is acid rain [17]. Acid rain occurs when pollutants in the form of SO_2 and NO_2 react with water (H_2O). Acid rain can affect soil fertility, residents' quality of life, and damage objects or infrastructure made of iron, limestone, concrete, and marble [18]. Rainwater that has a pH level of less than 5.6 can be categorized as acid rain [19].

The air quality of Jakarta City has become a serious topic of discussion among the national and international public. Throughout 2023, Jakarta's air quality even showed a fairly serious condition because it was categorized as unhealthy. Jakarta City has several times become the city with the worst air quality in the world in August and September 2023. The Ministry of Environment and Forestry (KLHK) revealed that several factors can cause air pollution in Jakarta, both natural and unnatural. Natural factors can be seasons, wind direction, and speed, and even the city landscape can also cause high pollution in Jakarta. When air pollution reaches a high level, it is typically during the dry season in Jakarta, when rainfall is minimal and air temperatures exceed 35 °C. This natural factor is a factor that is difficult for humans to control. Unnatural factors come from activities carried out by humans in an area such as the transportation sector, industry, and household activities.

Air is a very important element for living things [20], so air quality is something that every country needs to pay attention to following the Sustainable Development Goals (SDGs), which call for reducing deaths and diseases due to air pollution (point 3.9.1), ensuring access to clean energy at home (point 7.1.2), reducing the impact of urban environments by improving air quality (point 11.6.2). A spatial-temporal study is needed on the distribution of pollutants in Jakarta City and their relationship to meteorological factors and rainwater acidity. Therefore, the purpose of this study is to analyze the spatial and temporal distribution of SO_2 and NO_2 in 2023 using remote sensing data, and to develop a prediction model for rainwater acidity levels based on the distribution of SO_2 and NO_2 in 2023 within the study area.

MATERIAL AND METHOD

Study Area

The research was conducted in Jakarta City, which consists of North Jakarta, Central Jakarta, East Jakarta, West Jakarta, and South Jakarta. Jakarta has an area of 661.23 km^2 (Decree of the Minister of Home Affairs Number 050-145 of 2022 concerning the Granting and Updating of Codes, Data on Government Administrative Areas and Islands in 2021), consisting of 44 sub-districts and 267 urban villages. Geographically, Jakarta Province is between 106°22'42" East Longitude to 106°58'18" East Longitude and 5°19'12" South Latitude to 6°23'54" South Latitude. Jakarta has a tropical climate and has two seasons, namely the dry season and the rainy season. The peak of the rainy season usually occurs in January and February with an average temperature of 27 °C. In comparison, the peak of the dry season occurs in August-October with temperatures that can reach 40 °C. In 2023, the highest rainfall experienced in Jakarta was in February, 461.58 mm, and the lowest rainfall was in September, 3.44 mm. Based on the data, the population of DK Jakarta in 2023 reached 10,672,100 people [22]. This number has increased from the previous year, which was recorded at 10,640,007 people. The population of Jakarta City is equivalent to 3.87% of the total population in Indonesia, making Jakarta the province with the highest population density in Indonesia.

Methodology

This study used survey data, remote sensing data or satellite imagery, and observation data from agencies. The data obtained from the direct survey were pH data or rainwater acidity taken daily on March 1-15 when it rained. The remote sensing data or satellite imagery used was Sentinel 5P imagery. Its main purpose is to conduct atmospheric measurements with high spatial-temporal resolution, which are used for monitoring air quality, ozone, and ultraviolet radiation, and climate forecasting [23]. Sentinel 5P imagery was processed using Google Earth Engine (GEE) to see the distribution of SO_2 and NO_2 by month throughout 2023. Observation data on SO_2, NO_2, and rainwater pH from the Meteorological, Climatological, and Geophysical Agency (BMKG) are also needed to predict the estimated model for rainwater acidity in the study area. Wind speed data were obtained from windrose at each air observation station owned by the DKI Jakarta Environmental Service (DLH), and rainfall data were obtained from the BMKG.

The software used in this study was GEE, ArcGIS, and Microsoft Excel. GEE was used to analyze the distribution of SO_2 and NO_2 pollutants. GEE is a cloud-based geospatial processing platform for large-scale environmental monitoring and analysis [24]. GEE can be used for free and provides access to remote sensing imagery that is ready to use for various studies. The remote sensing image data used in this study was Sentinel 5P, which can present the distribution of SO_2 and NO_2. This distribution was then analyzed to determine whether it affected rainfall and wind speed. ArcGIS acts as a layout in presenting maps so that they are more informative and easier to understand. Microsoft Excel was used for calculating simple linear regression, multiple linear regression, and rainwater acidity prediction models. Simple linear regression was carried out to analyze the distribution of SO_2 and NO_2 with meteorological conditions, namely rainfall and wind speed. Multiple linear regression was carried out on SO_2, NO_2, and rainwater pH so that the effect of SO_2 and NO_2 on rainwater pH or rainwater acidity at each sample point could

Table 1. Data Sources and Collection Technique

Data Type	Component	Source	Data Collection Techniques
Primary Data	Rainwater Acidity	Direct Survey	Measured Using pH Meter
		BMKG	Request Data From The Agency
	SO_2 and NO_2	BMKG	Request Data From The Agency
Secondary Data	SO_2 and NO_2	Sentinel 5P Satellite Imagery	Google Earth Engine (GEE)
	Wind Speed	DLH DKI Jakarta	Literature Study From Web
	Precipitation	BMKG	Request Data From The Agency

be determined. The rainwater acidity prediction model can be obtained using multiple linear regression by calculating the coefficients generated from the previous calculations. The resulting model is then applied to the Sentinel 5P satellite imagery to produce a rainwater acidity prediction map.

The correlation value between SO_2, NO_2, and pH in this study is explained by the Pearson correlation coefficient value and determined by the equation:

$$r = \frac{\sum (xi - \overline{x})(yi - \overline{y})}{\sqrt{\sum (xi - \overline{x})^2 \sum (yi - \overline{y})}} \quad (1)$$

r is the correlation coefficient, while *x* is the value of the variable *x* at each point minus the average $(xi - \overline{x})$, and y is the value of the variable y at each point minus the average $(yi - \overline{y})$. The closer the correlation coefficient is to 1, the stronger the correlation. Correlation coefficients are categorized as <0.20, meaning very low; 0.21–0.40, meaning low; 0.41–0.60, meaning moderate; 0.61–0.80, meaning strong; and >0.81, meaning very strong. [25].

Model evaluation is carried out using Mean Absolute Percentage Error (MAPE). MAPE can provide an overview of how big the error or prediction error is by comparing it with the actual value and calculations using the model. MAPE is a measure that can be used to determine the percentage of deviation from the prediction results. Mathematically, the MAPE formula is as follows:

$$MAPE = \frac{1}{n} \sum_{i=1}^{n} \frac{|y - y'|}{y} \times 100\,\% \quad (2)$$

where: *y* =actual value, *i* =time period index, *y´* =prediction value, *n* =amount of data

If the MAPE calculation results are included in the category of reasonable to very good, it can be interpreted that the model has predictive capabilities that can be used to predict several future periods [26]. The lower the MAPE value, the better the forecasting model. There are categories to classify the resulting MAPE values [26], the classification of MAPE values is < 10 % means highly accurate forecasting, 10 – 20 % means good forecasting, 20 – 50 % means reasonable forecasting, and > 50 % means weak and inaccurate forecasting .

RESULT AND DISCUSSION

Distribution of Sulfur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) in 2023

The distribution of SO_2 in this research area was processed using Google Earth Engine (GEE). The distribution of SO_2 was obtained every month in 2023. The distribution of SO2 is the average SO_2 level every month throughout 2023 (Figure 1). The SO_2 level was then divided into 5 categories so that each month's spatial pattern was known.

Similar to SO_2, the distribution of NO_2 was also obtained by processing using GEE. NO_2 levels are

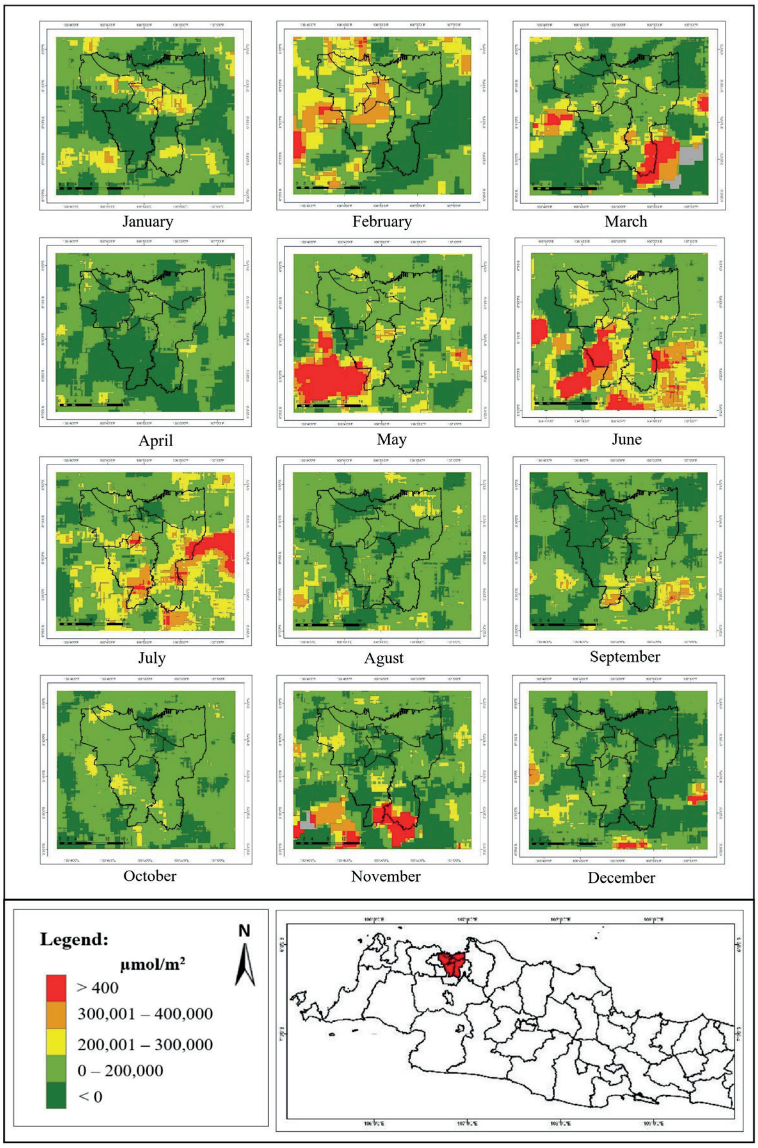


Fig. 1. Monthly SO_2 Distribution in Jakarta City Year 2023

presented in monthly ranges during 2023. The distribution of NO_2 levels in the study area has a very different pattern when compared to the distribution of SO_2 levels. In the distribution of NO_2, a fairly clear gradation of values is seen from high to low levels. In January-April, NO_2 levels appear to be dominated by very low levels (Figure 2).

Correlation of SO_2 and NO_2 Distribution with Meteorological Factors

Correlation with Precipitation

The distribution of pollutants in the air can be influenced by several meteorological factors [27], [28], one of which is precipitation. Precipitation can act as a cleaner of pollutants in the air. Jakarta has a tropical climate because it is located close to the equator. The seasons in Jakarta are the rainy season and the dry season. The rainy season usually falls in December-March. While the dry season falls in June-September.

In 2023, Jakarta experienced a drier dry season than the last three years. This was caused by the El Nino event in Indonesia. The severe drought occurred not only in Jakarta but also in other provinces such as Aceh, Bali, West Nusa Tenggara, and Lampung. Jakarta experienced an increase in scorching temperatures, reaching almost 400^0. The dry season conditions were also said to be the cause of the poor air quality in Jakarta, which was the worst in recent years. Low precipitation caused the haze of pollution in the air to persist for a long time. In August 2023, DLH DKI Jakarta and BMKG collaborated to utilize artificial rain technology to reduce the impact of pollution in Jakarta. These efforts succeeded in reducing air pollution, although not significantly.

Data from BMKG shows that precipitation in September is the lowest throughout the year. August

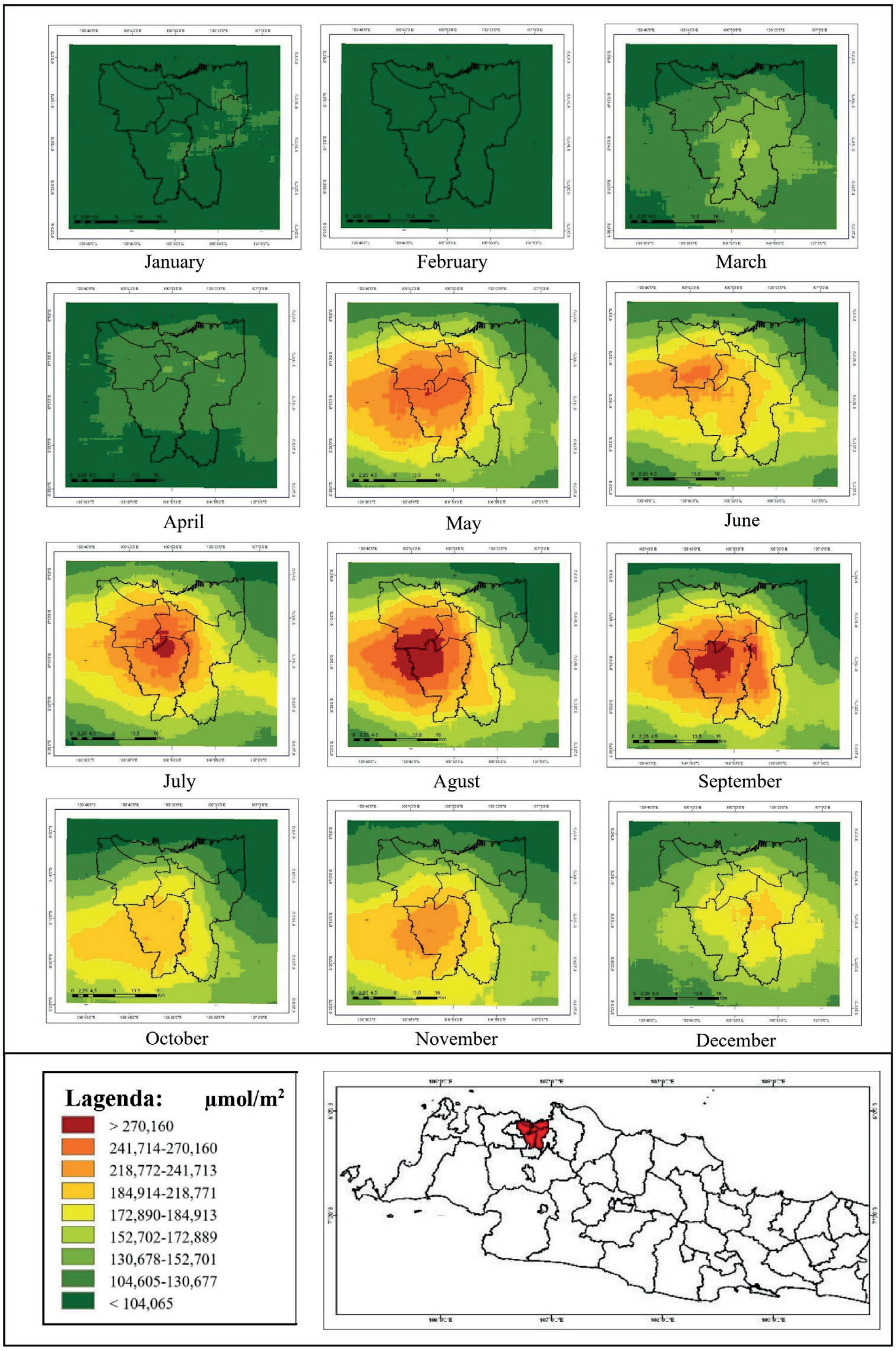


Fig. 2. Monthly NO_2 Distribution in Jakarta City Year 2023

and October are very dry months due to minimal rainfall. Meanwhile, February and March are the months with the highest precipitation in 2023. This precipitation data is then compared with SO_2 and NO_2 levels obtained from Sentinel 5P satellite processing. SO_2 and NO_2 level data are first averaged from eight BMKG observation stations to produce an average SO_2 and NO_2 level for each month in 2023 (Table 2). The locations of the eight BMKG observation stations can be seen in figure 3.

From figure 4, it is known that NO_2 levels are influenced by the amount of precipitation. The lowest NO_2 levels were obtained in February, when the rainfall that fell was the highest throughout the year. On the other hand, in August-October, rainfall was very low, at that time NO_2 levels increased. This proves that the higher the precipitation, the lower the NO_2 levels. Regression calculations were carried out to calculate the strength of the correlation between rainfall and NO_2, and the results of the correlation coefficient were obtained as much as (-) 0,725, which means that the correlation that occurred was included in the strong category. The calculation of the determination coefficient showed a value of 0.526, which means that precipitation affects NO_2 levels by 52%, the rest is influenced by other factors.

The SO_2 level has a different pattern when compared to NO_2, in figure 4, it can be seen that the SO_2 level is not inversely proportional to the high precipitation. In February when the rainfall is very high, the SO_2 level also shows a high level. The SO_2 level decreased in August-November, where in that month the rainfall also decreased. The correlation between precipitation and SO_2 levels tends to show a positive correlation. Regression calculations were carried out to see the correlation between the two and the results obtained a correlation coefficient of (+) 0,460 which means that the correlation is included in the moderate category. The resulting determination coefficient is 0.211 which shows that rainfall affects SO_2 levels by only 21%.

Table 2. Monthly Precipitation and Pollutant Levels in 2023

Month	Jakarta's Monthly Precipitation (mm)	SO_2 (μmol/m^2)	NO_2 (μmol/m^2)
January	162,54	171,17	97,00
February	461,58	254,83	84,63
March	283,72	231,67	127,88
April	111,29	136,00	117,88
May	136,20	146,86	213,63
June	111,83	142,75	197,88
July	47,58	287,25	223,00
Agust	4,10	68,00	220,38
September	3,44	126,25	214,00
October	9,17	81,88	171,38
November	180,67	22,00	177,63
December	95,93	32,33	168,38

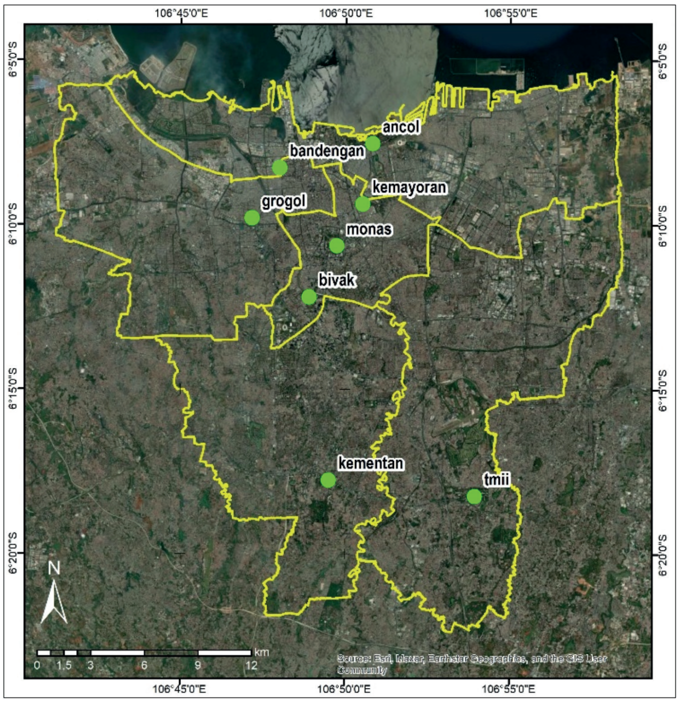


Fig. 3. BMKG Observation Station Location

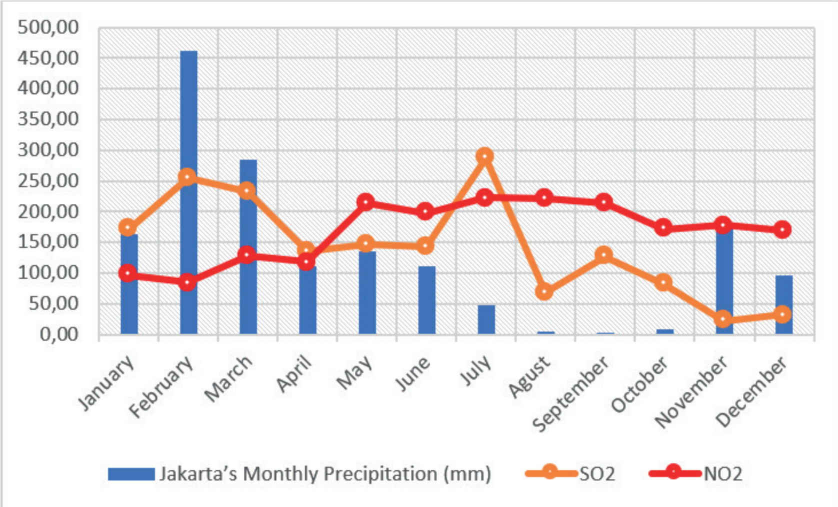


Fig. 4. Time Series of SO_2 and NO_2 Distribution with Precipitation in Jakarta

Correlation with Wind Speed

The correlation between wind speed and SO_2 and NO_2 pollutants was also analyzed from Sentinel 5P image processing data. Monthly wind speed data was obtained by calculating the average wind speed each month at five observation stations.

From the data above, a regression analysis was carried out between wind speed and NO_2, as well as between wind speed and SO_2. The results obtained explain that wind speed has a weak correlation with SO_2. This is proven by the results of calculating the correlation coefficient which is only (+) 0,2418. A P value of more than 0,05 confirms that wind speed does not have a significant influence on SO_2 distribution. This is different from the correlation between wind speed and NO_2 distribution. The results of the regression calculations show that wind speed and NO_2 distribution have a very strong correlation, which can be proven by the correlation coefficient which shows the number (-) 0,8022. The P value even shows that wind speed significantly influences the distribution of NO_2 because it is less than 0,05. The correlation between wind speed and NO_2 is negative, which means the higher the wind speed, the lower the NO_2 levels in the air.

Rainwater Acidity Level Prediction Model Based on SO_2 and NO_2 Distribution

One of the aims of this research is to create a prediction model for rainwater acidity based on the distribution of SO_2 and NO_2 in the research area. To ensure that the prediction model has a good level of confidence, it is necessary to calculate the correlation between the dependent variable (rainwater acidity) and the independent variables (SO_2 and NO_2). The correlation level calculation is carried out using multiple linear regression so that the correlation coefficient and determination coefficient of these variables can be known. Data on the acidity level (pH) of rainwater, SO_2 and NO_2 in the prediction calculations were obtained from BMKG (Table 4). All data is an average for each month in 2023.

The results of the regression calculations show that there is a correlation between the acidity (pH) of rainwater and the SO_2 and NO_2 values. The correlation coefficient is (-) 0,7305, which means the correlation is in the strong category. The coefficient of determination resulting from the calculation is 0,5337, which also means that the influence of SO_2 and NO_2 on acidity is strong. The value of 0,5337 explains that the influence of SO_2 and NO_2 on pH is 53,37%, while the remaining 46,63% is influenced by other factors. The coefficients of variables X1 and X2 are both negative, which indicates that the correlation

Table 3. Monthly Wind Speed and Pollutant Levels in 2023

Month	Jakarta's Monthly Wind Speed (m/s)	SO_2 (μmol/m²)	NO_2 (μmol/m²)
January	0,8592	171,17	97,00
February	0,8512	254,83	84,63
March	0,6204	231,67	127,88
April	0,6772	136,00	117,88
May	0,5322	146,86	213,63
June	0,5264	142,75	197,88
July	0,5436	287,25	223,00
Agust	0,6052	68,00	220,38
September	0,6662	126,25	214,00
October	0,6736	81,88	171,38
November	0,6038	22,00	177,63
December	0,5772	32,33	168,38

Table 4. Monthly Average Rainwater Acidity (pH), SO_2, and NO_2 in Jakarta City

Month	pH	SO_2 (ppm)	NO_2 (ppm)
January	4,78	0,0064	0,0162
February	5,09	0,0064	0,0174
March	4,99	0,0048	0,0202
April	4,87	0,0052	0,0150
May	5,11	0,0056	0,0220
June	4,59	0,0090	0,0222
July	4,88	0,0056	0,0210
Agust	4,45	0,0070	0,0214
September	-	0,0052	0,0178
October	-	0,0050	0,0174
November	4,66	0,0054	0,0260
December	4,36	0,0072	0,0280

Source: (BMKG, 2024)

is negative [30]. The greater the SO_2 and NO_2 levels, the greater the acidity of rainwater.

The rainwater acidity level prediction model is obtained using the formula:

$$y = a + x1coefficient + x2coefficient \quad (3)$$

where: *y =Rainwater Acidity (pH), x1 =SO_2, x2 = NO_2*

In this research, the rainwater acidity level prediction model was obtained:

y=5,994005+(-98,9218*x1)+(-28,4983*x2)

To find out whether the rainwater acidity prediction model is valid or can be accounted for, the prediction model was tested with rainwater acidity data taken directly by the author in March 2024. After that, the Mean Absolute Percentage Error (MAPE) value was calculated to see the accuracy of the prediction number for rainwater acidity level (pH).

Rainwater samples are collected directly from coordinate points adjacent to BMKG's observation station. The rainwater sample is then measured using a pH meter so that the acidity is known. Direct measurements in the field were carried out every time it rained from 1 to 15 March. The measurement locations were carried out at eight observation station points belonging to BMKG. The acidity (pH) data obtained is then calculated as an average (Table 5).

The results of the MAPE calculation are obtained by subtracting the actual and predicted pH values, and then the difference is calculated in absolute terms. The results are divided by the actual pH value at each station. Then the total value is added up and divided by 8 or as many air quality monitoring stations. To get the MAPE, the final result is multiplied by 100 to show the percentage number. The smaller the percentage, the more the predicted value is considered feasible to use. In the calculation results of this study, the MAPE value was obtained at 13%, which means that the rainwater acidity prediction model is included in the good forecasting category (Table 6).

Although the forecasting results from this study showed positive results, several limitations need to be addressed for future improvements. For example, extending the pH measurement timeframe. Other meteorological factors, such as wind direction, could also be added to future research to obtain more representative results. The resulting model can be applied using SO_2 and NO_2 distribution images (Sentinel 5P), so that a monthly rainwater acidity prediction map can be produced. Rainwater acidity predictions are generated using the raster calculator feature in ArcMap. The predicted values of monthly rainwater acidity throughout 2023 and January to May 2024 can be seen in figure 5.

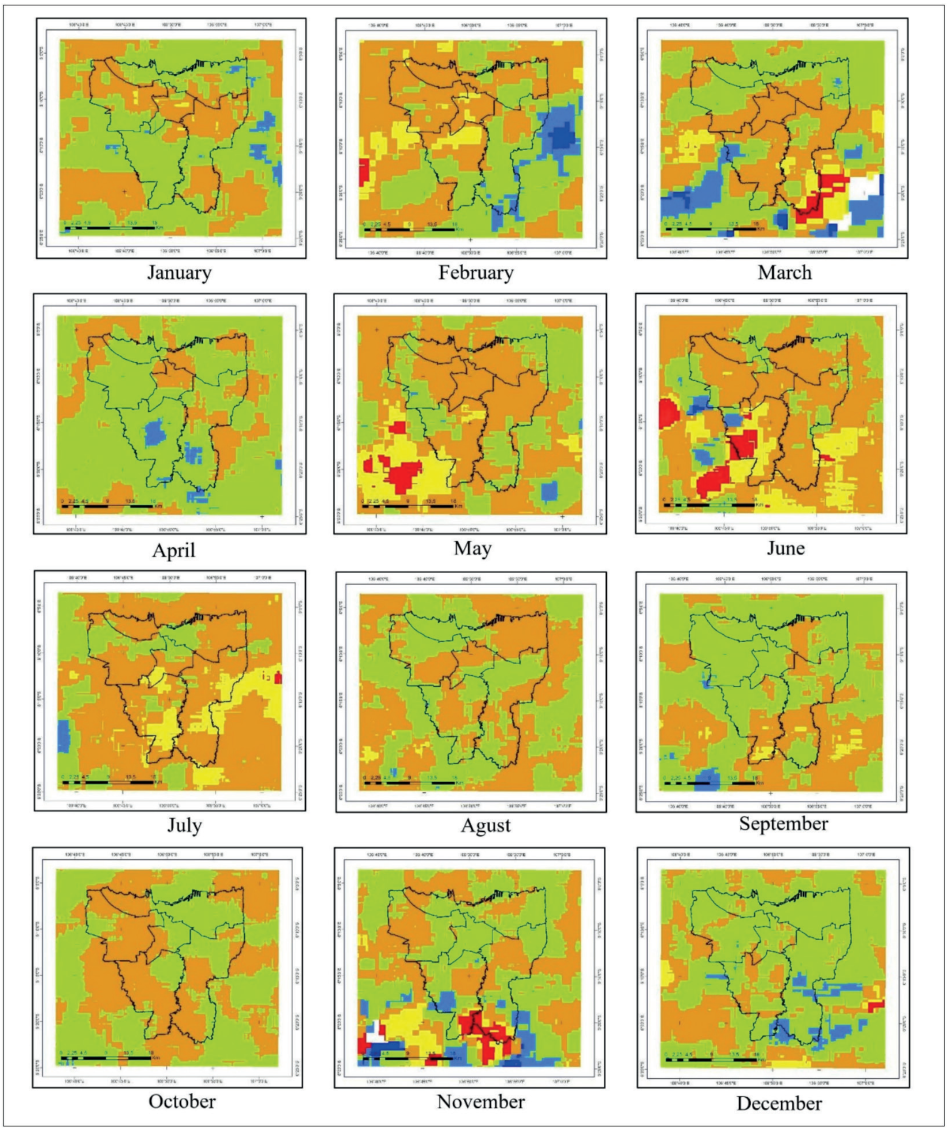
Table 5. Rainwater Acidity (pH) measurement Survey Results

BMKG Observation Station	MARCH 2024															Average
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Kemayoran			4,8	4,9					5,2	5,0	5,2		5,5	4,7	5,6	5,11
Ancol		4,0	4,9	4,9					5,4	5,5	4,9		4,8	4,4	5,0	4,87
Bandengan		7,0	6,6						6,3	7,0	5,9		6,3	6,0	6,8	6,49
Bivak			5,5	6,6	6,4				6,2	5,5	5,4		5,5	5,6	5,9	5,84
Grogol	5,4		5,5		6,0			5,4	5,6	5,5	5,7		5,2	5,0	5,4	5,47
Kementan	7,1	7,2	7,6		7,5			7,2	7,2	7,1	7,4	7,1	7,1	7,2	7,1	7,23
Monas			5,6	5,7					5,6	5,4	5,4		5,2	5,5	5,8	5,53
TMII	7,0	7,4		7,2	7,4	7,4		7,3	7,2	7,5	7,4	7,1		7,4	7,5	7,32

Table 6. MAPE Calculation of Rainwater Acidity Prediction Model

BMKG Observation Station	SO_2	NO_2	Actual pH (Survey Results)	Prediction pH	Error	Absolute Error	Absolut (Eror/ Actual pH)
Kemayoran	0,004	0,0178	5,11	5,09	0,02	0,21	0,004196
Ancol	0,005	0,0186	4,87	4,97	-0,10	0,10	0,021095
Bandengan	0,003	0,0176	6,56	5,20	1,36	1,36	0,207632
Bivak	0,002	0,0184	5,84	5,27	0,57	0,57	0,097982
Grogol	0,002	0,0202	5,47	5,22	0,25	0,24	0,045613
Kementan	0,002	0,0172	7,23	5,31	1,93	1,92	0,266453
Monas	0,007	0,0156	5,53	4,86	0,67	0,66	0,120909
TMII	0,002	0,0196	7,32	5,24	2,08	2,08	0,284156
Total							1,048036
MAPE	= (1,048036/8)*100						13.1 %

(a)



(b)

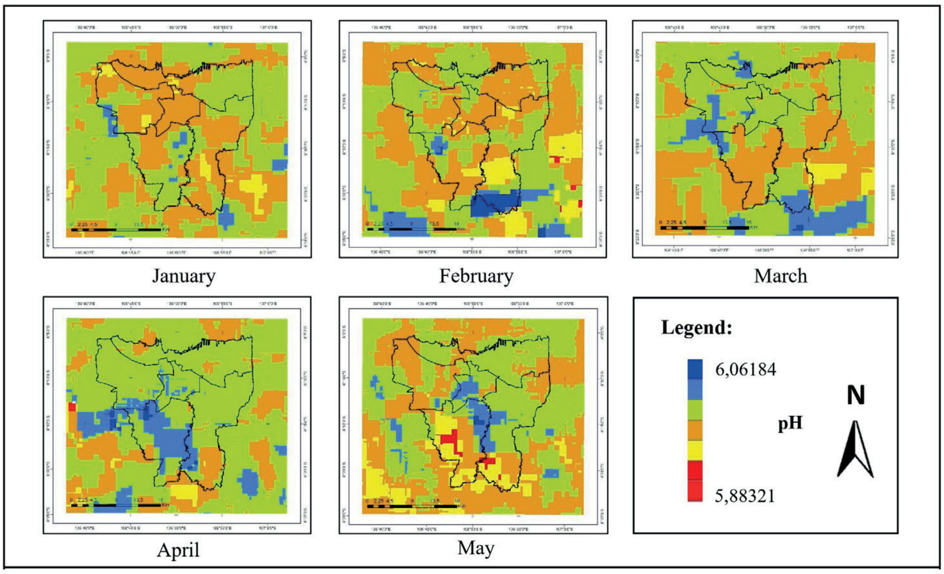


Fig. 5. Rainwater Acidity (pH) Prediction Based on the Distribution of SO_2 and NO_2 in Jakarta City (a) 2023 (b) 2024

CONCLUSION

The spatial-temporal distribution of SO_2 and NO_2 in 2023 produced by Sentinel 5P imagery has different patterns. The spatial distribution of SO_2 has a scattered pattern and is statistically influenced by rainfall with a moderate but insignificant positive correlation category. The spatial distribution of SO_2 is not influenced by wind speed, this is evident from statistical calculations which show that the distribution of SO_2 has a weak and insignificant positive correlation with wind speed. Meanwhile, the NO_2 distribution pattern is more clustered and has a gradation of values that are sequential from the highest to the lowest. The distribution of NO_2 is influenced by rainfall and also wind speed. The distribution of NO_2 has a strong and significant negative correlation with rainfall and a very strong negative correlation with wind speed. Temporally, the distribution of SO_2 in 2023 has the highest value in June, and the distribution of NO_2 has the highest value in August.

The prediction model for the acidity level of rainwater based on the distribution of SO_2 and NO_2 in 2023 in Jakarta was obtained from monthly data throughout 2023. The results of multiple linear regression show that there is a correlation between rainwater acidity and the distribution of SO_2 and NO_2. The correlation coefficient is (-) 0.7305, which means that the correlation is in the strong category. The correlation is negative, which explains that the higher the levels of SO_2 and NO_2, the more acidic the rainwater will be. To test whether the resulting model is suitable for use or not, a MAPE calculation is carried out. MAPE is obtained by comparing the actual acidity taken directly from the direct survey in March 2024 with the predicted acidity produced by the model. The results of the calculations from this study obtained a MAPE value of 13%, which means that the prediction model is included in the good forecasting category and can be used to predict rainwater acidity in Jakarta.

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