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ESTIMATED SULFUR DIOXIDE POLLUTANT CONCENTRATIONS IN MEDAN CITY USING ORDINARY KRIGING AND INVERSE DISTANCE WEIGHTING APPROACHES

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ABSTRACT
Sulfur dioxide (SO2) pollution is a serious problem that negatively affects air quality and human health. So2 is generated by various human activities, especially the combustion of fossil fuels, as well as from natural sources such as volcanic eruptions. The emission of SO2 in urban areas, including Medan, Indonesia, has raised concerns as it is associated with respiratory diseases and the formation of acid rain. This research aimed to estimate comparative SO2 concentrations in Medan City using geostatistical methods, specifically ordinary kriging and inverse distance weighted (IDW). Air quality monitoring data from the Dinas Lingkungan Hidup Kota Medan were collected during a certain period. The collected data were analyzed and then interpolated using ordinary kriging and IDW methods. Furthermore, the Ordinary Kriging method involves testing the OK assumption, calculation of the experimental semivariogram, calculation of the theoretical semivariogram, structural analysis, and calculation of Root Mean Square Error (RMSE). Meanwhile, the Inverse Distance Weighted method involves calculating the Euclidean distance, determining the weights based on the power parameter, calculating the RMSE value, and estimating the SO2 concentration. The comparison results show that the OK method is more accurate in determining SO2 concentration compared to the IDW method in Medan City. In the estimation of sulfur dioxide (SO2) concentration, the OK method used the best theoretical semivariogram model, namely the exponential model, and in the estimation process of the IDW method, the power parameter 1 was used.
Keywords: Sulfur Dioxide, Air Quality, Ordinary Kriging, Inverse Distance Weighted, Pollution

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PRELIMINARY

Pollutants are substances or materials that cause pollution, whether air, land or water pollution. Pollutants have the effect of reducing the air quality of an element. A substance is called a pollutant when its presence in an environment has exceeded the normal threshold, occurs at an inappropriate time and place so that it has a detrimental impact on the environmental ecosystem, both living things and property (Ivan, 2019).

There are two kinds of Pollutant classifications, namely primary pollutant and secondary pollutant. Primary Pollutant comes from the direct release of pollutant into the air as a result of human activities, such as carbon compounds, nitrogen, sulfur, chlorine, bromine, hydrogen chloride etc. Secondary Pollutant occurs from the mixing process of chemical reactions of two or more compounds between pollutants and normal air elements in the atmosphere (Wulandari, 2021). The source of air pollution is expanding as a result of technological progress, leading to a worsening air quality crisis. As a result, the ecology is harmed and people's health is threatened by the contamination of their air supply (Abidin & Hasibuan, 2019).

Along with the rapid growth of the city, the increase in human activities, and the increase in the number of vehicles in urban areas, especially in Medan City has resulted in changes in air quality. The decline in air quality is also caused by the large number of motor vehicles on congested roads (Indrayani & Asfiati, 2018). Air pollution is a problem that requires special attention, especially in large urban areas (Maherdyta et al., 2022). The dominant air pollutants in the urban environment are: SO2, NO and NO2, CO, O3, SPM (Suspended Particulate Matter) and Pb (lead). SO2 contributes to acid rain and aerosolized sulfate particle pollution (Male et al., 2021).

Sulfur dioxide comes from two sources, natural and artificial. Natural sources of SO2 come from volcanic activity, biological sulfate reduction, and the organic decomposition of microorganisms. Artificial sources come from the combustion of fuel oil, gas, coal and compounds with high sulfur content. According to the chemicals of sulfur dioxide, SO2 is a gas that can't burn, has no color and has a sharp odor. The sulfur dioxide can cause damage to living things and the environment (Sihayuardhi, 2021).Sulfur oxides (SOx) are divided into two, namely sulfur dioxide (SO2) and sulfur trioxide (SO3). SO2 is a gas that is easily dissolved in water, has an odor, is colorless and non-flammable. SO2 gas is a pollutant gas that comes from the combustion of sulfur-containing fossil fuels such as oil, gas, coal and coke. SOx absorbed on particles can be inhaled and enter the respiratory tract. Absorbed SOx is then dissolved in body fluids and enters the bloodstream, lymphatic system or connecting lung tissue. The effects of SO2 gas can lead to respiratory disturbances, headaches, chest pain, and can potentially affect human nerves (Tampa et al., 2020).

SO2 gas has low solubility in water and becomes soluble in alkaline solutions. SO2 stimulates shortness of breath and is harmful to the human respiratory system. SO2 can also cause acid rain when it reacts with water vapor and produces H2SO4. SO2 gas has a characteristic pungent odor, reddish brown in color and yellow under 21.2°C. It has health effects such as decreased lung function, shortness of breath, and even death. SO2 is produced by burning gasoline, burning garbage, and coal industry from human activities (Putrakoranto, 2021). The dispersion of SO2 gas into the environment depends on the local meteorological and geographical conditions. Air humidity also influences the rate of conversion of SO2 into sulfuric acid or sulfurous acid, which will accumulate with clouds and eventually fall as acid rain (Sugiarto, 2018).

Risza (2021) employed Ordinary Kriging method to estimate the carbon monoxide levels in the air in 2020 in Surabaya City. The sample data used consisted of measurements at 40 points. The research findings indicate that Surabaya City has a safe status regarding carbon monoxide (CO) exposure. Subsequent research addressing air pollution was conducted by Muthia et al. (2022) to interpolate pollutants in Yogyakarta City using Ordinary Kriging and Inverse Distance Weighted methods. The sample data included NO2 levels at 25 locations in Yogyakarta City. The research results demonstrate that the most accurate method for estimating SO2 is Ordinary Kriging.

In this paper, the Ordinary Kriging (OK) method and the Inverse Distance Weighted (IDW) method are used. Estimating the concentration of sulfur dioxide pollutants can be done using deterministic interpolation methods and geostatistical interpolation methods. The Ordinary Kriging (OK) method is considered an optimal interpolation method. However, in its application, the OK method requires accurate spatial structure analysis through the construction of a semivariogram and model selection. The Inverse Distance Weighting (IDW) method is a deterministic interpolation method that uses ordinary mathematical functions in its interpolation technique. The IDW method involves comparing the interpolation results and manipulating the exponent or power used. This method is widely applied in various fields because it is simpler, easy to understand, and can be applied to cases with limited data (Purnomo & Wijaya, 2022). In Ordinary Kriging, the estimation of a variable at a specific point is done by observing similar data in relation to other data points (Rohma, 2022). Interpolation using Inverse Distance Weighted with a proximity-based approach will result in values that are more similar compared to values that are more distant (Febriarta et al., 2020). Spatial interpolation methods such as IDW and OK have been extensively applied in various fields to create spatial distribution maps. (Purnomo & Wijaya, 2022).

Based on the context above, the problem formulations to be discussed are: How do the comparing results of sulfur dioxide pollution in Medan city differ using Ordinary Kriging and Inverse Distance Weighted approaches? Which method is the most effective in determining sulfur dioxide pollution?.

METHODS

This research was conducted based on the Medan City Sulfur Dioxide (SO2) Pollutant data available at the Medan City Environmental Agency. This paper uses quantitative research, which entails research on specific populations or samples, data collection using research instruments, quantitative or statistical data analysis, and the testing of predetermined hypotheses. Quantitative research methods are based on the philosophy of positivism. (Sugiyono, 2019). The data used is secondary data. Secondary data is data that is not collected directly from the source and is already available in published forms such as company documents and archives (Darmawan & Lubis, 2023).

In this work, data analysis was performed utilizing Ordinary Kriging and Inverse Distance Weighted which aims to estimate the concentration of Sulfur Dioxide pollutants in non-sampled locations. This research used R studio software.

Ordinary Kriging

Common in geostatistics, the Ordinary Kriging technique is an algorithm for spatial interpolation. Adjusting the semivariogram needed for kriging interpolation so that it maximizes the theoretical accuracy of the resulting spatial interpolation is crucial. (Yang et al., 2022).

One of the most used kriging methods is called Ordinary Kriging. Predicting the value (s0), which is equal to the line sum of the known measured values (i.e. observed values), provides a geographic forecast of the unknown point s0. The equation for the Ordinary Kriging (OK) statistical model is as follows:

$$\hat{z}(s_0) = \sum_{i=1}^{n} w_i Z(s_i) \quad (1)$$

where

$\hat{z}(s_0)$ is the predicted value at the unknown location s_0

$Z(s_i)$ is the value measured at location s_i,

w_i is the weighting coefficient from the measured location to s_0,

n is the location of the object that has n locations.

In order to show the spatial relationship between different pairs of points and to describe the spatial continuity of the data, an appropriate model that is based on the distribution of the input data is required. (Pham et al., 2019).

To ensure unbiased predictions, an additional row and column are required to ensure that the sum of the weights equals one, i.e. $\sum_{i=1}^{n} w_i = 1$. The weights are determined using the model coefficients for the semivariogram and will minimize the Kriging prediction error through the Lagrange Multiplier method. The calculation of the Ordinary Kriging weight value can be written in matrix form in the following equation (Safira et al., 2022).

$$\begin{pmatrix} \gamma(s_1,s_1) & \dots & \gamma(s_1,s_n) & 1 \\ \vdots & \ddots & \vdots & \vdots \\ \gamma(s_n,s_1) & \dots & \gamma(s_n,s_n) & 1 \\ 1 & \dots & 1 & 0 \end{pmatrix} \begin{pmatrix} w_1 \\ \vdots \\ w_n \\ \varphi \end{pmatrix} = \begin{pmatrix} \gamma(s_0,s_1) \\ \vdots \\ \gamma(s_0,s_n) \\ 1 \end{pmatrix} \tag{2}$$

Or

$$\mathbf{A}\,\mathbf{w} = \mathbf{b}, \tag{3}$$

Therefore, the value of **w** can be obtained with the following equation:

$$\mathbf{w} = \mathbf{A}^{-1}\,\mathbf{b} \tag{4}$$

Euclidean Distance

Euclidean distance is a type of distance measure in cluster analysis that is used to measure the distance from a data object to a cluster center that has a continuous data scale and is the distance from a data object to a cluster center that has a continuous data scale and is the geometric distance of two data objects (Wulandari, 2021).

The general form of the Euclidean distance equation can be written in the following equation (Ropiqoh & Lubis, 2023):

$$d(a,b) = \sqrt{(x_b - x_a)^2 + (y_b - y_a)^2} \tag{5}$$

Ordinary Kriging Assumption Test

1. Data doesn't contain outliers

Outliers are usually caused by errors in the measurement system, errors in data input or because the data is indeed an unusual event.

2. Normally distributed data

The purpose of the normality test is to establish whether or not the data follow a normal distribution. There are several statistical tests that can be done to test the normality of data, including the Anderson-Darling (AD) test, Kolmogorov-Smirnov test and Shapiro-Wilk test. However, if the data used is a small sample ($n \leq 25$), the Anderson-Darling test is chosen.

The hypotheses are used:

H_0: the data is normally distributed,

H_1: the data is not normally distributed, with decision making

- if the p-value < the significance level (α) then reject H_0 which means the data is not normally distributed,

- if the p-value > the significance level (α) then fail to reject H_0 which means the data is normally distributed (Safira et al., 2022)

3. Stationary data

Data is called stationary if the data has no tendency towards a certain trend or in other words, if the data fluctuations are centered around a stable average value, regardless of the passage of time or the degree to which these fluctuations vary from one another. (Yendra & Risman, 2019).

The hypothesis taken for the ADF test is:

H_0: data is not stationary.

H_1: the data is stationary.

Decisions to determine whether the data is stationary or not include:

- If p-value < significance level (α) then reject H_0 which means the data is stationary.
- If p-value > significance level (α) then fail to reject H_0 which means the data is not stationary.

Experimental Semivariogram

An experimental semivariogram is a semivariogram obtained based on sample data. The semivariogram is a visualization of the spatial correlation.

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [z(x_i) - z(x_i + h)]^2 \quad (6)$$

γ(h) : semivariogram value

h : distance between sample locations or lags

N(h) : total number of point sample pairs that have distance h

$z(x_i)$: observation value at location x_i

$z(x_i + h)$: observation value at location $x_i + h$

There are several parameters needed to determine the theoretical semivariogram value, namely nugget effect (C_0), sill (C_0+C), and range (a).

Theoretical Semivariogram

1. Spherical Model

$$\gamma(h) = \begin{cases} C_0 + C\left[\left(\frac{3h}{2a} - \frac{h}{a}\right)^3\right] & untuk\ 0 < h \le a \\ C_0 + C & untuk\ h > a \end{cases} \quad (7)$$

h: sample location distance

C_0: nugget effect

C: partial sill

a: range

2. The Exponential Model

$$\gamma(h) = C_0 + C\left[1 - exp\left(-\frac{h}{a}\right)\right] \quad (8)$$

3. The Gaussian Model

$$\gamma(h) = C_0 + C\left[1 - exp\left(-\frac{-h^2}{a^2}\right)\right] \quad (9)$$

After these parameters are obtained, the matching process between the experimental semivariogram and the theoretical semivariogram is completed, and then compared using RMSE to find the best theoretical semivariogram model based on the smallest RMSE value. The RMSE calculation is formulated:

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(\hat{z}_i - z_i)^2}{n}} \quad (10)$$

Where z_i is the observed value for the i point, $\hat{z}_i$ is the predicted value for the I point and n is the amount of data for modeling (Safira et al., 2022).

Invers Distance Weighted

The Inverse Distance Weighted (IDW) method is a simple deterministic method that accounts for neighboring points. Inverse Distance Weighted (IDW) assumes that each point size has a local influence that decreases with distance (Sari et al., 2021). Inverse Distance Weighted (IDW) is calculated using the following equation:

$$w_i = \frac{\frac{1}{d_i^k}}{\sum_{i=1}^{n} \frac{1}{d_i^k}} \quad (11)$$

And,

$$\widehat{Z_0} = \sum_{i=1}^{n} w_i Z_i \quad (12)$$

Where,

$\widehat{Z_0}$: The estimated value at the target location $\widehat{Z_0}$,

w_i : Sample weight at location I,

d_i : Distance between location i and target location,

k : Power parameter,

Z_i : Sample value at location i.

The value of power is important because it is one of the main factors that affect the accuracy of the interpolation results of Inverse Distance Weighted (IDW) (Purnomo & Wijaya, 2022).

Table 1. Research Variable

Variable	Description
X	Longitude
Y	Latitude
Z	SO2 concentration

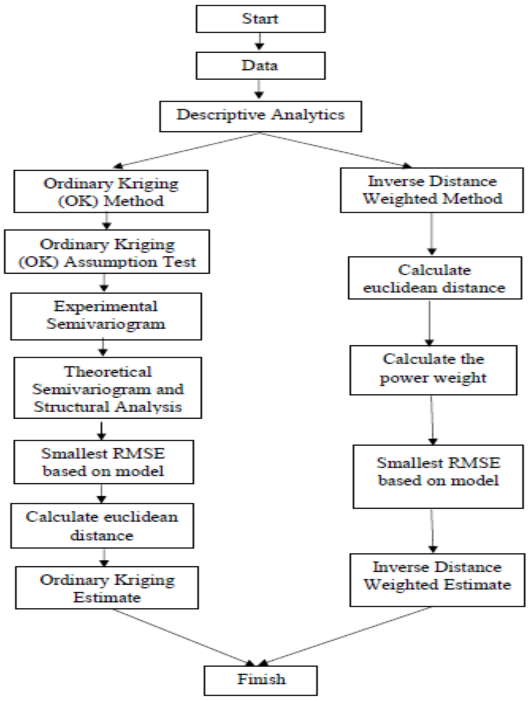

Figure 1. Research Flowchart

The Research Procedure

The first step in this research is data collection, followed by a descriptive analysis. The third step is to estimate using the OK method, which includes testing the OK assumptions; calculating the experimental semivariogram value; calculating the theoretical semivariogram value using the needed parameters, and performing structural analysis by comparing the theoretical semivariogram values such as exponential, spherical, and gaussian models; calculating the RMSE value; find location points that are close to each other; calculate the weight value for the target location using one of the best semivariogram models; and estimate the sulfur dioxide pollutant concentration using the Ordinary Kriging method. The last stage is estimating using the IDW method, which includes calculating the euclidean distance between sample points and target locations; calculating weights using the power parameter; calculating the smallest RMSE value; and estimating SO2 pollutant concentrations using the Inverse Distance Weighted model

RESULT AND DISCUSSION

The data used in this study is the air pollution data of Medan City in 2022 Sulfur Dioxide (SO2) pollutant taken from the Medan City Environment Office. The data has been measured at 10 location points spread across Medan City.

Table 2 Descriptive Analysis

Criteria	Value
Minimum	32,64
Maximum	53,17
Average	39,427
Variance	39,06013
Standard Deviation	6,2498

Ordinary Kriging

As one of the assumptions that must be met in Ordinary Kriging estimation is data that does not contain outliers, it is necessary to detect outliers using Boxplot.

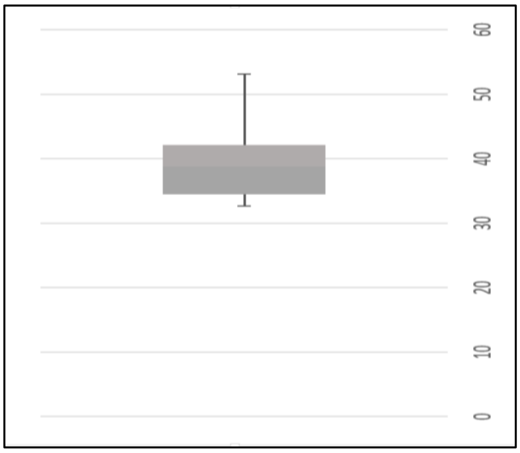

Figure 2. Outlier Detection With A Boxplot

Figure 2 indicates the absence of data containing outliers. Subsequently, the data undergoes a normality test using the Anderson-Darling (AD) test. Furthermore, the data is tested for normality using the Anderson Darling (AD) test using a 95% confidence level, the results show that the data fails to reject H0 because the P-value is 0.3728 > 0.05(α), It show the data is normally distributed. Analysis can be applied to data that meets stationarity assumptions. Data stationary can be done using the unit root test, namely the Augmented Dickey Fuller (ADF) test. Using a 95% confidence level, the data rejects H0 because the P-value is 0.01 < 0.05(α), it can be concluded that the data is stationary.

Table 3. Experimental Semivariogram

Class	Interval Class	Distance (h)	N(h)
1	0 - 0,014554	9,434E-06	1
2	0,014554 - 0,029108	0,01288247	2
3	0,029108 - 0,043662	0,01826788	2
4	0,043662 - 0,058216	0,02062021	1
5	0,058216 - 0,07277	0,02988505	1
6	0,07277 - 0,087324	0,03640224	4
7	0,087324 - 0,101878	0,04274261	1
8	0,101878 - 0,116432	0,04482404	1
9	0,116432 - 0,130986	0,04933823	2

After all the OK assumption tests are done, the next step is to calculate the experimental semivariogram using RStudio software. Obtained class intervals formed as many as 9 classes. The sill value is obtained from the data variance value of 39.06013, the calculation of the range value is obtained from the sill value which is close to the experimental semivariogram value of 0.123709.

The calculation of the theoretical semivariogram model of this research will compare with the exponential model which has known sill and range values.

Table 4. Structural Analysis

Experimental	Spherical	Exponential	Gaussian
12,103725	$4{,}75334X10^{-11}$	0,00297859	$2{,}27154X10^{-7}$
17,786263	0,00551363	3,86291	0,421286
117,870326	0,0157219	5,36228	0,842521
110,521239	0,022611	5,99699	1,07028
7,648327	4,71798	8,38271	2,21426
82,341105	5,74686	9,95701	3,23982
4,378136	0,201383	11,41104	4,3953
44,001992	0,232259	11,87235	4,8057
37,535988	0,309735	12,84656	5,74402

After calculating the value of each theoretical semivariogram model, then calculate the best RMSE value to estimate the SO2 pollutant concentration.

Tabel 5. RMSE Value

Model	RMSE
Spherical	63,03136
Exponential	58,55195
Gaussian	62,3223

The results in Table 5 show that the theoretical semivariogram model that has the smallest RMSE value is the exponential model. After the best semivariogram model is selected, namely the exponential model, it is then used to estimate the concentration of SO2 pollutants in urban villages in Medan City. The first point to be estimated is Titipapan urban village which is located at longitude 98.66812 and latitude 3.68850 coordinates denoted by point P. To find the weight value of each sample point, we must first know the theoretical semivariogram of the exponential model denoted by matrix A, then the matrix is converted into matrix A^{-1}.

The first step taken to find the sample point with the target location is to calculate the euclidean distance, the second step is to determine the value of the matrix A based on the theoretical semivariogram of the exponential model of each sample point. Then the A matrix is converted into matrix A^{-1}. After obtaining the value of matrix A^{-1}, it then takes the value in the form of vector B, which is the value of the exponential theoretical semivariogram between the sample points and the target location. Then calculate the weight of the Ordinary Kriging method. Using the equation:

$$w = A^{-1}. B \tag{13}$$

The last step is estimate the concentration of Sulfur Dioxide pollutant in Medan City using Ordinary Kriging.

$$\hat{z}(s_0) = \sum_{i=1}^{n} w_i Z(s_i) \tag{14}$$

The following are the results of estimating sulfur dioxide (SO2) concentrations using the Ordinary Kriging method:

Tabel 6. Estimated SO2 Concentration in Medan City Using OK

No	Name of Urban Village	X	Y	Estimasi
1	Titi Papan	98,66812	3,68850	40,77
2	Tanjung Mulia	98,66646	3,63773	49,73
3	Kota Bangun	98,66333	3,67494	41,15
⋮	⋮	⋮	⋮	⋮
149	Bantan Timur	98,70879	3,59757	42,37
150	Kesawan	98,67488	3,59426	43,18
151	Sei Sikambing C	98,63181	3,59186	35,01

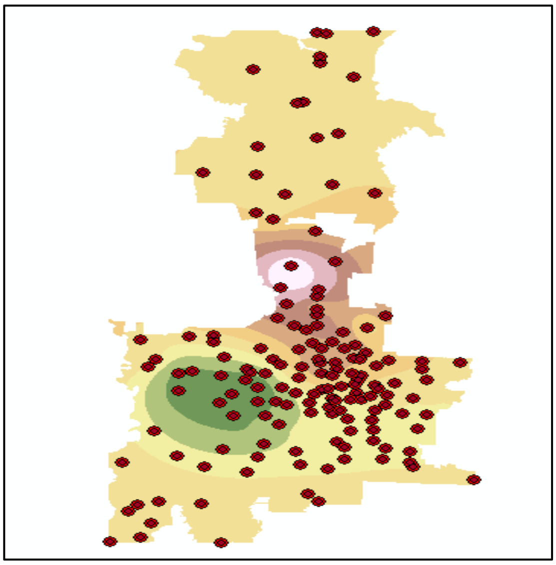

Figure 3. Plot of estimated SO2 OK

The estimation of concentration of Sulfur Dioxide pollutant in Medan City using the OK method will result in 151 location points presented in Figure 3. As can be seen in Figure 3, the red point indicate the observation location points that have the estimated concentration of SO2 pollutant from the lowest to the highest and are visualized based on the white to green color gradient. The higher the estimation value is white and the lower the estimation value is green

Inverse Distance Weighted

Before calculating the Inverse Distance Weighted estimation, we need to calculate the distance between the target location point and the sampled location point. Using the equation:

$$d(a,b) = \sqrt{(x_b - x_a)^2 + (y_b - y_a)^2} \quad (15)$$

Then calculate the weights using power parameters 1, 2, 3, and 4.

Table 7. Parameter Power

power 1	power 2	power 3	Power 4
0,045214	0,012143	0,002262	0,000363
0,315695	0,591977	0,770064	0,862668
0,064712	0,024874	0,006633	0,001523
0,064713	0,024874	0,006633	0,001523
0,069685	0,028844	0,008282	0,002048
0,047021	0,013133	0,002545	0,000425
0,065745	0,025674	0,006955	0,001623
0,19535	0,226671	0,182458	0,126481
0,062162	0,022952	0,005879	0,001297
0,069703	0,028858	0,008288	0,00205

After get the value of power parameters 1, 2, 3, and 4, the next step is to calculate the smallest RMSE value.

Table 8. RMSE IDW

Parameter	RMSE
Power 1	380,95
Power 2	464,033
Power 3	540,688
Power 4	598,053

The best power value selection is based on the lowest RMSE value that is most close to zero. The smallest RMSE value is 380.95 at power value 1, it shows the Inverse Distance Weighted (IDW) power 1 estimation results have a smaller error value and more accurate than power 2, power 3, and power 4.

To calculate the Inverse Distance Weighted method, the smallest parameter is utilized, namely the power 1 parameter. This approach is employed to ensure the accuracy of the estimation by selecting the smallest parameter, resulting in an optimal outcome. The final step that needs to be taken is to estimate the concentration of Sulfur Dioxide pollutant in Medan City using the Inverse Distance Weighted method.

$$\widehat{Z_0} = \sum_{i=1}^{n} w_i Z_i \qquad (16)$$

The following are the results of estimating sulfur dioxide (SO2) concentrations using the Inverse Distance Weighted method:

Tabel 9. Estimated SO2 Concentration in Medan City Using IDW

No	Name of Urban Village	X	Y	Estimasi
1	Titi Papan	98,66812	3,68850	41,89
2	Tanjung Mulia	98,66646	3,63773	42,87
3	Kota Bangun	98,66333	3,67494	42,35
⋮	⋮	⋮	⋮	⋮
149	Bantan Timur	98,70879	3,59757	39,23
150	Kesawan	98,67488	3,59426	39,67
151	Sei Sikambing C	98,63181	3,59186	38,14

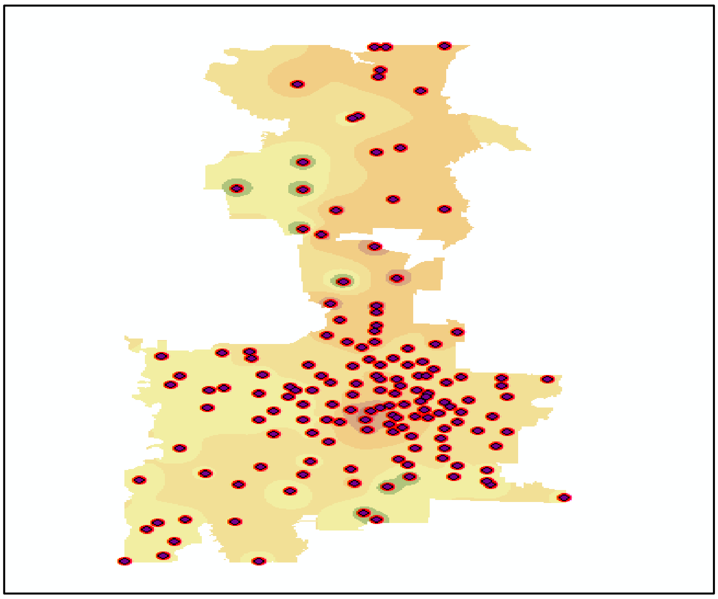

Figure 4. Plot of IDW estimate

Estimation of Sulfur Dioxide pollutants using the IDW method produces a mapping of areas with the closest distance. Based on Figure 4, the red dot indicates the point of the sampled observation location, the gray to green color gradient illustrates the Sulfur Dioxide estimation results from highest to lowest. Therefore, the higher the estimated value, the resulting color is purplish gray and the lower the estimated value is green.

Best Method Sulfur Dioxide (So2) Pollutant Concentration Estimation

The accuracy of prediction and determination of the interpolation method that provides the best results can be assessed through cross-validation. The model with the smallest RMSE value is selected as the best. In the Ordinary Kriging (OK) interpolation method, fitting the experimental semivariogram model is carried out using spherical, exponential, and gaussian models. Based on calculations, the smallest RMSE value in the OK method indicates that the best theoretical semivariogram model is exponential with a value of 62.32. Additionally, in the Inverse Distance Weighted (IDW) method, parameter power calculations reveal that the smallest RMSE value for SO2 concentration estimation is achieved with IDW power 1, amounting to 380.95. Therefore, it is concluded that the OK method is more accurate in estimating SO2 concentrations compared to the IDW method in Medan city.

CONCLUSION

Based on the results of the analysis and discussion above, it can be concluded that Ordinary Kriging (OK) is the right model to estimate the concentration of Sulfur Dioxide

(SO_2) pollutant in Medan City. This is because the calculation results of the smallest Root Mean Square Error (RMSE) value in the OK method are smaller than the IDW method, which is 62.32 while the IDW method is 380.95.

The estimation results of Sulfur Dioxide (SO_2) concentration using the Ordinary Kriging approach obtained that the best theoretical semivariogram model is the Exponential model with a sill value of 39.06013 and a range of 0.123709. The highest estimated value of Sulfur Dioxide concentration in Medan City is at point (98.67049; 3.64958) of Tanjung Mulia Hilir village at 51.51 μg/Nm3, and the lowest estimated concentration value is at point (98.64801; 3.56708) of Padang Bulan Selayang I village at 33.37 μg/Nm3. The estimation results of Sulfur Dioxide (SO_2) concentration using the Inverse Distance Weighted approach obtained that the best power parameter is power parameter 1 with an RMSE value of 380.95. The lowest Sulfur Dioxide concentration estimation value in Medan City is at point (98.67049; 3.64958) of Tanjung Mulia Hilir village at 35.31 μg/Nm3, and the highest concentration estimation value is at point (98.67931; 3.57922) of Hamdan village at 46.22 μg/Nm3.

With the existence of this research, it is anticipated to provide insights into the presence of SO_2 pollutants in Medan City, aiming to enhance environmental air quality. The findings are expected to contribute to a better understanding of air pollution dynamics in the area, fostering efforts to improve air quality gradually. It is recommended to increase the number of sampling points, as increasing the number of sample points involved in the calculations tends to result in more accurate predicted values.

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