CARBON MONOXIDE SPATIAL PATTERN BASED ON VEHICLE VOLUME DISTRIBUTION IN TANGERANG CITY

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Abstract. Air pollution conditions in urban areas continue to increase due to the volume of vehicles every year. This volume increases sources of pollution such as motor vehicles which account for 60-70% of pollution. This study aims to analyze the distribution of vehicle volume and spatial pattern of CO in Tangerang City and see the relationship. The analysis used is descriptive and statistical spatial analysis. The results showed the distribution of vehicle volume in the morning ranged from <800-1600 vehicles on primary collector roads, while in the afternoon, there were 800 to >2000 vehicles on primary arterial roads. The spatial pattern of CO that formed on primary and collector arterial roads with residential land uses, industrial areas, and warehouses, then the CO concentration tends to be high. Meanwhile, other primary collector roads have low to moderate CO concentrations. The Spearman test and linear regression results showed a significant effect between vehicle volume on the Tangerang City CO pattern, with a strength value of 0.689 and an R Square of 0.476.

Keywords: *Vehicle Volume, Air Pollution, Carbon Monoxide, Spatial Pattern.*

1 INTRODUCTION

Air pollution conditions in large urban areas continue to grow due to population growth which adds to various sources of pollution such as motor vehicles, industry, construction, and business activities over the last few years (Hazarin et al., 2019; Safarian Zengir et al., 2020). Especially in metropolitan cities such as Jakarta, which is the center of the economy and consistently everyone mostly uses motorized vehicles (Azaria et al., 2018). Sources of air pollution in Jakarta generally come from human activities that produce Carbon Monoxide (CO), especially from development activities or human activities using vehicles (Arista et al., 2019).

Carbon Monoxide (CO) is a colorless, odorless, tasteless, and non-irritating, but lethal gas that results from incomplete combustion of liquid, solid, and gaseous fuels, the most common source of CO in free air is from vehicles. motorized (Erawan et al., 2021). Transportation emissions are the highest contributor to air pollution, in addition to transportation emissions there are also industrial activities and waste disposal sites (DKI Jakarta Environmental Agency, 2013). Among the types of gas carried by vehicles, carbon monoxide is the largest contributor as a pollutant (Satria, 2006), and 60% of carbon monoxide gas comes from vehicles that use fuel oil, causing air pollution (Siregar, 2005). Meanwhile, the participation of exhaust gases from industrial activities only ranges from 10-15% and the rest comes from other sources of combustion, such as households, burning garbage, forest/field fires and others. The increasing volume of vehicles can cause blockage and air pollution due to the outflow caused by vehicles (Basuki et al, 2012).

Given the very rapid modern development supported by the presence of several industrial areas in Tangerang City, the implication is that it can increase the number of people living in Tangerang City, which is followed by an increase in the number of motorized vehicles, both two-wheeled and four-wheeled (Maulana et al., 2016). Based on data from the Tangerang City Central Statistics Agency, the number of passenger car vehicles in 2020 reached 213,264 units. However, with the volume of vehicles in Tangerang City continuing to increase, it is not followed by an increase in available road infrastructure, so that the increase in the volume of vehicles in Tangerang City certainly causes several problems such as increased air pollution, especially CO pollution (Ismiyati et al., 2014; Salean et al. .2019). In addition to the problem of air pollution, it also causes several traffic problems such as increasing congestion (Handoyo & Afriansyah, 2008). Especially in Tangerang City, there are approximately 33 congestion points because the Tangerang City area is an area that connects activities between surrounding areas such as DKI Jakarta, Tangerang Regency, and South Tangerang City (Tangerang City Transportation Agency, 2018). So that in areas with high levels of congestion, this can create a sharp agglomeration of air pollution due to the outflow of motor vehicle fumes that are focused on certain areas (Ribeiro et al., 2016).

Remote sensing is a massive strategy used in assessing CO estimation because it is considered to provide benefits in terms of time, and cost estimation for large inclusion areas and can be used in areas with limited access (Hairiah et al., 2001). One of the methods used is the *spline* which is used to estimate the spatial value based on the known point value of the measurement location.

Remote sensing innovation can make it easier to get air pollution values, or spatial air quality information such as Sentinel-5P satellite imagery that can be used to monitor air pollution in the atmosphere (Lin, 2019). Sentinel-5P has a spatial resolution of 7.5x3.5 km, this resolution is higher than the spatial resolution of OMI, which is 13x25 km (Van Geffen et al., 2020; Borsdorff et al., 2018). Based on the problems above, this study was conducted analyze the volume distribution of vehicles formed in the City of Tangerang, analyze the spatial pattern of carbon monoxide in the City of Tangerang. As well as analyzing the relationship of vehicle volume to the distribution of carbon monoxide in Tangerang City.

2 MATERIALS AND METHODOLOGY

2.1 Location and Data

Tangerang City, which was formed on February 28, 1993, based on Law no. 2 of 1993, geographically located at 106'36 – 106'42 East Longitude (BT) and 6'6 - 6 South Latitude (LS), with an area of 183.78 Km² (calculated by Soekarno-Hatta Airport area of 19, 69 km²) (Figure 2-1).

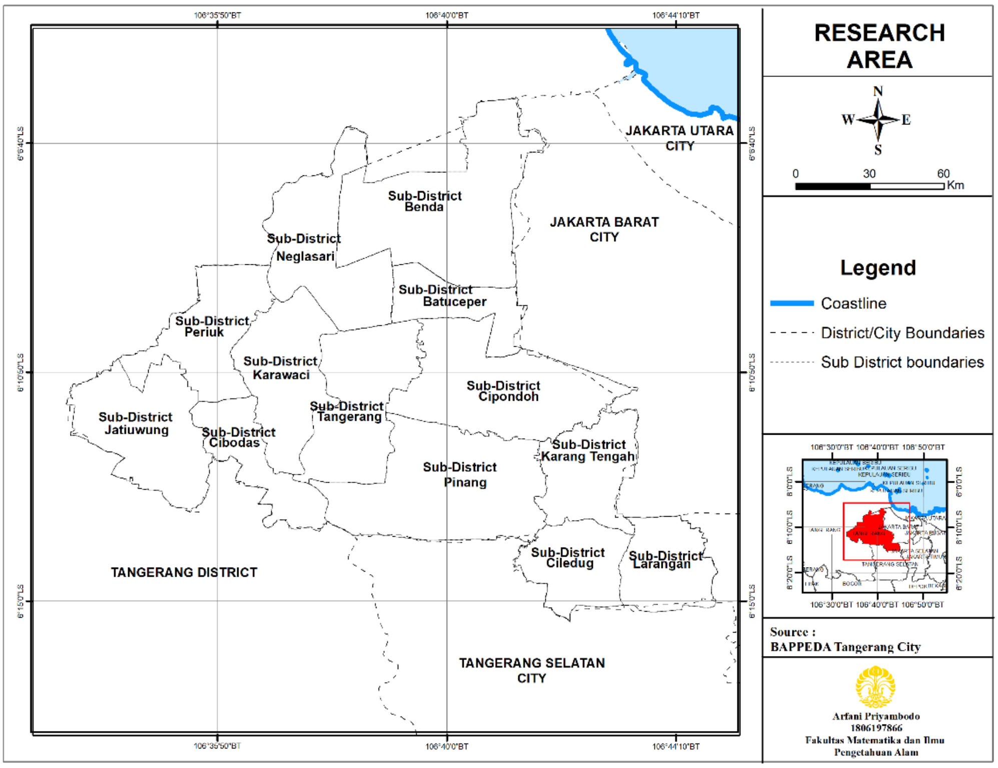


Figure 2-1. Research Area

The data used in this study consisted of primary data and secondary data. The primary data used are carbon monoxide data, the number or volume of car vehicles, and the length of traffic jam. Secondary data used in this study such as administrative boundaries, land use, and road networks were obtained from the Geospatial Information Agency, as well as congestion information data and carbon monoxide data obtained from relevant agencies and google maps. In determining the sample point using purposive sampling technique. The number of primary arterial and primary collector roads in Tangerang City is 11 roads. The sample points are determined based on the criteria that have been made, namely primary roads that experience congestion at 07.00 – 10.00 WIB (UTC +7) and/or at 16.00 – 18.00 WIB on weekdays (Monday, Wednesday, and Saturday). It is assumed that these hours are busy hours, which occur at 7.00 – 10.00 WIB and 16.00 – 18.00 WIB, where each point is observed for one hour and the roads that experience congestion have a high volume of vehicles (Kusuma, 2010). The sample points represent the road segment with the road segment as the unit of analysis**.** Then, after obtaining the spatial pattern of CO from vehicle emissions, validation was carried out using the help random points with CO spatial data or patterns sourced from DLH and Sentinel 5P. Sentinel-5P was first introduced in 2017, Citra Sentinel-5p has a TROPOMI mission which functions to pay attention to air quality (Kaplan et.al., 2020). The advantage of the TROPOMI mission over other missions is that it has a high spatial resolution of 7x3.5 km (increases to 5.5 × 3.5 km after 6 August 2019) and covers the world every day due to its large swath (Van Geffen et al.,2020); Borsdorff et al., 2018). So that the air quality observations carried out by sentinel 5P images are carried out on a city scale.

2.2 Methods

Data processing (**Figure 3-1**) is carried out using the help of several software such as Arcgis 10.x which is used to process spatial data, Microsoft excel is used to process tabular data, and SPSS to process and test statistical data. Road congestion data obtained from *Google Maps* is used to visualize congestion spatially in the form of a map.

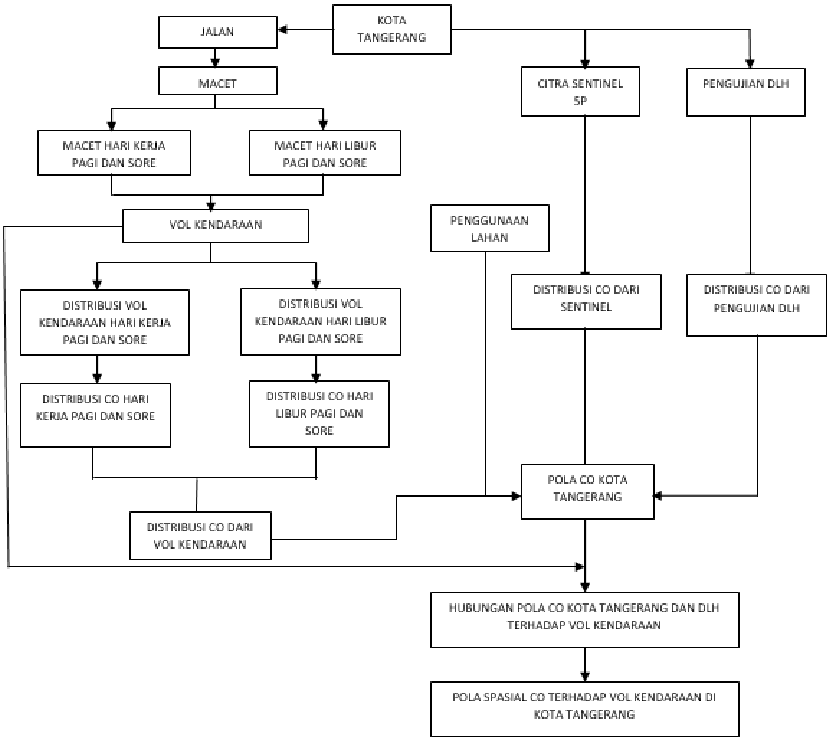


Figure 3-1. Flow Chart

Vehicle volume data that has been obtained from field observations based on congestion points from the *Google Maps*, is used to calculate the amount of carbon monoxide in Tangerang City. The data from the observations are tabulated in Excel which is then processed into vehicles per month or per year which is then linked to spatial data in ArcGIS.

After the number of cars has been calculated in per day, which is then converted to per month, it can be done by multiplying the passenger car unit (SMP) into the volume of the vehicle, then entering it in the vehicle mileage equation to get the carbon monoxide emission load based on each congestion point, data obtained in tabular form so it must be used as a spatial form. (Swanwick C, 1978; Muzianyah et.al., 2015). The formula used is as follows:

$$\mathbf{E = V \times Px\ FE \times 10^{-3}} \text{..............(1)}$$

E: Emission load (tonnes/year), V: Traffic volume (vehicles/year), FE: Emission Factor (g/km/vehicle), P: Road length (km). Meanwhile, to get the carbon monoxide value from the sentinel 5P, it is processed using the help of the Google Earth Engine.

3 RESULTS AND DISCUSSION

3.1 Vehicle Volume Distribution

From the results of data processing congestion (Figure 3-2) which has been recorded from the Google Maps application, it is assumed that the points experiencing congestion have a high volume of vehicles, the distribution of vehicle volume in the morning formed in Tangerang City on weekdays in 2021 mostly has a volume vehicle that tend to be low to medium, which is around 800-1600 pcu. On weekdays (Monday and Wednesday) there is an increase in the volume of vehicles in the south and west. Because in the morning, especially on weekdays, many people mobilize out of Tangerang either to offices in Jakarta and its surroundings or factories located in the southern part of Tangerang City.

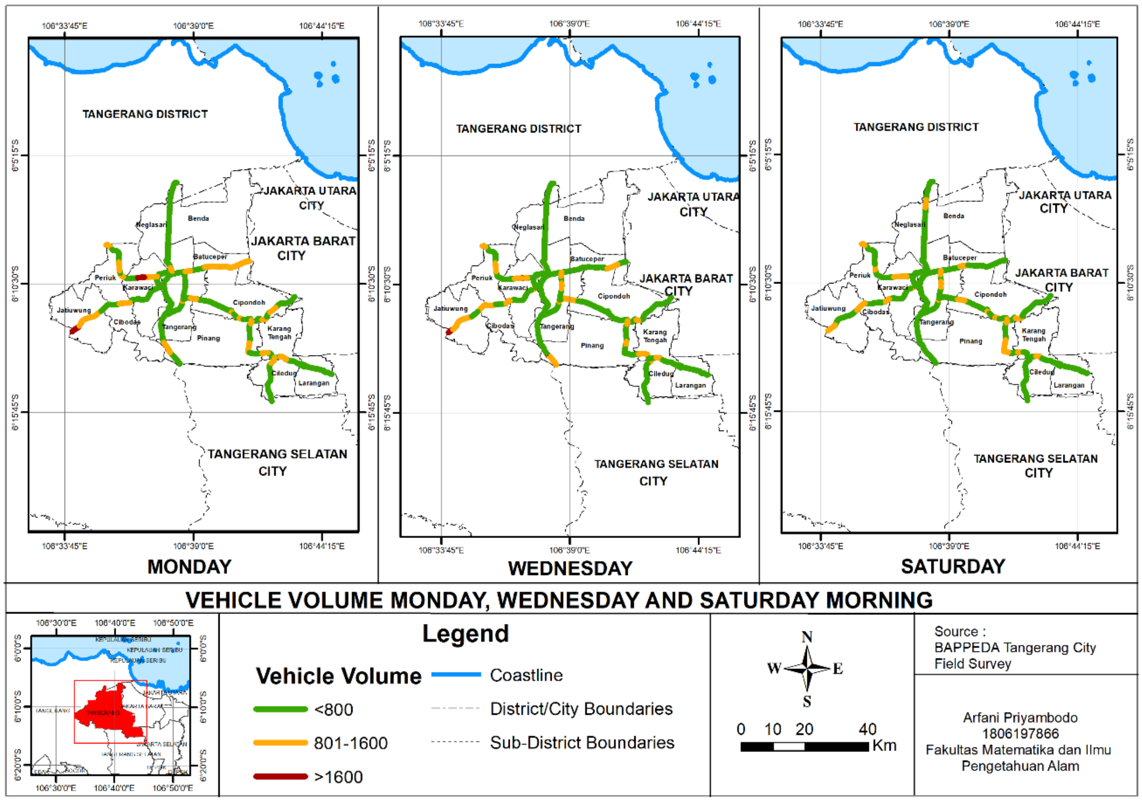


Figure 3-2. Distribution of Vehicle Volume Monday, Wednesday, and Saturday Morning.

From the processing results (Figure 3-3), the distribution of vehicle volume in the afternoon formed on weekdays in 2021 is dominated by medium to high vehicle volume levels ranging from 800 to > 1600, some have low vehicle volume levels, namely <800. In the afternoon, almost all roads are congested and even experience long traffic jams, especially during working hours. This is due to the mobility of people returning from work from Jakarta to Tangerang City. Because most of the people of Tangerang city work in Jakarta, it has the potential to cause piles of vehicles on several roads.

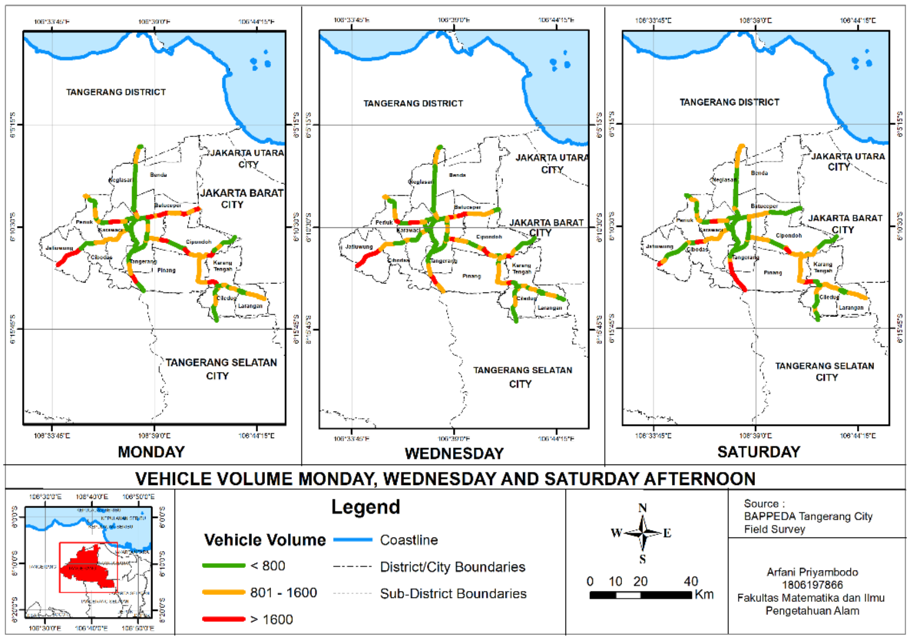


Figure 3-3. Distribution of Vehicle Volume Monday, Wednesday, and Saturday Afternoon.

3.2 Carbon Monoxide Spatial Pattern

3.2.1 Spatial Patterns of Carbon Monoxide from Vehicle Emissions, DLH, and Sentinel 5P

Based on Figure 3-4, the results of visualization of vehicle emissions show that primary collector roads such as Moh Toha Road have low levels of carbon monoxide emissions. However, based on the interpolation results from tests conducted by DLH Tangerang City, the primary arterial and primary collector roads have carbon monoxide emission levels ranging from moderate to high. Then, from the distribution of CO from DLH, areas with low concentrations tend to be in areas far from the roads under study. The primary arterial road, Jalan Sudirman, has the highest carbon monoxide content from vehicle emissions, while the primary collector road section, Jalan Marsekal Suryadharma, has the lowest carbon monoxide content.

Based on Figure 3-5, the distribution of CO sourced from sentinel 5P, it can be seen that arterial and primary collector roads display differences in terms of CO concentration. The spatial pattern of CO formed can be seen that on the primary collector road, namely Jalan Marsekal Suryadharma with land use dominated by rice fields and swamps, the CO concentration is low, while the primary collector road and a few primary arterial roads have moderate to moderate CO concentrations. tall. This difference is due to other factors that can affect the value of CO concentration, namely pollution from unidentified sources, household air pollution, meteorological conditions such as weather, topographic conditions, chemical reactions that change air pollutants in the air, and the movement of pollutants in the air.

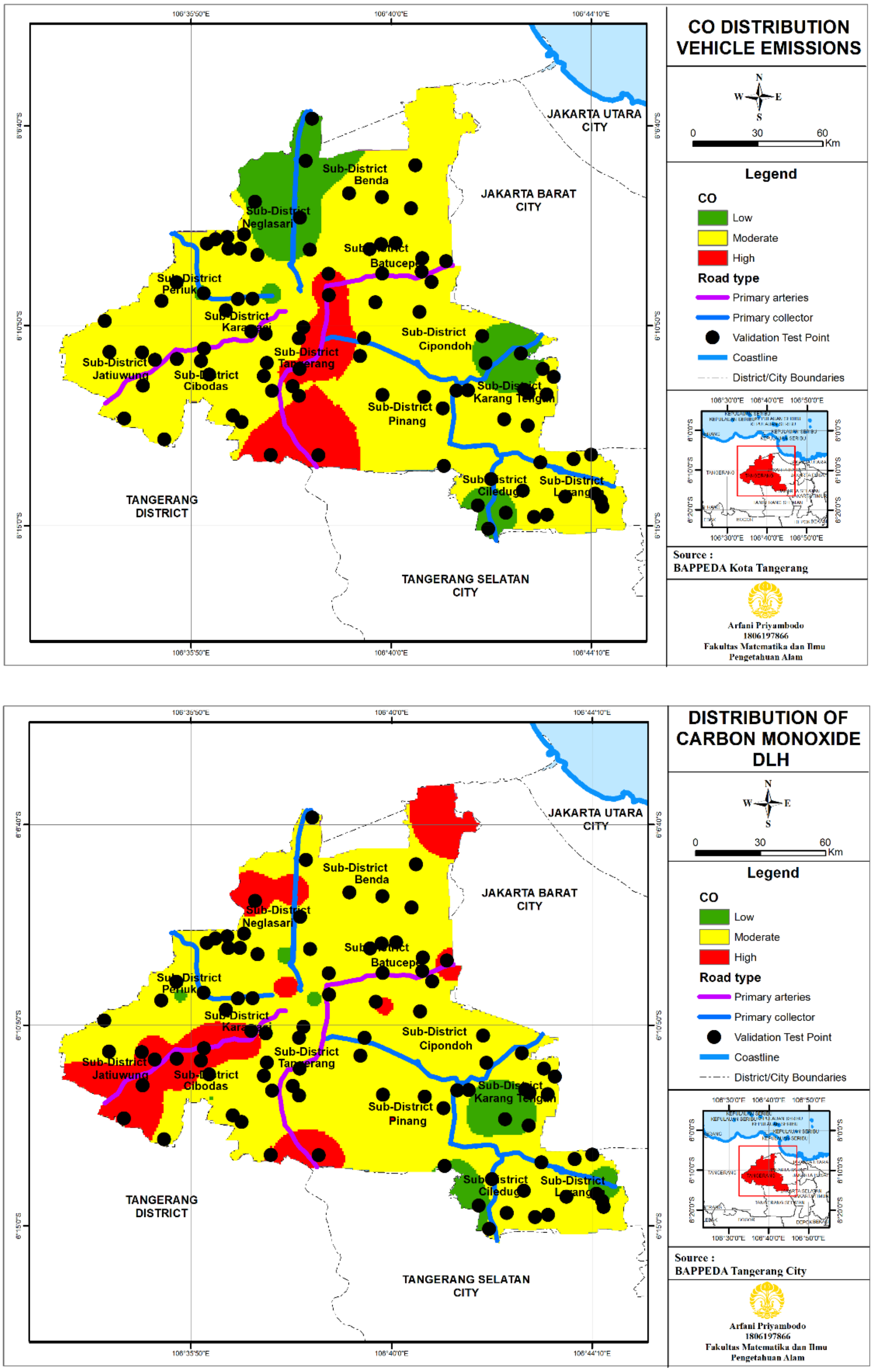


Figure 3-4. Distribution of Carbon Monoxide between Vehicle Emissions and DLH.

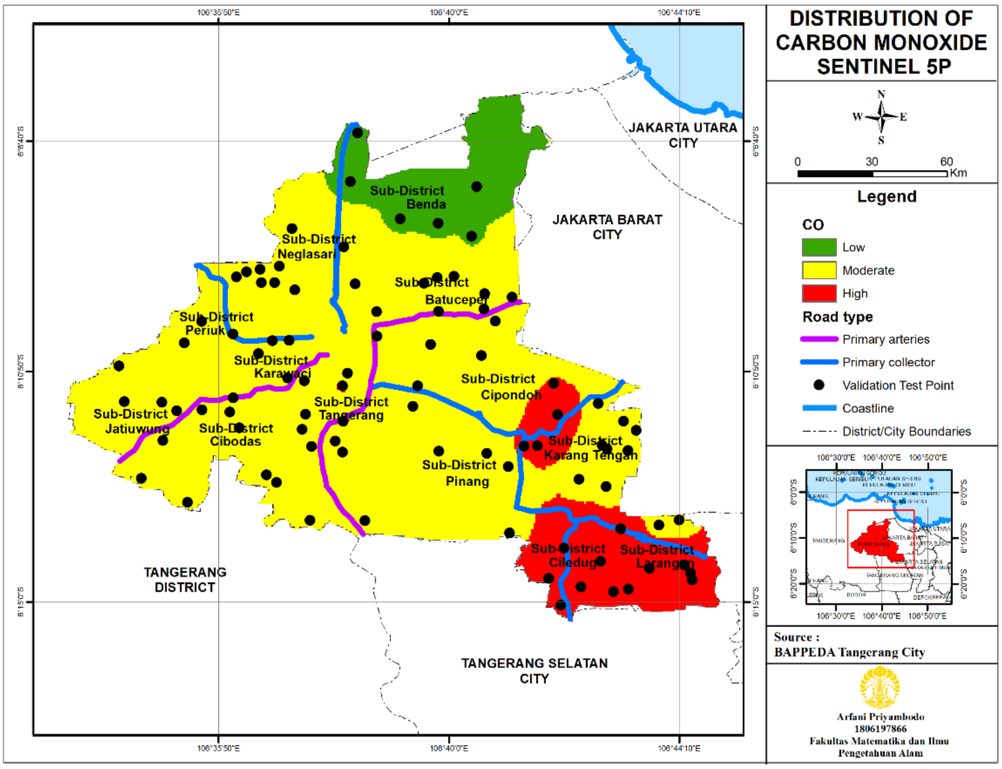
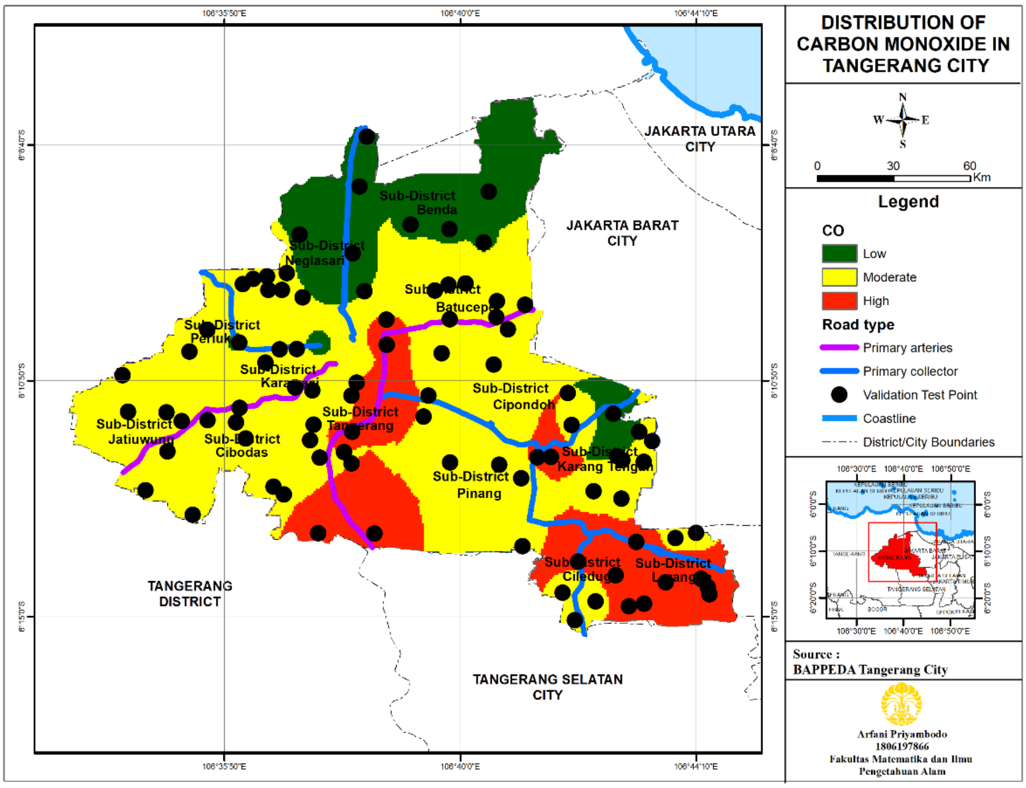


Figure 3-5. Distribution of Carbon from Sentinel 5P.

3.2.2 Tangerang City Carbon Monoxide Spatial Pattern

Based on Figure 3-6, the spatial pattern of carbon monoxide in Tangerang City is a combination of the spatial pattern of CO from vehicle emissions and Sentinel 5P. The visualization results show the distribution of carbon monoxide in Tangerang City on some primary arterial roads such as Jalan Gatot Subroto, Jalan Daan Mogot, and Jalan Sudirman, and the primary collector road is dominated by moderate CO conditions, while on other primary arterial roads, namely Jalan MH Thamrin has high levels of carbon monoxide, namely in the southern part of Tangerang City. Then, other primary collector roads such as Jalan Marshal Suryadharma have low CO levels.

Based on Figure 3-7, the results of the CO distribution sourced from the validation results, the spatial pattern of CO formed can be seen that on primary arterial roads with an average road width of 9-18 meters, namely Jalan Gatot Subroto, parts of Jalan Daan Mogot, Jalan Sudirman, and Jalan MH Thamrin and primary collector roads such as HOS Cokroaminoto road with dominant land use such as residential areas, then there are also industrial areas, and warehouses which tend to have high concentrations of CO. Meanwhile, on other primary collector roads, such as Jalan Marsekal Suryadharma and Jalan Kh Ahmad Dahlan with an average road width of 7-9 meters, the CO concentration is low to moderate, where on the primary collector roads with residential land use dominance, and there are rice fields. , swamps, and lakes have CO which tends to be low, this is because vegetation areas such as plantations and rice fields can reduce PM concentrations (Xie & Wu, 2017), then on other primary collector roads such as Jalan Moh Toha, and Jalan KH Hasyim Ashari with the dominant land use is residential only has a CO which tends to be moderate.



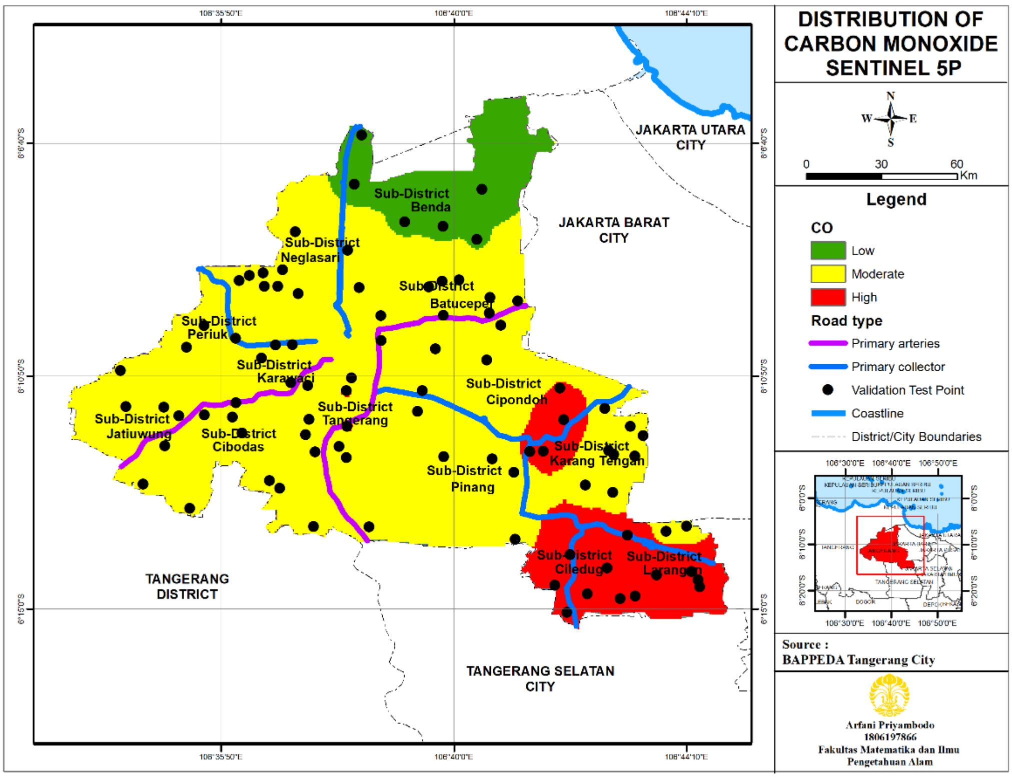


Figure 3-6. Distribution of Carbon Monoxide in Tangerang City (Before Validation) and Sentinel 5P.

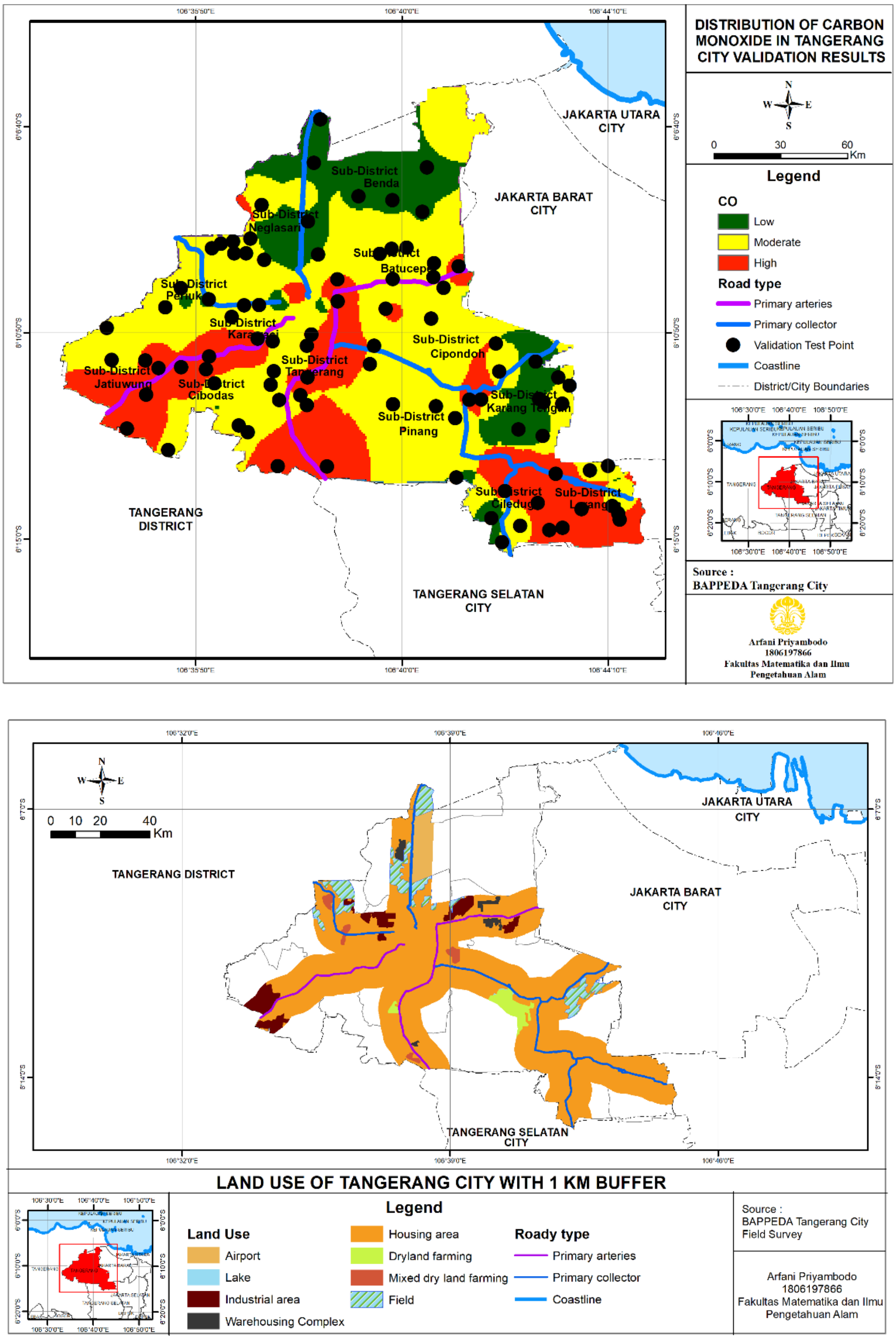


Figure 3-7. CO Map Validation Results and Land Use.

Then, a re-validation test was carried out from the CO spatial pattern of the city of Tangerang with the CO spatial pattern from the sentinel 5P image and the CO spatial pattern from the DLH using the validation test points carried out as shown in Table 3-1. The results of the validation test between the distribution of CO in Tangerang City (Validation Results) and the distribution of CO from sentinel using 91 validation points. It can be seen that the *overall accuracy* obtained is 68%, with the *kappa accuracy* obtained at 0.403, which value is included in the moderate level of confidence. While the validation test between the distribution of

CO Tangerang City (Validation Results) with the distribution of CO from DLH. It can be seen that the *overall accuracy* obtained is 70%, with the *kappa accuracy* obtained at 0.43, which is a moderate level of confidence.

Table 3-1. CO Validity Test with DLH and Sentinel.

	Data Acuan (Sentinel 5P)				
Data Hasil Model	Rendah	Sedang	Tinggi	Total	User Accuracy
Rendah	6	8	1	15	40
Sedang	0	44	5	49	90
Tinggi	0	15	12	27	44
Total	6	67	18	91	
Producer Accuracy	100	66	67		

	Data Acuan (DLH)				
Data Hasil Model	Rendah	Sedang	Tinggi	Total	User Accuracy
Rendah	5	10	0	15	33
Sedang	1	47	1	49	96
Tinggi	0	15	12	27	44
Total	6	72	13	91	
Producer Accuracy	83	65	92		

The difference in the *overall accuracy* and *kappa* obtained between validation tests may be caused by differences in the location of the measurements taken. Whereas the results of the DLH are carried out at each sub-district office in Tangerang City, while the results of vehicle emissions are carried out on the edge of the road segment being studied. In addition, the air quality monitoring equipment used by DLH operates 24 hours continuously. As well as in taking measurements, the equipment used should meet the requirements such as being placed in the open air with an open angle of 120° (one hundred and twenty degrees) to the barrier, the inlet sampling height from the ground surface for particles and gasses of at least 2 (two) meters, and a distance of at least 2 (two) meters. air quality monitoring device from the nearest emission source of at least 20 (twenty) meters and is also influenced by meteorological conditions.

3.3 Statistical Test between Vehicle Volume and CO Concentration

3.3.1 Statistical Test between Vehicle Volume and Tangerang City CO Concentration

Based on the results of Table 3-2. the correlation test produces a significance value of 0.001. This means that because it is smaller than 0.05, it can be interpreted that there is a significant influence between the volume of vehicles on the carbon monoxide pattern in Tangerang City. With the magnitude of the relationship strength of 0.689 which means that the volume of the vehicle is positively related to the concentration of carbon monoxide with a degree of relationship of 0.689 which means that it has a strong and unidirectional relationship. It can be concluded that the higher the volume of passing vehicles, the higher the concentration of carbon monoxide.

Based on Table 3-3, from the results of a simple linear regression test, the coefficient of determination (R Square) is 0.476 which means that the volume of the vehicle has an effect of 47.6% on the concentration of carbon monoxide, while the rest is influenced by other variables not examined. Then the results of the next simple linear regression obtained the regression equation, namely: Y = -0.538 + 1.023X. Which means that for every 1% addition of the morning vehicle volume value, the participation value will increase by 1.023.

Table 3-2. Correlation Test between Vehicle Volume and Tangerang City Carbon Monoxide concentration.

Correlations

			Vehicle Volume	CO in Tangerang City
Spearman's rho	Vehicle Volume	Correlation Coefficient	1.000	.689**
		Sig. (2-tailed)	.	.001
		N	21	21
	CO in Tangerang City	Correlation Coefficient	.689**	1.000
		Sig. (2-tailed)	.001	.
		N	21	21

**. Correlation is significant at the 0.01 level (2-tailed).
Sumber: Pengolahan Data

Table 3-3. Regression Test between Vehicle Volume and Tangerang City's Carbon Monoxide Concentration.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.690a	.476	.449	.6171

a. Predictors: (Constant), Volume Kendaraan

Coefficientsa

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.538	.681		-.789	.440
	Vehicle Volume	1.023	.246	.690	4.155	.001

a. Dependent Variable: CO Kota Tangerang
Source: Data processing

3.3.2 Statistical Test between Vehicle Volume and CO Concentration from DLH

Based on **Table 3-4**, the results of the correlation test table between vehicle volume and carbon monoxide concentration sourced from measurements by the Tangerang City Environment Service obtained a significance value of 0.085. This means that because it is greater than 0.05, it can be interpreted that there is no significant effect between vehicle volume on the carbon monoxide pattern sourced from the test results of the Tangerang City Environmental Service.

Based on **Table 3-5**, from the results of a simple linear regression test, the coefficient of determination (R Square) is

0.120, which means that the vehicle volume has an effect of 12% on the concentration of carbon monoxide originating from DLH Tangerang City, while the rest is influenced by other variables. Then the results of the next simple linear regression obtained the regression equation, namely: Y = 1.341+0.295X. Which means that for every 1% addition to the value of the vehicle volume, the participation value increases by 0.295.

Table 3-4. Correlation Test between Vehicle Volume and Carbon Monoxide Concentration from DLH.

Correlations

			Volume Kendaraan	CO DLH
Spearman's rho	Vehicle Volume	Correlation Coefficient	1.000	.385
		Sig. (2-tailed)	.	.085
		N	21	21
	CO DLH	Correlation Coefficient	.385	1.000
		Sig. (2-tailed)	.085	.
		N	21	21

Table 3-5. Regression Test between Vehicle Volume and Carbon Monoxide Concentration from DLH.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.346 a	.120	.074	.4601

a. Predictors: (Constant), Volume Kendaraan

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.341	.508		2.639	.016
	Vehicle Volume	.295	.184	.346	1.610	.124

Dependent Variable: CO DLH
Source: Data processing

The low correlation value is caused by differences in the location of the measurements taken. Then it is also influenced by meteorological conditions such as wind so that the carbon monoxide emissions released by vehicles are carried away by the wind so that not all of them are caught by the tool. In addition, the conditions of land use found at the observation location can also affect the concentration of carbon monoxide recorded by the tool, for example if there is a lot of green open space around the observation location, a lot of oxygen is around the observation location causing greater oxygen to combine with the oxygen that is emitted. there is. And there are other factors that can affect the distribution of carbon monoxide concentrations, such as pollution from unidentified sources (eg burning garbage, cooking on the roadside), Meteorological conditions (eg, temperature, turbidity, rainfall humidity, wind patterns), Topographical Conditions , Chemical transformations that alter airborne air pollutants (e.g., secondary aerosols) and the regional movement of pollutants, Household air pollution (e.g., use of solid fuels for cooking) can also cause ambient air pollution (Environment Agency of DKI Jakarta and Vital Strategies, 2019).

4 CONCLUSIONS

Based on the results of research and analysis, the distribution of vehicle volume on Monday, Wednesday, and Saturday morning has a low to moderate level of vehicle volume, starting from <800-1600 vehicles found on primary collector roads with the dominance of land use such as settlements, and rice fields in some areas. part. while in the afternoon it has a medium to high level of vehicle volume, namely 800 to > 1600 vehicles, which are found on primary arterial roads and some primary collector roads with the dominance of settlements, industrial areas, and warehousing.

The spatial pattern of CO formed can be seen that on primary arterial roads with an average road width of 9-18 meters, namely Gatot Subroto Road, some Daan Mogot roads, Sudirman roads, and MH Thamrin roads and primary collector roads such as HOS Cokroaminoto road with a dominance of use land such as settlements, then there are also industrial areas, and warehouses have CO concentrations that tend to be high. While on other primary collector roads, such as Marshal Suryadharma Road and KH Ahmad Dahlan Road with an average road width of 7-9 meters, the CO concentration is low to moderate, where on the primary collector road with the dominance of residential land use, and there are rice fields. , swamps, and lakes have CO which tends to be low, on other primary collector roads such as Jalan Moh Toha, and Jalan KH Hasyim Ashari with the dominant land use being residential only, which tends to be moderate.

Based on the results of the Spearman correlation test, there is a significant effect between the volume of vehicles on the carbon monoxide pattern in Tangerang City, with the magnitude of the relationship strength of 0.689 which means it has a strong and unidirectional relationship. Meanwhile, if tested against the carbon monoxide pattern from DLH, the significance value was 0.085. This means that there is no significant effect between the volume of vehicles on the pattern of carbon monoxide sourced from the test results of the Tangerang City Environmental Service. From the results of a simple linear regression test, the coefficient of determination is 0.476. Which means that the volume of vehicles has an effect of 47.6% on the concentration of carbon monoxide patterns in Tangerang City, while the rest is influenced by other variables not examined. Meanwhile, from the results of a simple linear regression test, the volume of vehicles with a concentration of carbon monoxide from DLH obtained a coefficient of determination of 0.120, which means that the volume of vehicles has an effect of 12% on the concentration of carbon monoxide originating from DLH, Tangerang City.

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