Linear and polynomial regression analysis of the relationship between vehicle volume and PM_{10} concentration on road sections in Makassar City

Sumarni Hamid Aly[1,2*], *Nurul* Masyiah *Rani* Harusi [1,2], *Yuen Choon* Wah[3,2], *Aisyah* Handayani[1], and *Putri Humaira* Salsabila[1]

[1]Departement of Environmental Engineering, Faculty of Engineering, University of Hasanuddin, St. Poros Malino KM.6, Bontomarannu, Gowa, South Sulawesi, 92172, Indonesia
[2]Transportation and Air Quality Research Group, University of Hasanuddin, St. Perintis Kemerdakaan No. KM 10, Makassar South Sulawesi, 90245, Indonesia
[3]Centre for Transportation Research, Department of Civil Engineering, Faculty of Engineering, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

Abstract. Urban air quality has become a critical concern in the context of climate change, as increasing emissions from the transportation sector contribute not only to greenhouse gases but also to particulate pollution that directly affects public health. In rapidly developing cities like Makassar, understanding the factors influencing PM_{10} concentrations is essential for supporting climate-responsive urban planning. This study aims to analyze the predictive relationship between vehicle volume and PM_{10} concentration on 6/2D arterial roads and 2/2UD undivided two-way roads using linear and polynomial regression models. Vehicle volume and PM_{10} data were collected from eight measurement points on each road type across four time intervals. PM_{10} concentrations were measured using a High Volume Air Sampler (HVAS), while vehicle volume was recorded simultaneously using a traffic counter application. Results show that vehicle volume on 2/2UD roads was lower than on 6/2D roads, with motorcycles dominating traffic composition (71.42–82.54%). All points recorded PM_{10} concentrations exceeding the national standard of 75 $\mu g/m^3$. Linear regression produced a moderate relationship ($r = 0.519$; $R^2 = 26.9\%$), whereas the polynomial model showed stronger predictive ability ($r = 0.696$; $R^2 = 48.5\%$). These findings indicate that vehicle volume alone cannot reliably predict PM_{10} levels, highlighting the need to incorporate variables such as vehicle speed and wind speed in future climate-related air quality modelling.

1 Introduction

Air pollution is a major problem in urban areas with heavy vehicle activity, especially in large cities. According to a report by the Ministry of Environment and Forestry (2024) [1],

* Corresponding author: marni_hamidaly@yahoo.com

the transportation sector is the largest contributor to air pollution, accounting for 44%. One of the parameters of air pollution generated by the transportation sector is particulate matter (PM_{10}), which are particles in the air measuring 10 micrometers. PM_{10} comes from direct emissions from motor vehicles, especially in urban areas with high traffic conditions [2].

In Indonesia, air pollution caused by vehicle traffic is a major concern, especially in various large cities. Data from the Ministry of Environment and Forestry (KLHK) shows that air pollution levels in several cities have exceeded the thresholds set by national air quality standards [3]. Approximately 87% of air pollution comes from transportation such as motorcycles and cars. Imperfectly burned gasoline is one of the main causes of air pollution in urban areas [4]. Polluted air can contain carbon monoxide, nitrogen oxides, sulfur oxides, and solid particles such as lead [5].

Rapid population growth contributes to infrastructure development and motor vehicle volume [6]. Several studies show that vehicle volume has a significant correlation with PM_{10} concentrations in the air. A study conducted by [7] found that an increase in vehicle traffic is directly related to an increase in PM_{10} levels, especially during rush hour. In addition to vehicle volume, other factors such as weather conditions, air humidity, and topography also play a role in the distribution and accumulation of PM_{10} in an area. In a previous study conducted by Dhaifullah & Purnomo [8], it was stated that traffic volume is directly proportional to the increase in PM_{10}, indicating that the large number of vehicles will affect the concentration of PM_{10} in the air.

Increased air pollution from the transportation sector in Indonesia is estimated to occur due to an increase in the number of motor vehicles that is not proportional to the increase in road length, the use of low-quality fuel, and influenced by traffic characteristics such as vehicle volume, speed and traffic density, vehicle type, driving patterns, and so on [9]. Motor vehicles, including light vehicles, heavy vehicles, and motorcycles, emit dust particles, soot, and fossil fuel combustion residues. Therefore, the volume of vehicles on a particular road section can be an important indicator in predicting PM_{10} concentrations in the air [10].

Makassar is one of the cities that has experienced rapid progress. As a city undergoing rapid development, it inevitably faces several urban problems, one of which is traffic congestion on highways, especially on major roads and in busy commercial areas such as arterial and collector roads. The increasing number of private vehicles, rising by 13-14% per year for motorcycles and 9-10% per year for four-wheeled vehicles [11], is not matched by proportional infrastructure expansion. As a result, congestion frequently occurs in commercial and high-density activity areas, contributing to deteriorating ambient air quality. Although many studies have examined the relationship between traffic activity and particulate pollution, most research does not differentiate between road types with distinct geometric designs and functional capacities. Existing studies generally assess PM_{10} levels in relation to overall traffic density without comparing how arterial and collector roads with different volumes, speeds, and vehicle compositions may influence PM_{10} dispersion patterns. Furthermore, limited research integrates direct HVAS-based PM_{10} measurements with multi-interval, real-time traffic volume data in a rapidly developing Indonesian urban setting. This creates a knowledge gap regarding how variations in road function and traffic characteristics specifically affect PM10 concentrations in Makassar.

This study was conducted on type 6/2 D and type 2/2 UD road sections in Makassar City because these two roads have different characteristics in terms of traffic capacity and function. Type 6/2 D road sections are arterial roads that generally have high vehicle traffic, including heavy vehicles, while type 2/2 UD road sections are collector roads that usually serve medium-sized vehicles but remain congested in residential and commercial areas. These two types of road sections were chosen to see how differences in road structure and function affect the concentration levels of PM_{10} produced. By comparing these two types of

roads, it is hoped that a more comprehensive understanding of the distribution patterns of air pollution caused by vehicle traffic can be obtained.

2 Methodology

2.1. Research Design

This study began with a literature review of previous studies, which were used as references in preparing the report. The study focused on PM_{10} concentrations generated by passing motor vehicles and the types of vehicles used. A preliminary survey was conducted before the study. The preliminary research was conducted to determine the sampling location by calculating the traffic volume on 6/2 D and 2/2 UD type roads in Makassar City, which were predicted to have the potential to produce air pollutant concentrations. The calculation of traffic volume was carried out by counting the number of vehicles per hour. Then, the primary research data was obtained directly from the vehicle volume data at the points where direct measurements were taken during four intervals, as well as sample data, road conditions, and meteorological data. The research was conducted at 16 road points in Makassar City on 6/2 D and 2/2 UD type roads. These locations were selected based on the high level of commercial activity around the location, which allowed for high vehicle activity.

The data used in this study is vehicle volume data passing through the three road sections. Vehicles are classified into three types, namely motorcycles (MC), light vehicles (LV), and heavy vehicles (HV). In the data analysis stage, the first step is to enter vehicle volume data from direct measurements. Then, calculations were made on the concentration of Particulate Matter (PM_{10}). After obtaining the PM_{10} concentration values at each interval, a normality test was carried out for the validity of the data obtained, followed by a homogeneity test to determine whether the data types at each different point and on different days were identical or not. After conducting the normality and homogeneity tests, all homogeneous data can be used to continue with data correlation analysis to determine the relationship between the number of motorcycles, light vehicles, and heavy vehicles with particulate matter (PM_{10}) concentration.

After obtaining the results of the relationship between PM_{10} concentration and vehicle volume, to see more clearly the distribution of PM_{10} concentration, a map visualizing PM_{10} concentration was created at 8 points on 6/2 D type roads and 2/2 UD type roads to see the comparison of PM_{10} concentration distribution on different roads. A clearer description of the research design can be seen in Figure 1.

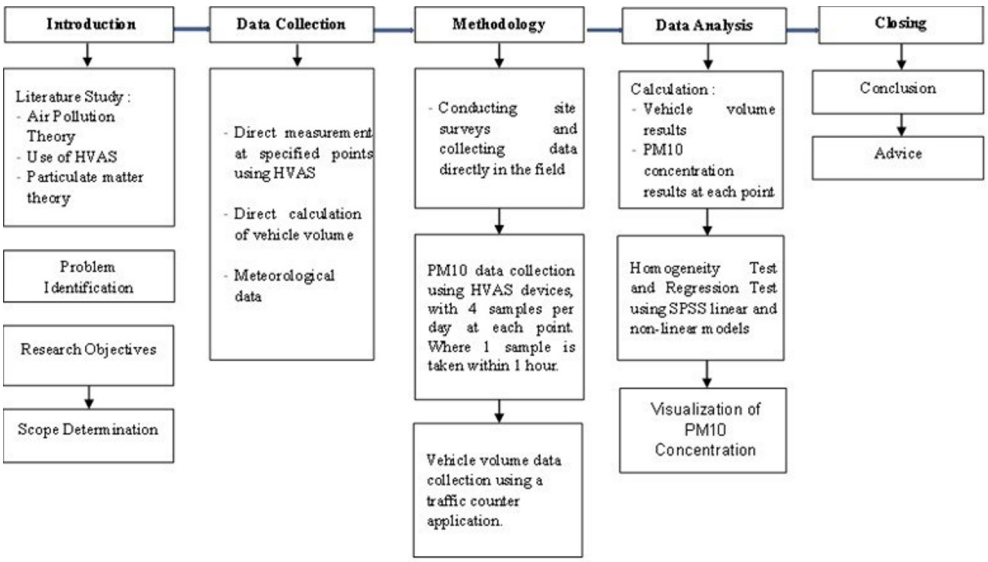


Fig. 1. Research Flowchart

2.2. Research Location and Time

This study was conducted at 16 road locations in Makassar , with 8 points on the 6/2 D road section and 8 points on the 2/2 UD road section, as presented in Figure 2 and detailed in Table 1. Several of these locations were selected based on their proximity to commercial areas, which allows for high vehicle activity at these locations. Data was collected from February 25 to March 2, 2025, with measurements taken during four time intervals: morning (09:00–10:00), afternoon (13:00–14:00), evening (16:00–17:00), and night interval (7:00 PM – 8:00 PM).

Fig. 2. Measurement Point Location

Table 1. Measurement Location for Road Sections Type 6/2D and 2/2UD

Point	Time	Road Name	Coordinate Point	Description	Road Type	Road Width (m)
1.	February 25, 2025 – March 20, 2025	G.Bawakaraeng St.	5° 8'22.12"S 119°25'24.92"E	Veteran	6/2 D	19.20
2.		Metro Tj. Bunga St.	5° 8'55.45"S 119°23'53.01"E	Makassar Centre Point of Indonesia (CPI) Area	6/2 D	19.50
3.		Perintis Kemerdekaan St.	5° 8'39.45"S 119°28'29.58"E	Makassar Town Square	6/2 D	19.30
4.		Perintis Kemerdekaan St.	5° 7'44.97"S 119°29'57.50"E	Bumi Tamalanrea Permai Residential Area	6/2 D	18.00
5.		Boulevard St.	5° 9'23.27"S 119°26'44.55"E	Panakukang Mall	6/2 D	27.00
6.		Urip Sumoharjo St.	5° 8'37.63"S 119°27'42.86"E	Heroes Cemetety	6/2 D	11.10
7.		Urip Sumoharjo St.	5° 8'24.22"S 119°26'58.17"E	Nipah Mall	6/2 D	20.00
8.		Letjen Hertasning St.	5° 9'49.42"S 119°26'42.82"E	PLN Hertasning	6/2 D	16.50
9.		Sabutung St.	5° 6'43.22"S 119°25'15.76"E	In front of Paotere Gate	2/2 UD	6.00
10.		Sunu St.	5° 7'15.62"S 119°25'49.16"E	Makassar 17 Senior High School	2/2 UD	8.45
11.		Teuku Umar Raya St.	5° 7'3.24"S 119°25'55.76"E	Galangan Kapal Three-Way Junction	2/2 UD	8.90
12.		Rajawali St.	5° 9'7.39"S 119°24'37.83"E	Rajawali Auction Market	2/2 UD	11.20
13.		Niaga Daya Ruko St.	5° 6'52.07"S 119°30'20.78"E	Daya New Market	2/2 UD	11.60
14.		Toddopuli Raya Timur St.	5° 9'28.61"S 119°28'41.63"E	Toddopuli Intersection	2/2 UD	4.00
15		Antang Raya St.	5° 9'50.04"S 119°28'6.40"E	Perempatan Antang Raya – Jembatan Pannara	2/2 UD	7.50
16.		Borong Raya St.	5° 9'50.04"S 119°28'6.40"E	Borong- Antang	2/2 UD	7.20

2.3. Data Collection Methods

The data collection method is an effort to obtain data using methods determined by the researcher. The data in this study are primary data consisting of vehicle volume data, meteorological data, and particulate matter (PM_{10}), obtained from direct measurements at the research location. Meanwhile, the guidelines in [12] SNI 19-7119.6-2005 for the Determination of Ambient Air Sampling Locations are used to determine the location of the HVAS device for PM_{10} concentration sampling.

Data collection was carried out at 4 intervals based on [13] on testing particles with a size of ≤10 μm (PM_{10}) using High Volume Air Sampler (HVAS) equipment with the gravimetric method for PM_{10} concentrations over 24 hours, so that the 4 interval sampling times can represent the PM_{10} concentration values over 24 hours. The data collection was conducted for one hour at each time interval. The selected intervals included the morning interval (08:00–09:00 WITA), the afternoon interval (13:00–14:00 WITA), the evening interval (16:00–17:00 WITA), and the night interval (19:00–20:00 WITA), all based on Central Indonesian Time.

At each interval, data was collected for 1 hour using HVAS equipment with Whatman GF/A Glass Microfiber Filters. The data obtained was then weighed in the laboratory. Vehicle volume data was collected using a traffic counter application.

2.4. Data Analysis

The data collected in the study will then be analysed based on the research objectives. Data processing and analysis include vehicle volume data, particulate concentration analysis, and statistical tests, including homogeneity tests and analysis of the relationship between PM_{10} concentrations in ambient air and vehicle volume. The specific steps in data analysis are explained as follows.

2.4.1 Analysis of Traffic Volume

In the vehicle volume data analysis stage, we looked at how variations in vehicle volume could affect PM_{10} concentrations. The volume data obtained from direct measurements was grouped into three types: motorcycles (MC), light vehicles (LV), and heavy vehicles (HV). The data was analyzed based on four time intervals: morning, afternoon, evening, and night at each data collection point. Then, to see the data distribution clearly, a histogram was created to visualize the differences in vehicle volume in each category and time, so that vehicle movement patterns could be seen more clearly.

2.4.2 Analysis PM_{10} Concentration

During the data analysis stage, PM_{10} concentrations were analyzed to determine the concentration of PM_{10} particles at each data collection point. PM_{10} concentrations were taken as an indicator of air quality, measured at four time intervals: morning, afternoon, evening, and night. To analyze PM_{10} concentrations, the data collected consisted of sample weights before and after measurement. The filter weight data obtained from the measurements was then calculated based on [13] concerning the method for testing particles ≤μm (PM_{10}) using high volume air sampling (HVAS) equipment. This produced PM_{10} concentration data for each interval.

2.4.3 Statistic Test

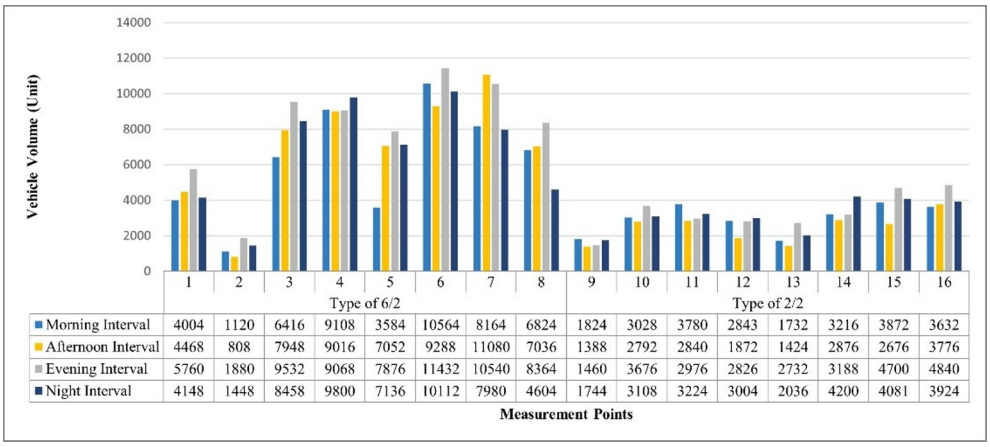
After obtaining the calculation results, a normality test was conducted to determine whether the sample data came from a normal distribution or not. Then, a homogeneity test was conducted using one-way ANOVA on PM_{10} concentrations to determine whether the variance of the data in different groups was similar or not. This test was conducted before proceeding to the next test, which was a regression test.

The relationship between PM_{10} concentrations in ambient air and traffic characteristics was analyzed using correlation regression analysis. Regression analysis was used to obtain a mathematical model of the relationship between PM_{10} concentrations in ambient air as the dependent variable (y) and vehicle volume as the independent variable (x), while correlation analysis was used to measure the degree of closeness of the relationship between the variables. The correlation coefficient (r) can be defined as a measure of the degree of linear relationship between two variables. The correlation coefficient ranges from 0 (no correlation at all) to 1 (perfect correlation). A coefficient closer to 1 means a strong correlation, while one closer to 0 means a weaker correlation [14]. From this analysis, we obtain the function form, mathematical model, coefficient of determination (R^2) value, and correlation coefficient (r) value. The type of regression used is linear and nonlinear regression.

3 Result and Discussion

3.1 Vehicle Volume

The results of total vehicle volume measurements for motorcycles (MC), light vehicles (LV), and heavy vehicles (HV) were conducted during four observation periods: morning, afternoon, evening, and night on road sections of type 6.2 D and 2/2 UD. Figure 3 shows the total vehicle volume at each interval at 16 measurement points, each on 8 (eight) 6/2 D and 2/2 UD road sections.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Morning Interval	4004	1120	6416	9108	3584	10564	8164	6824	1824	3028	3780	2843	1732	3216	3872	3632
Afternoon Interval	4468	808	7948	9016	7052	9288	11080	7036	1388	2792	2840	1872	1424	2876	2676	3776
Evening Interval	5760	1880	9532	9068	7876	11432	10540	8364	1460	3676	2976	2826	2732	3188	4700	4840
Night Interval	4148	1448	8458	9800	7136	10112	7980	4604	1744	3108	3224	3004	2036	4200	4081	3924

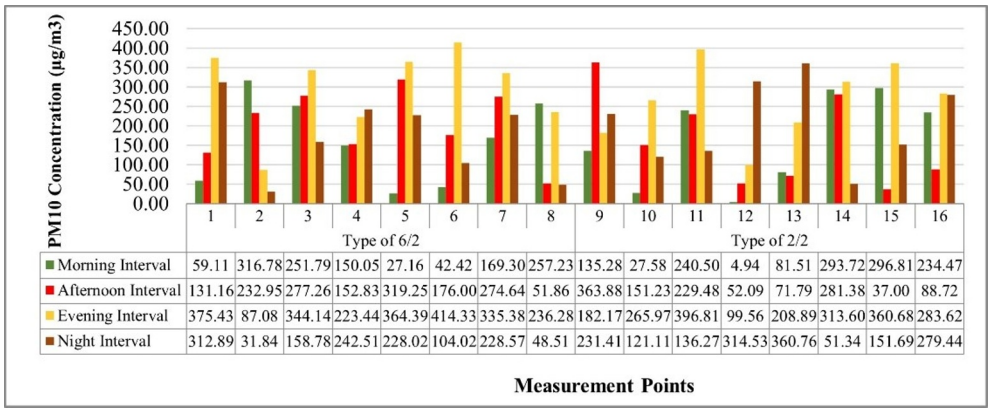
Fig. 3. Total vehicle volume on Road Sections 6/2D and 2/2UD

The highest total vehicle volume on the 6/2D road section was at point 6 on Jalan Urip Sumoharjo with a total of 41,396 vehicles. Meanwhile, the lowest vehicle volume was at point 2 on Jalan Metro Tanjung Bunga with a total of 5,256 vehicles. The total vehicle volume on the 2/2UD road section is the highest at point 16 on Jalan Ujung Bori with 16,172 units, while the lowest vehicle volume is at point 9 on Jalan Sabutung with 6,416

units. In general, the vehicle volume obtained on the 2/2UD road section is lower than that on the 6/2D road section, reflecting the smaller road capacity. This variation in vehicle volume indicates that the difference in traffic activity intensity on each road section can be influenced by residential density and road conditions around the measurement point. The percentage of vehicle type classification is dominated by MC at 71.42-82.54%, which is consistently the most common type of vehicle at each measurement point, followed by LV at 27.17%-15.75% and HV at only 1.42%-1.71%. This dominance of MCs reflects the mobility patterns of the community, which tends to choose two-wheeled vehicles as their primary mode of transportation, especially in urban areas.

3.2 PM_{10} Concentration

3.2.1 PM_{10} Concentration Measurement



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Morning Interval	59.11	316.78	251.79	150.05	27.16	42.42	169.30	257.23	135.28	27.58	240.50	4.94	81.51	293.72	296.81	234.47
Afternoon Interval	131.16	232.95	277.26	152.83	319.25	176.00	274.64	51.86	363.88	151.23	229.48	52.09	71.79	281.38	37.00	88.72
Evening Interval	375.43	87.08	344.14	223.44	364.39	414.33	335.38	236.28	182.17	265.97	396.81	99.56	208.89	313.60	360.68	283.62
Night Interval	312.89	31.84	158.78	242.51	228.02	104.02	228.57	48.51	231.41	121.11	136.27	314.53	360.76	51.34	151.69	279.44

Fig. 4. PM_{10} concentration at each measurement interval on road sections 6/2 D and 2/2 UD

The highest PM_{10} concentration was found at point 3 on Jalan Poros Makassar-Maros with a value of 257.99 µg/m^3. Meanwhile, the lowest PM_{10} concentration was found at point 8 on Jalan Letjen Hertasning with a value of 148.47 µg/m^3. The highest PM_{10} concentration on the 2/2 UD road section was at point 11 on Jalan Teuku Umar Raya with a value of 250.77 µg/m^3, and the lowest concentration was at point 12 on Jalan Rajawali with a value of 117.78 µg/m^3. All points on the 6/2D road section showed fairly high levels of PM_{10} particulate pollution, which has the potential to negatively impact air quality and the health of the surrounding community. Similarly, the 2/2 UD road section showed that traffic density, low vehicle speeds, and environmental factors can also contribute to an increase in particulates.

3.2.2 PM_{10} Concentration for 24 Hours

A summary of PM_{10} concentrations at 16 (sixteen) points on 6/2 D and 2/2 UD type roads, representing PM_{10} concentrations for 24 hours of observation, can be seen in Figure 5.

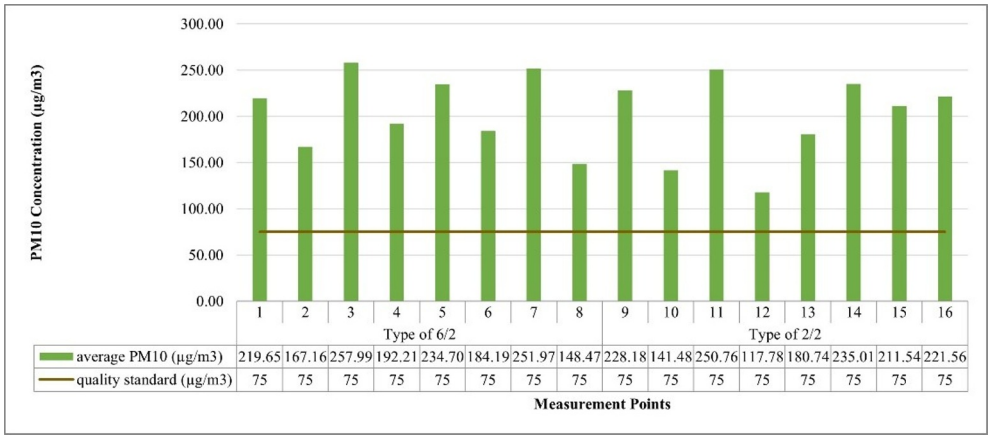


Fig. 5. PM_{10} concentration based on quality standards on road sections 6/2 D and 2/2 UD

Based on the graph in Figure 3, it can be seen that all 8 measurement points on each section of the 6/2 D and 2/2 UD road types show that the average PM_{10} concentration exceeds the quality standard set by PP No. 22 of 2021 of 75 µg/m^3. The highest PM_{10} concentration was found at point 3 on the Makassar-Maros Road with a value of 257.99 µg/m^3. Meanwhile, the lowest PM_{10} concentration was found at point 8 on Letjen Hertasning Road with a value of 148.47 µg/m^3. All 16 measurement points or 16 sections of type 6/2 D and 2/2 UD roads showed fairly high levels of PM_{10} particulate pollution, which could potentially have a negative impact on air quality and the health of the community around the roads at the observation sites.

3.3 Predictive Analysis of The Relationship between Vehicle Volume and PM_{10}

The measurement results are shown graphically, and the correlation between vehicle volume and PM_{10} concentration is shown in Figure 6 for road types 6/2 D and 2/2 UD.

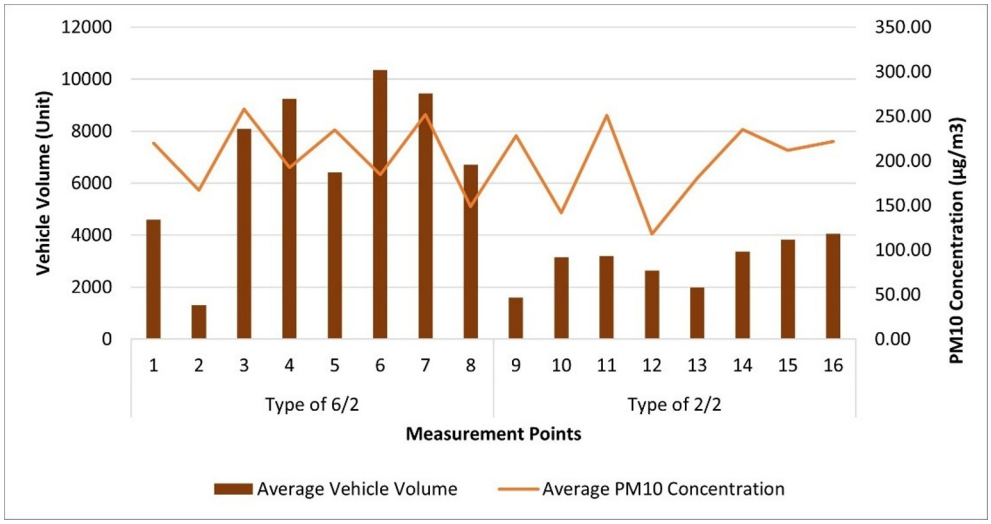


Fig. 6. Correlation between vehicle volume and PM_{10} concentration type 6/2 D and 2/2 UD

Figure 6 shows that graphically, the correlation between vehicle volume and PM_{10} concentration types 6/2 D and 2/2 UD shows no correlation when vehicle volume is high, PM_{10} is also high, except on road type 6/2 D. Meanwhile, on road type 2/2 UD, PM_{10} concentration is lower than on road type 6/2 D, even though vehicle volume is higher. The high PM_{10} concentration values obtained at these points indicate heavy traffic activity and the possible dominance of motor vehicles with high emissions, although overall they are still below the quality standards. Furthermore, this graphical model is differentiated into a mathematical correlation model with several statistical tests. The tests that were carried out before analyzing the relationship between vehicle volume and PM_{10} were data normality and data homogeneity tests.

3.3.1 Normality Test

Vehicle volume and PM_{10} data were tested for normality to determine that the data were parametric data, as indicated by normally distributed data. The normality test results are shown in Table 2.

Table 2. Normality test of PM_{10} concentration and vehicle volume

Road Section Type	Measurement point	PM_{10}		Vehicle Volume		Description
		***P* Value**	**Sig.**	***P* Value**	**Sig.**	
6/2 D	Point 1	0.92	0.54	0.88	0.35	Normal Distribution
	Point 2	0.94	0.67	0.99	0.93	
	Point 3	0.98	0.90	0.86	0.25	
	Point 4	0.83	0.17	0.96	0.75	
	Point 5	0.91	0.48	0.91	0.49	
	Point 6	0.90	0.43	0.89	0.40	
	Point 7	1.00	1.00	0.89	0.37	
	Point 8	0.78	0.07	0.93	0.59	
2/2 UD	Point 9	0.94	0.63	0.91	0.49	Normal Distribution
	Point 10	0.98	0.92	0.99	0.94	
	Point 11	0.94	0.62	0.89	0.38	
	Point 12	0.87	0.29	0.83	0.17	
	Point 13	0.88	0.34	0.97	0.83	
	Point 14	0.73	0.03	0.80	0.10	
	Point 15	0.96	0.76	0.87	0.29	
	Point 16	0.80	0.10	0.96	0.78	

All significance values (sig) in Table 2 are greater than 0.05, indicating that PM_{10} and vehicle volume data are normally distributed on 6/2 D and 2/2 UD road sections.

3.3.2 Homogeneity Test

Assumptions Data validity is required due to the different sources of vehicle volume and PM_{10} data from different measurement points. The validity test results were obtained using a homogeneity test, as shown in Tables 3 and 4.

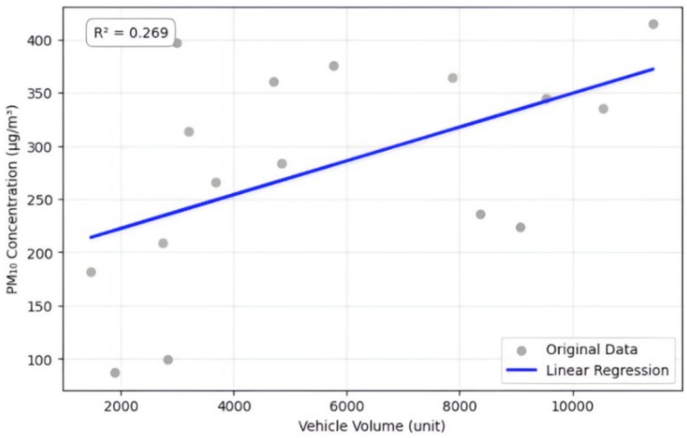
Table 3. Testing the Homogeneity of PM_{10} Concentration and Vehicle Volume

Road Section	Measurement Point	PM_{10}	Vehicle Volume	Road Type	Point Pengukuran	PM_{10}	Vehicle Volume
		Sig.				Sig	
6/2 D	Point 1 & Point 2	0.57	0.32	2/2 UD	Point 9 & Point 11	0.94	0.46
	Point 1 & Point 3	0.06	0.29		Point 9 & Point 12	0.57	0.10
	Point 1 & Point 5	0.72	0.32		Point 9 & Point 13	0.44	0.18
	Point 1 & Point 6	0.86	0.96		Point 9 & Point 14	0.62	0.17
	Point 1 & Point 8	0.24	0.49		Point 9 & Point 15	0.27	0.09
	Point 2 & Point 3	0.13	0.09		Point 11 & Point 12	0.64	0.48
	Point 2 & Point 5	0.99	0.14		Point 11 & Point 13	0.52	0.53
	Point 2 & Point 6	0.89	0.36		Point 11 & Point 14	0.70	0.39
	Point 2 & Point 8	0.67	0.21		Point 11 & Point 15	0.35	0.19
	Point 3 & Point 5	0.30	0.92		Point 12 & Point 13	0.91	0.98
	Point 3 & Point 6	0.28	0.33		Point 12 & Point 14	0.90	0.71
	Point 3 & Point 8	0.10	0.82		Point 12 & Point 15	0.70	0.32
	Point 5 & Point 6	0.90	0.35		Point 13 & Point 14	0.79	0.74
	Point 5 & Point 8	0.84	0.76		Point 13 & Point 15	0.76	0.36
	Point 6 & Point 8	0.84	0.53		Point 14 & Point 15	0.56	0.54

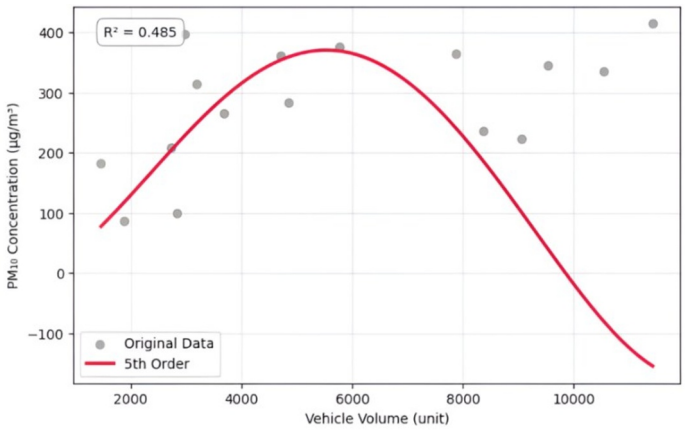
The results of the homogeneity test in Table 3 show that all PM_{10} concentration and vehicle volume data on the 6/2 UD and 2/2 UD road sections are homogeneous, with Sig. values for all data greater than 0.05. This indicates that the variation in PM_{10} concentration and vehicle volume between various measurement points on these road sections is not significantly different. Based on these test results, an analysis of the correlation prediction model for vehicle volume and PM_{10} was conducted.

3.3.3 Prediction of Vehicle Volume and PM_{10} Correlation Model

An analysis of the extent to which vehicle volume affects PM_{10} concentrations was conducted using modeling approaches involving linear regression (reference) and polynomial regression (reference). Graphical models of both models can be seen in Figure 5, and the results of these two models can be seen in Table 3. Linear regression model equation Y= a + bX and 5th order polynomial regression equation Y= a + bX + cX2 + dX3 + ex4 + fX5. Where Y is the PM_{10} concentration, X is the vehicle volume, a is the model constant, and b, c, d, and e are the model coefficients.



(a)



(b)

Figure 7 Graphical Model (a) Linear Regression Model (b) Polynomial Model

Table 4 Correlation Model Parameters for Vehicle Volume and PM_{10} Concentration

Variable	Symbols	Parameters Linear Regression Model		Polynomial Model Parameters	
		Value	P Value	Value	P Value
Vehicle Volume	a	190.707	0.001	8.23E-12	0.000
	b	0.016	0.039	2.46E-08	0.000
	c	-	-	0.00004837	0.000
	d	-	-	-8.83E-09	0.000
	e	-	-	4.27E-09	0.000
	f	-	-	-2.97E-13	0.665
Correlation	r	0.519		0.696	
Determination	R^2	0.269		0.485	

The results of the correlation model parameter prediction analysis using the linear regression approach in Table 4 and Figure 7 show a coefficient of determination value (R^2) of 0.269, meaning that only about 26.9% of vehicle volume affects PM_{10} concentration, even though the correlation value of 0.519 is considered sufficient and the P value for vehicle volume is significant at 0.029, which is less than 0.050. The value obtained with the linear model to describe the relationship between the two variables is considered sufficient.

Prediction of model parameters with polynomial regression produces a correlation value of 0.696 and an R^2 value of 0.485 (48.5%), which is almost twice the effect of vehicle volume on PM_{10} concentration in the linear model. This indicates that the correlation value of the polynomial model is stronger than that of the linear regression model, even though there is a non-significant P value for the f coefficient of vehicle volume. Thus, the polynomial regression approach is more representative than linear regression in describing the effect of vehicle volume on PM_{10} concentration on all road sections. This is in line with previous research conducted by Dhaifullah & Purnomo [8] and Jia et al. [15] that traffic volume is directly proportional to an increase in PM_{10}, indicating that the volume of vehicles will affect the concentration of PM_{10} in the air. The values of the model parameters still need to be developed by considering larger data sets. Therefore, for further research, in addition to increasing the amount of data, it is also necessary to consider vehicle speed and wind speed as model variables.

4 Conclusion

The results of this study show that PM_{10} concentrations on both 6/2D and 2/2UD road sections consistently exceeded the national air quality standard, indicating high particulate pollution across all measurement points. Although vehicle volume differed between the two road types, regression analysis revealed that vehicle volume alone has a limited ability to predict PM_{10} levels. The linear regression model produced a moderate relationship ($r = 0.519$; $R^2 = 26.9\%$), while the polynomial model improved predictive strength ($r = 0.696$; $R^2 = 48.5\%$). These findings demonstrate that while vehicle volume contributes to PM_{10} concentration, it is not the dominant factor influencing particulate levels along urban road corridors. Additional variables—such as vehicle speed, traffic flow characteristics, and meteorological conditions—likely play significant roles and should be incorporated into future modelling.

Reference

1. Kementerian Lingkungan Hidup dan Kehutanan, Laporan Kinerja 2024 (2024)
2. A. Azhari, N. D. A. Halim, A. A. A. Mohtar, K. Aiyub, M. T. Latif, and M. Ketzel, Evaluation and prediction of PM10 and PM2.5 from road source emissions in Kuala Lumpur city centre. Sustainability (Switzerland). **13**, 10 (2021). https://doi.org/10.3390/su13105402
3. Kementerian Lingkungan Hidup dan Kehutanan, Laporan Kinerja 2023 (2023)
4. D. Jandacka, D. Durcanska, and R. Cibula, Concentration and inorganic elemental analysis of particulate matter in a road tunnel environment (Žilina, Slovakia): Contribution of non-exhaust sources. Frontiers in Environmental Science. **Volume 10**, (2022). https://doi.org/10.3389/fenvs.2022.952577
5. H. Jusuf, E. Prasetya, and N. Igirisa, Analisis Risiko Kesehatan Lingkungan Pajanan Particulate Matter (PM10) dan Karbon Monoksida (CO) pada Masyarakat di Desa Buata Kecamatan Botupingge. Sulolipu: Media Komunikasi Sivitas Akademika Dan Masyarakat. **23**, 1 (2023). https://doi.org/10.32382/sulolipu.v23i1.3155
6. Y. Sunitiyoso, A. Wicaksono, N. F. Pambudi, W. A. Rahayu, I. F. Nurdayat, F. Hadiansyah, S. Nuraeni, and A. A. Muhammad, Future of mobility in Jakarta Metropolitan Area: A Multi-Stakeholder scenario planning. Transportation Research Interdisciplinary Perspectives. **19**, (2023). https://doi.org/https://doi.org/10.1016/j.trip.2023.100810
7. D. Wangsa, V. S. Bachtiar, and S. Raharjo, Uji Model Aeromod Terhadap Sebaran Particulate Matter 10 μm (PM10) di Sekitar Kawasan PT Semen Padang. Jurnal Ilmu Lingkungan. **20**, 2 (2022). https://doi.org/10.14710/jil.20.2.291-301
8. M. D. Dhaifullah and Y. S. Purnomo, Analisis Dampak Meteorologi dan Volume Lalu Lintas Terkait Kadar CO dan Pm 10 Terhadap Kesehatan Masyarakat Sekitar Jalan Raya Menganti Surabaya. Serambi Engineering. **X**, 1 (2024)
9. H. Gunawan, Y. Ruslinda, V. S. Bachtiar, and A. Dwinta, Model Hubungan Konsentrasi Particulate Matter 10 (PM10) di Udara Ambien Dengan Karakteristik Lalu Lintas di Jaringan Jalan Primer Kota Padang. Jurnal UMJ Seminar Nasional Sains Dan Teknologi 2018. (2018)
10. H. Ardianto, N. Dyah Prasetyawati, and S. Sudaryanto, Distribution of Motor Vehicle Volumes and Ambient Air Dust Levels in Hot Points of Yogyakarta City, Indonesia. JURNAL KESEHATAN LINGKUNGAN . **16**, 1 SE-Articles (2024).

https://doi.org/10.20473/jkl.v16i1.2024.76-88

11. A. Pratiwi and Z. Zaenab, Faktor-Faktor Yang Mempengaruhi Kepadatan Kendaraan Dengan Kandungan Karbon Monoksida (CO) Di Kota Makassar Tahun 2019. Sulolipu: Media Komunikasi Sivitas Akademika Dan Masyarakat. **20**, 1 (2020). https://doi.org/10.32382/sulolipu.v20i1.1471
12. Badan Standar Nasional, SNI 19-7119.6-2005. Udara Ambien — Bagian 6: Penentuan Lokasi Pengambilan Contoh Uji. (2005)
13. Badan Standar Nasional, SNI 7119.15:2016. Udara Ambien – Bagian 15: Cara Uji Partikel ≤ 10 Mm (PM10) Dengan HVAS Gravimetri. (2016)
14. S. N. Papageorgiou, On correlation coefficients and their interpretation. Journal of Orthodontics. **49**, 3 (2022). https://doi.org/10.1177/14653125221076142
15. C. Jia, W. Li, T. Wu, and M. He, Road traffic and air pollution: Evidence from a nationwide traffic control during coronavirus disease 2019 outbreak. Science of the Total Environment. **781**, (2021). https://doi.org/10.1016/j.scitotenv.2021.146618