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VARIATION OF ROADSIDE AIR POLLUTANT CONCENTRATIONS IN RELATION TO TRAFFIC VOLUME AND METEOROLOGICAL CONDITIONS IN JAMBI CITY

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Abstract

This study examines roadside air pollutant variation in relation to traffic volume and meteorological conditions on Jl. RE Marta Dinata, Jambi City. An observational descriptive-analytical approach used 21 observations collected from 16:00 to 18:00 WIB during 10–16 October 2024. Traffic volume was counted directly, whereas air pollutants and meteorological data were obtained from application-based sources. Analyses included vehicle count, PM10, PM2.5, NO_2, CO, temperature, humidity, and wind speed, using descriptive statistics and Pearson correlation. Vehicle counts ranged from 959 to 3,051 units per observation, with motorcycles comprising 67.2% of total volume. Mean concentrations were 23.21 ± 10.23 µg/m³ for PM10, 19.81 ± 8.16 µg/m³ for PM2.5, 2.15 ± 0.95 µg/m³ for NO_2, and 435.03 ± 52.97 µg/m³ for CO. Traffic volume was not significantly correlated with pollutants ($|r|$ = 0.128–0.397; $p > 0.05$). Of 16 correlations, three were significant: temperature–NO_2 ($r = -0.674$; $p = 0.001$), humidity–NO_2 ($r = 0.592$; $p = 0.005$), and wind speed–CO ($r = -0.569$; $p = 0.007$). After Bonferroni correction ($\alpha = 0.003$), only temperature–NO_2 remained significant. The highest particulate concentrations occurred at the lowest traffic volume, on Sunday, 13 October 2024. These findings indicate that roadside pollutant variation was not solely driven by instantaneous traffic volume; atmospheric dispersion and non-traffic sources should be considered in Jambi's urban air-quality management.

Keywords: *roadside air pollution; PM10; PM2.5; nitrogen dioxide; carbon monoxide; meteorological factors.*

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1. Introduction

Air pollution remains one of the most pressing urban environmental problems, as it is associated with environmental degradation, reduced comfort, and increased risks to public health. In urban areas, land transport is frequently reported as a principal source of air pollutant emissions, particularly along road corridors with high traffic intensity. Motor vehicle emissions contribute to elevated concentrations of particulate matter (PM) and gaseous pollutants such as NO_2 and CO, which under certain conditions can degrade ambient air quality in the vicinity of roads. Long-term exposure to traffic-related air pollution (TRAP) has been systematically linked to a range of health disorders, including cardiovascular disease, respiratory impairment, and an increased risk of childhood asthma (Khreis et al. 2017; Health Effects Institute 2022).

The roadside environment is dynamic because it is directly influenced by traffic emissions and other activities occurring alongside the road. Near-road monitoring is therefore crucial for understanding the exposure experienced by the public along major transport corridors (Xie et al. 2024). Variations in measured pollutant concentrations are related to changes in vehicle volume over a given time interval, although this relationship is not necessarily direct, as other local sources also contribute. Beyond tailpipe emissions, roadside pollutants originate substantially from non-exhaust sources such as resuspended road dust and tyre and brake wear (Askariyeh et al. 2020; Amato et al. 2014; Grigoratos and Martini 2015). Commercial activity, small-scale burning, and roadside dust further shape the air quality of urban road corridors, which frequently exhibit higher exposure than residential areas located away from major roads (Manisalidis et al. 2020; Karagulian et al. 2015).

Given these conditions, Jl. RE Marta Dinata in Jambi City is a relevant study location. The observation site is situated near the Postgraduate Building of Universitas Jambi, on an arterial road segment with high traffic density that is expected to be representative of urban road conditions in Jambi City. The surrounding area is dominated by mixed land use, encompassing education, offices, residential areas, and commerce. Das et al. (2024), working in Jambi, report that increasing vehicle density along arterial corridors correlates positively with the accumulation of gaseous pollutants such as carbon monoxide. Nevertheless, comprehensive mapping of ambient air quality in non-metropolitan Indonesian cities remains limited compared with larger cities such as Jakarta or Bandung (Lukman et al. 2025; M. Santoso et al. 2020).

Pollutant concentrations in roadside areas are determined not only by the magnitude of vehicle emissions but also by meteorological conditions. Temperature, humidity, wind direction, and wind speed all govern the dilution, transport, and dispersion of pollutants in the atmosphere. Consequently, the relationship between traffic volume and pollutant concentration is not always linear, as it can be modified by atmospheric conditions prevailing during the observation period (Garsa et al. 2023). Within street canyons, wind speed and direction largely determine whether pollutants disperse or accumulate (Y. Zhang, Gu, and Yu 2020). Pollutants such as NO_2 are particularly sensitive to traffic dynamics and to the diurnal cycle of the surface atmosphere (Mucha and Mainka 2026). In this study, the meteorological parameters

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observed were temperature, humidity, wind speed, and wind direction, enabling a more balanced interpretation of pollutant variation.

Previous studies have shown that traffic density is associated with increased concentrations of pollutants closely linked to vehicle emissions, such as PM, NO_2, and CO. Internet of Things (IoT) technology and low-cost sensors have been increasingly deployed in Indonesian cities such as Jakarta and Bandung to monitor the temporal variation of pollutants (Pratomo et al. 2023; D. H. Santoso, Santosa, and Sekaranom 2025; Kurniawati et al. 2025). Sinaga et al. (2020) report that meteorological factors can amplify or attenuate pollutant concentrations through their influence on dispersion and atmospheric transformation. However, locally contextualized studies that integrate observations of vehicle volume, pollutant concentrations, and meteorological conditions along a single urban road segment in Jambi City remain scarce. Although several application-based monitoring platforms have been developed, their accuracy and reliability require verification through field-based observational studies (Yushananta 2023; Morawska et al. 2018; Imami et al. 2022).

This research was conducted from 10-16 October 2024 between 16:00 to 18:00 WIB, a late-afternoon period when the road segment tends to experience congestion due to commuter mobility. The data collected comprise vehicle counts, air pollutant concentrations, and meteorological conditions at the time of observation.

Because the pollutant data used here are application-derived and resolved at the sub-district scale rather than at the roadside micro-environment, this study is positioned as an application-data-based observational study rather than as continuous roadside monitoring; the implications of that choice are set out in Section 2.5. Within this constraint, the contribution of the present research lies in presenting an integrated, locally grounded analysis of roadside pollutant variation in relation to meteorological conditions and vehicle volume simultaneously, in an urban corridor in Jambi City, a context in which most previous work has examined a single variable in isolation. This approach is intended to help address the literature gap concerning air quality in cities on the island of Sumatra, which remain relatively under-represented in the national air quality picture (Lukman et al. 2025; Das et al. 2024).

The research question addressed is how roadside air pollutant concentrations on Jl. RE Marta Dinata vary in relation to traffic volume and meteorological conditions during the observation period. The study aims to analyse this variation and to identify which of these factors is more closely associated with the observed pollutant levels.

2. Method

2.1 Research Design

This is an observational study employing a descriptive-analytical approach to evaluate roadside air pollutant variation and its relationship with traffic volume and meteorological conditions along an urban road corridor. The study is restricted to short-term observations, using an identical observation window across seven consecutive days, so that hour-to-hour and day-to-day changes can be compared directly.

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

2.2 Location and Time

The research was conducted in the area surrounding the Postgraduate Building of Universitas Jambi on Jl. RE Marta Dinata, Jambi City, with the observation point located at 1°36’34.7” S, 103°34’49.5” E (Figure 1). The site was selected because it is an urban arterial segment with high daily traffic density and is considered representative of the main road segments of Jambi City. Observations were carried out from 10-16 October 2024 between 16:00 to 18:00 WIB. This window was chosen because vehicle mobility is high during this period, driven primarily by the journey home from work and school.

Figure 1. Observation Site

2.3 Variables and Data Sources

The observed variables include traffic characteristics, air pollutant concentrations, and meteorological conditions. Traffic variables include the numbers of motorcycles, cars, and buses/trucks passing the site during each observation. Pollutant parameters recorded include NO_2, PM10, PM2.5, O_3, CO, NO, SO_2, and NH_3. Meteorological variables comprise air temperature, relative humidity, wind speed, and wind direction. Although the application also reports O_3, NO, SO_2, and NH_3, these parameters were recorded but excluded from the analysis: O_3 is a secondary pollutant governed by photochemical processes that operate over spatial and temporal scales far larger than a single road segment observed for two hours, while NO, SO_2, and NH_3 showed either negligible variation or values at the reporting floor of the application over the observation period and could not support correlation analysis.

Vehicle counts were obtained by direct field counting. Passing vehicles were tallied on site using Traffic Counter (package at.development.clickcounter), a manual tally application for Android providing eight independent counter buttons; the application performs no measurement of its own. Counts were recorded separately for each direction of travel and for motorcycles, cars, and buses/trucks. Pollutant data were obtained from a freely available Android application that redistributes the

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

OpenWeatherMap Air Pollution API. The application returns the eight parameters supplied by that API — CO, NO, NO_2, O_3, SO_2, NH_3, PM2.5, and PM10 — together with a five-level air quality index, and reports them under the locality label of Telanaipura. The provider supplies values for arbitrary coordinates worldwide and does not state whether these are measured, interpolated, or modelled. Because global coverage at arbitrary coordinates cannot be achieved from ground-based monitoring alone, the reported values are best understood as modelled estimates rather than point measurements, and the locality label should not be interpreted as a measurement location. This reading is consistent with the configuration of the national monitoring network: the only air quality monitoring station operated within Jambi City by the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) is sited at the Sultan Thaha Meteorological Station, Paal Merah, approximately 7.8 km south-east of the observation point and within the airport complex, and that station reports PM2.5 only. No station in the city publishes PM10, NO_2, or CO at hourly resolution. Meteorological data were obtained from the Weather application supplied with Apple iOS, which reports conditions for the Telanai Pura locality. Apple derives these values from its own forecast model rather than from a single named observing station. Air temperature, relative humidity, wind speed, and wind direction were read directly from the application at each observation time. Neither the pollutant nor the meteorological source was calibrated against reference-grade instrumentation by the authors, and no co-located reference measurement was available for verification. The study is therefore positioned as an application-data-based observational study, and the implications for interpretation are set out in Sections 2.5 and 3.5. The main analysis focused on total vehicle count and PM10, PM2.5, NO_2, and CO, with temperature, humidity, and wind speed as explanatory variables for inter-variable relationships.

Table 1. Observation Characteristics

Parameter	Description
Research location	Jl. RE Marta Dinata, Jambi City
Location coordinates	1°36’34.7” S; 103°34’49.5” E
Location type	Urban arterial road segment
Observation period	10–16 October 2024
Observation time	16:00, 17:00, and 18:00 WIB
Number of observations	21 (7 days × 3 time points)
Traffic variables	Motorcycles, cars, buses/trucks, total vehicles
Pollutant variables	PM10, PM2.5, NO_2, O_3, CO, NO, SO_2, NH_3
Meteorological variables	Temperature, humidity, wind speed, wind direction, UV index
Traffic data source	Manual field count; Traffic Counter (at.development.clickcounter), both directions
Pollutant data source	OpenWeatherMap Air Pollution API, via Android application (locality label: Telanaipura)
Meteorological data source	Apple Weather (iOS), Telanai Pura locality

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

2.4 Data Collection and Analysis

Data collection proceeded in four stages: (i) determination of the observation point along the selected road segment; (ii) counting of passing vehicles using the Traffic Counter application in three consecutive one-hour intervals commencing at 16:00, 17:00, and 18:00 WIB, corresponding respectively to the hour before, during, and after the afternoon peak; the choice of the late-afternoon window follows the sampling guidance of Regulation of the Minister of Environment No. 12 of 2010 on the implementation of regional air pollution control. Counts covered both directions of travel, tallied separately on the application's two sets of counters, and vehicles were grouped into motorcycles, cars, and buses/trucks; counting was carried out by members of the research team positioned at the observation point; (iii) recording of air pollutant concentrations from the air quality application described in Section 2.3 at the same three time points; and (iv) recording of meteorological conditions from the Apple Weather application at the same intervals. With seven observation days and three times per day, 21 observations were obtained.

The data were compiled into a single master table organised by date and time. Total vehicle count was calculated as the sum of motorcycles, cars, and buses/trucks at each observation time. Data cleaning addressed consistency in time formats, variable names, and measurement units. Analysis was performed in Microsoft Excel. Descriptive statistics (minimum, maximum, mean, and sample standard deviation) were computed for total vehicle count, PM10, PM2.5, NO_2, CO, temperature, humidity, and wind speed.

Relationships among variables were assessed using the Pearson correlation coefficient, computed between total vehicle count and each of PM10, PM2.5, NO_2, and CO, and between temperature, humidity, and wind speed and the same pollutants. Statistical significance was evaluated at $\alpha = 0.05$ (two-tailed) with $n = 21$ ($df = 19$), for which the critical value is $|r| = 0.433$. Correlation coefficients are reported with their associated p-values, and only significant coefficients are interpreted substantively. Because the three observation times within each day are not independent of the diurnal cycle, partial correlations controlling for the hour of observation were additionally computed for the significant relationships to distinguish genuine meteorological effects from the shared time-of-day trend. Correlation is used here to describe linear association and is not interpreted as causation. Temporal graphs were constructed to depict changes in vehicle volume, pollutant concentrations, and meteorological conditions across the observation period. Wind direction was recorded as a categorical variable and used only to support the qualitative interpretation of dispersion patterns; it was not included in the correlation analysis.

2.5 Methodological Note

The pollutant data were obtained from an application redistributing the OpenWeatherMap Air Pollution API, which reports its values under the sub-district locality label of Telanaipura, whereas the traffic observations refer to a single roadside point on Jl. RE Marta Dinata. The two data streams therefore differ in spatial support. Furthermore, application-derived values may be updated at intervals longer than one hour: on 16 October 2024, the values reported at 17:00 and 18:00 were identical across all four pollutants, indicating that the application had not refreshed between the two

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

observations. This study is consequently positioned as a local, application-data-based observational study rather than as continuous roadside monitoring, and its results should be read as a preliminary characterisation rather than as a definitive quantification of roadside exposure. These constraints are revisited in Section 3.5.

3. Result and Discussion

3.1 Variation of Traffic Volume

Vehicle volume at the study site fluctuated appreciably over the seven observation days (Table 2). Total vehicle counts ranged from 959 to 3,051 vehicles per observation, with a mean of 1,959.24 ± 557.00 vehicles. The highest volume was recorded on Thursday, 10 October 2024, at 16:00 WIB (3,051 vehicles), and the lowest on Sunday, 13 October 2024, at 18:00 WIB (959 vehicles). The corridor thus maintained relatively high traffic intensity throughout the late afternoon, although its magnitude varies by day and hour.

Table 2. Variation of Total Vehicle Volume Over the Observation Period

Date	Day	Time	Total Vehicles
10/10/2024	Thursday	16:00	3051
		17:00	2788
		18:00	1483
11/10/2024	Friday	16:00	2038
		17:00	2949
		18:00	1479
12/10/2024	Saturday	16:00	2307
		17:00	2034
		18:00	1690
13/10/2024	Sunday	16:00	2160
		17:00	1427
		18:00	959
14/10/2024	Monday	16:00	2425
		17:00	1547
		18:00	2099
15/10/2024	Tuesday	16:00	1927
		17:00	1701
		18:00	2238
16/10/2024	Wednesday	16:00	1715
		17:00	2030
		18:00	1097

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

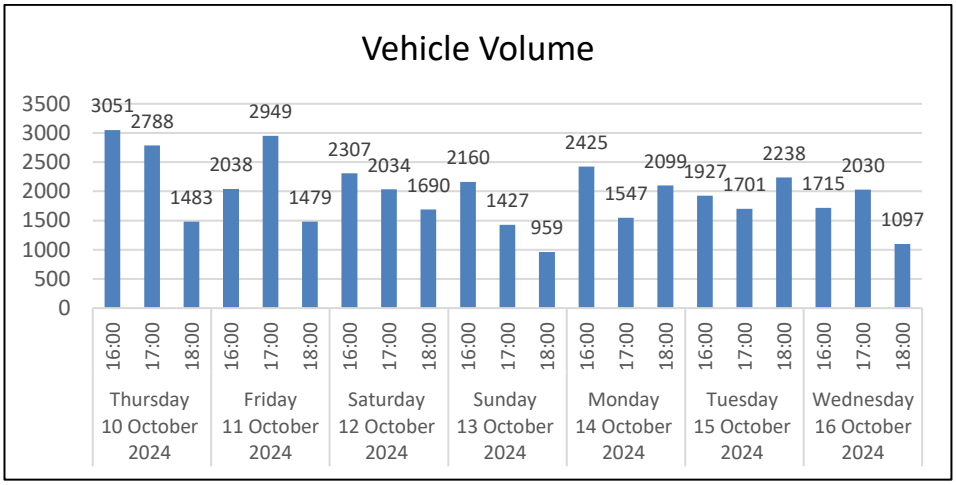

Figure 2. Temporal Variation of Total Vehicle Volume Over the Observation Period

By vehicle type, motorcycles dominated at all observation times, with 627–2,113 vehicles per interval, compared with 315–1,185 cars and only 4–65 buses/trucks. Cumulatively, motorcycles accounted for approximately 67.2% of all vehicles, followed by cars (31.5%) and buses/trucks (1.3%). This confirms the strong dominance of two-wheeled vehicles in daily mobility along the corridor, consistent with patterns reported in Indonesian cities such as Bandung, Semarang, and Jakarta, where the motorcycle modal share frequently exceeds 70% owing to travel-time efficiency and low cost (Anas and Manullang 2017; Dharmowijoyo and Maharani 2022; Nadillah et al 2023).

Temporally, vehicle counts at 16:00 and 17:00 WIB were higher, on average, than at 18:00 WIB. The mean total count was 2,231.86 vehicles at 16:00, 2,068.00 at 17:00, and 1,577.86 at 18:00. Traffic accumulation is therefore concentrated in the early to middle part of the late-afternoon period and declines towards the evening, consistent with the overlap of the journeys home from work and school and with student extracurricular activity, which cluster in this time window in urban activity centres (Anas and Manullang 2017; Farda and Balijepalli 2018).

These traffic characteristics matter for air quality because the magnitude of vehicle volume and the dominance of two-wheeled vehicles shape emission dynamics in the roadside environment, with motorcycles frequently constituting the principal contributor to CO emissions in Indonesian urban areas (Farda and Balijepalli 2018; Lestari et al. 2023). The scale of this two-wheeled fleet is also what makes it a policy lever: fleet-level interventions, such as converting motorcycles to electric propulsion, have been proposed as a route to reducing transport emissions in Indonesian cities (A. D. Santoso et al. 2024). These characteristics therefore provide the baseline against which the pollutant patterns reported below are interpreted.

3.2 Variation of the Main Pollutant Concentrations

Pollutant concentrations fluctuated appreciably over the observation period (Table 3). PM10 ranged from 7.64 to 41.52 µg/m³ (mean 23.21 ± 10.23 µg/m³) and PM2.5 from 6.72 to 33.07 µg/m³ (mean 19.81 ± 8.16 µg/m³). Among the gaseous pollutants, NO_2 ranged from 0.63 to 3.81 µg/m³ (mean 2.15 ± 0.95 µg/m³) and CO from 357.15 to 547.41 µg/m³ (mean 435.03 ± 52.97 µg/m³). Pollutant variation was not

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

uniform across parameters, indicating that each pollutant is influenced by a different combination of source intensity and local atmospheric dispersion capacity (Khan et al. 2016; Tang et al. 2020). The NO_2 values warrant particular caution. A range of 0.63–3.81 µg/m³ is substantially lower than concentrations typically measured beside a busy urban arterial during the afternoon peak, and lies well below the WHO 24-hour guideline of 25 µg/m³ (World Health Organization 2021); such levels are more characteristic of a regional background than of a roadside micro-environment. This is consistent with the sub-district spatial support of the application data described in Section 2.5, and it reinforces the position that the pollutant series analysed here should not be read as a direct measure of roadside exposure.

Table 3. Variation of Main Pollutant Concentrations Over the Observation Period (all values in µg/m³)

Date	Day	Time	PM10	PM2.5	NO_2	CO
10/10/2024	Thursday	16:00	16.34	15.58	2.19	410.56
		17:00	18.58	17.68	3.04	417.23
		18:00	20.96	19.92	3.17	423.91
11/10/2024	Friday	16:00	7.64	6.72	2.01	413.90
		17:00	9.77	8.52	3.26	420.57
		18:00	13.29	11.88	3.81	427.25
12/10/2024	Saturday	16:00	13.07	10.30	1.93	390.53
		17:00	11.60	8.98	2.53	390.53
		18:00	11.84	8.94	3.47	400.54
13/10/2024	Sunday	16:00	36.97	29.49	1.11	500.68
		17:00	39.02	31.08	1.82	500.68
		18:00	41.52	33.07	3.17	507.36
14/10/2024	Monday	16:00	33.56	27.76	0.63	447.27
		17:00	33.27	27.50	0.96	440.60
		18:00	34.67	28.65	1.80	447.27
15/10/2024	Tuesday	16:00	22.13	20.77	0.75	547.41
		17:00	22.69	20.83	1.17	527.38
		18:00	23.78	23.09	1.34	417.23
16/10/2024	Wednesday	16:00	24.87	21.44	1.71	357.15
		17:00	25.87	21.87	2.66	373.84
		18:00	25.87	21.87	2.66	373.84

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

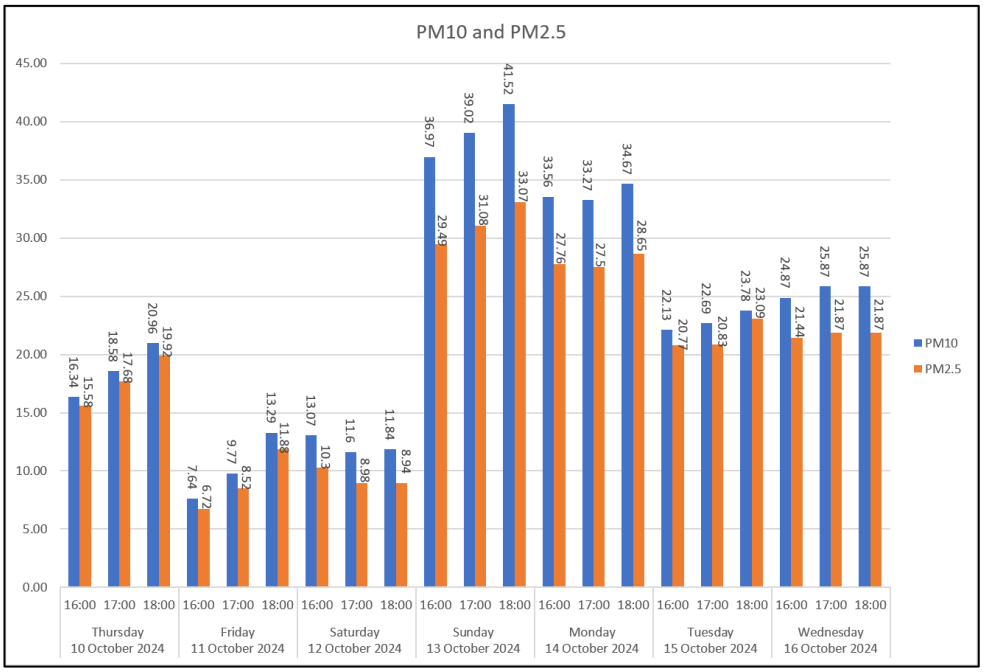

Figure 3. Temporal Variation of PM10 and PM2.5 Concentrations

PM10 and PM2.5 followed closely parallel temporal patterns. The lowest concentrations of both were recorded on Friday, 11 October 2024, at 16:00 WIB (7.64 and 6.72 µg/m³, respectively), and the highest on Sunday, 13 October 2024, at 18:00 WIB (41.52 and 33.07 µg/m³). The near-identical patterns indicate overlapping source contributions to the two size fractions (Guttikunda, Dammalapati, and Jakubowski 2025; M. Santoso et al. 2020).

The particulate maximum, however, coincided with the traffic *minimum*. The highest PM10 and PM2.5 values in the entire study occurred at the same observation, Sunday, 13 October 2024, at 18:00 WIB, when the total vehicle count was the lowest (959 vehicles). Indeed, Sunday recorded the three highest PM10 values of the week (36.97, 39.02, 41.52 µg/m³) although Sunday had the lowest overall traffic. This inversion is the single most informative result of the study: it indicates that particulate variation at this site during the observation week was not controlled by local tailpipe emissions. Plausible explanations include (i) a regional or background particulate source unrelated to the corridor, (ii) non-exhaust contributions such as road dust resuspension and combustion activity in the surrounding area, and (iii) the sub-district spatial support of the pollutant data, which averages over an area far larger than the road segment where traffic was counted (J. Zhang et al. 2018; Amato et al. 2014; Sahanavin, Tantrakarnapa, and Prueksasit 2016). Distinguishing among these requires elemental source apportionment and co-located measurement, neither of which was available here; studies in Jakarta have shown that intra-city particulate composition varies markedly between sites even within a single urban area, so that concentration data alone cannot attribute particulate mass to a source (Driejana et al. 2025). The present data can identify the anomaly but cannot resolve its cause.

For reference, the observed mean PM2.5 concentration (19.81 µg/m³) exceeds the WHO 24-hour air quality guideline of 15 µg/m³, and the maximum (33.07 µg/m³) exceeds it by more than a factor of two (World Health Organization 2021). This

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comparison is indicative only, since the observations are hourly snapshots taken within a fixed late-afternoon window rather than 24-hour means, and the two are not formally comparable.

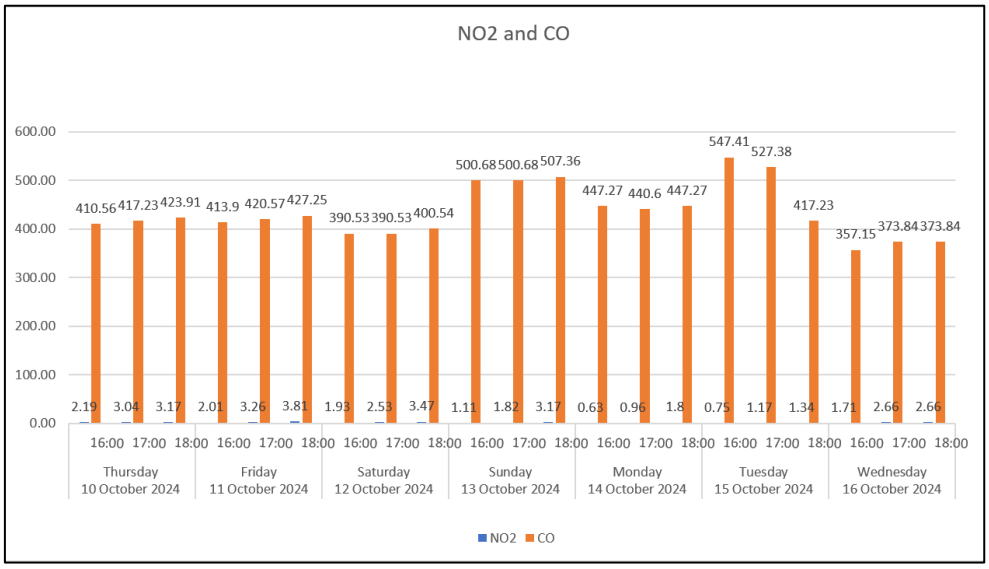

Figure 4. Temporal Variation of NO_2 and CO Concentrations

NO_2 and CO also fluctuated over time, but with dissimilar patterns. NO_2 increased monotonically from 16:00 to 18:00 on all seven observation days, producing a systematic diurnal signal (r with hour of observation = 0.570; $p = 0.007$). CO showed no such trend (r with hour = −0.079; $p = 0.733$) and instead varied primarily between days. NO_2 is widely used as an indicator of combustion emissions from road transport (Mucha and Mainka 2026; Ngo et al. 2023), whereas CO is a product of incomplete combustion whose concentration is sensitive to vehicle operating regime (for example, stop-and-go conditions) and to local dispersion (Sendow et al. 2019; Bachtiar et al. 2018). The divergence of the two patterns indicates that the gaseous pollutants at this site do not respond to a single common controlling factor (Tang et al. 2020).

Overall, PM10, PM2.5, NO_2, and CO fluctuated asynchronously. The particulate fractions peaked in the middle of the observation period, on Sunday and Monday, 13–14 October 2024, whereas the gaseous pollutants varied along different axes: NO_2 diurnally, CO between days. Roadside air quality at this site is therefore governed by multi-factor interactions encompassing traffic dynamics, meteorology, particle resuspension, and regional background pollution (Ngo et al. 2023; Guttikunda, Dammalapati, and Jakubowski 2025; Das et al. 2024).

3.3 Meteorological Conditions

Meteorological conditions varied appreciably over the observation period (Table 4). Air temperature ranged from 29 to 35 °C (mean 32.38 ± 2.04 °C), relative humidity from 41% to 78% (mean 53.95 ± 9.59%), and wind speed from 5 to 12 km/h (mean 6.90 ± 1.84 km/h). Atmospheric conditions were therefore not constant and could plausibly influence pollutant concentrations through dispersion and transport (Bachtiar et al. 2018; Tang et al. 2020).

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Table 4. Meteorological Conditions at Each Observation Time

Date	Day	Time	Temperature (°C)	Humidity (%)	Wind speed (km/h)
10/10/2024	Thursday	16:00	32	65	6
		17:00	31	70	8
		18:00	29	78	6
11/10/2024	Friday	16:00	33	58	6
		17:00	31	50	6
		18:00	29	60	7
12/10/2024	Saturday	16:00	35	47	9
		17:00	33	51	8
		18:00	30	62	9
13/10/2024	Sunday	16:00	34	46	5
		17:00	33	51	5
		18:00	31	57	6
14/10/2024	Monday	16:00	35	41	6
		17:00	34	45	5
		18:00	30	60	5
15/10/2024	Tuesday	16:00	35	45	8
		17:00	33	52	5
		18:00	30	57	6
16/10/2024	Wednesday	16:00	35	41	9
		17:00	34	47	12
		18:00	33	50	8

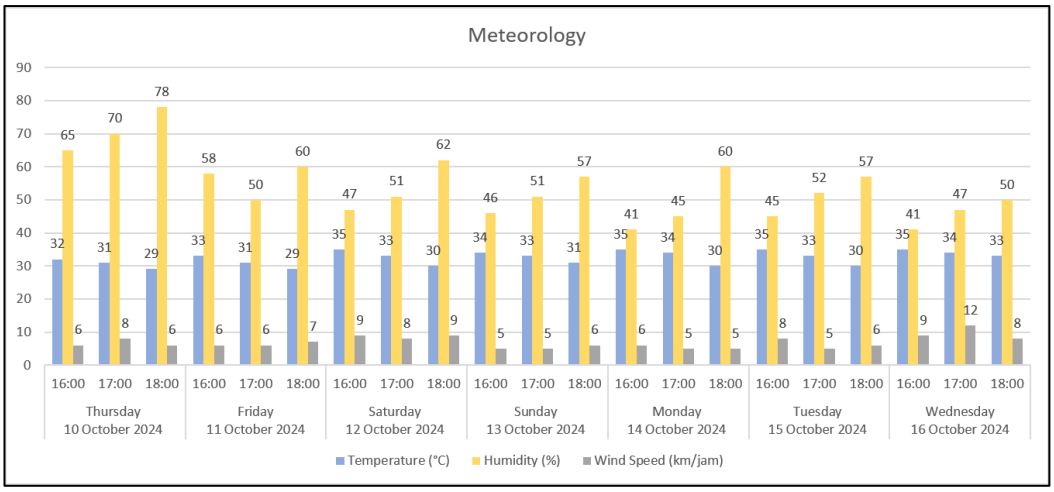

Figure 5. Temporal Variation of Meteorological Conditions

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Temperature was consistently higher at the start of each observation window and declined towards 18:00 (r with hour = −0.792; $p < 0.001$), while relative humidity showed the inverse pattern. The two variables are strongly collinear (r = −0.821), as expected for surface conditions in the humid tropics, where falling temperature raises relative humidity at approximately constant absolute water vapour content (Khan et al. 2016; Ramadhanil, Bachtiar, and Aziz 2025). This collinearity is important for interpreting the correlation results in Section 3.4: temperature and humidity should not be treated as two independent predictors.

Wind speed, by contrast, showed no consistent within-day trend (r with hour = −0.065; p = 0.780). Most observations fell between 5 and 9 km/h; the maximum of 12 km/h occurred on Wednesday, 16 October 2024, at 17:00 WIB. Air movement at the site therefore fluctuated and may have affected dilution and dispersion differently at each observation, with higher wind speeds generally promoting dilution (Bachtiar et al. 2018; Sahanavin, Tantrakarnapa, and Prueksasit 2016).

3.4 Relationships Among Traffic, Pollutants, and Meteorology

Pearson correlation coefficients are presented in Table 5. Of the sixteen relationships tested, only three were statistically significant at α = 0.05 (critical |r| = 0.433 for n = 21).

Table 5. Pearson Correlation Coefficients (R) with p-Values Between Traffic, Meteorological, And Pollutant Variables (N = 21; Df = 19)

Variable	PM10	PM2.5	NO_2	CO
Total vehicles	−0.397 (p = 0.075)	−0.363 (p = 0.106)	−0.128 (p = 0.580)	−0.190 (p = 0.410)
Temperature	0.195 (p = 0.398)	0.161 (p = 0.485)	**−0.674 (p = 0.001)**	0.072 (p = 0.758)
Humidity	−0.282 (p = 0.215)	−0.228 (p = 0.321)	**0.592 (p = 0.005)**	−0.092 (p = 0.693)
Wind speed	−0.354 (p = 0.116)	−0.367 (p = 0.102)	0.323 (p = 0.154)	**−0.569 (p = 0.007)**

Bold indicates significance at α = 0.05 (two-tailed)

Traffic volume. None of the four correlations between total vehicle count and the main pollutants reached significance (|r| = 0.128–0.397; all $p > 0.05$). The correlation with PM10 (r = −0.397; p = 0.075) approaches, but does not attain, the conventional threshold. The appropriate conclusion is therefore that no significant association was detected between instantaneous traffic volume and roadside pollutant concentrations at this site, not that traffic volume is negatively associated with pollution. The negative signs of these coefficients should not be interpreted substantively; they are driven largely by the single Sunday episode described in Section 3.2, in which the lowest traffic coincided with the highest particulate levels.

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

Several factors may account for this null result. First, and most importantly, the pollutant data have sub-district spatial support while the traffic data have single-point support, so any genuine roadside signal is diluted by the surrounding area before it enters the analysis. Second, roadside pollutant concentrations respond to emissions with a lag and vary with atmospheric stability, so a contemporaneous linear response to vehicle counts is not expected (Iriani and Pribadi 2023; Husnina et al. 2023). Third, the fleet is dominated by motorcycles (67.2%), whose emission profiles differ from those of four-wheeled vehicles (Amin et al. 2023; Napitupulu, Ismiyati, and Handajani 2018). Fourth, for the particulate fractions specifically, roadside PM is also generated by dust resuspension and by other anthropogenic activity along the corridor, including commerce and street vending, which contribute to particulate loads independently of vehicle throughput (Salydin et al. 2024; Sahanavin, Tantrakarnapa, and Prueksasit 2016). Fifth, with n = 21, the study has limited power: an effect of r = 0.4 would be detected only about half the time. A null result under these conditions is weak evidence of absence.

Meteorology. Temperature correlated negatively with NO_2 ($r = -0.674$; $p = 0.001$) and humidity positively ($r = 0.592$; $p = 0.005$). Because temperature and humidity are strongly collinear ($r = -0.821$), these are not two independent findings but two expressions of the same relationship. Moreover, both are partly confounded with the time of day: NO_2 rose and temperature fell monotonically from 16:00 to 18:00 on every observation day. When controlling for the hour of observation is partialled out, the temperature–NO_2 association weakens substantially, from $r = -0.674$ to a partial $r = -0.442$ ($p = 0.045$). The relationship is therefore real but considerably smaller than the bivariate coefficient implies, and it is best described as the joint expression of the evening decline in mixing height and the evening peak of combustion emissions, rather than as a direct thermal effect on NO_2 (Sari 2024; Saputra, Hasibuan, and Amin 2025; Khan et al. 2016).

Of the three significant associations, the one least affected by the diurnal cycle is that between wind speed and CO ($r = -0.569$; $p = 0.007$). Unlike the NO_2 relationships, it is not confounded by time of day: wind speed shows no diurnal trend, and the association is essentially unchanged when hour is partialled out (partial $r = -0.577$; $p = 0.006$). Higher wind speeds were accompanied by lower CO concentrations, consistent with the role of wind in enhancing dilution and dispersion of combustion products in ambient air (Sari 2024; Husnina et al. 2023; Bachtiar et al. 2018). Among the three significant associations, this is therefore the one least vulnerable to time-of-day confounding. It should nonetheless be read cautiously: under the Bonferroni correction applied in Section 3.5 ($\alpha = 0.003$) it would not be retained as significant, so it is best described as suggestive rather than established.

Taken together, the results indicate that, at the resolution available, atmospheric ventilation was more closely associated with roadside pollutant concentrations than instantaneous traffic volume was. This does not imply that traffic is unimportant as an emission source; the study cannot test that, but it does imply that pollutant concentrations measured at a point in time cannot be read as a proxy for traffic intensity at that same time (Saputra, Hasibuan, and Amin 2025; Ngo et al. 2023).

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

3.5 Limitations

The findings should be interpreted in light of five constraints.

Spatial mismatch. The pollutant data represent the Telanaipura sub-district, whereas the traffic data represent a single point on Jl. RE Marta Dinata. The two variables are therefore not measured over the same spatial domain, and this mismatch is the most likely explanation for the weak traffic–pollutant associations reported in Section 3.4. Co-located measurements are required before any conclusion about the traffic–pollution relationship in this corridor can be considered established.

Data provenance. Application-derived air quality values may be interpolated or modelled rather than directly measured, and their accuracy at the roadside micro-environment has not been validated against reference instrumentation (Morawska et al. 2018; Imami et al. 2022).

Temporal resolution. The identical values reported at 17:00 and 18:00 on 16 October 2024 indicate that the application does not necessarily refresh at hourly intervals. Some observations may therefore not be temporally independent.

Statistical power and multiplicity. With n = 21, the study is underpowered for moderate effects. In addition, sixteen correlations were tested without adjustment for multiple comparisons; under a Bonferroni correction ($\alpha = 0.05/16 = 0.003$), only the temperature–NO_2 association would remain significant. The reported p-values should be read accordingly.

Scope of inference. Observations are confined to a single site, a single seven-day period, and a single two-hour late-afternoon window. Morning peaks, night-time conditions, and seasonal variation, including the regional biomass-burning haze episodes to which Jambi is periodically subject, are outside the scope of these data and cannot be assessed here.

4. Conclusion

Roadside air quality on Jl. RE Marta Dinata, Jambi City, exhibited clear temporal variation over the observation period of 10–16 October 2024. Traffic volume was consistently high, averaging 1,959 vehicles per observation and dominated by motorcycles (67.2%), yet no statistically significant correlation was detected between traffic volume and any of PM10, PM2.5, NO_2, or CO. The highest particulate concentrations of the study occurred on the day with the lowest traffic volume, indicating that particulate levels at this site were not governed by local traffic emissions during the observation week.

Of the sixteen relationships tested, only three were significant, and all involved meteorological variables. The association between wind speed and CO ($r = -0.569$; $p = 0.007$) was the least affected by time-of-day confounding, remaining essentially unchanged after the hour of observation was partialled out, and is consistent with the role of atmospheric ventilation in dispersing combustion products; it does not, however, survive correction for multiple comparisons and is therefore reported as suggestive rather than established. The associations of temperature and humidity with NO_2, though statistically significant, are collinear and partly confounded by the diurnal cycle; their independent contributions are smaller than the bivariate coefficients suggest.

Manuscript received 15 July 2026; revised 16 July 2026; accepted 20 October 2026

The practical implication is that roadside pollutant concentrations in Jambi cannot be inferred from traffic counts alone, and that air quality management in the city must account for atmospheric dispersion conditions and for non-traffic and regional sources. The methodological implication is more pressing: the spatial mismatch between sub-district-scale pollutant data and point-scale traffic data limits what any such analysis can establish. Confirming the relationships reported here will require co-located, continuous roadside monitoring with reference-grade or validated low-cost instrumentation, over a longer period and across a wider range of diurnal and seasonal conditions.

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During the preparation of this manuscript, the authors used ChatGPT (GPT-5.5, OpenAI, 2026) for editing English, refining grammar, and improving clarity in academic writing. The authors have reviewed, verified, and edited all AI-assisted content and accept full responsibility for the integrity and accuracy of the manuscript.

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