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NOISE LEVEL DISTRIBUTION BASED ON VEHICLE CATEGORY AND SPEED ON SUPRAPTO ROAD OF PALU CITY

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Abstract

The urban development of Palu City has been accompanied by a significant increase in land transportation activities. Vehicle speed is one of the primary factors influencing road traffic noise and environmental vibration levels. This study aims to analyze the effect of vehicle speed on the intensity of road noise and environmental vibration, and to evaluate their conformity with applicable environmental quality standards. Data collection was conducted at three observation time (L1, L2, L3) by measuring vehicle speed using a speed gun, noise levels using a Sound Level Meter (SLM), and traffic volume. Measurements were taken during three time periods: morning (07:00–11:00 WITA), midday (11:00–14:00 WITA), and afternoon (14:00–18:00 WITA). Vehicle categories included motorcycles (MC), light vehicles (LV), and heavy vehicles (HV). Noise analysis was performed using frequency distribution and equivalent noise level (Leq) calculations. Results showed that noise levels at all three locations ranged from 53.6 to 92.0 dBA, exceeding the standard set by the Decree of the State Minister of Environment No. 48 of 1996. This study offers a useful foundation for comprehending and reducing noise pollution caused by traffic in Palu CIty, and may act as a reference point for formulating specific noise control strategies in urban areas.

Keywords: Traffic, Speed, Noise Level, Palu City

1. Introduction

The development of urban areas in Palu City in recent years has been accompanied by a significant increase in land transportation activities. Urban roads not only function as mobility infrastructure but have also become a major source of physical environmental pollution in the form of noise. Noise pollution represents an invisible yet real hazard that exists across terrestrial and aquatic environments despite being imperceptible to the eye. Traffic noise that exceed threshold limits can degrade environmental quality, disturb community comfort, and potentially cause adverse health impacts. It is broadly defined as any unwanted or disturbing sound that negatively affects the physical health and overall well-being of humans as well as other living organisms (Karki et al., 2024).

One of the primary factors influencing the level of traffic noise is vehicle speed. Road traffic noise shaped primarily by vehicle volume, vehicle speed, and the proportion of heavy vehicles in the traffic

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stream is known to cause a spectrum of adverse health outcomes including sleep disturbance, cardiovascular stress, reduced cognitive performance, and progressive hearing impairment (Danilevičius et al., 2023). High vehicle speeds, especially on roads with heavy traffic density and a high proportion of heavy vehicles, can increase the intensity of sound and vibrational energy transmitted to the surrounding road environment. This issue becomes increasingly critical in urban areas with mixed land use, such as residential zones, office districts, educational facilities, and public services.

Among the determinants of traffic noise intensity, vehicle speed and traffic composition are consistently identified as the most influential variables. Research conducted by Abbood et al. (2023) using the response surface method demonstrated that traffic flow, speed, density, and vehicle composition all exert direct effects on roadside noise levels, with the Leq rate of increase being most pronounced at flow values below 1,204 vehicles per hour. Similarly, Hussain et al. (2024), studying multiple urban roads in the Philippines, found an average Leq of 70.81 dB(A) and confirmed a strong correlation between heavy vehicle proportion and noise levels, recommending time-based restrictions on heavy vehicles along critical corridors as a primary mitigation measure.

Within Sulawesi, Hustim et al. (2025), measuring noise at median U-turn facilities in Makassar City, found that noise levels consistently exceeded 75 dB(A), with motorcycles accounting for 65% of the traffic composition and contributing dominantly to the measured noise. Mediastika et al. (2022) documented that an outdated 55 dBA noise regulation adopted in 1996 remains the sole national standard, while field surveys in multiple Indonesian cities routinely record ambient noise levels on arterial roads exceeding 70–75 dBA, a gap that underscores the urgency of empirical studies to support policy revision.

In Palu City, measurements conducted at Pasar Lasoani showed that vehicle volume has a positive effect on noise levels, while vehicle speed has a negative effect (lower speeds correspond to higher noise under congested conditions). A similar study at Simpang Emmy Saelan reported an average noise level reaching 78 dB, well above the applicable standard (Rifki Abdi, 2025). Kadir et al. (2024), in a case study on Jalan Gatot Subroto, Palu City, found that higher motorized vehicle activity corresponds to higher noise levels, which has disturbed the comfort of residents along the road.

This study aims to analyze the effect of vehicle speed on road noise levels and environmental vibration, as well as to evaluate whether the measured levels comply with applicable environmental quality standards.

2. Method

2.1 Study Location

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The research was conducted along Jalan Soeprapto, Palu City, Central Sulawesi, Indonesia. This road segment traverses an established educational zone where several schools of varying levels are situated directly along the corridor, ranging from early childhood education centers (kindergarten) to senior secondary schools. The concentration of educational facilities along this road makes the area particularly susceptible to traffic-induced noise disturbance, given the critical need for acoustically conducive environments to support effective teaching and learning activities. Accordingly, this location was selected as representative of a noise-sensitive land use context in an urban setting as the Figure 1.

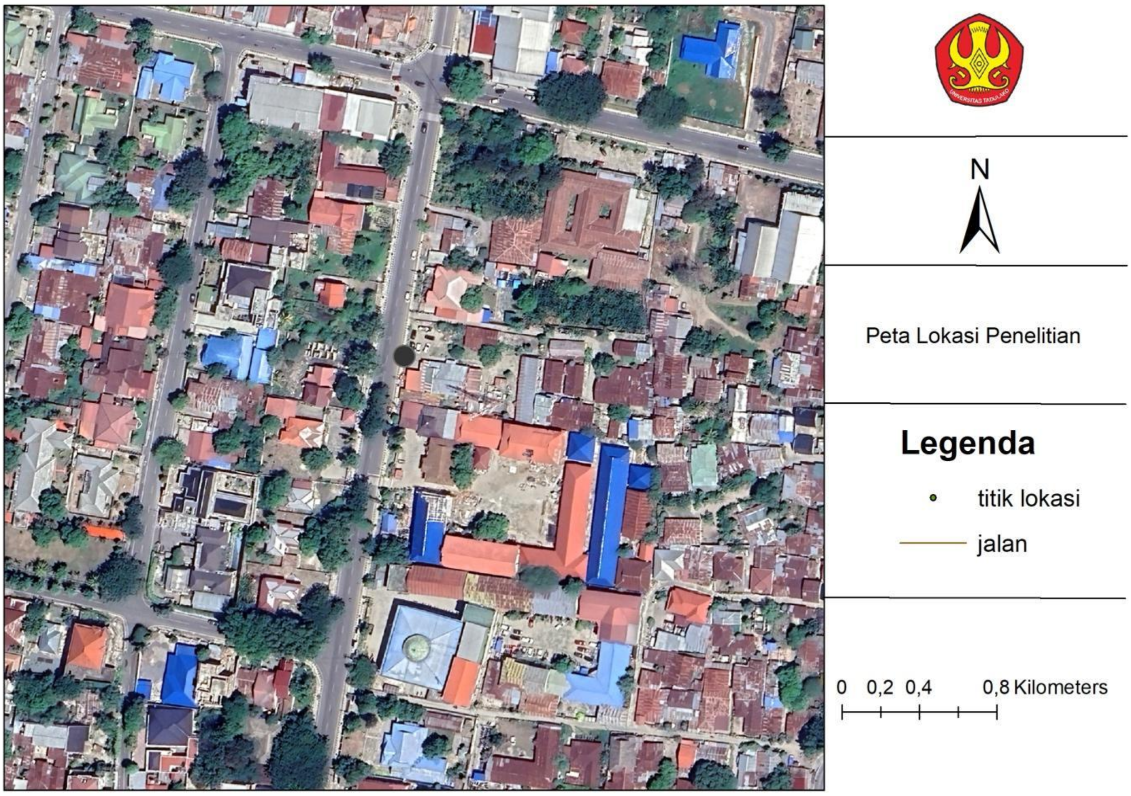

Figure 1. Study Location

2.2 Data Collection

The vehicles studied were motorcycles (MC), light vehicles (LV), and heavy vehicles (HV) in accordance with the *Indonesian Highway Capacity Manual (MKJI)*. Data collected included vehicle speed, noise levels, and traffic volume.

2.3 Data Collection Methods

2.3.1 Vehicle Speed Data

Vehicle speed data were collected using a *speed gun* placed at the roadside. The instrument was aimed at passing vehicles at the angle and distance specified by its technical requirements, allowing direct and accurate speed readings to be obtained.

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2.3.2 Environmental Noise Measurement

The field measurement method employed the following equipment:

1. *Sound Level Meter (SLM)*: measures noise in decibels using A-weighting, corresponding to the human auditory response, providing objective results.
2. *Tripod*: stabilizes the SLM during measurement.
3. *Counter*: records traffic volume.
4. *Stopwatch*: records measurement duration.

Noise measurements were conducted over 10-minute intervals at each of three daily periods: morning (07:00–11:00 WITA) for L1, midday (11:00–14:00 WITA) for L2, and afternoon (14:00–18:00 WITA) for L3.

2.3.2 Traffic Volume

Vehicle volume data were collected through direct counting over a 10-minute observation interval at each measurement point. The vehicles were separated into three categories in accordance with the Indonesian Highway Capacity Manual (PKJI 2023): motorcycles (MC), light vehicles (LV), and heavy vehicles (HV).

2.4 Data Analysis

Noise analysis used frequency distribution to group data into classes and calculate equivalent noise level (Leq). The following equations were applied:

a. Range: $R = Data\ max - Data\ min$ .... (1)

b. Number of classes: $k = 1 + 3.3 \log(n)$ .... (2)

c. Class interval: $i = R / k$ .... (3)

d. Class midpoint: $Midpoint = (LL + UL) / 2$ .... (4)

where: R = range; k = number of classes; n = total data; i = class interval; LL = lower class boundary; UL = upper class boundary.

The grouped data were then processed to obtain the equivalent noise level using:

$$Leq = 10 \log \left[(1/n)\ \Sigma\ T_n \cdot 10\text{^}(0.1\ L_n) \right] \quad ....\ (5)$$

where: *Leq* = equivalent continuous noise level; *n* = total number of data; T_n = class frequency; L_n = class midpoint (dBA).

3. Results and Discussion

3.1 Traffic Volume

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The vehicle volume data for three vehicle categories across three observation periods are presented in Table 1.

A total of 728 vehicles were recorded. Motorcycles dominated with 402 units (≈55%), followed by light vehicles (283 units) and heavy vehicles (43 units). Volume increased from L1 (153 vehicles) through L2 (210 vehicles) to a peak at L3 (365 vehicles), indicating denser traffic conditions at L3 consistent with peak-hour activity. At L1, motorcycles accounted for 71% of volume. This proportion declined to 60% at L2 and 46% at L3, concurrent with a sharp increase in light vehicles (≈45% at L3) and heavy vehicles (9.6% at L3). This shift reflects afternoon return-commute patterns, commercial activity, and freight distribution concentrated in the later period.

Table 1. Vehicle Volume at Each Observation Point

Location	Vehicle Category	Volume (vehicles/10 min)
L1	Motorcycle (MC)	109
	Light Vehicle (LV)	39
	Heavy Vehicle (HV)	5
L2	Motorcycle (MC)	126
	Light Vehicle (LV)	81
	Heavy Vehicle (HV)	3
L3	Motorcycle (MC)	167
	Light Vehicle (LV)	163
	Heavy Vehicle (HV)	35

3.2 Vehicle Speed

Among the most commonly identified contributors to excessive noise in city transportation are mechanical vibrations from engines, vehicle exhaust pipes, friction between tires and road surfaces, as well as abrupt movements of vehicles (Morales et al, 2025) .For motorcycles, the highest speeds were recorded in the afternoon period, peaking at 130–140 km/h between 16:00 and 18:00, while morning speeds averaged 20–50 km/h. The midday period was intermediate (18–80 km/h). This indicates freer traffic flow in the afternoon, whereas morning congestion from school and work commutes restricts motorcycle speeds.

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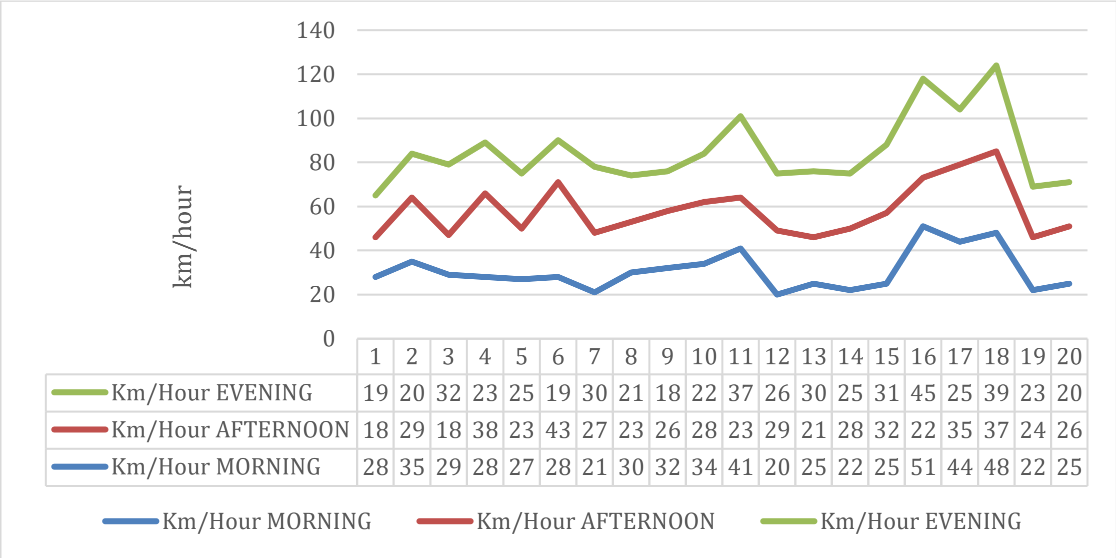
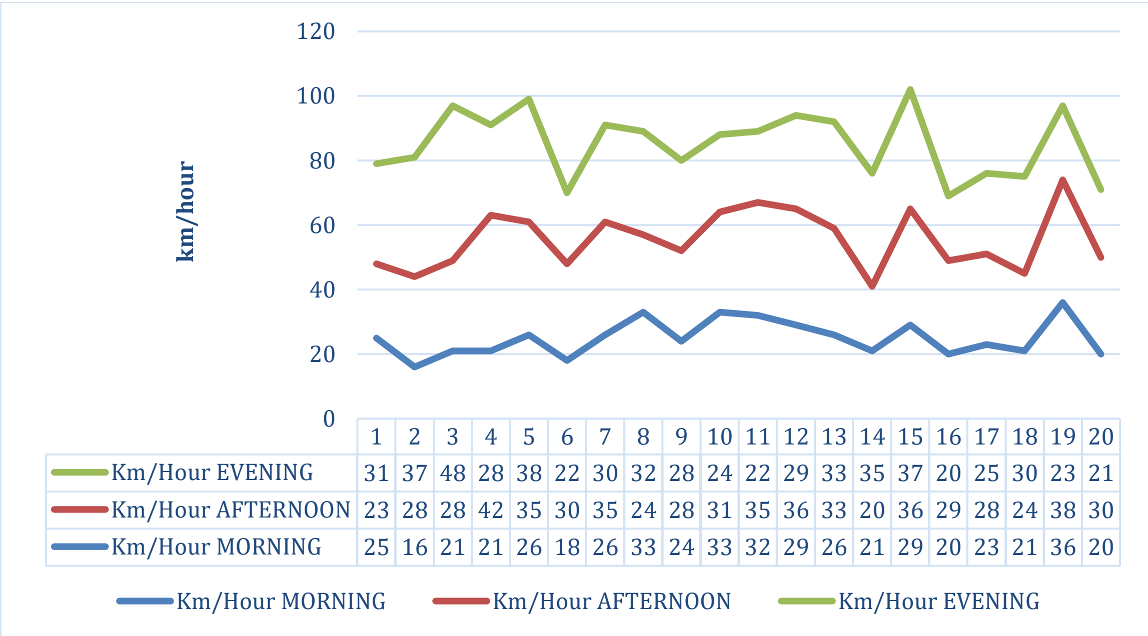


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Km/Hour EVENING	19	20	32	23	25	19	30	21	18	22	37	26	30	25	31	45	25	39	23	20
Km/Hour AFTERNOON	18	29	18	38	23	43	27	23	26	28	23	29	21	28	32	22	35	37	24	26
Km/Hour MORNING	28	35	29	28	27	28	21	30	32	34	41	20	25	22	25	51	44	48	22	25

Figure 2. Motorcycles Speed

For light vehicles (cars), the highest speeds also occurred in the afternoon (20–100 km/h, with several peaks at 80–100 km/h), while the morning period showed the lowest speeds (predominantly below 40 km/h), reflecting peak congestion during morning commute hours.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Km/Hour EVENING	31	37	48	28	38	22	30	32	28	24	22	29	33	35	37	20	25	30	23	21
Km/Hour AFTERNOON	23	28	28	42	35	30	35	24	28	31	35	36	33	20	36	29	28	24	38	30
Km/Hour MORNING	25	16	21	21	26	18	26	33	24	33	32	29	26	21	29	20	23	21	36	20

Figure 3. Light Vehicles Speed

For heavy vehicles, the afternoon period recorded the highest speeds, frequently exceeding 80 km/h and peaking at approximately 110–120 km/h, while the morning period showed the lowest speeds (18–40 km/h). The relatively high afternoon speeds for heavy vehicles likely reflect reduced overall traffic congestion or more flexible freight scheduling, allowing speeds to approach the maximum limit on certain road segments.

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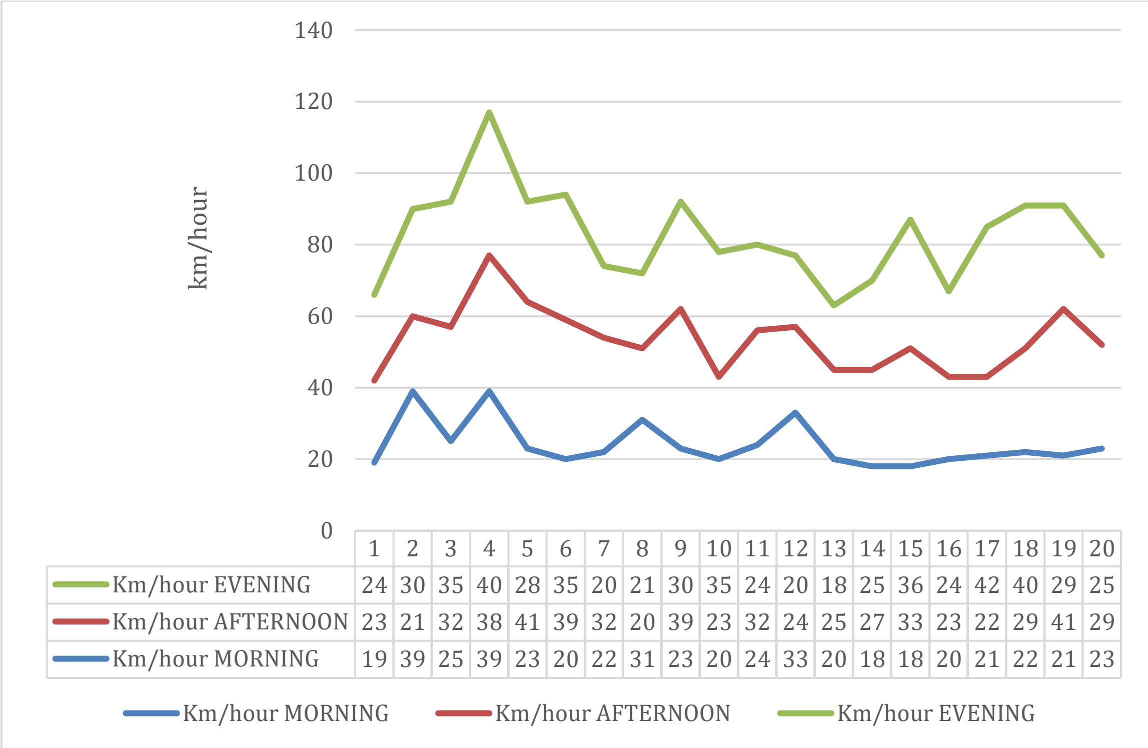

Figure 4. Heavy Vehicles Speed

3.3 Noise Level

3.3.1 Frequency Distribution

The frequency distribution of noise measurements at each observation location is presented in Tables 2, 3, and 4.

Table 2. Frequency Distribution of Noise Levels at Location L1

Class	Interval (dBA)	Midpoint (dBA)	Frequency
1	53.6 – 56.8	55.2	7
2	57.8 – 60.0	58.9	12
3	61.0 – 63.2	62.1	20
4	64.2 – 66.4	65.3	26
5	67.4 – 69.6	68.5	25
6	70.6 – 72.8	71.7	16
7	73.8 – 75.9	74.9	8
8	76.9 – 79.1	78.0	6

The L1 frequency distribution groups 120 measurements into eight classes with an interval of approximately 3.2 dBA. Frequency peaks at Classes 4–5 (65–69 dBA) and decreases toward the extremes, indicating predominantly moderate-to-moderately-high noise conditions. Very low levels (<57 dBA) and very high levels (>76 dBA) are infrequent. The pattern approximates a slightly left-skewed normal distribution.

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Table 3. Frequency Distribution of Noise Levels at Location L2

Class	Interval (dBA)	Midpoint (dBA)	Frequency
1	53.9 – 57.9	55.9	4
2	58.9 – 61.7	60.3	20
3	62.7 – 65.4	64.0	28
4	66.4 – 69.2	67.8	27
5	70.2 – 72.9	71.5	27
6	73.9 – 76.7	75.3	7
7	77.7 – 80.4	79.0	6
8	81.4 – 84.2	82.8	1

At L2, the highest frequencies are at Class 3 (28 occurrences) and Classes 4–5 (27 each), indicating a strong concentration of data in the 62–73 dBA range. Extreme values (<58 dBA, only 4; >81 dBA, only 1) are rare.

Table 4. Frequency Distribution of Noise Levels at Location L3

Class	Interval (dBA)	Midpoint (dBA)	Frequency
1	52 – 57	54.5	4
2	58 – 62	60.0	8
3	63 – 67	65.0	14
4	68 – 72	70.0	31
5	73 – 77	75.0	34
6	78 – 82	80.0	20
7	83 – 87	85.0	7
8	88 – 92	90.0	2

At L3, the highest frequency is at Class 5 (73–77 dBA, 34 occurrences), followed by Class 4 (68–72 dBA, 31 occurrences). Data are strongly concentrated in the 68–77 dBA range, reflecting the dominant presence of heavy vehicles. The overall noise level at L3 is noticeably higher than at L1 and L2.

3.3.2 Noise Level Fluctuation

At L1, minute-by-minute noise levels fluctuated between 64.0 and 67.0 dBA, with peaks at minutes 1 and 4, and troughs at minutes 6 and 8. The average of approximately 65–66 dBA is consistent with a moderate traffic noise environment characterized by intermittent vehicle passage.

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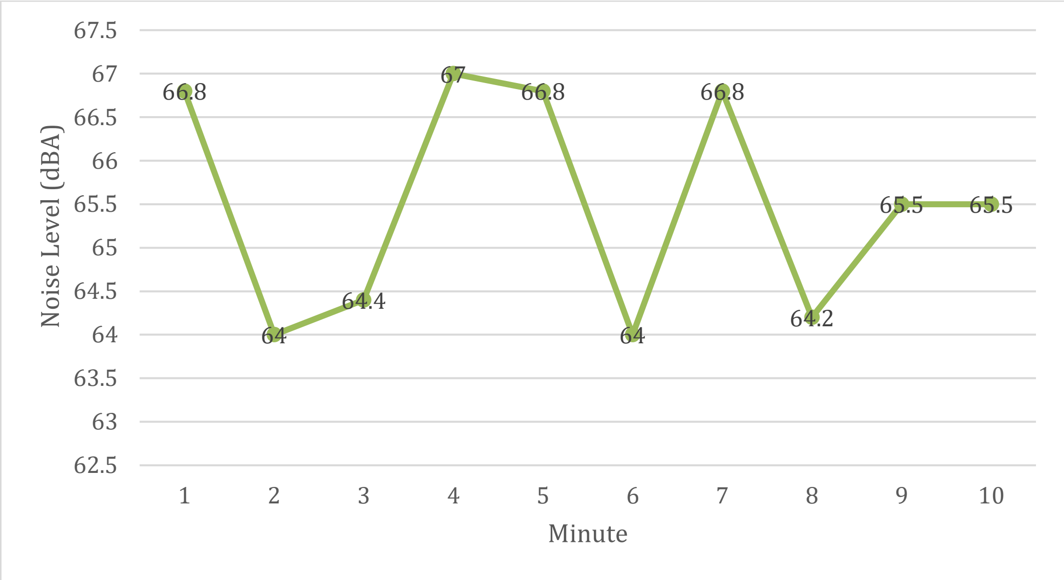

Figure 5. Average of L1

At L2, noise levels showed a wider range (62.3–71.6 dBA), with the highest peaks at minutes 1 and 4, and the lowest values at minutes 7 and 10. The span of approximately 9.3 dBA between peak and trough reflects a more dynamic noise environment, with a general declining trend from the start to the end of the measurement period.

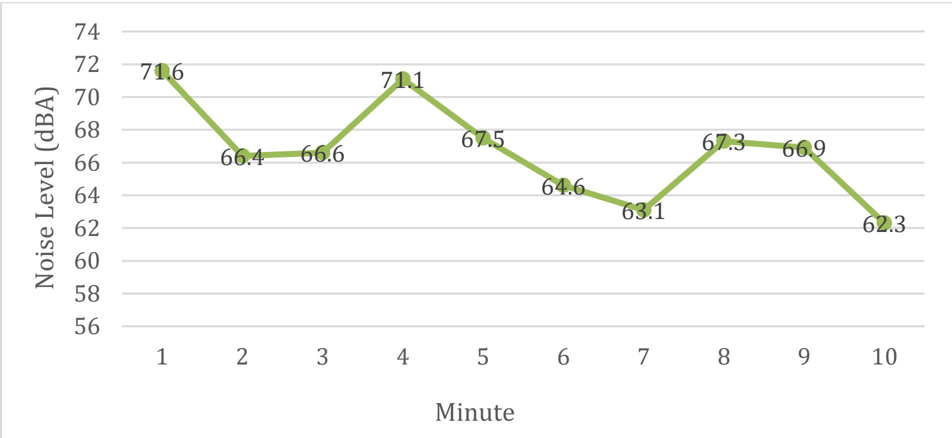

Figure 6. Average of L2

At L3, noise levels were the highest overall (66.1–75.9 dBA), with peaks at minutes 4 and 10. The average of approximately 71–73 dBA and the tendency for levels to rise toward the end of the period are consistent with the strong and recurring noise sources — primarily heavy vehicles — that dominated the traffic composition at this location.

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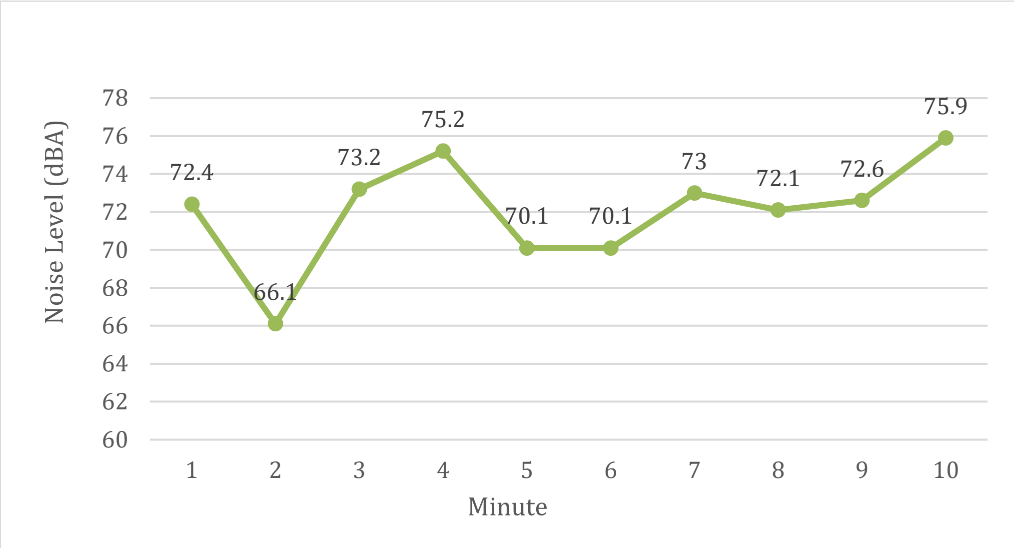

Figure 7. Average of L3

3.3.3 Equivalent Noise Level (Leq) and Compliance

Leq values calculated at all three locations exceeded the noise quality standard of 55 dBA for residential and commercial areas prescribed by the Decree of the State Minister of Environment No. 48 of 1996. Location L3, which recorded the highest traffic volume and the largest proportion of heavy vehicles, consistently showed the highest Leq values, confirming that heavy vehicle composition and operating speed are the dominant drivers of noise levels on urban road segments in Palu City.

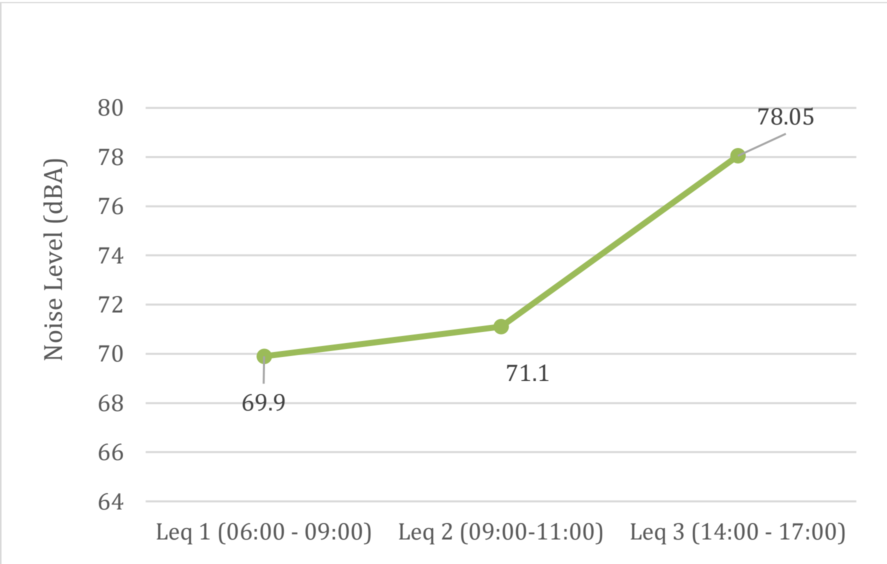

Figure 7. Leq Noon

The research highlights the pressing necessity for regulatory measures, including the strict implementation of horn restriction rules, encouragement of High Occupancy Vehicle (HOV) usage,

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coordination of traffic light systems, and awareness programs directed at the general public (Malik et al., 2026). Other research also emphasized that exposure of traffic noise is linked to health problems, including cardiovascular diseases, sleep disturbances, and impaired cognitive function (Chua et al, 2026) .

4. Conclusions

Noise levels at all three locations ranged from 53.6 to 92.0 dBA. The frequency distribution showed that the most prevalent noise range was 65–69 dBA at L1, 62–73 dBA at L2, and 68–77 dBA at L3. Location L3 consistently recorded the highest noise levels, which is attributable to the simultaneous increase in traffic volume, vehicle speed, and the proportion of heavy vehicles during the afternoon period. The Equivalent Noise Level (Leq) calculated at all three locations exceeded the noise quality threshold of 55 dBA stipulated by the Decree of the State Minister of Environment No. 48 of 1996. This indicates that Jalan Soeprapto does not comply with the applicable environmental noise standard, posing a potential risk to the health and comfort of residents and students in the surrounding educational zone.

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