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Spatial and Temporal Analysis of Noise Level Distribution in Residential Areas Around Poris Station

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Abstract
The rapid expansion of urban areas in Indonesia has led to an increase in noise pollution, especially in residential areas near transportation hubs. Poris Station is surrounded by dense settlements and exposed to train activity that may affect community well-being. This study aims to analyze the spatial and temporal distribution of noise levels around Poris Station using a Geographic Information System (GIS). Measurements were conducted at 14 points (seven points in the north, seven points in the south) from 07:00 to 21:00 WIB for two weeks. The highest noise levels were at points closest to the station (1A and 1B), with an average of 70 dBA during morning and evening rush hours, reaching 81 dBA at 07:00 AM. In contrast, more distant points like 4A, 4B, and 6A tend to be below 55 dBA, especially at night. Most southern points recorded daytime and nighttime average noise levels above the 55 dBA threshold set by Decree of the Minister of Environment No. 48 of 1996. This confirms that the distance to rail activities affects noise exposure. GIS-based noise mapping can support noise control and urban planning, including the use of vegetation or structural barriers to reduce impacts.
Keywords: *noise pollution, spatial analysis, urban environment, residential noise, noise mapping*

Abstrak
Perkembangan pesat kawasan perkotaan di Indonesia menyebabkan peningkatan polusi kebisingan, terutama di daerah permukiman yang berdekatan dengan pusat transportasi. Stasiun Poris dikelilingi oleh permukiman padat dan terpapar aktivitas kereta api yang berpotensi mengganggu kenyamanan warga. Penelitian ini bertujuan menganalisis sebaran spasial dan variasi temporal tingkat kebisingan di sekitar Stasiun Poris dengan Sistem Informasi Geografis (SIG). Pengukuran dilakukan pada 14 titik (tujuh titik di utara dan tujuj titik di selatan) dari pukul 07:00-21:00 WIB selama dua minggu. Tingkat kebisingan tertinggi terjadi di titik yang paling dekat dengan stasiun (1A dan 1B), dengan rata-rata mencapai 70 dBA saat jam sibuk pagi dan sore, mencapai 81 dBA pada pukul 07:00 AM. Sebaliknya, titik yang lebih jauh seperti 4A, 4B, dan 6A cenderung berada di bawah 55 dBA, terutama malam hari. Sebagian besar titik di selatan mencatat tingkat kebisingan rata-rata siang dan malam di atas ambang batas 55 dBA sesuai Keputusan Menteri LH No. 48/1996. Hal ini menegaskan bahwa jarak terhadap aktivitas rel kereta mempengaruhi paparan kebisingan. Pemetaan kebisingan berbasis SIG dapat mendukung perencanaan pengendalian kebisingan dan pembangunan kota yang ramah lingkungan.
Kata Kunci: *polusi kebisingan, analisis spasial, lingkungan perkotaan, kebisingan permukiman, pemetaan kebisingan*

1. Introduction

The rapid development of urban areas in Indonesia across various sectors, such as industry, transportation, and housing expansion, has a significant impact on the environment [1]. One of the main consequences of this development is the increasing density of residential areas exposed to noise sources, such as industrial zones, highways, airports, and railway stations [2]. While urban growth contributes to economic progress and infrastructure development, its negative effects on the quality of human life cannot be overlooked [3][4].

Noise, as one of the most common forms of pollution in urban areas, especially around railway stations, directly disrupts daily activities and can adversely affect human comfort and health [5][6]. According to the Decree of the Minister of Environment No. 48 of 1996 regarding Noise Level Standards, noise is defined as unwanted sound from a source of activity that can cause health problems and discomfort [7]. The effects of noise pollution can vary depending on the intensity and duration of exposure, with the potential to cause hearing impairment, sleep disturbances, stress, headaches, and hypertension [8][9].

Poris Station, as one of the stations densely surrounded by residential areas, is at risk of high noise levels due to the activities of train arrivals, departures, and deceleration. The residential environment adjacent to the station raises concerns about continuous noise exposure, which ideally should not disrupt the peaceful atmosphere that residents desire.

This study aims to analyze and map the spatial distribution and temporal variation of noise levels in the residential areas surrounding Poris Station using a Geographic Information System (GIS) approach. The research will also investigate whether the noise levels exceed the quality standards outlined in the Decree of the Minister of Environment No. 48 of 1996, which establishes a limit of 55 dBA for residential zones [7]. Furthermore, this study seeks to provide accurate data that can support noise management strategies and recommend measures to reduce public exposure. One suggested mitigation strategy is the implementation of noise barriers, both natural (vegetation combined with earth mounds) and artificial (walls, glass, wood, aluminum, and other materials)[10][11]. The findings of this research are expected to inform appropriate urban planning interventions to reduce noise pollution and enhance the quality of life for residents living near Poris Station.

2. Research Method

Research Location

This research was conducted in residential areas around Poris Station, Tangerang City, Indonesia, a densely populated transit hub within the Greater Jakarta commuter rail network. This residential area was chosen due to its potential exposure to train noise pollution.

The research area was divided into two areas: South Area *(Zone A)* and North Area *(Zone B)*, separated by two active railway lines. This zone enabled comparative analysis based on settlement density and proximity to the station. A total of 13 physical locations were selected to represent a variety of noise conditions and human activity patterns. However, in total, 14 measurement points were used as points 1A *(South)* and 1B *(North)* refer to the same physical location but were measured in different weeks. The distribution of all sampling points is illustrated in **Figure 1.**

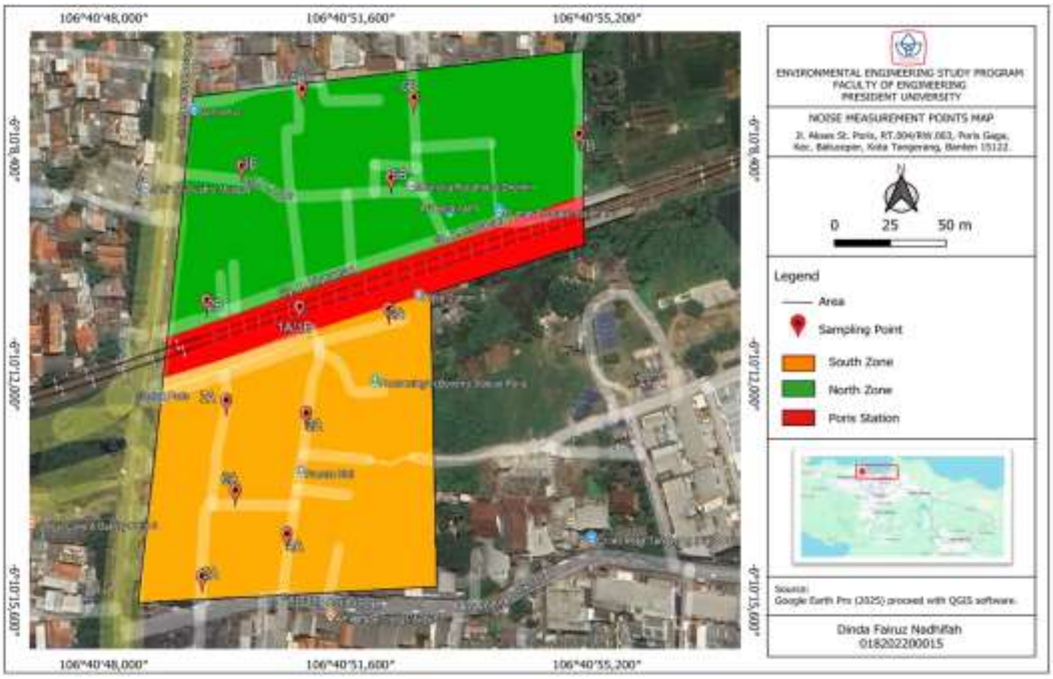

Figure 1. Map of research area
Source: Google Earth Pro

The types of data used in this study are primary and secondary data. Primary data was obtained or collected through direct measurements in the field using the CEM DT-8820 Sound Level Meter (SLM). The secondary data in this study is the quality standard sourced from the Decree of the Minister of Environment Number KEP-48/MENLH/11/1996 concerning Noise Intensity Standards, as well as geographical maps from Google Earth Pro and ESRI Base map.

This study uses a quantitative descriptive approach that aims to measure and analyze the noise level around Poris Station, Tangerang City, objectively and measurably. Then, noise data is collected from primary data, such as noise level data taken from around the residential Poris Station, and secondary data obtained from noise quality standards. The results of noise measurement will be analyzed by comparing them with the standard based on the Decree of the Minister of Environment Number KEP-48/MENLH/11/1996 concerning Noise Intensity Standards. Then, noise mapping uses the QGIS application version 3.40.7, supported by the OpenNoise plugin for mapping and visualizing the noise distribution around the residential Poris Station.

Instruments and Materials

The main instruments for noise measurement were the CEM DT-8820 Sound Level Meter (SLM), a stopwatch, a tripod to ensure stable a height of 1.2 to 1.5 meters above ground level simulating the height of a person's ear while standing, a GPS application to determine the coordinates of each sampling location, and a data recording sheet to document the noise levels observed at each site.

Noise Sampling Schedule

Noise measurements were conducted over two consecutive weeks: the first week in the South Area and the second week in the North Area. At each sampling point, record the noise level displayed on the device screen at 5-second intervals for 10 minutes, resulting in a total of 120 data points per measurement.

Noise data collection occurred during seven distinct time intervals within a day, corresponding to community activity patterns [12], to analyze temporal variation:

- L1: 06.00-09.00, measurement at 07.00
- L2: 09.00-12.00, measurement at 10.00
- L3: 12.00-15.00, measurement at 13.00
- L4: 15.00-18.00, measurement at 17.00
- L5: 18.00-19.00, measurement at 18.00
- L6: 19.00-20.00, measurement at 19.00
- L7: 20.00-06.00, measurement at 21.00

2.3 Data Analysis

The data analysis is calculated manually using a formula based on the provisions of SNI 8427:2017 concerning Environmental Noise Level Measurement using Equation 2.1, Equation 2.2, Equation 2.3, and Equation 2.4.

- LTM5 Leq (Equivalent Continuous Sound Level) calculation
  Based on the 120 recorded data points at each sampling point and time interval, Leq is calculated using the formula:
  $$Leq = 10 log \frac{1}{n} \sum_{i=1}^{n} 10^{0.1 \times Li}\ dBA \quad (2.1)$$

- Leq (daytime) is calculated as follows:
  $$Ls = 10 log \frac{1}{n} (T_1 10^{0.1 \times L1} + T_2 10^{0.1 \times L2} + T_3 10^{0.1 \times L3} + T_4 10^{0.1 \times L4}) \quad (2.2)$$

- Leq (nighttime) is calculated as follows:
  $$Lm = 10 log \frac{1}{n} (T_5 10^{0.1 \times L5} + T_6 10^{0.1 \times L6} + T_7 10^{0.1 \times L7}) \quad (2.3)$$

To find out whether the noise has exceeded the noise level, it is necessary to look for the Lsm value from field measurements. Combines Ls and Lm that take into account a higher sensitivity to noise at night by adding a 5 dBA correction to the Lm, as standard [12]. Lsm is calculated by the formula:

- $$Lsm = 10 \log \frac{1}{24} (12 \times 10^{0.1 \times Ls} 12 \times 10^{0.1 \times (Lm+5)}) \quad (2.4)$$

Where:

- LTM5 : Leq with sampling time every 5 seconds.
- Ls : Daytime Noise Level L1-L4 in dBA.
- Lm : Nighttime Noise Level L5-L7 in dBA.
- Lsm : Average continuous noise levels during the day and night *(24 hours)* in dBA.
- T : Duration of the representation time for each measurement in hours.

- L : Leq value *(in dBA)* obtained at each measurement time.
- Li : Instantaneous noise level.

3. Results and Discussion

Noise Measurement

Noise measurements were conducted across 14 sampling points using a Sound Level Meter (SLM), focusing on noise sources from train operations, including train departures and arrivals at Poris Station [13][14]. The collected data were compared against the noise quality standards for residential areas as stipulated in the Decree of the Minister of Environment No. 48 of 1996, which sets a maximum permissible noise level of 55 dBA.

First Week Measurements in the South Area

The following table presents the results of the first week of noise level measurements in the south area of Poris Station.

Table 1. Noise Measurement Results in the Southern Area

Sampling Point	Day/Date	Distance (m)	Time Code						
			L1 (07:00)	L2 (10:00)	L3 (13:00)	L4 (17:00)	L5 (18:00)	L6 (19:00)	L7 (21:00)
1A	Thu, 15/5/25	0	81.64	70.65	69.70	69.63	71.69	70.55	66.43
2A	Fri, 16/5/25	19	63.56	65.96	63.50	64.42	78.24	64.19	69.90
3A	Sat, 17/5/25	65	64.99	60.55	53.38	62.82	65.16	61.09	55.94
4A	Sun, 18/5/25	131	54.88	60.42	59.87	62.84	69.92	61.68	51.13
5A	Mon, 19/5/25	133	70.22	67.11	69.08	69.12	73.64	68.00	69.09
6A	Tue, 20/5/25	92	54.93	50.56	54.87	50.23	49.60	53.51	44.66
7A	Wed, 21/5/25	34	68.49	66.95	62.41	73.51	71.31	74.02	72.52

Table 1 summarizes the noise levels recorded in the southern area. The highest level of 81.64 dBA was recorded at point 1A, which is located directly inside the station at 0 meters, at 07:00 on Thursday, most probably due to intense morning commuter activity. Point 2A, located 19 meters from the station, experiences a peak of 78.24 dBA at 18:00 on Friday, matching with evening rush hour. In contrast, the lowest noise level of 44.66 dBA was recorded at Point 6A, located 92 meters from the station at 21:00 on Tuesday, quieter nighttime conditions away from the station. The data shows that noise levels generally decrease with increasing distance from the station and vary significantly throughout the day.

Second Week Measurements in the North Area

Table 2 shows the noise levels recorded in the north area. The highest level was 74.99 dBA at Point 1B, located directly inside the station at 0 meters, at 07:00 on Thursday, which corresponds to the morning rush hour. Another high level was 74.43 dBA at Point 3B, located 75 meters away from the station at 18:00 on Saturday, possibly due to traffic and weekend activities. Additionally, Point 3B is situated near to major road, which possibly contributes to the increased noise level, indicating that the noise source does not only come from the station or train activities. The lowest reading was 38.14 dBA at Point 4B, located 112 meters from the station at 21:00 on Sunday, which shows a quiet residential environment far from the station.

Table 2. Noise Measurement Results in the North Area

Sampling Point	Day/Date	Distance (m)	Time Code						
			L1 (07:00)	L2 (10:00)	L3 (13:00)	L4 (17:00)	L5 (18:00)	L6 (19:00)	L7 (21:00)
1B	Thu, 22/5/25	0	74.99	74.45	70.48	71.46	72.44	73.37	64.18
2B	Fri, 23/5/25	10	67.21	68.07	62.78	66.09	66.13	66.99	66.95
3B	Sat, 24/5/25	75	71.05	63.98	66.86	74.18	74.43	66.48	65.05
4B	Sun, 25/5/25	112	53.14	51.93	51.99	51.97	47.65	48.46	38.14
5B	Mon, 26/5/25	42	66.90	67.02	58.83	64.23	52.12	54.78	46.32
6B	Tue, 27/5/25	80	66.79	65.67	60.76	62.24	49.08	54.93	39.43
7B	Wed, 28/5/25	34	66.55	66.44	62.21	63.25	65.58	66.50	62.86

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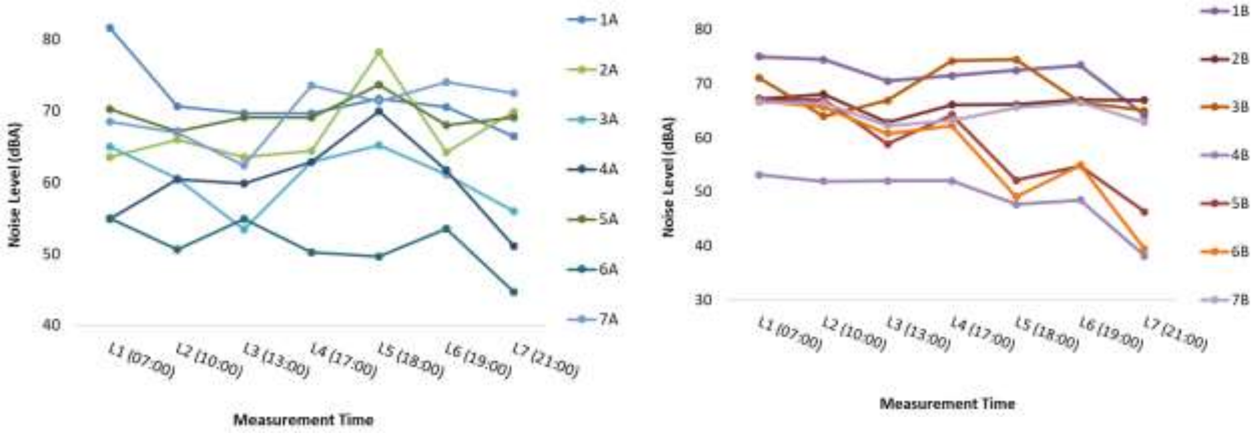
Daily Noise Level Variation (Leq) Across All Sampling Points

To understand the variation in noise levels (Leq), measurements were taken at seven different times of day across 14 sampling points in the South Area (Zone A) and North Area (Zone B). This graph illustrates the fluctuation in noise intensity throughout the day at various locations.



(a) (b)

Figure 3. Full-Day of Noise Levels Variation (Leq) at (a) South and (b) North Sampling Point over 24 Hours

Figure 3 shows the combined noise levels (Leq) at all 14 sampling points from 07:00 (L1) to 21:00 (L7). Points 1A and 1B, both located directly adjacent to the station at 0 meters, consistently recorded noise levels above 70 dBA during peak hours, with the highest level was 81 dBA at Point 1A at 07:00, corresponding to the morning rush hour.

Other points near the station, such as 2A and 3B, also experienced higher noise levels during busy hours (L1, L4, L5), reflecting the combined influence of both train activity and nearby traffic. In contrast, points situated farther from the station, such as 4A, 4B, 6A, and 6B, generally recorded lower Leq values, often below 60 dBA and dropped below 50 dBA during nighttime (L7), indicating quieter residential conditions with minimal transportation and human activity.

Temporal Noise Level

Noise level data were divided into average daytime (Ls) and nighttime (Lm) values. Ls includes readings from 06:00-18:00 (L1-L4), and Lm includes readings from 18:00-06:00 (L5-L7).

Daytime and Nighttime in the First Week (South Area)

Table 3 shows that most points in the south had both daytime and nighttime levels above the 55 dBA limit as established by the Decree of the Minister of Environment No. 48 of 1996. The highest daytime noise level (Ls) was found at Point 1A, reaching 76.43 dBA, located directly at Poris Station. This reflects heavy daytime activity and traffic near the station. For nighttime levels, the highest Lm was recorded at Point 7A, reaching 72.58 dBA, which is located near a busy motorcycle route and surrounded by active community areas. These elevated values indicate that some parts of the southern area are exposed to continuous noise disturbances, both day and night.

Table 3. Daytime and Nighttime Noise Level Data in the South Area

Sampling Point	Day/Date	Daytime Ls (dBA)	Nighttime Lm (dBA)
1A	Thu, 15/5/25	76,43	67,66
2A	Fri, 16/5/25	64,48	71,43
3A	Sat, 17/5/25	62,06	58,50
4A	Sun, 18/5/25	60,32	60,20
5A	Mon, 19/5/25	69,02	69,64
6A	Tue, 20/5/25	53,21	47,05
7A	Wed, 21/5/25	69,56	72,58

In contrast, Point 6A was the only location where both Ls at 53.21 dBA and Lm at 47.05 dBA remained below the regulatory limit, indicating a quieter environment. Despite being within a residential zone, its relative distance from major traffic and transit hubs may contribute to lower noise exposure.

Daytime and Nighttime in the Second Week (North Area)

Table 4 shows that most points in the north had both daytime and nighttime levels above the 55 dbA limit as established by the Decree of the Minister of Environment No. 48 of 1996. The highest values were recorded at Point 1B, with Ls reaching 72.63 dBA and Lm reaching 67.36 dBA. These elevated readings reflect the point's location directly at Poris Station, where continuous transportation and passenger movement contribute to high noise exposure throughout the day and night. Another location with elevated noise levels was Point 3B, which recorded a Ls of 70.63 dBA. Its proximity to traffic and other active areas near the station likely explains the higher values.

Table 4. Daytime and Nighttime Noise Level Data in the North Area

Sampling Point	Day/Date	Daytime Ls (dBA)	Nighttime Lm (dBA)
1B	Thu, 22/5/25	72,63	67,36
2B	Fri, 23/5/25	66,44	66,90
3B	Sat, 24/5/25	70,63	67,28
4B	Sun, 25/5/25	52,58	42,08
5B	Mon, 26/5/25	65,23	48,71
6B	Tue, 27/5/25	64,52	45,42
7B	Wed, 28/5/25	65,01	63,58

In contrast, point 4B recorded the lowest noise levels among all points, with Ls at 52.58 dBA and Lm at 42.08 dBA, both of which are below the 55 dBA limit set by the Decree of the Minister of Environment No. 48 of 1996 for residential areas. The relatively quiet conditions at Point 4B may be attributed to its greater distance from the station [17] at 112 meters and its location within a less congested residential environment.

3.3 Compliance with Noise Quality Standards

A comprehensive evaluation of noise levels surrounding Poris Station was conducted to assess compliance with the applicable noise quality standards. The results are presented in **Table 5**, highlighting variations in noise exposure across different measurement points and periods.

Table 5. Noise Level Measurements and Evaluation in Residential Areas Around Poris Station – South and North Area

Sampling Point	Day/Date	Latitude	Longitude	Distance (m)	Ls (dBA)	Lm (dBA)	Lsm (dBA)	NAB (dBA)	Status
1A	Thu, 15/05/25	-6.1698	106°40'49.92"E	0	76.43	67.66	75.02	55	Not Comply
2A	Fri, 16/05/25	-6.1699	106°40'51.65"E	19	64.48	71.43	73.68	55	Not Comply
3A	Sat, 17/05/25	-6.1703	106°40'49.82"E	65	62.06	58.50	62.84	55	Not Comply
4A	Sun, 18/05/25	-6.1709	106°40'49.18"E	131	60.32	60.20	63.41	55	Not Comply
5A	Mon, 19/05/25	-6.1710	106°40'47.47"E	133	69.02	69.64	72.68	55	Not Comply
6A	Tue, 20/05/25	-6.1706	106°40'48.28"E	92	53.21	47.05	52.66	55	Comply
7A	Wed, 21/05/25	-6.1702	106°40'48.30"E	34	69.56	72.58	75.20	55	Not Comply
1B	Thu, 22/05/25	-6.1698	106°40'49.92"E	0	72.63	67.36	72.50	55	Not Comply
2B	Fri, 23/05/25	-6.1697	106°40'48.13"E	10	66.44	66.90	69.67	55	Not Comply
3B	Sat, 24/05/25	-6.1690	106°40'49.11"E	75	70.63	67.28	71.53	55	Not Comply
4B	Sun, 25/05/25	-6.1687	106°40'50.46"E	112	52.58	42.08	50.41	55	Comply
5B	Mon, 26/05/25	-6.1692	106°40'52.00"E	42	65.23	48.71	62.51	55	Not Comply
6B	Tue, 27/05/25	-6.1688	106°40'52.63"E	80	64.52	45.42	61.67	55	Not Comply
7B	Wed, 28/05/25	-6.1691	106°40'55.78"E	34	65.01	63.58	67.15	55	Not Comply

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Table 5 provides a summary of the overall noise level compliance across both residential areas around Poris Station, using the weighted daily noise level (Lsm) as the key indicator. This evaluation is based on the 55 dBA noise quality standard defined in the Decree of the Minister of Environment No. 48 of 1996, which applies to residential areas.

Out of fourteen sampling locations, twelve points (approximately 85.7%) exceeded the 55 dBA threshold, indicating that most areas around Poris Station are subjected to continuous and significant noise exposure throughout the day and night. The highest Lsm value was recorded at Point 7A at 75.20 dBA, followed closely by Point 1A, which reached 75.02 dBA, both located in the southern area near Poris Station. These high values reflect the intense and persistent transportation activity, particularly motorcycle traffic, that characterizes this side of the station. In contrast, only two points, Point 6A at 52.66 dBA in the southern area and Point 4B at 50.41 dBA in the northern area, complied with the 55 dBA standard, indicating relatively quiet conditions likely due to their greater distance from major noise sources and lower traffic intensity.

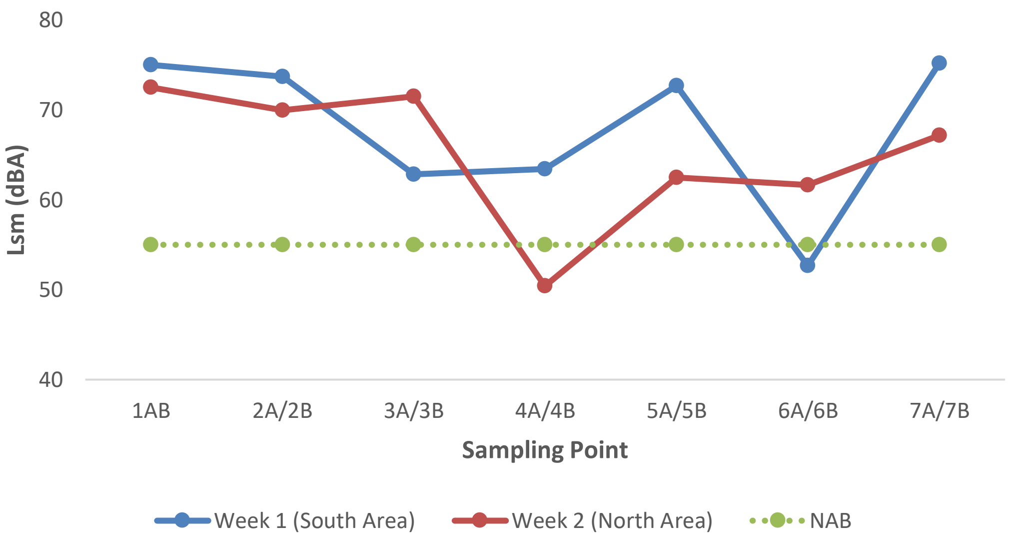

Figure 6. Comparison Between Measured Noise Levels and Environmental Standards

Figure 6 presents a comparative overview of Lsm values between the southern (Week 1, labeled A) and northern (Week 2, labeled B) areas. The dashed line represents the 55 dBA compliance threshold, enabling a clear visual assessment. It can be observed that Lsm levels in the southern area tend to be higher than those in the northern area across most corresponding points. An exception is Point 3B, which registered a slightly higher Lsm than Point 3A. These differences can be attributed to distinct environmental and traffic patterns [16]. The southern area functions as a main access route to Poris Station and is characterized by dense motorcycle traffic and public activity, contributing to higher noise levels. On the other hand, the northern area, while also residential, is affected primarily by commuter train operations, especially during departure times. Departing trains, which accelerate rapidly, generate higher noise levels compared to arriving trains, which decelerate as they approach the station.

Overall, the data in **Table 5** and **Figure 6** highlight that most measurement points exceeded the standard, underscoring the presence of chronic noise pollution in both residential areas. Only Points 6A and 4B consistently met the noise quality standard, making them the quietest and most compliant zones within the study area.

3.4 Spatial Distribution of Noise Levels Based on Temporal Variations

The following section presents the spatial distribution of noise levels in the study area during the daytime, nighttime, and the combined full-day period [17].

Daytime Noise Map (Ls)

This spatial visualization of daytime noise level (LS) illustrates the distribution of noise based on field measurement data.

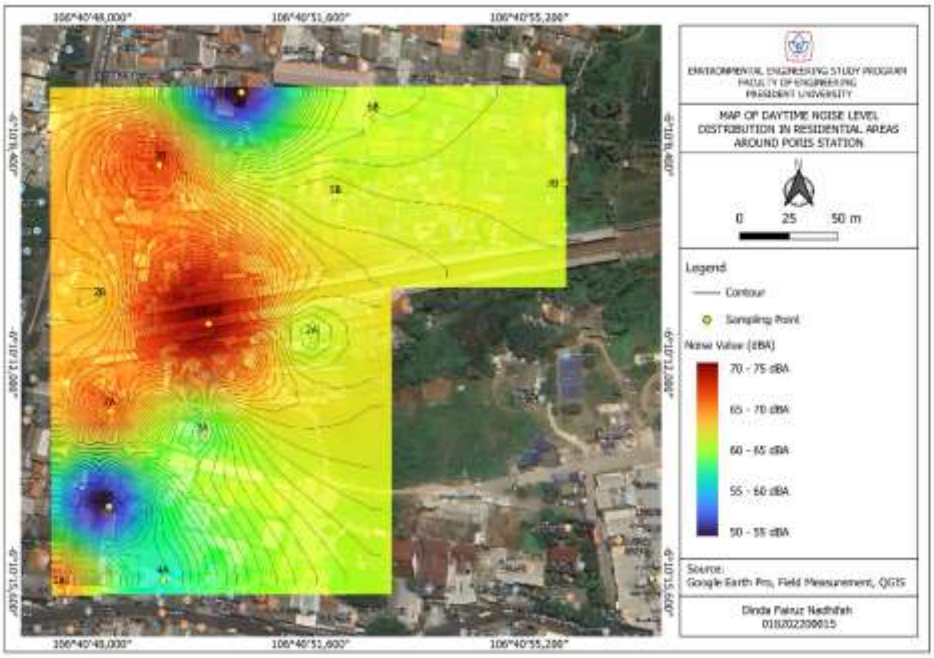

Figure 7. Noise Mapping of Daytime (Ls)

Based on **Figure 7**, high noise levels are concentrated in residential areas around Poris Station. The northern area tends to be more exposed to daytime noise compared to the southern area, although some zones remain below the residential noise quality standard threshold (55 dBA). This spatial pattern indicates that noise intensity decreases with increasing distance from the source, reflecting the effect of sound attenuation.

Nighttime Noise Map (Lm)

This nighttime noise level (Lm) distribution map was prepared based on the interpolation of field measurement data.

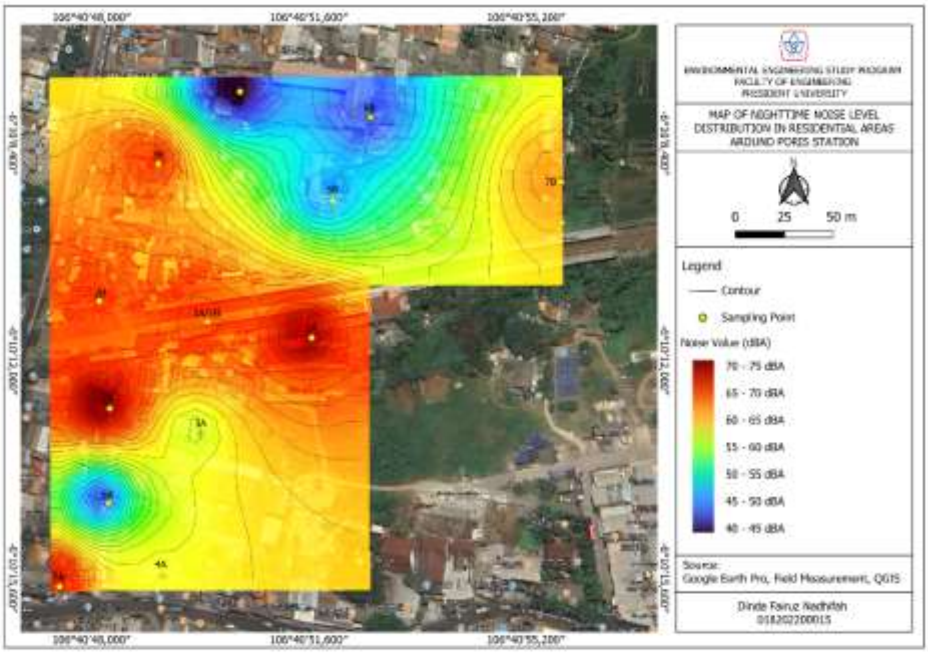

Figure 8. Noise Mapping of Nighttime (Lm)

Figure 8 shows that nighttime noise distribution is more widespread than during the daytime, as indicated by the dominance of red-orange areas, especially in the residential area around Poris Station. The southern area is more affected by nighttime noise compared to the northern area. This suggests an increase in railway, vehicular, and community activities during this period, directly impacting the surrounding residential environment.

Weighted Daily Noise Map (Lsm)

The following map shows the weighted daily noise level (Lsm) combining daytime and nighttime noise data around Poris Station.

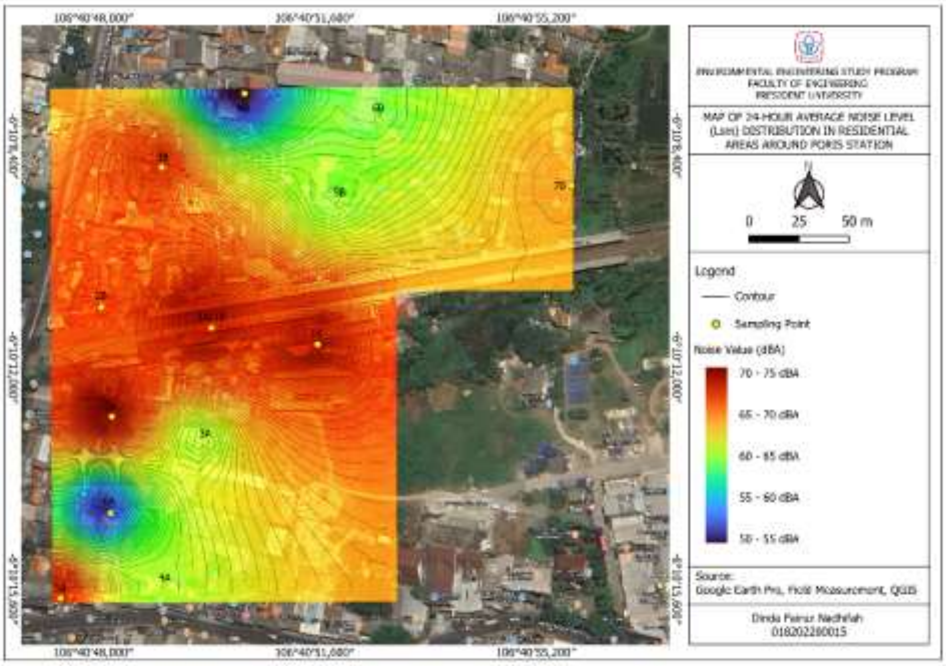

Figure 9. Noise Mapping of Full-Day (Lsm)

Based on **Figure 9**, the weighted daily noise level (Lsm) shows that residential areas around Poris Station, both in the southern and northern areas, are exposed to environmental noise. However, the southern area experiences higher noise exposure, with levels exceeding 70 dBA. On the other hand, the highest recorded levels in the northern area remain below 70 dBA. This pattern indicates that the southern area tends to experience more significant noise accumulation throughout the day.

4. Conclusion

The results of two weeks of noise level measurements in both the southern and northern residential areas surrounding Poris Station indicate that several locations exceed the noise quality standard set by the Decree of the Minister of Environment No. 48 of 1996, which is 55 dBA for residential zones. The highest noise levels were recorded in the southern area, particularly at sampling points 1A, 2A, and 7A, with values reaching 75.02 dBA, 73.68 dBA, and 75.20 dBA, respectively, at distances of 0 to 34 meters from the station. Spatial analysis shows that noise is concentrated around the station, decreasing with distance from the source, with the southern area more affected than the north, both during the day and at night. This suggests a natural attenuation effect as noise dissipates away from sources such as trains and vehicular activity near the station. Temporally, noise levels fluctuate throughout the day, peaking at 07:00 and again between 17:00 and 19:00 due to rush hour activity, and decreasing significantly after 21:00. These fluctuations are strongly influenced by community activity patterns, train schedules, and traffic flow, indicating that transportation-related activities are the primary contributors to environmental noise in the study area.

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