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Noise mitigation based on noise barrier for railway Makassar – Parepare line

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Abstract. This research aimed to analyze the noise reduction based on the noise barrier along the Makassar-Parepare railway. The measurement was conducted on Makassar-Parepare line, which consists of 4 types of areas. Six of the observation points are in residential areas, 1 point in commerce area, 1 point in the green open space area, and 1 point in the station area. Each region has 6 measurement points. So that the whole measurement points are 54 measurement points. The noise level measurement was conducted using simple SLM (sound level meter) placed at 3 meters from the side of the road with a height of 1.2 meters from the road surface and omitted the background noise by using windscreen from the SLM. Measurements were operated every 10 minutes for four-time intervals which are 06.00-09.00, 09.00-14.00, and at 14.00-17.00. The research result shows the settlement areas consisting of 36 measurement points, in which 69% has exceeded the quality standard, and 31% are still below the standard. For the green open space area which includes six measurement points, 17% has exceeded the quality standard, and 83% are still below the standard. For the commerce area and stations which consist of 6 measurement points, 100% of the areas are still below the standards. The noise barrier design could reduce the noise level 5.0 until 7.7 dB.

1. Introduction

Population growth in an area will have a linear correspondence to the increase in transportation, where transportation has a critical role to support city development. Transportation in the community is one of the essential factors that support the movement of human life because it cannot be denied that transportation becomes a very important need to be able to carry out all activities. One of the most popular types of transportation in Indonesia is the train because it is not jammed and can get to the destination faster.

According to Decree of the Minister of State for the Environment: KEP-48 / MENLH / 11/1996 [1], it stated that while in the train, passengers will feel the vibrations generated by the train engine. The vibration is a regular movement of objects or media with an alternating motion from a position of balance.

One of the ways to overcome traffic congestion is that the Makassar city government is planning to build the Makassar-Parepare railway, which is where the construction is part of a transportation network system that connects from Makassar to Parepare in South Sulawesi. Train activities that will operate will cause both noise and vibrations as negative impacts on the environment and the community around



the railway tracks because the noise generated from the train is quite noisy. The railway track passes through quite dense settlements that cause noise disturbance so that it can disturb the comfort of residents around the railroad tracks.

Based on the noise source, there are also various noise controls based on the source, which is usually a silencer made around the noise source. In the transmission, noise reduction is planned in the form of barriers, and noise control for the recipient is usually done by using PPE (personal protective equipment), for example, earplugs and earmuffs. So, to reduce noise levels, it is necessary to plan the noise controls using barriers in residential areas with the Nomograph method which is used to calculate how high the barriers needed to reduce noise as much as desired. So the results will be subtracted from the total scenario simulation. In this study, a noise management plan will be carried out using a barrier intended for settlement areas on the Makassar-Parepare railway as an action to reduce noise levels and can maintain health and psychology to create a residential environment that comfortable and calm.

The noise from the train also has a double form of steam, sound, and vibration due to the friction of the train wheels and railway tracks which are also made of hard material. The noise that comes from the train engine, horn, and friction between the wheels and brakes, often produce a squeaking sound. Noise from the train is felt by people who live or do some activities around the train station. Therefore, ideally, buildings along the railway line are designed with good acoustics to reduce noise and are designed with good attenuation to minimize vibrations from entering the building [2].

Based on these problems, the purpose of this study is to analyze the noise level in several areas along the Makassar-Parepare railway, make a mapping of noise distribution patterns along the Makassar-Parepare railway, and analyze the noise reduction based on noise barrier along the Makassar-Parepare railway.

2. Methodology

2.1. Data collection

The noise level measurement points on Makassar-Parepare line consist of 4 types of areas, i.e., 6 of the observation points in residential areas, 1 point in the commerce area, 1 point in the green open space area, and 1 point in the station area. Figure 1 shows the four measurement areas. Each region has 6 measurement points. So that the whole measurement point is 54 measurement points. Table 1 provides the distance between each observation point. The selected points considered suitable location condition criteria such as not blocked and the gap between instruments reflecting the sound.

The data collection process was conducted in March until May 2019. The noise level measurement used simple SLM (sound level meter) placed at 3 meters from the side of the road with height 1.2 meters from the road surface and omitted the background noise by using windscreen from the SLM [3]. The measurements were every 10 minutes for four-time intervals, i.e., in the morning between 06.00-09.00 WITA, afternoon measurements between 09.00-14.00 WITA, evening measurements at 14.00-17.00 WITA and night measurements at 17.00-22.00 WITA. Figure 2 shows the measurement method and equipment.

2.2. Methodology of data collection

2.2.1. *Noise level.* Value of L_{Aeq} and $L_{Aeq,day}$ (daily equivalent) obtained by calculation of equation (1) and equation (2) [4].

$$L_{Aeq} = L_{50} + 0.43 (L_1 + L_{50}) \quad (1)$$

Where:

L_{Aeq}	=	Noise level equivalent (dB),
L_{50}	=	Noise level 50% (dB), and
L_1	=	Noise level 99% (dB).

$$L_{Aeq,day} = 10 \log 10 \left[\left(\frac{1}{tn} \right) \cdot \left(10^{\frac{L_{eq1}}{10}} \right) + \dots + \left(10^{\frac{L_{eq}tn}{10}} \right) \right] \tag{2}$$

Where:

- $L_{Aeq,day}$ = Daily noise level equivalent (dB),
- $L_{eq}tn$ = Day-n noise level (dB), and
- tn = Daily number of measurements.

2.2.2. *Noise mapping using surfer 12.0.* To find out the pattern of noise spreads that occurs at the school area, noise mapping was created by using the Surfer 12.0 program. This program is needed to create the visual of noise spreads from traffic activities around the school after calculating the noise level at each point of observation, where the distribution is classified in color.



Figure 1. Observation points.

Table 1. Distance between each observation points.

Land use	Observation points	Distance (m)					
		1	2	3	4	5	6
Settlements	Jl. Baco Enni	46	30	25	33	25	41
	Jl.A.Beddu Dg.Mange	54	25	41	25	45	49
	Jl.Pahlawan	35	25	25	83	96	110
	Jl.Pramuka	52	25	39	25	73	55
	Jl.A. Usman	200	145	110	85	25	25
	Jl.H.Ambo Tang	25	28	25	60	42	29
Green open space	Jl. Ceppaga	46	25	45	25	47	34
Commerce	Pasar Ajakkang	51	25	61	25	42	47
Stations	Stasiun Pekkae Soppeng	25	25	61	30	33	44



Figure 2. Measurement method.

2.2.3. Noise reduction. Noise reduction planned in the form of a fence (barrier) to reduce noise levels by using the Nomograph method and Noisetools software on the railway project in Barru Regency. Nomograph method was used to calculate how high the barrier needed to reduce noise as much as desired. Nomograph provides an accurate prediction for reducing the sound pressure level. Sound transmission loss is also affected by the frequency. For low frequencies, TL is influenced by the thickness of the wall, whereas for greater frequencies, it is affected by the mass of the wall [5]:

$$TL = (20 \log W) + (20 \log f) - C \quad (3)$$

The noise barrier is the most effective method to reduce the noise caused by vehicle engines (such as on the highway, in railway tracks, and airports) and industrial noise sources without stopping the activity of using this method.

3. Results and discussion

3.1. Results of measurement of noise level analysis in the settlement area

3.1.1. Noise level analysis in the settlement area. The value of noise level resulted from the measurements for the settlement area can be seen in figure 3 until figure 8. Figure 3 shows that point 1 has exceeded the standard by 2 dBA, and point 6 exceeds the standard by 1 dBA, while the other points are still below the standards. Figure 4 shows that the noise level is maximum at 61 dB and minimum at 54 dB. Comparing to the noise quality standard, which is 55 dBA, there are 5 points have exceeded the standard and 1 point is still below the standards. The result in figure 5 shows the noise maximum at 70 dB and minimum at 68 dB. All the point measurements exceeded the standard 55 dB. The result in figure 6 shows the noise maximum at 70 dB and minimum at 68 dB. All the point measurements exceeded the standard 55 dB. The result in figure 7 shows the noise maximum at 52 dB and minimum at 54 dB. All the point measurements are below the standard 55 dB. Figure 8 shows that the noise level maximum at 83 dB and minimum level at 69 dB if compared with the noise quality standard, which is 55 dBA, whole the points exceed the standard.

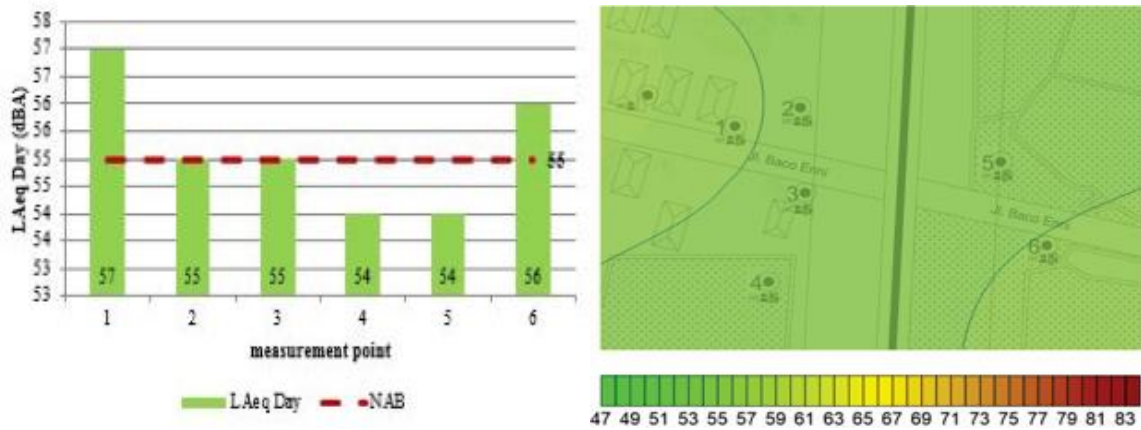


Figure 3. Noise level ($L_{Aeq,Day}$) in settlement area Jl. Baco Enni, Kab. Barru.

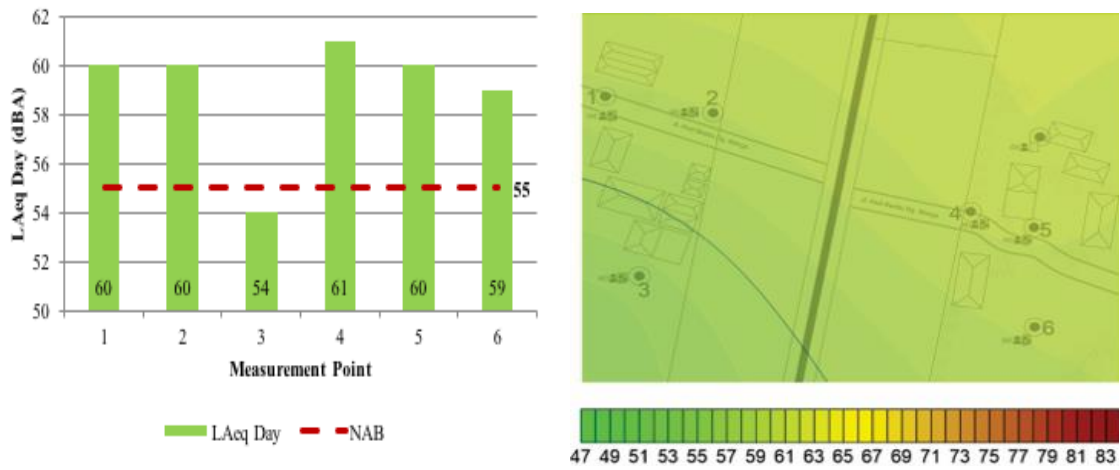


Figure 4. Noise level ($L_{Aeq,Day}$) in settlement area Jl. A. Beddu Dg. Mange, Barru Regency.

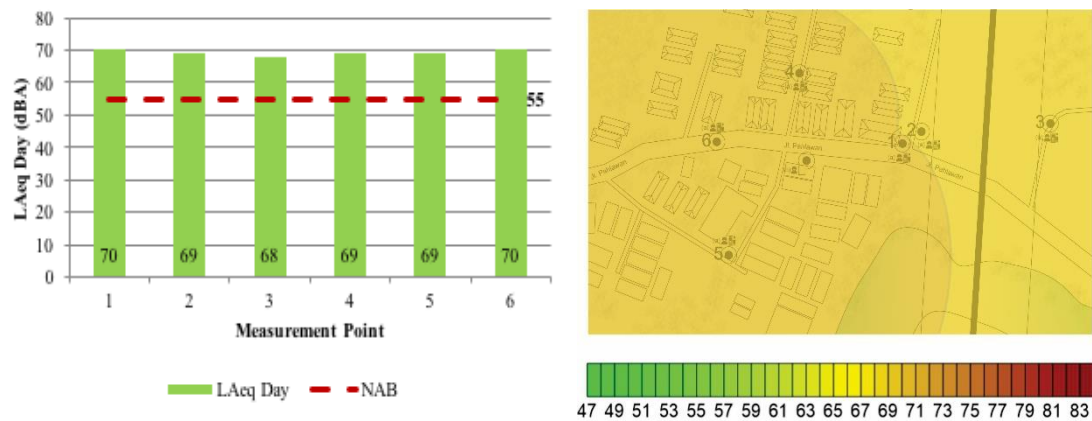


Figure 5. Noise level ($L_{Aeq,Day}$) in settlement area Jl. Pahlawan, Barru Regency.

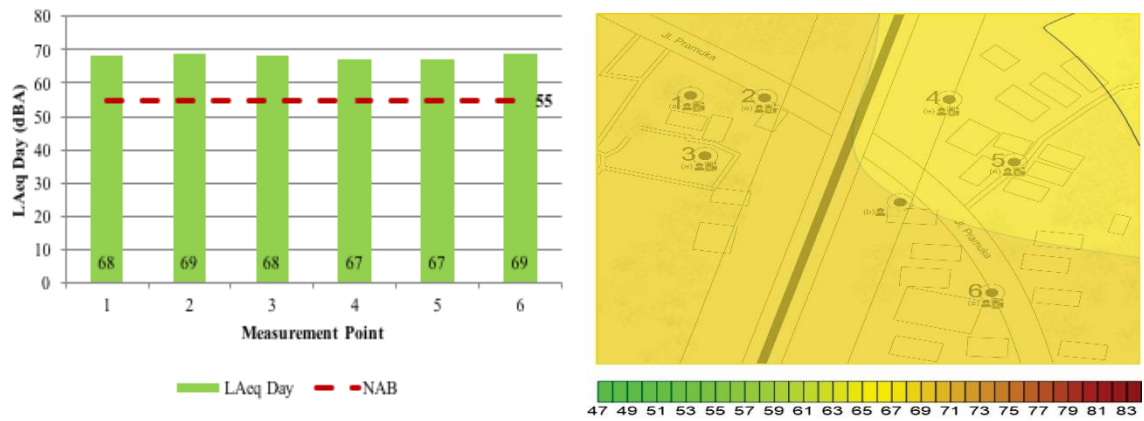


Figure 6. Noise level ($L_{Aeq,Day}$) in settlement area Jl. Pramuka, Barru Regency.

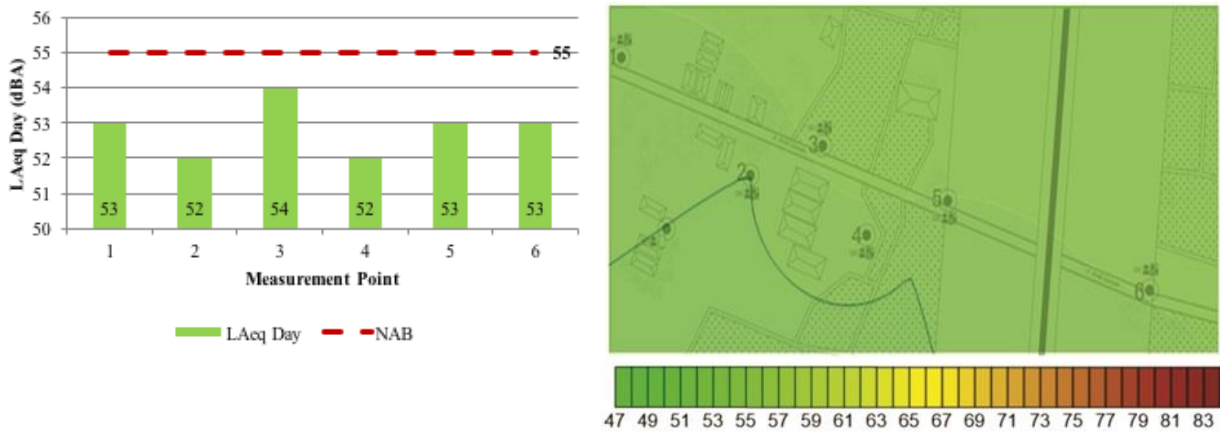


Figure 7. Noise level ($L_{Aeq,Day}$) in settlement area Jl. A. Usman, Barru Regency.

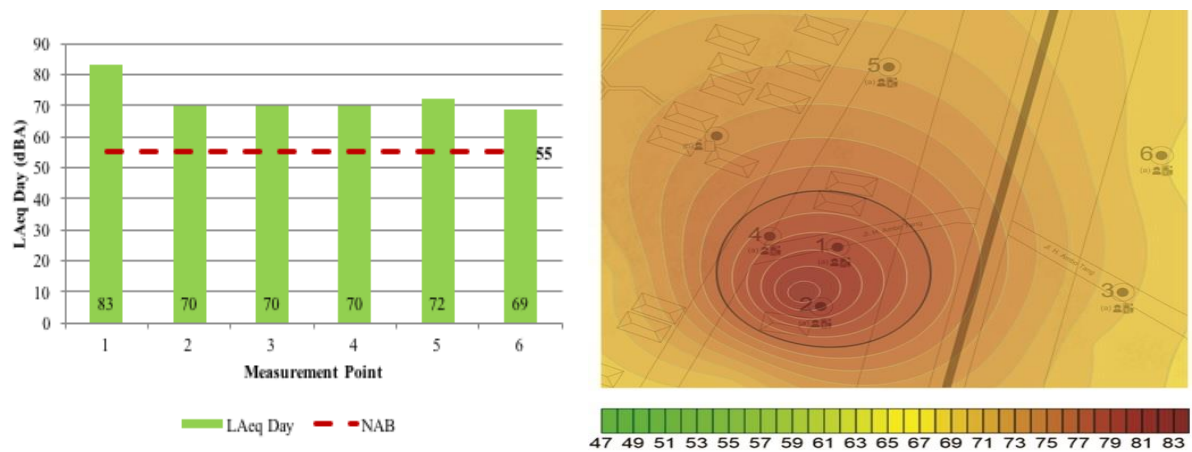


Figure 8. Noise level ($L_{Aeq,Day}$) in settlement area Jl. H. Ambo Tang, Barru Regency.

3.1.2. *Noise level analysis in the green open space area.* Compared to the noise quality standard according to pollution Decree of the Minister of State for the Environment: KEP-48 / MENLH / 11/1996, for the green space area of 50 dBA, point 1 has exceeded the standard with 4 dBA. Points 2, 3, 4, and 5 have exceeded the standard with 2 dBA. While point 6 is still below the standards.

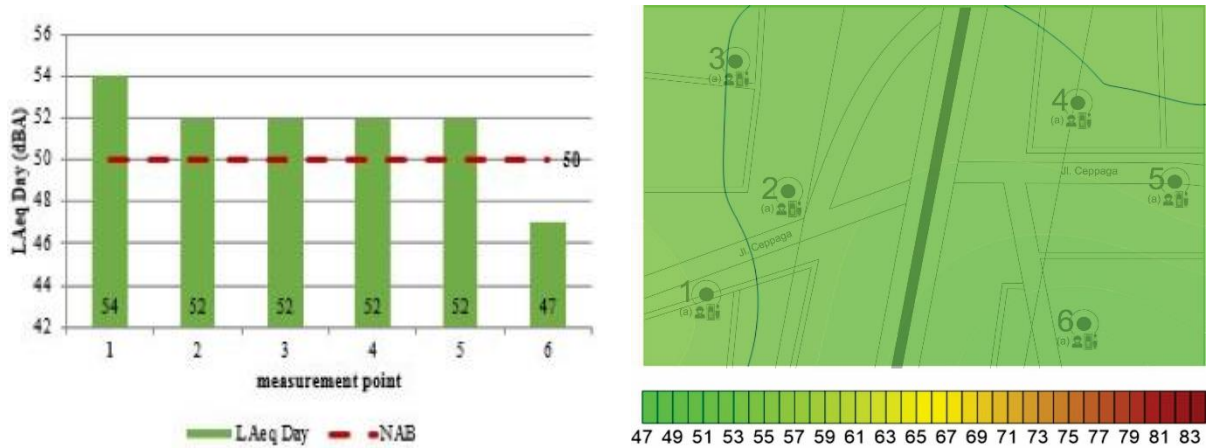


Figure 9. Noise level ($L_{Aeq,Day}$) in green open space Jl. Ceppaga, Barru Regency.

3.1.3. *Noise level analysis in the commerce area.* The noise level in commerce in figure 10 shows the maximum level is 62 dB if compared with the environmental quality standard of noise pollution Decree of the Minister of State for the Environment: KEP-48 / MENLH / 11/1996 for the commerce area of 70 dBA, all observation points were below the quality standard.

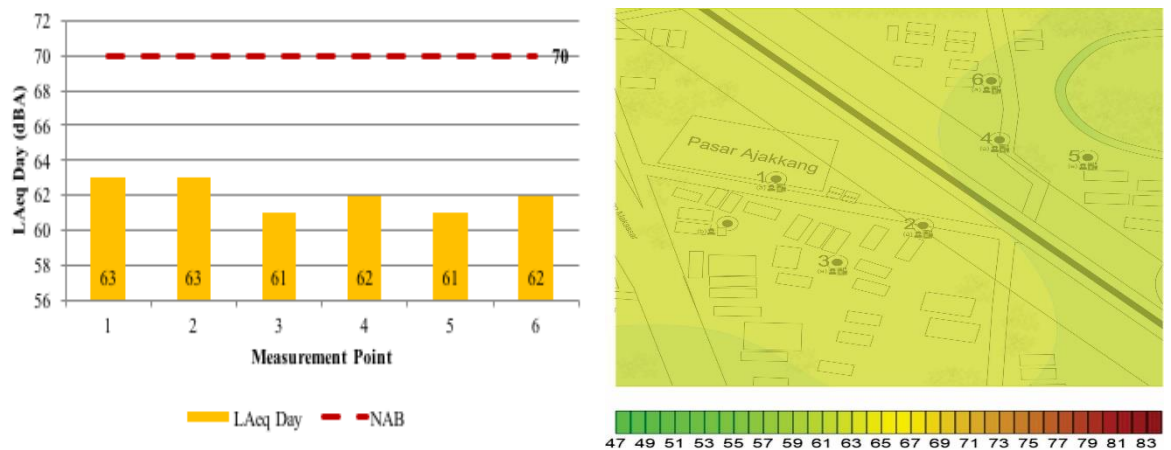


Figure 10. Noise level ($L_{Aeq,Day}$) in commerce area Pasar Ajakkang, Barru Regency.

3.1.4. *The noise level was analysis in the station area.* Compared with the noise standard according to the RI Health Minister No.718 of 1987 for Zone D for the station area, 60 dBA is recommended and 70 dBA is allowed. Then, all points had exceeded the recommended limit, i.e., points 1,3,5 exceeds 4 dBA and points 2, 4, 6 exceeds 5 dBA, so they have the potential to cause health problems

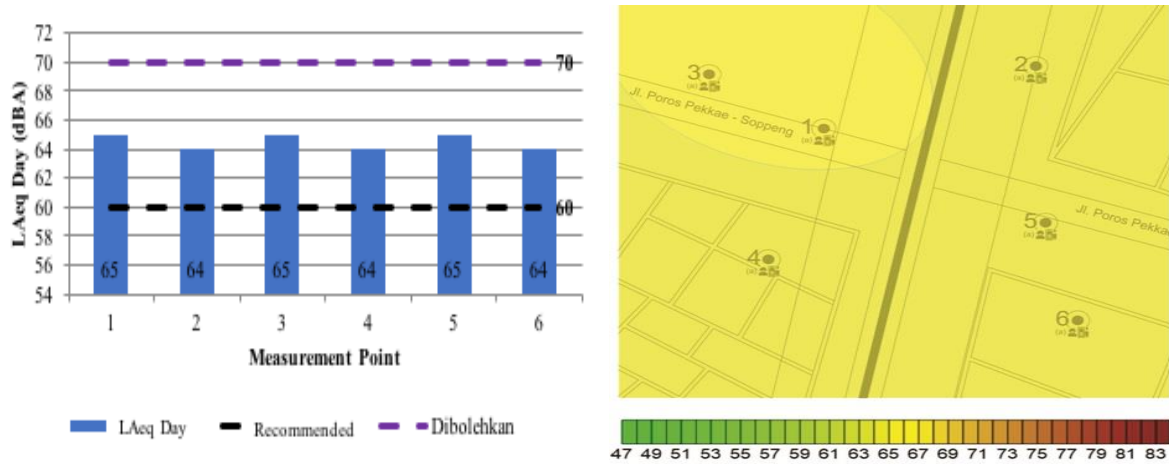


Figure 11. Noise level ($L_{Aeq,Day}$) in station area Jl. Poros Pekkae Soppeng, Barru Regency.

3.2. Noise reduction using the nomograph method

To reduce noise levels due to the construction of the Makassar-parepare railroad, the noise barrier method is used. The reduction by the nomograph method is applied by plotting on the graph. The location plan of the barrier design plan can be seen in figure 12, 13 and 14.

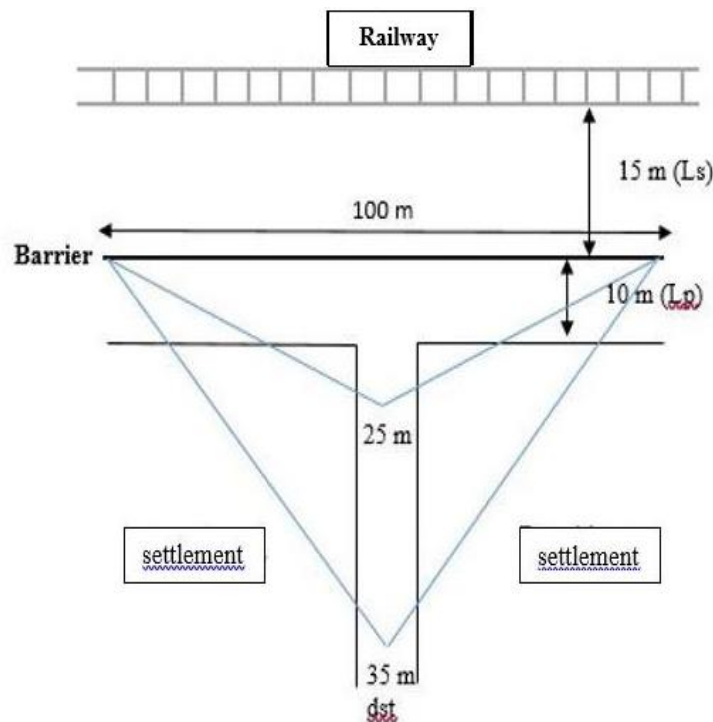


Figure 12. Noise barrier design plan.

The noise level before the barrier is 57 dBA, which if compared to the quality standard according to Decree of the Minister of State for the Environment: KEP-48/MENLH/11/1996 is 55 dBA and it means that it has exceeded the quality standard. The Nomograph graphic plotting results shows that with a distance between the noise source to the receiver of 25 m using a 15 m barrier break, barrier position of 25.3 m, and the angel substandard of 136.87, the result is the attenuation barrier of 7.2 dB which can be seen in table 2.

The result from noise barrier analysis indicates that noise barrier design could reduce noise level 5.0 until 7.7 dB. The noise level reduction, the difference between noise measured before and after the existence of the barrier, on the H. Ambo Tang road with a noise value before the barrier of 83 dB and after the barrier, the barrier attenuation is 5.0 dB. While the minimum difference can be seen in the Baco Enni road with a noise value before the barrier of 57 dB and after the barrier, the barrier attenuation is 7.2 dB in settlement areas. In the commercial area which is located in the Ajakkang road with a noise level before the barrier of 54 dB and after the barrier, the attenuation barrier value is 7.5 dB, and for the Pekkae station area, the noise level value before the barrier is 65 dB and after the existence of barrier is 7.0 dB.

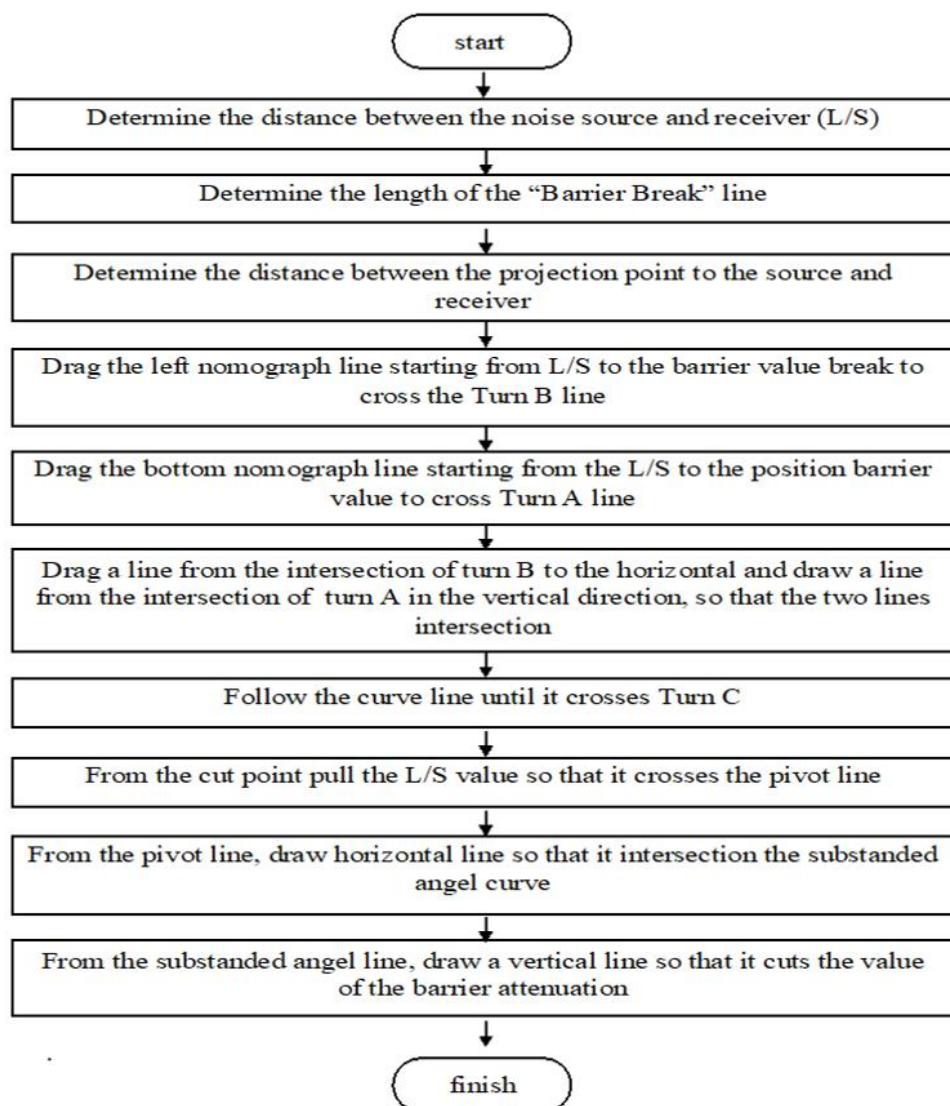


Figure 13. Nomograph method flowchart.

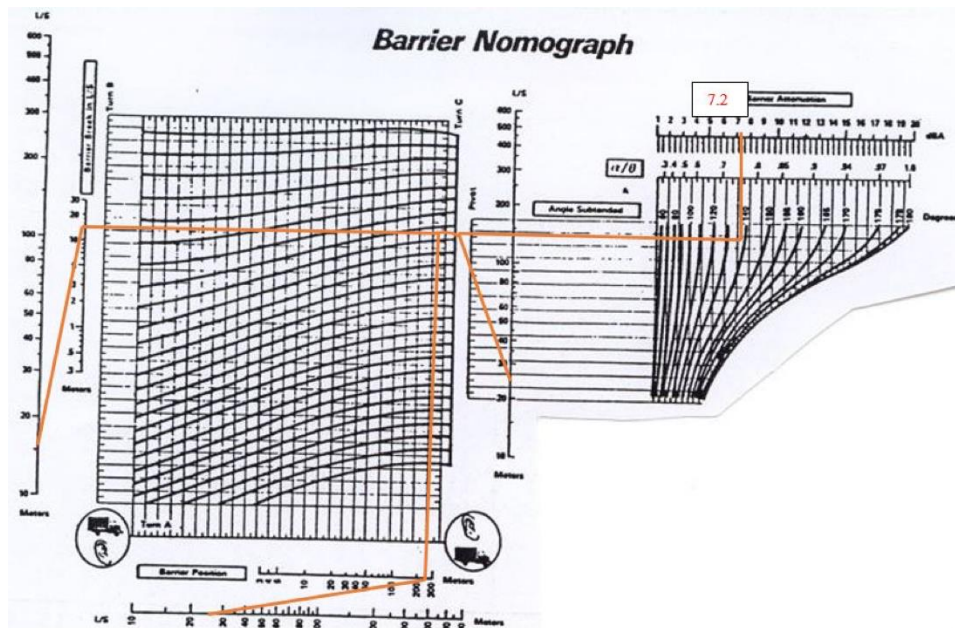


Figure 14. Nomograph graphic plotting.

Table 2. Barrier attenuation values for all location.

Observation points	Distance	$L_{Aeq\ day}$ Measurement (dB)	Angle subtended	Barrier Attenuation (dBA)	NAB
Baco Enni	46	57	136.87°	7.2	55
A.Beddu	54	60	142.78°	7.6	55
Pahlawan	35	70	125.22°	6.0	55
Pramuka	52	68	141.44°	7.7	55
A. Usman	25	53	108.14°	5.0	55
Jl. H. Ambo Tang	25	83	108.14°	5.0	55
Pasar Ajakkang	51	54	140.82°	7.5	70
Stasiun Pekkae	44	65	135.08°	7.0	60

4. Conclusion

Based on the analysis of noise measurement for 4 types of areas around the railway tracks in Barru Regency, the different noise level percentages were obtained. The percentage of noise levels for settlement areas, green open space, and commerce is compared with the environmental quality standard for noise pollution, while the percentage of noise levels for the station area is compared with the noise standard of the Republic of Indonesia Minister of Health No.718 of 1987. For settlement areas consisting of 36 measurement points, 69% have exceeded the quality standard and 31% are still below the standard. For green open space area consists of 6 measurement points, 17% has exceeded the quality standard and 83% are still below the standard. For the commerce area and stations which include 6 measurement points, 100% of the area is still below the standards.

From the results of the noise measurement by using a different type of barrier reduction, different results are obtained. The result from noise barrier analysis indicates that noise barrier design could reduce noise level 5.0 until 7.7 dB.

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