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AN ANALYSIS OF THE LEVEL OF SERVICE AND NOISE IN AHMAD. A. WAHAB STREET, LIMBOTO

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ABSTRACT

Ahmad A. Wahab street is the most dominant and busiest road in the center of Limboto, Gorontalo Regency. One of the factors causing a high level of vehicle density on this road is its location near a center for tourism, offices, and education, namely the University of Gorontalo and SMA Negeri 1 Limboto. The objective of this study was to analyze traffic performance and noise levels in Ahmad A. Wahab street, Limboto. Therefore, the object of this study is Ahmad A. Wahab street which is divided into four segments. In this study, the researchers examined primary data (i.e., traffic volume and noise intensity) and secondary data (i.e., road geometry). The tool used was a sound level meter to get the noise value. The type of method used in this study was descriptive. Results indicated that the highest traffic volume was found at 16.00-17.00 o'clock with a total flow of 1236.05 LVU/hour taken on Wednesday, December 1, 2021. Furthermore, the highest noise level (*Leq*) on each day of observation was 69.98 dB(A) in segment 1 on Monday, November 29, 2021, 68.44 dB(A) in segment 3 on Wednesday, December 1, 2021, and 69.98 dB(A) in segment 3 on Saturday, December 4, 2021.

Keywords: traffic, noise level,

1. INTRODUCTION

Noise is unwanted sound or sound at an inappropriate time and place. Sources of noise are traffic and industry, in which traffic becomes one of the main sources. If the traffic components are different, it will produce different levels of noise emission (Machdar, 2018). A study conducted by Heriyatna (2017) reveals that the value of noise caused by the flow of motorized vehicles is 72.10 dB at a distance of 0 meters, 66.10 dB at a distance of 17.5, and 63.56 dB at a distance of 35 meters. The further away the capture point is, the less noise it will make. A study by Balirante, Lefrandt, & Kumaat (2020) shows that the larger the volume of the vehicle is, the lower the speed of the vehicle will be, resulting in a high level of noise.

The noise of Limboto, Gorontalo Regency has experienced a lot of development. Along with its progress, Limboto has had a major influence as a center for education, trade, and tourism activities in Gorontalo Regency. One of the benchmarks for the development of a city area can be seen in the progress and development of shopping center facilities for its people. The construction of these shopping centers has an impact on the surrounding roads in the form of a decrease in the level of service (LOS), which at a certain point will cause congestion. This is due to the addition of movement as a result of increased commercial activity on the road section. The objective of this study was to analyze the levels of service and noise in Ahmad A. Wahab street, Limboto Gorontalo Regency.

2. METHODOLOGY

The research location in this study was Ahmad A. Wahab street, Limboto, Gorontalo Regency. The analyzed spots were from the Majesty Tower of Limboto (Indonesian: *Menara Keagungan Limboto*) to the Resort Police of Gorontalo (Indonesian: *Kepolisian Resor* (POLRES) *Gorontalo*). The survey was conducted by dividing the road into 4 segments: segment 1 in the



area of Majesty Tower of Limboto, segment 2 in the area of SMP Negeri 1 Limboto, segment 3 in front of the University of Gorontalo, and segment 4 in the area of the Resort Police of Gorontalo. The map of the research location is shown in Figure 1.

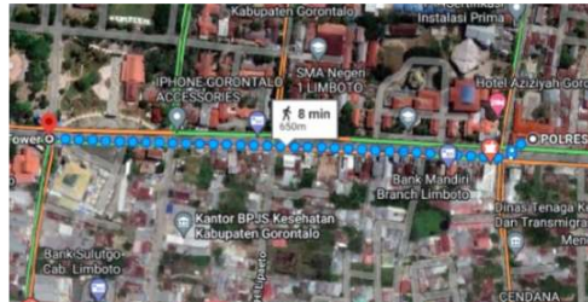


Figure 1. Research Location

The tools used in this study were (1) research form, (2) sound level meter, (3) stopwatch, and (4) camera. Concerning data collection methods, the researchers conducted preliminary surveys to determine the types of passing vehicles and to find out road geometry data to get an overview of traffic at the research location and the right position for the placement of surveyors, in which 3 to 5 surveyors were needed at the reviewed points. The collection of data of equivalent noise levels (L_s) during the day started at 06.00-22.00. Furthermore, the data were at least taken 4 times within a certain period. The analysis method for determining noise intensity level used the equation stipulated in the Decree of Indonesia's Minister of the Environment No. 48/1996. Meanwhile, the calculation of the level of road saturation followed the Indonesian Road Capacity Guidelines (PKJI, 2014). The collected data in this study were analyzed using the descriptive method by describing tables and graphs of traffic volume and noise level to determine the highest traffic volume and noise level in the 4 examined segments.

One of the calculations of sound level is the equivalent continuous sound pressure level in which a certain value of sound that fluctuates for a certain time is equivalent to a steady state sound level at the same time interval. The average sound pressure level over time (L_{eq}) can be determined using Equations 1 and 2.

$$1 \quad L_{eq} (1 \text{ menit}) = 10 \log \frac{1}{60} [(10^{0,1 \times L1} + 10^{0,1 \times L2} + \dots + 10^{0,1 \times L12})5] dBA \quad (1)$$

$$2 \quad L_{eq} (10 \text{ menit}) = 10 \log \frac{1}{10} [(10^{0,1 \times L1} + 10^{0,1 \times L2} + \dots + 10^{0,1 \times Lx})1] dBA \quad (2)$$

Where:

L_{eq} : Equivalent continuous sound pressure level (dB(A))

$L1, \dots, L12$: Noise every 5 seconds for 60 seconds (dB(A))

$L1, \dots, L1x$: Noise every 1 minute for 10 minutes (dB(A))

Data collection related to noise during the day started at 06.00-22.00, which was carried out at least 4 times with a certain frequency range. The daytime noise level was denoted by the symbol L_s as formulated in Equation 3 below.

$$L_s = 10 \log \frac{1}{16} (T_a \cdot 10^{0,1 \times L(2)a} + \dots + T_d \cdot 10^{0,1 \times Ld}) \text{ dBA} \quad (3)$$

Where:

L_s : Leq in daytime (dB(A))

T : the measurement time range in the daytime (hours)

To calculate the flow of motorized vehicles, this study used Equation 4.

$$Q = \{(ekr_{KR} \times KR) + (ekr_{KB} \times KB) + (ekr_{SM} \times SM)\} \quad (4)$$

Where:

Q : number of vehicle flows (LVU)

KR : light vehicle

KB : heavy vehicle

To find the saturation value, this study employed Equation 9.

$$D_j = \frac{Q}{C}$$

3. RESULT AND DISCUSSION

3.1 Result

3.1.1. Traffic Flow

The survey was conducted on three days: Monday, Wednesday, and Saturday. In addition, it was carried out in 4 segments with an observation time of 16 hours per day from 06.00 to 22.00. Vehicle traffic volume data were recorded using the 2014 PKJI method as presented in Equation 2.4. The recapitulation of the total vehicle flows on Monday in segment 1 is shown in Table 1.

Table 1. The Recapitulation of Total Vehicle Flows on Monday in Segment 1

Interval Waktu	Jumlah Kendaraan			Total Arus (dirjam)
	KR	KB	SM	
06.00-07.00	273	3	697	555,7
07.00-08.00	482	1	1438	844,1
08.00-09.00	480	1	1316	810,3
09.00-10.00	452	2	1059	719,35
10.00-11.00	441	0	1037	855,8
11.00-12.00	503	5	914	875,1
12.00-13.00	463	7	932	844,9
13.00-14.00	501	0	971	889,4
14.00-15.00	547	3	1108	827,9
15.00-16.00	532	1	1171	826,05
16.00-17.00	678	4	1475	1051,95
17.00-18.00	766	3	1606	1171,4
18.00-19.00	600	1	1314	929,8
19.00-20.00	514	0	1314	842,5
20.00-21.00	584	0	1210	886,5
21.00-22.00	319	0	645	577

Ket: KR = Kendaraan Ringan, KB = Kendaraan Berat, SM = Sepeda Motor

Table 1 shows that the number of vehicles was 26,398 and the highest total flow that passes Ahmad A. Wahab street in segment 1 occurred at the time interval of 17.00-18.00, namely 1171.4 LVU/hour. The recapitulation of total daily vehicle flow indicating the volume of vehicle traffic obtained from the results of the observation conducted on Monday (November 29, 2021)

is presented in Table 2 and Figure 2.

Table 2. The Recapitulation of Monday's Total Vehicle Flow in Segments 1-4

Interval Waktu	segment			
	1	2	3	4
06.00-07.00	556	580,3	577,4	553
07.00-08.00	844	947,1	634,2	752,95
08.00-09.00	810	1074,4	691,6	732,6
09.00-10.00	719	875	836,25	873,25
10.00-11.00	856	842,8	789,6	737,1
11.00-12.00	875	908,2	899,2	792
12.00-13.00	845	857,9	878,7	734
13.00-14.00	889	771	813	808,5
14.00-15.00	828	826,1	819,85	981,3
15.00-16.00	826	876,05	884,55	900,3
16.00-17.00	1.052	975,5	1032,2	1054,2
17.00-18.00	1.171	1109,9	1148,9	1167,15
18.00-19.00	930	923,55	984,55	959,8
19.00-20.00	843	740,5	870,75	762,75
20.00-21.00	887	889,05	797,55	765,8
21.00-22.00	577	577,2	606,2	542,8

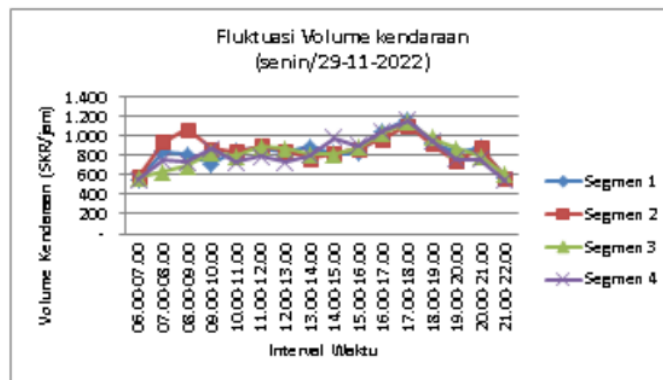


Figure 2. The Graph of Total Vehicle Flow Fluctuation on Monday

Based on the data shown in Figure 2, the section in Jl. Ahmad A. Wahab which experienced the highest traffic density during the observation process occurred on Wednesday, December 1, 2021, namely in segment 2. Specifically, the peak traffic density occurred at 16.00-17.00, which reached 1236.05 LVU/hour.

3.1.2 Analysis of Speed

The survey and measurement of speed were carried out on Jalan Ahmad A. Wahab in the area of the Majesty Tower of Limboto. The road was divided into 4 segments, namely segment 1 with a length of 0.35 km, segment 2 with a length of 0.13 km, segment 3 with a length of 0.35 km, and segment 4 with a length of 0.35 km. The results of the analysis of vehicle speed are shown in Figure 3.

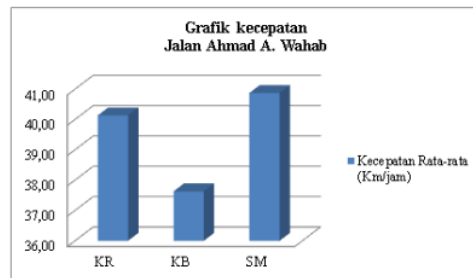


Figure 3. Data of Average Vehicle Speed (km/hour)

In Figure 3, it can be seen that the average vehicle speed for light vehicles is 40.13 km/hour. For heavy vehicles, it is 37.63 km/hour. Meanwhile, for motorcycles, it is 40.87 km/hour. The results of vehicle speed calculations carried out during rush hours with the highest traffic volume showed 1,236.05 LVU/hour. Noise can fluctuate depending on the condition of the sound source. Traffic noise includes intermittent noise and its magnitude which can vary (Tambunan, 2005). A study conducted by Nafisah, Darsono, & Sulhadi (2020) indicates that the noise level is influenced by the speed of the vehicle. They concluded that the higher the vehicle speed is, the higher the noise will be generated.

3.1.3 Analysis of Road Section Capacity

To determine the value of the capacity of the road section, we used Equation 2.9, which calculation is presented in the following.

$$\begin{aligned}
 C &= C_o \times FCLJ \times FCPA \times FCHS \times FCUK \\
 &= 1650 \times 1 \times 1 \times 0.95 \times 1 \\
 &= 1567.5 \text{ LVU/hour}
 \end{aligned}$$

3.1.4 Analysis of the Degree of Saturation

To get the value of the degree of saturation (ds), we used Equation 2.11, in which its calculation is presented in the following.

$$\begin{aligned}
 D_j &= Q/C \\
 &= 1236.05/1567.5 \\
 &= 0.79
 \end{aligned}$$

From the calculation above, the obtained value of the degree of saturation is 0.79 on the roads under study. According to the standards set in the 2014 Indonesian Road Capacity Guidelines, the obtained value of the degree of saturation still meets the feasibility requirements.

3.1.5 Analysis of Level of Service

The Level of Service (LOS) is obtained by comparing the highest traffic volume (occurring on Wednesday, December 1, 2021, in segment 2 at 16.00-17.00 with a total of 1236.05 LVU/hour) and the available capacity (Q/C). Only after that, we may find the classification of the road or the level of road service on the segment.

$$\begin{aligned}
 Q &= 1236.05 \\
 C &= 1567.5 \\
 LOS &= 0.79
 \end{aligned}$$

Based on the obtained value of the Level of Service (i.e., 0.79) and the classification of the level of road service stipulated in the 2014 Indonesian Road Capacity Guidelines, the road segment that becomes the research object is in category D. Its traffic characteristics are that the flow is nearly stable, speed can still be controlled, and V/C is still tolerable.

3.2 Analysis of the Level of Noise

3.2.1 Data on the Level of Noise

To obtain data on the level of noise, the researchers conducted a noise survey using a sound level meter which is a tool used to measure unwanted sound or that can cause noise between 30 and 130 dB.

1. Results of Noise Level Calculation on Monday, November 29, 2021

The recapitulation of the calculation results of the level of noise is shown in Table 3 and Figure 4.

Table 3. The Results of the Calculation of the Level of Noise of Ahmad A. Wahab street on Monday, November 29, 2021

Waktu	Leq 10 Menit			
	Segmen			
	1	2	3	4
06.00-09.00	68,44	71,59	67,95	66,30
09.00-11.00	63,14	64,70	68,54	64,26
11.00-17.00	71,40	65,10	67,26	65,36
17.00-22.00	70,12	68,20	70,51	70,72

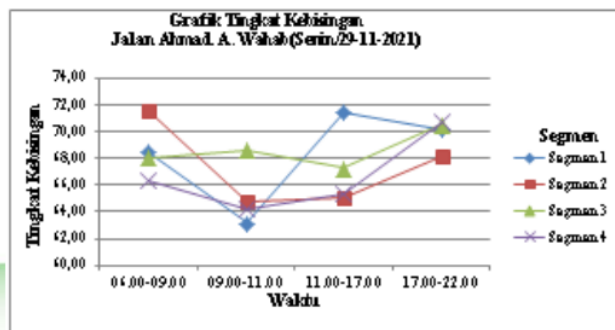


Figure 4. The Level of Noise (Monday, 29-11-2021)

The results of a survey of noise level measurements conducted on Monday at Ahmad A. Wahab street, Limboto, Gorontalo Regency showed that the highest obtained intensity was 71.40 dB(A) in segment 1 (i.e., between 11.00 and 17.00 o'clock, represented by 14.00 o'clock), 71.59 dB(A) in segment 2 (i.e., between 06.00 and 09.00 o'clock, represented by 07.00 o'clock), 70.51 dB(A) in segment 3 (i.e., between 17.00 and 22.00 o'clock, represented by 20.00 o'clock), and 70.72 dB(A) in segment 4 (i.e., between 17.00 and 22.00 o'clock, represented by 20.00 o'clock). These results exceed the quality standards set for office areas. A study on noise intensity has also been conducted by Juniardi (2014). He found that the noise due to transportation with a vehicle volume of 1,230 vehicles/hour is 69.8 dB(A) at a distance of 10.3 m, 67.8 dB(A) at a distance of 20 m, and 67.09 dB(A) at a distance of 25 m. This distance exceeds the limit recommended by

the US Department of Housing and Urban Development, namely 65 dB(A). A study conducted by Rusmayanti, Nurhasanah, & Zulfian (2021) shows that the noise level on weekdays (Monday) is higher than the noise level on holidays (Saturday-Sunday).

2. Results of Noise Level Calculation on Wednesday, December 1, 2021

The recapitulation of the calculation results of the level of noise is shown in Table 4 and Figure 5.

Table 4. The Results of the Calculation of the Level of Noise of Ahmad A. Wahab street on Wednesday, December 1, 2022

Waktu	Leq 10 Menit			
	Segmen			
	1	2	3	4
06.00-09.00	67,60	63,61	67,45	68,36
09.00-11.00	65,41	64,93	67,06	64,97
11.00-17.00	63,06	65,36	67,16	67,01
17.00-22.00	70,02	68,42	70,30	70,10

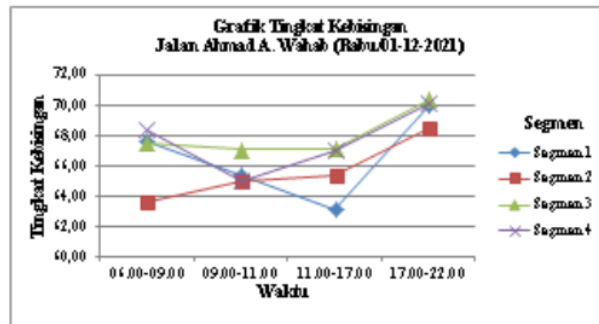


Figure 5. The Level of Noise (Wednesday, 01-11-2021)

3. Results of Noise Level Calculation on Saturday, December 4, 2021

The recapitulation of the calculation results of the level of noise is shown in Table 5 and Figure 6.

Table 5. The Results of the Calculation of the Level of Noise of Ahmad A. Wahab street on Saturday, December 4, 2022

Waktu	Leq 10 Menit			
	Segmen			
	1	2	3	4
06.00-09.00	62,85	67,17	67,73	67,37
09.00-11.00	64,89	70,82	69,03	66,13
11.00-17.00	64,40	64,69	66,51	65,79
17.00-22.00	70,20	67,45	69,15	66,59

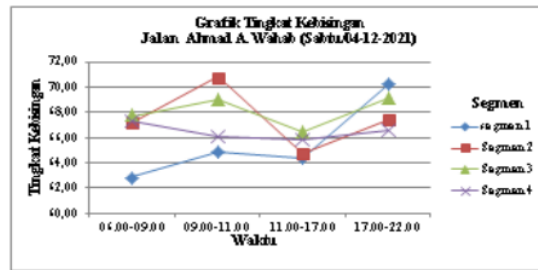


Figure 6. The Level of Noise (Saturday, 04-12-2021)

The results of a survey of noise level measurements conducted on Saturday at Ahmad A. Wahab street, Limboto, Gorontalo Regency showed that the highest obtained intensity was 70.20 dB(A) in segment 1 (i.e., between 17.00 and 22.00 o'clock, represented by 20.00 o'clock), 70.82 dB(A) in segment 2 (i.e., between 09.00 and 11.00 o'clock, represented by 10.00 o'clock), 69.15 dB(A) in segment 3 (i.e., between 17.00 and 22.00 o'clock, represented by 20.00 o'clock), and 67.37 dB(A) in segment 4 (i.e., between 06.00 and 09.00 o'clock, represented by 07.00 o'clock). These results tend to be similar to what was found in a study conducted by Abdi & Rahma (2018). They found that noise increases in the afternoon and the average noise level is above 70dB(A).

Distance contributes to the noise level of the vehicle. The closer the distance to the noise source is, the higher the noise level will be (Wedagama, Suthanaya, & Permana Wirya, 2022).

3.2.2 Data of the Level of Noise in the Daytime (Ls)

In this study, noise level measurements were carried out on 3 days, namely Monday, Wednesday, and Saturday. The result is 10-minute noise level data (Leq 10 minutes) for every hour. After that, the daytime noise level data (Ls) were processed further using Equation 2.3.

1. Daytime Noise Level (Ls) on Monday

The results of the analysis of data concerning daytime noise level at the area of Majesty Tower of Limboto on Ahmad A. Wahab street on Monday are presented in Table 6 and Figure 7.

Table 6. Daytime Noise Level (Ls) on Monday (29-11-2021) (Segment 1)

Leq	Waktu	Mewakili	dB(A)	keterangan
La	Pukul 07.00	06.00-09.00	68,44	Ta = 3 Jam
Lb	Pukul 10.00	09.00-11.00	63,14	Tb = 2 Jam
Lc	Pukul 14.00	11.00-17.00	71,40	Tc = 6 Jam
Ld	Pukul 20.00	17.00-22.00	70,12	Td = 5 Jam
LS	16 jam	Siang Hari	69,98	

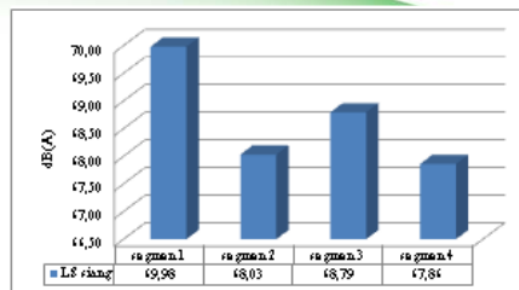


Figure 7. Daytime Noise Level (Ls) on Monday (29-11-2021)

Based on Table 6 and Figure 7 regarding the measurement of daytime noise (Ls) on Monday, the highest intensity occurred in Segment 1 with a noise value of 69.98 dB(A), while the lowest intensity occurred in Segment 4 with a noise value of 67.86 dB(A). A study conducted by Rahayu, Prihandono, & Handayani (2016) showed that the noise that occurs in front of SMP Negeri Bangil (i.e., 66.4 dBA) is greater than the noise in front of MTs (i.e., 53 dBA) so that the noise in front of the SMP needs to be handled to make it lower.

2. Daytime Noise Level (Ls) on Wednesday

The results of the analysis of data concerning daytime noise level at the area of Majesty Tower of Limboto on Ahmad A. Wahab street on Wednesday are presented in Table 7 and Figure 8.

Table 7. Daytime Noise Level (Ls) on Wednesday (01-12-2021) (Segment 1)

Leq	Waktu	Mewakili	dB(A)	Keterangan
<i>La</i>	Pukul 07.00	06.00-09.00	67,60	Ta = 3 Jam
<i>Lb</i>	Pukul 10.00	09.00-11.00	65,41	Tb = 2 Jam
<i>Lc</i>	Pukul 14.00	11.00-17.00	63,06	Tc = 6 Jam
<i>Ld</i>	Pukul 20.00	17.00-22.00	70,02	Td = 5 Jam
LS	16 jam	Siang Hari	67,33	

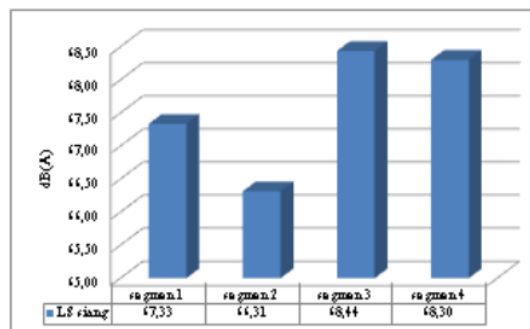


Figure 8. Daytime Noise Level (Ls) on Wednesday (01-12-2021)

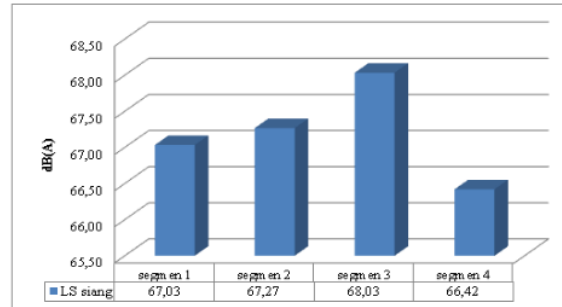
Based on Table 7 and Figure 8 regarding the measurement of daytime noise (Ls) on Wednesday, the highest intensity occurred in Segment 3 with a noise value of 68.44 dB(A), while the lowest intensity occurred in Segment 2 with a noise value of 66.31 dB(A). The Decree of Indonesia's Minister of the Environment No. 48/1996 regulates the noise limit for office areas, which must not exceed 65 dB. For this reason, the noise level of Jl. Ahmad A. Wahab is above the required quality standard. Therefore, it is necessary to regulate traffic to limit the noise level by arranging alternative roads or planting trees around the area. A study conducted by Atina & Safitri (2020) found the opposite, in which Leq in the Kayu Agung City Office Area is considered not noisy because it is below the set threshold of 65 dB. Likewise, a study conducted by Ahmad, Handayani, & Margiantono (2018) that measured noise at the campus of Semarang University found a range of 40-50 dB(A).

3. Daytime Noise Level (Ls) on Saturday

The results of the analysis of data concerning daytime noise level at the area of Majesty Tower of Limboto on Ahmad A. Wahab street on Saturday are presented in Table 8 and Figure 9.

Table 8. Daytime Noise Level (Ls) on Saturday (04-12-2021) (Segment 1)

Leq	Waktu	Mewakili	dB(A)	keterangan
La	Pukul 07.00	06.00-09.00	62,85	Ta = 3 Jam
Lb	Pukul 10.00	09.00-11.00	64,89	Tb = 2 Jam
Lc	Pukul 14.00	11.00-17.00	64,40	Tc = 6 Jam
Ld	Pukul 20.00	17.00-22.00	70,20	Td = 5 Jam
LS	16 jam	Siang Hari	67,03	

**Figure 9.** Daytime Noise Level (Ls) on Saturday (04-12-2021)

Based on Table 8 and Figure 9 regarding the measurement of daytime noise (Ls) on Saturday, the highest intensity occurred in Segment 3 with a noise value of 69.98 dB(A), while the lowest intensity occurred in Segment 4 with a noise value of 67.86 dB(A). According to the Decree of Indonesia's Minister of Environment No. 48/1996, the noise level for the office area must not exceed 65 dB. For this reason, the noise level of Jl. Ahmad A. Wahab is above the required quality standard. Therefore, it is necessary to regulate traffic to limit the noise level by arranging alternative roads. A study conducted by Putra & Lisha (2017) revealed that if the number of motorcycles and light vehicles increases, the noise level will also increase. However, it will be inversely proportional to heavy vehicles. There are several ways to deal with noise. One of them is by making a barrier in the form of a fence or wall that is higher than usual so that noise is suppressed and does not enter the building space. Another way is to add curtains to reduce noise. Another alternative is to plant trees around buildings to muffle the sound by absorbing sound waves carried out by leaves, branches, and twigs. The most effective plant species are those with thick crowns and shady leaves. Foliage can absorb up to 95% of noise (Huda, 2020).

4. CONCLUSION ²⁹

The conclusions of this study are as follows:

1. The results of this study conducted in three days showed that the highest traffic volume occurred on Wednesdays in segment 2 between 16.00-17.00, namely 1,236.05 LUV/hour, meaning that this time interval is the peak traffic volume found in this study. Furthermore, the obtained value for the Level of Service is 0.79. Referring to the road classification or road service level specified in the Indonesian Road Capacity Guidelines, Ahmad A. Wahab street, Limboto is in category D. The traffic characteristics for this category are that the flow is close to stable, and speed can still be controlled.
2. The results of the measurement of the daytime noise level (Ls) on Monday showed that the highest intensity occurred in segment 1, which was 69.98 dB(A). On Wednesday, the highest

noise intensity occurred in segment 3, which was 68.44 dB(A). Furthermore, on Saturday, the highest noise intensity also occurred in segment 3, which was 69.98 dB(A). Because of the consideration of the Decree of Indonesia's Minister of the Environment No. 48/1996, having social activity areas (e.g., schools and places of worship), and the maximum noise limit for the office environment (i.e., 65 dBA), the noise level in that area has exceeded the threshold.

5. ACKNOWLEDGMENT

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