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Analysis of noise level characteristics on Jalan Metro in Makassar city

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Abstract: One of the main collector routes in Makassar that connecting Makassar City and Gowa Regency, is Jalan Metro. The development of transportation in Makassar City caused higher level of noise which coming from transportation. Noise from vehicles is one of the environmental problems on this area. The disruption of public comfort and communication problems are both impacted by the noise from vehicles. The purpose of this study is to evaluate the noise characteristics and level on Jalan Metro.
Quantitative research was used in this study. There were 14 sampling points which were the data was collected for 12 hours from 07.00 - 18.00 WITA in every 10 minutes to represent hourly measurements. The data was analyzed by LAeq calculation analysis and Paired Sample T-Test by using SPSS program.
Noise level in this study were found to be fluctuated in all sampling points. This result might be attributed by vehicles volume, vehicle speed, and amount of horns. The results of the analysis show LAeq Day noise level value on Jalan Metro section has exceeded noise level quality standard required by KepMenLH No. 48 Tahun 1996. The maximum LAeq Day value is 78.23 dB at R2 and the minimum LAeq Day is 72.16 dB at R12. In addition, a comparison of the measurement results with Pedoman PU No. 13/2003 concerning the maximum and minimum limits of Leq10 and LAeq was also carried out.

1. Introduction

The development of transportation in cities in Indonesia causes higher of level noise which coming from transportation. The number of motorized vehicles in Indonesia is increasing rapidly with 133,617,012 units. The motorized vehicle population is divided by category, such as motorcycles, passenger cars, buses, and freight vehicles[1]. The amount of pollution that happens in Indonesia, such as noise, vibration, and air pollution, is rising along with the number of transport modes [2].

Urban noise pollution has been directly related to an increase in ground transportation due to city growth and everyday population demands in terms of increased traffic noise levels[3]. Noise was characterized as undesirable sound due to their impact to the environment and human health. Many previous studies have demonstrated its effect on irritability, stress, and subsequent cardiovascular diseases, sleep disturbances, and further impairments [4-5]. In 2014, the European Environment Agency (EEA) classified urban noise as one of the biggest environmental health hazards in all of Europe [6].

Sources of road traffic noise was vehicles, includes heavy vehicles, light vehicles, and motorcycles, with sources of noise including horn, mechanical friction between tires, the sound of the vehicle exhaust, the volume of the vehicle, and the speed of the vehicle [7]. In metropolitan regions, noise-free periods in urban areas are rare during the day and tend to diminish during night-time [8].

Heavy vehicles such as trucks, buses, etc., and passenger cars are the main sources of noise on the highway. In generally, the noise control strategy is divided into three elements, namely control of noise sources, control of noise paths, and control of noise receivers [9]. The purpose of this study is to analyze the characteristics of the noise level on Jalan Metro Makassar and to analyze the level of noise generated by vehicles on Jalan Metro Makassar.

2. Material and methods

2.1 Study Area

Jalan Metro is one of the roads in Makassar which is included in the type of primary collector road, where this road connects Makassar City with Barombong District, Gowa. The land uses that can be found on Jalan Metro Makassar, such as offices and trade, hospitals, trade and services, housing and settlements, green open spaces, as well as government and public facilities. From the land use mentioned above, the noise caused by motorized vehicles crossing Jalan Metro Makassar can have an impact on communication disturbances and disturbances in the comfort of the people living in that location.

Figure 1. Sampling Point

2.2 Data Collection

In this study, noise level, volume of vehicle, speed of vehicle, number of horns from vehicle, and sampling point characteristics (i.e road width, median width, shoulder width, and other things which related to the sampling point). Noise data was collected by using Sound Level Meter (*10176566 Sound Level Meter Datalogger*). Data was collected for 12 hours from 07.00 - 18.00 WITA in every 10 minutes to represent hourly measurements in 14 sampling points (Figure 1). USB cable, Laptop, Tripod were supporting tools that used for noise field measurement. Moreover, *camera or handphone, speed gun, Counter, Walking Distance Meter* was used to calculate the volume of vehicles, the speed of vehicles, the numbers of horns, and the road characteristics, respectively.

2.3 Data Analysis

- Frequency distribution/frequency table of noise level

The noise calculation can be analyzed by making a frequency distribution/frequency table and analyzing the noise level in indicator numbers. Frequency distribution or frequency table is grouping data into several classes and then counting the number of observations that fall into each class. The frequency distribution is created by calculating the number of class intervals, interval values, class marks/middle values, and frequency.

a. Range or range is the difference between the largest value and the smallest value.

$$\text{Range} = \text{Max data} - \text{min data} \quad [1]$$

Where: Max data = largest value data; Min data = smallest value data

b. Number of classes (k)

$$k = 1 + 3{,}3 \log (n) \quad [2]$$

Where: k = number of classes; and n = number of data

c. Interval is data obtained by measurement, where the distance between two scale points is known.

$$I = (\max - \min)k = rk \quad [3]$$

Where:
I = Interval; max = maximum data value; min = minimum value of data; r = range; k = number of class intervals

d. The class mark is the midpoint of the class interval.

$$\text{Middle} = (\text{BB-BA})2 \quad [4]$$

Where: BB = lower limit of a class interval; BA = upper limit of a class interval

- Noise Indicator Level

Indicator number system was also called the equivalent index (Leq)). The equivalent indicator number was change (fluctuating) where noise level was measured over a certain time and the amount of which is equivalent to a steady noise level measured at the same time interval.

$$LAeq = Leq_{50} + 0.43\ (Leq_1 - Leq_{50}) \quad [5]$$

where: Leq= Equivalent noise level; Leq50 = 50% noise indicator number; Leq1 = 1% noise indicator

- Normality Test

Normality test is a test in the regression model, the dependent variable, independent, or both have normal distribution or close to normal. Normality test to determine whether the studied residues are normally distributed or not. The method used to test for normality is to use the Kolmogorov-Smirnov test. If the significant value of the Kolmogorov-Smirnov test result is e" 0.05, then it is normally distributed and otherwise is not normally distributed [10].

- Paired Sample T-Test

Paired-Sample T-Test is an analysis involving two measurements on the same subject to a certain effect. If a treatment has no effect, then the average difference is zero [11]. The decision-making guidelines in the Paired Sample T-Test are based on significant values: (1) If the significant value (Sig.) < 0.05, then the conclusion is that there is a significant difference, which means the effect; and (2) If

the value is Significant (Sig.) > 0.05, then the conclusion is that there is no difference, which means that there is no influence [12].

2.4 Quality Assurance

Weather conditions are also one of the things that must be considered when measuring noise levels. If it rains, the measurement must be stopped and postponed until the rain stops or measurements are taken the following week on the same day and at the same time with the same area conditions. In addition, the sound of sirens or long horns, the noise measurement is temporarily stopped. In order to make the noise level data more accurate, the Sound Level Meter is set so that the device can record data every second so that in 10 minutes 600 data will be recorded. Noise level measurements were carried out for 10 minutes representing 1 hour starting from 07.00-18.00 WITA.

3. Result and Discussion

Average equivalent noise level value (LAeq) which represents the 10 minutes measurement was calculated. The stage of calculating the value of the average equivalent noise level (LAeq) begins by making a frequency distribution in the form of range, number of classes, class intervals, and the midpoint of the class interval.

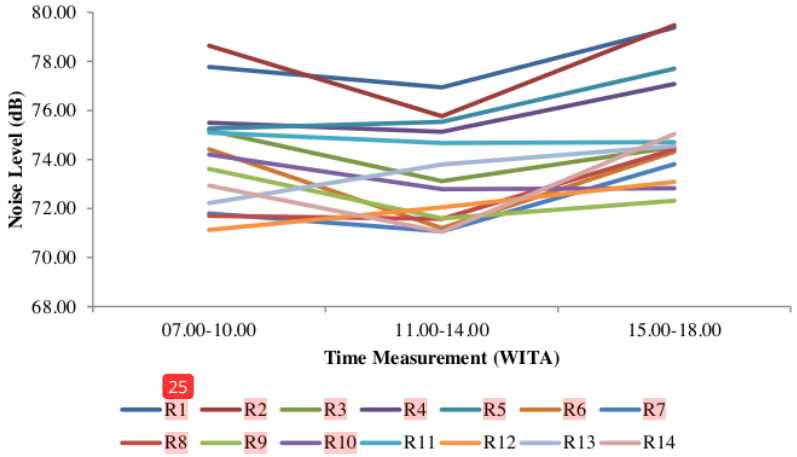

Figure 2. LAeq Value

It can be seen in Figure 2, in the morning the maximum LAeq value is 78.64 dB at the observation point R2 and the minimum LAeq value is 71.13 dB at the observation point R12. During the day, the maximum LAeq value is 76.94 dB at the observation point R1 and the minimum LAeq value is 71.05 at the observation point R14. For the evening, the maximum LAeq value is 79.48 dB at the observation point R2 and the minimum LAeq value is 72.31 dB at the observation point R9. These results could be affected by volume of vehicles, speed of vehicles, number of horns, and the characteristic of the road.

Based on Table 1, it can be seen that the SPSS output results from the significance test of the difference in two measurements were Noise Level Data Relationship between Morning - Afternoon. The significance is 0.025 > 0.05. The result showed that there's no significant difference between the morning and afternoon noise level data statistically. However, between Afternoon-Evening and

Morning-Evening there's a significant different. It can be shown at the mean difference which has minus results.

Tabel 1. Paired Sample Test Data Noise Level

Time Measurement		Paired Differences					
		Mean Difference	*Std. Deviation*	*Std. Error Mean*	t	df	*Sig. (2-tailed)*
Pair 1	Morning - Afternoon	1	1.38840	.37107	2.535	13	.025
Pair 2	Afternoon – Evening	-2	1.29245	.34542	-5.565	13	.000
Pair 3	Morning - Evening	-1	1.45520	.38892	-2.523	13	.025

One of the factors that affect the high level of noise, the similarities and differences in the d between the noise levels in the morning, afternoon, and evening on the Jalan Met Makassar was the volume of vehicles. The volume of vehicles was calculated at the same time as the measurement of traffic noise on the Metro Road Section Makassar use counter. The types of vehicles that are calculated are vehicles that cross the observation point, motorcycles (MC), light vehicles (LV), and heavy vehicles (HV). According to Figure 3, it can be seen that the highest number of vehicles was found in evening. Volume of vehicles in morning and afternoon was found to be more fluctuated in each sampling points.

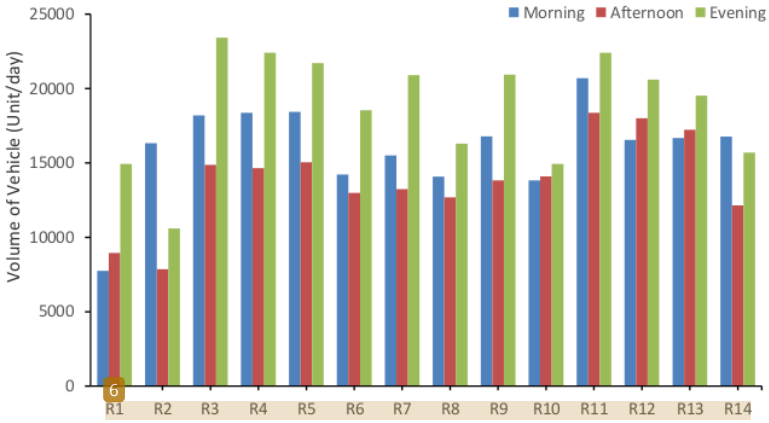

Figure 3. Volume of Vehicles

Based on Table 2, it was established that there was a significant difference between the morning and afternoon traffic volume data using the Paired Samples T-Test difference test, $t(13) = 3.057$; $p > 0.05$. The average for the morning data is higher than the average for the afternoon data (Mean = 13854; Std. Deviation = 3007.52975) (Mean = 16013; Std. Deviation = 3041,18183). This indicates that, in terms of numbers, morning traffic is heavier than daytime traffic.

For traffic volume data relationship between morning and evening was calculated by using the Paired Samples T-Test difference test (Table 2). The result was proven that there was a significant difference in the data volume of traffic during the day and evening, $t(13) = -7,620$; $p < 0.05$. Afternoon data (Mean = 18777; Std. Deviation = 3737.16073) had a larger average than daytime data (Mean =

13854; Std. Deviation = 3007.52975). This means that, numerically, the traffic volume in the evening was higher than during the day.

According to Table 2, the significance of 0.006 < 0.05 means that there was a significant difference between the morning and evening traffic volume data, which means that they were not statistically the same. By looking at the difference in the mean/average of the morning and evening data, it was -2764. The minus number indicates that the morning mean/average was smaller. To find out the magnitude of the difference can be seen from the mean / average.

Tabel 2. Paired Sample Test Data Volume of Vehicle

Time Measurement		*Paired Differences*					
		Mean Difference	***Std. Deviation***	***Std. Error Mean***	**t**	**df**	***Sig. (2-tailed)***
Pair 1	Morning - Afternoon	2160	2643.45243	706.49238	3.507	13	.009
Pair 2	Afternoon – Evening	-4923	2417.61770	646.13551	-7.620	13	.000
Pair 3	Morning - Evening	-2764	3178.56073	849.50609	-3.253	13	.006

Another factor that affect the noise level was the speed of vehicle. The highest average vehicle speed is at the observation point R14. This is because the observation point R14 is an observation point that can be said to be quite close to the Barombong bridge, where this bridge is an exit or entry access to Jalan Metro or to Barombong. In addition, the high average speed of vehicles at the observation point R14 is caused by the width of the road lane so that it provides a lot of space for vehicles to make it easier for drivers to increase their vehicle speed.

Based on the Figure 4, the speed of vehicles in morning was found to be higher in some sampling points. It might be attributed by the peak time of people to start their activity in the morning. However, the speed of vehicles was found to be more fluctuated in all sampling points. The characteristics of roads might affect the speed of vehicles.

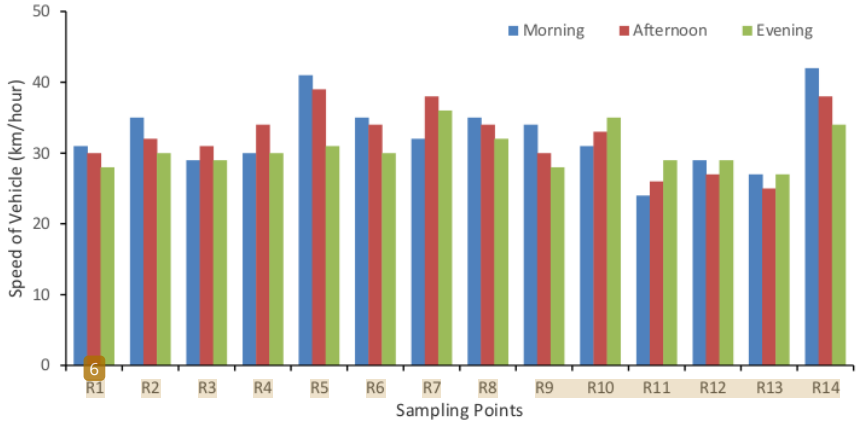

Figure 4. Speed of Vehicles

The morning and afternoon traffic volume statistics did not significantly differ from one another, according to the Paired Samples T-Test difference test. Based on Table 3, it can be concluded, the early traffic volume was greater than the daytime traffic in terms of numbers. Moreover, the relation between afternoon and evening of traffic volume from paired sample T-Test indicated that the volume of traffic was greater during the afternoon than in the evening, in terms of numbers. This result was found to be similar with traffic volume data relationship between morning and afternoon means that numerically the traffic volume in the morning was higher than in the afternoon.

Table 3. Paired Sample Test Data Speed of Vehicle

Time Measurement		Paired Differences					
		Mean Difference	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pair 1	Morning - Afternoon	0	3.024	.808	.354	13	.729
Pair 2	Afternoon – Evening	2	3.028	.809	2.030	13	.063
Pair 3	Morning - Evening	2	4.582	1.225	1.575	13	.139

The horn usually was used to communicate between drivers as a signal to other drivers to avoid possible dangers that will occur. In general, the horn was sounded when the driver is about to overtake another driver, asking for road space, or even when there is a long queue of vehicles, such as at the fork in Jalan G. Bromo-Jalan Metro and U-Turn around the observation point R5. Furthermore, data on the number of horn sounds in the morning, afternoon, and evening can be seen in Figure 5.

According to Figure 5, it can be seen that horn was frequently used in evening. In morning and afternoon time, the numbers of horn were found more fluctuated in each sampling points. This numbers of horn might affect the noise level in that sampling points [13].

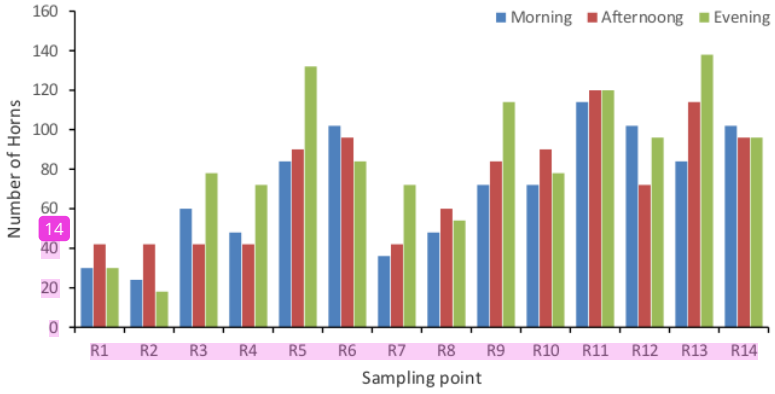

Figure 5. Numbers of Horn

Significant values were 0.000 < 0.05. This study came to the conclusion that the statistics on the quantity of horn sounds in the morning and during the day show a substantial difference, indicating that they are not statistically equivalent. By comparing the mean or average of the morning and afternoon's statistics, we see that the difference is 176. Similar with morning-afternoon statistic, the morning-

evening and afternoon-evening were found not statistically equivalent by compared the mean difference in each time measurement with the difference was found 85 and 176, respectively.

Table 4. Paired Sample Test Data Numbers of Horns

Time Measurement		Paired Differences					
		Mean Difference	*Std. Deviation*	*Std. Error Mean*	t	df	*Sig. (2-tailed)*
Pair 1	Morning - Afternoon	91	42.547	11.371	7.990	13	.000
Pair 2	Afternoon - Evening	85	47.294	12.640	6.713	13	.000
Pair 3	Morning - Evening	176	82.786	22.125	7.942	13	.000

For the LAeq Day value at each observation point on Jalan Metro was calculate by using data from the LAeq value at the time of observation at 07.00-18.00 WITA. Figure 6 shows that the maximum LAeq Day value was found at the observation point R2 with 78.23 dB and the minimum LAeq Day value was found at the R12 sampling point with 72.16 dB. The noise level at point R2 was found to be high even though it has a relatively small number of vehicles when compared to other sampling points. This might be attributed by the activities around sampling point area, not only from transportation. Based on its characteristics, R2 is located close to the floating mosque parking lot, one of the tourist attractions in the city of Makassar. Meanwhile, noise level in sampling point R4 and R5 was found to be increased from R3 with 75,99 dB and 76,31 dB, respectively. This result might be attributed by activities around observation point and characteristic of the road.

Based on the results of the noise level analysis, it shows that the daily equivalent noise level value (LAeq Day) on Jalan Metro Makassar for 14 observation points has exceeded the noise level quality standard required by KepMenLH No. 48 Tahun 1996 for green open space areas, government and public facilities, hospitals, offices and trade, trade and services, as well as housing and settlements, which is 50 to 70 dB. The maximum LAeq day value is at the R2 observation point of 78.23 dB and the minimum LAeq day value is at the R12 observation point of 72.16 dB. In addition, a comparison of the measurement results with the technical limits of road environmental capacity as stated in the PU guidelines No. 13 of 2003 regarding the maximum and minimum limits of Leq10 and LAeq values with the category of commercial local roads for observation points R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12 and local residential roads for observation points R13 and R14.

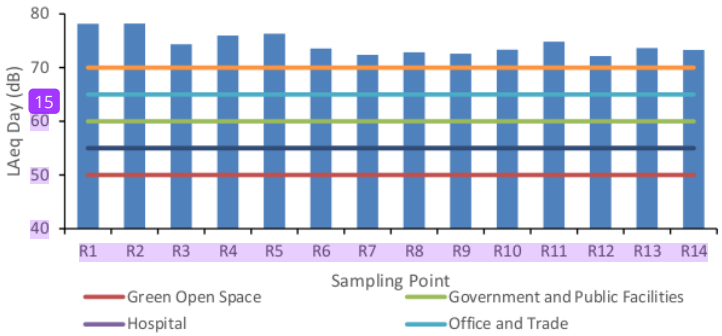

Figure 6. LAeq Day

4. Conclusion

The characteristics of the noise level at all sampling points on Jalan Metro Makassar were different, where each point has a different traffic volume, vehicle speed, number of horns. This is due to differences in road function and land use at each observation point. The characteristics of this noise level were tested using the SPSS program. The results of the Paired Samples T-Test showed the relationship between noise level data in the morning and afternoon, afternoon and evening, as well as in the morning and evening. For the time of measurement in the morning and afternoon, afternoon and evening, morning and evening, each has a significance value of 0.025 < 0.05; 0.000 < 0.05; 0.025 < 0.05, respectively. From this result, it can be concluded that there is a difference significant noise level measurement data at all times statistically the same observations. The LAeqday was describe about the noise level in each sampling points per day. This result was compared between the noise standard from government regulations. Based on the results of the noise level analysis, it shows that the daily equivalent noise level value (LAeq Day) on Jalan Metro Makassar for 14 observation points has exceeded the noise level quality standard required by the KepMenLH No. 48 Tahun 1996 for green open space areas, government and public facilities, hospitals, offices and trade, trade and services, as well as housing and settlements, which is 50 to 70 dB.

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