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THE DETERMINATION OF NOISE AREA CRITERIA BASED ON PREDICTION DISTANCE

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ABSTRACT

The purpose of this study is to analyze the volume and level of traffic noise in the educational area on Ahmad Yani Street, to predict the intensity of noise that reaches the school environment, and to obtain the criteria for noisy areas (KDB) in each of these educational areas. The research method uses descriptive and mathematical statistics approaches. The results showed that the average traffic volume on Ahmad Yani Street was 2408 veh/h. The highest noise level on the roadside occurred in the Senior High School 4 Kendari area, which is 75.4 dB, followed by Vocational High School 1 Kendari 75.0 dB, and the lowest was in the Vocational High School 2 Kendari area 74.4 dB. The intensity of traffic noise is affected by the volume of the vehicle and the composition of heavy vehicles. Although based on the distance from the roadside the three school areas are still at a safe noise distance. Based on the intensity of the noise that occurs, the Senior High School 4 Kendari area is included in the category of Moderate Noise Area (DMB). The farther the receiver is from the noise source, the smaller the noise intensity, with an average reduction of 1.3 dB.

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INTRODUCTION

The development of regions and cities in Indonesia is marked by the increasing number of commuters traveling between the main city and the surrounding suburbs (hinterland) and between regions within the city. This phenomenon is the result of an increase in population, population activities, types of services, and the interaction of a country's economic functions. As the capital of Southeast Sulawesi Province, Kendari City is one of the developing cities in Indonesia with the category of Big City. It will, of course, experience the phenomenon of noise as it does in developed countries and other big cities. This is in line with the growth of travel generation centers which trigger high mobility of traffic movements. The average noise level on arterial and collector roads in Kendari City has reached a level of 75.4 dB and 73.5 dB (Lakawa, 2015a). This is very rational because the growth rate of motorized vehicles in Kendari is quite high, an average of 19%. Ironically, the high vehicle growth is not balanced by the provision of road infrastructure, where the road growth rate is only 1.9% per year. The unbalanced proportion causes problems with the transportation system's convenience, such as traffic congestion. Moreover, the high growth of motorized vehicles also has implications for declining environmental quality. One of which is the result of the accumulation of sounds produced by vehicles, both engine sounds, horns, and friction between tires and the road surface.

Therefore, in an effort to control environmental noise, the Government establish the recommended quality standards for noise levels in each area in accordance with its designation in Indonesia through the Decree of the State Minister for the Environment of the Republic of Indonesia Number 48/MENLH/11/1996. One of the land uses that are vulnerable to noise exposure is the education area, where noise exposure can interfere with student learning activities. To maintain public health in urban areas, it is necessary to have a new policy to control traffic noise (Kim at al, 2012).

Based on the above description, the statement of the problem of this research is the high volume of motorized vehicles passing through Ahmad Yani Street from year to year, which has the potential to trigger an increase in noise on these roads, especially during peak hours. This can cause individual disturbances, including communication, hearing, and psychological disorders, particularly in the education area. Thus, it is necessary to conduct a study to determine the Criteria for a Noisy Area (KDB) in the three educational areas, namely Senior High School 4 Kendari, Vocational High School 1 Kendari, and Vocational High School 2 Kendari. This is crucial to do to provide information to the government regarding the status of noisy areas in the three education areas.

MATERIAL AND METHODS

Noise is undesirable sound from a business or activity at a specific level and time that can interfere with human health and environmental comfort (Kep-48/MENLH/11/1996). No matter how small the sound, if it is unwanted, it is referred to as noise. Noise caused by human activities and other objects that can be measured with measuring instruments is referred to as objective noise, whereas sounds that are incompatible with the human ear's sensation of hearing are referred to as subjective noise. One of the most influential sources of noise in urban areas is the result of motorized vehicle traffic activities. A variety of acoustic factor noise indicators are frequently used in various parts of the world to quantitatively evaluate disturbance. However, such evaluation is often challenging due to non-acoustic factors such as sensitivity to the socio-economic situation, age, and gender. The disturbance is partially brought on by acoustic factors and partially by non-acoustic moderating variables e.g., the personal and social aspects of a residential environment. The relationship between density, speed, and noise cannot be perceived only partially as there will be a relationship that does not meet the elements of common logic. For that reason, it is necessary to understand comprehensively that the trigger for noise fluctuation on the road is the accumulated interaction of various factors, not just vehicle speed (Lakawa, 2015a). The sound produced by motorized vehicles on the road is not always constant depending on the intensity of the passing vehicles. Traffic noise will increase along with the increasing number of passing vehicles. So it is necessary to have noise criteria that can be used as a standard for assessing environmental noise levels. Heavy vehicles with a composition of 4% play a vital role in influencing arterial road noise. While on the contrary, the collector road with a composition of 3% contributes little to the increase in noise, where the noise is primarily influenced by motorcycles and light vehicles (Lakawa, 2015b). A noisy area is an area lane with a certain distance (width) that is located on both sides and is parallel to the road lane, which is based on a certain noise level (Leq), length of exposure time (hours/day), and roadside land designation for settlements/housing.

Noise area is divided into 3 criteria, namely

Noise Safe Area (DAB)

- An area with a width of 21 to 30 meters from the edge of the pavement.
- The noise level is less than 65 dB (A) (Leq).
- Length of exposure (60 - 65 dB (A)) maximum 12 hours per day.
- Length of night exposure <3 (hr/day).

Noise Moderate Area (DMB)

- An area with a width of 11 to 20 meters from the edge of the pavement.
- Noise level between 65 to 75 dB (A) (Leq).
- Long exposure time (65 - 75 dB (A)) maximum 10 hours per day.
- Length of night exposure < 4 (hr/day).

Noise Risk Area (DRB)

- An area with a width of 0 to 10 meters from the edge of the pavement.
- Noise level is more than 75 dB (A) (Leq).
- Long exposure time (75 - 90 dB (A)) maximum 10 hours per day.
- Length of night exposure <4 (hr/day).

Several studies conducted in many countries show that roads are the main source of noise in cities. The greater the volume of motorcycle traffic, the higher the noise level. The volume of a motorcycle has an effect of 26.7% on the noise level. This is due to the large use of motorized vehicles compared to other types of vehicles, both two-wheeled, four-wheeled, and those with more than four wheels (Wedagama, 2012). Heavy vehicles (trucks, buses) and passenger cars are the main sources of noise on the road even though the composition of motorcycles is more dominant, reaching 60% (Mondal, 2013). Sooriyaarachchi (2008) made a prediction model and traffic noise simulation based on the distance and speed of various types of vehicles, which were divided into 8 groups, namely buses, cars, double cabin taxis, jeeps, trucks, motorcycles, three-wheeled vehicles, and vans. Golmohammadi (2009) built a traffic noise prediction model that can be used effectively according to the conditions of cities in Iran. The variables used include total vehicle volume, speed, percentage of trucks, road length and width, gradient, and observation distance. Agarwal (2011) obtained data on motorized vehicles in the city of Jaipur, India, consisting of two-wheeled, 72%, followed by cars/jeeps (15%), three-wheeled (12%), and buses/trucks (1%). Akhtar et al (2012) conducted a mapping of traffic noise in the Delhi region, India. The digital map generated by the optimization technique can describe the horizontal and vertical profile of the noise level with several variations in the measurement distance. Al-Mutairi (2009) predicted noise using a model (US FHWA-TNM) and a regression model, where the peak hour noise level is based on time, type of road, and the number of traffic lanes. Mishra (2010) carried out noise prediction and noise reduction strategies utilizing barrier walls. Tripathi (2012) modified the noise generation model in India with a comparative analysis between the RTM (Road traffic Noise) model and the Calixto model for residential and commercial areas with scenarios of reducing heavy vehicles & alternative routes.

In general, it is known that exposure to noise for 8 hours per day should not exceed the threshold value of 85 dB. Exposure to loud noise above 85 dB can cause temporary deafness. In urban settlements, a noise level that exceeds 55 dB causes significant disturbance. Sub urban areas with a population density of 3,237-12,949 people/km2 cause a significant disturbance if the noise level is above 50 dB, and rural areas with a population density of fewer than 3,237 people/km2 cause a significant disturbance if the noise level is above 45 dB. The threshold value is the maximum level of noise that is allowed to be discharged into the environment so that it does not cause disturbance to human health and environmental comfort (Kep-48/MENLH/11/1996).

For noise from motorized vehicles (road), the noise level (L_{eq}) is calculated by the equation:

$$Leq = L_{50} + 0{,}43\,(L_1 - L_{50}) \qquad (1)$$

where:

L_{eq} = equivalent noise level (dB)
L_{50} = noise indication rate 50% (dB)
L_1 = noise indication rate 1% (dB)

The prediction of the noise level at a certain distance from the moving traffic sound source uses the equation:

$$L_{eq2} = L_{eq1} - 10 \log (r_2/r_1) \qquad (2)$$

where:

L_{eq2} = noise level at a distance of r_2 from a mid-road noise source (dB)
L_{eq1} = noise level at a distance of r_1 from a mid-road noise source (dB)

The farther the receiver is from the noise source, the weaker the received sound will be. The amount of noise reduction caused by distance will vary depending on single or multiple noise sources. For a single sound source, each time the receiver's distance increases from the sound source, the sound power will decrease by 6 dB. Whereas for a multiple sound source, each time the receiver's distance doubles from the sound source, the power will decrease by 3 dB. Every time the traffic density increases, the vehicle speed decreases, and vice versa. However, under certain conditions, the low speed is also caused by poor road pavement conditions and the behavior of drivers who do not drive their vehicles despite the low density and good road conditions (Lakawa, 2015a). The traffic survey was conducted for 12 hours from 6.00 am to 6.00 pm. This survey was conducted at three locations, namely Senior High School 4 Kendari, Vocational High School 1 Kendari, and Vocational High School 2 Kendari. Likewise, noise measurements were carried out for 12 hours, from 6.00 am to 6.00 pm. The SLM microphone is placed at a distance of 1 m from the roadside, with a tripod height of 1.2 m from the ground. The noise survey is carried out simultaneously with the traffic survey. Traffic and noise surveys were carried out for two days, namely Wednesday (representing routine days) and Sunday (representing holidays).

RESULTS AND DISCUSSION

The condition of the research area on Ahmad Yani Street in front of Senior High School 4 Kendari is described as having a road type of 4/2 UD (4 lanes 2 way undivided), a pavement width of 11.5 meters, a sidewalk width of 1.8 meters, and a surface type between the roadside to the school is grass. The land use around the dominant area is trade. Likewise, the condition of the research area on Ahmad Yani Street in front of Vocational High School 1 Kendari is described as having a road type of 4/2 UD, a pavement width of 11.3 meters, a sidewalk width of 1.6 meters, and a surface type between the roadside to the school are paving blocks. The land use around the dominant area is trade. Meanwhile, the condition of the research area on Ahmad Yani Street in front of Vocational High School 2 Kendari is described as having a road type of 4/2 UD, a pavement width of 11.7 meters, a sidewalk width of 2.0 meters, and a surface type between the roadside to the school is grass. The land use around the dominant area is trade.

Table 1. Quality Standards of Noise Level

Description	Noise Level dB(A)
a. Appropriation of region	
1. Housing and Settlements	55
2. Trade and Services	70
3. Office and Commerce	65
4. Green open space	50
5. Industry	70
6. Government and Public Facilities	60
7. Recreation	70
8. Specifically:	
- airport *	
- Railway station *	
- harbor	70
- Cultural heritage	60
b. Surrounding Activity	
1. Hospital or the like	55
2. School or the like	55
3. Worship place or the like	55

Table 2. Roadside Noise Level

Area	School	Location	Traffic Volume (Veh/h)	Noise Level (dB)
1	Senior High School 4 Kendari	Ahmad Yani Street	2407	75.4 dB
2	Vocational High School 1 Kendari	Ahmad Yani Street	2555	75.0 dB
3	Vocational High School 2 Kendari	Ahmad Yani Street	2263	74.4 dB

The type of building construction of each school studied is a permanent building and its location to the edge of the pavement is as follows:

- The distance between the building of Senior High School 4 Kendari to the edge of the pavement is 26 meters.
- The distance between the building of Vocational High School 1 Kendari to the edge of the pavement is 69 meters.
- The distance between the building of Vocational High School 2 Kendari to the edge of the pavement is 86 meters.

The calculation of traffic volume on Ahmad Yani Street is based on the number of vehicles passing through the research location and is expressed in units of vehicles per hour. In general, it can be seen that the peak volume of motorized vehicle traffic for routine days (Wednesday) at the three locations occurs on average in the morning and daytime. This occurs as a result of the prevalent movement of people/vehicles from their homes to destinations for activities such as schools and offices. Meanwhile, the peak traffic volume on holidays (Sunday) at the three locations occurs on average in the afternoon. This is due to the dominance of people/vehicles moving from their homes to places of entertainment/weekend refreshments such as shopping centers, markets, cinemas, cafes, and restaurants. The roadside noise level in the three educational areas has exceeded the environmental threshold according to the Decree of the State Minister for the Environment of the Republic of Indonesia Number: 48/MENLH/11/1996 especially the designation of school areas. Based on the area category in Table 2, the highest noise level on the side of the road occurs in the Senior High School 4 Kendari area, then followed by Vocational High School 1 Kendari, and the lowest is in the Vocational High School 2 Kendari area. This is identical to the intensity of traffic volume in the area. Even though there is less traffic in the area around Senior High School 4 Kendari than around Vocational High School 1, the noise level is higher. This is because the heavy vehicle (HV) composition in the Senior High School 4 Kendari area is higher at 2.6%, while it is 2.4% in Vocational High School 1 Kendari. Meanwhile, the composition of heavy vehicles (HV) in the Vocational High School 2 Kendari area is only 2.3%. The high intensity of noise in each land use is not only due to the attraction of travel at that location but also due to its strategic location on the road that connects several centers of community activity in Kendari City. The calculation of noise exposure is to determine the noise level that reaches the recipient, in this case, school students. The noise exposure distance is calculated from the center of the sound source, namely the center line to the receiver (the front wall of the building). The prediction was carried out at each school, namely Senior High School 4 Kendari, Vocational High School 1 Kendari, and Vocational High School 2 Kendari as shown in Figures 1, 2, and 3. In Figure 1, it can be seen that the noise exposure that reaches the Senior High School 4 Kendari school area is 68.7 dB with an average decrease in noise from noise sources of 1.1 dB.

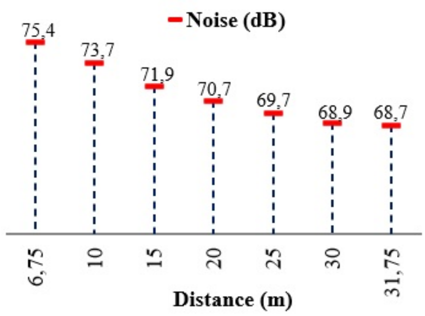

Fig. 1. Noise at Senior High School 4 Kendari

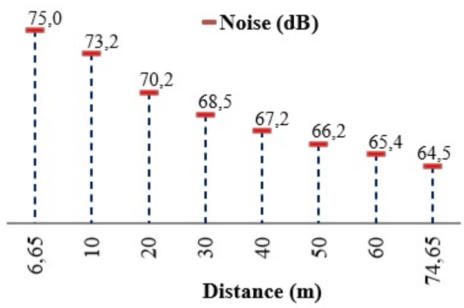

Fig. 2. Noise at Vocational High School 1 Kendari

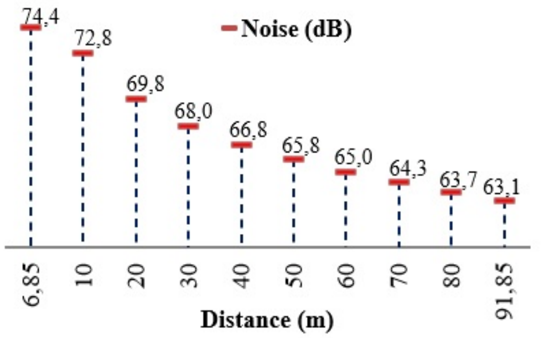

Fig 3. Noise at Vocational High School 2 Kendari

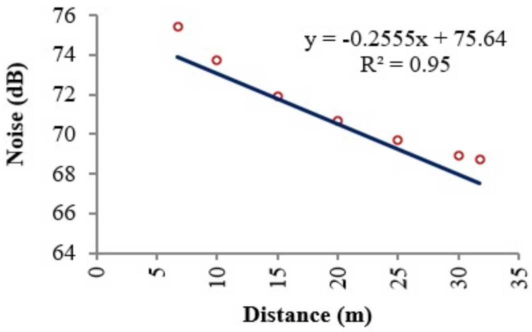

Fig 4. Noise Prediction based on Distance

In Figure 2, it can be seen that the noise exposure that reaches the Vocational High School 1 Kendari school area is 64.5 dB with an average reduction in noise from noise sources of 1.5 dB. In Figure 3, it can be seen that the noise exposure that reaches the Vocational

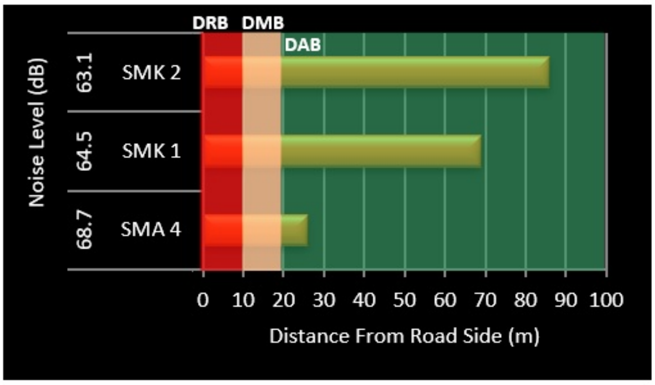

Fig. 5. Visualization of Noise Area Criteria

High School 2 Kendari school area is 63.1 dB with an average reduction in noise from noise sources of 1.3 dB. This shows that the farther the receiver is from the noise source, the smaller the noise intensity that occurs. It can be interpreted that the increase in distance can affect the decrease in noise levels in an area. Therefore, the determination of noise level exposure is based on the intensity that occurs in the area and the length of time of exposure. The difference in noise reduction in the three school areas apart from the increase in distance is also influenced by the type of ground surface from the roadside to the school and the shade and density of trees on the roadside. Figure 4 shows the distance prediction model to the noise level with a value of $R^2 = 0.95$.

Analysis of noise area criteria (KDB) is carried out based on a certain distance located on both sides and parallel to the length of the road, as well as the intensity of the noise that reaches the receiver in an area. Visually, the noise intensity in the education area that reaches the recipient can be seen in Figure 5. In Figure 5, it can be seen that the area noise intensity reaching the receiver for Senior High School 4 Kendari is 68.7 dB, Vocational High School 1 Kendari is 64.5 dB, and Vocational High School 2 Kendari is 63.1 dB. Based on noise criteria from the Department of Settlement & Regional Infrastructure (2004), the recipient's distance from the roadside in the three educational areas is 100% still within the Noise Safe Area (DAB). If the intensity of the noise is taken into consideration, the Senior High School 4 Kendari area is included in the category of Moderate Noise Area (DMB), whereas the Vocational High School 1 Kendari and Vocational High School 2 Kendari areas are still included in the category of Noisy Safe Area (DAB). The noise intensity parameter is used to determine the criteria for noisy areas.

CONCLUSION

The intensity of traffic noise is affected by the volume of the vehicle and the composition of heavy vehicles. Although the three school areas are still within a safe noise distance based on their distance from the roadside (DMB), the Senior High School 4 Kendari area is included in the category of Moderate Noise Area (DMB) due to the level of noise that is present. The farther the receiver is from the noise source, the smaller the noise intensity will be, with an average reduction of 1.3 dB.

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