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Road Traffic Noise Analysis at the U-Turn in Makassar City

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Abstract. This research aims to analyze and predict the level of road traffic noise in a U-turn. This study was conducted on 4 different roads with 2 points of observation in each road. Noise level, number of horn, number of vehicle, speed of vehicle were recorded for 10 min in every hour for 14 h by using SLM, counter and speed gun. The noise level prediction is calculated by using the 2008 ASJ-RTN model. The results show the average of noise level for all observation points is 80.8 dB. This value has exceeded the technical limit of the road capacity, which is between 63.2 dB to 76.0 dB. From the noise prediction result show the average noise level is 78.8 dB. The comparison showed the measurement and prediction had under 3 dB in difference, so that the measurement data and prediction models can be well received.

Keywords: Road traffic noise · U-turn · Asj-rtn model · Makassar city

1 Introduction

Transportation in the community is one important factor that supports the mobilization/movement of human life. Without vehicles or transportation activities, human life will become slower and harder to develop (Ariyanti 2017). Transportation is divided into three types, namely land, water and air transportation. Land transportation is inseparable from the presence of motorized vehicles. The development of a country in the transportation sector is marked by the increasing number of motorized vehicles, including in Indonesia. Makassar City is one of the cities in Indonesia with a population of 1,489,011 residents in 2017 with a growth rate of 1.32% from the previous year (BPS, South Sulawesi Province, 2018).

Increased population growth will be followed by growth in vehicle ownership for transportation needs. Based on Makassar Samsat data, the number of vehicles in 2018 was recorded 1,563,608 units or an increase of 57,773 units compared to 2017. As for 2016 the number of motorcycles ranged from 1,425,150 units. That is, in the last two years there was an increase of 138,458 units. Ownership of private vehicles both

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motorbikes and cars in South Sulawesi increases 5 to 6% annually. In contrast to the growth rate of roads in Makassar City, it is only 1.51% per year (Warta Ekonomi, 2017). Thus the growth of motorcycles caused more of congestion in Makassar City, because the rate of growth of motorized vehicles is not proportional to the growth of roads.

Traffic flow intensity causes several transportation problems, both temporary (periodic) and routine (permanent) that arise. This condition is caused by side obstacle factors such as vehicles parked on the roadside, the occurrence of queue lengths at certain places, such as intersections and at the median opening which is used as a U-turn. Urban roads always have a divider that divides each direction, the barrier is called the road median. The installation of the median of the road can be applied in all road conditions, freeway, arterial roads, collector roads and local roads (Muh. Arif 2018).

The installation of the median of the road which is higher than the road surface can be installed on the freeway, arterial road and collector road, while local roads usually only use road markings. The use of the median of the freeway, arterial road and collector road must have a U-turns, which is equipped with a directional turning sign so that vehicles that want to turn around will be easy to move without having to turn at an intersection. In Indonesia as a developing country, shows that the increasing number of vehicles and road segments is very rapid, which means that the greater movement of vehicles on the road and the problem of traffic also increases, including due to the implementation of the median of the road opened as a turning point for the direction of movement of vehicles (Muh. Arif 2018).

The main problem is the occurrence of congestion on several roads can be caused by several factors including vehicle queues that occur in the U-Turn direction. U-Turn can cause queues caused by vehicle maneuvers, causing delays. For delays that occur in a long time can cause long queues, causing more congestion (Muh. Arif 2018). Problems caused in the transportation sector are not only congestion problems but also environmental problems such as air pollution and noise pollution.

Noise is all unwanted sounds that originate from tools in the production process or working tools which at some level can cause hearing loss (Kepmennaker number: KEP-51/MEN/1999). Sound is heard as stimuli in the ear by vibrations through the elastic media, and when the sound is not desired, it is expressed as noise. Sound quality is mainly determined by the frequency and intensity. Frequency is expressed in the number of vibrations per second or called Hertz (Hz), which is the number of groups that reach the ear every second. Intensity or current energy per unit area is usually expressed in logarithmic units called decibels (dB).

Previous studies show that the noise level on the main-commercial road in Makassar City exceeds the quality standard with an average LAeq value of each road, 79.7 dB (Ariyanti 2017). A study conducted at the intersection of four signaled Jalan Jendral Sudirman—G. Tinggi Mae at 78.90 dB and the intersection of four road Jendral Sudirman—S. Saddang at 77.18 dB (Fadilah 2016). From those previous researches, the noise level in Makassar has exceeded the environmental standard which is limited from 55 dB to 70 dB according to its designation.

Based on the description above, the paper purpose are to analyze the noise level in the U-turns located in Makassar city and to predict the level of traffic noise in the U-turns located in Makassar using the ASJ-RTN Model 2008.

2 Study Literatur

2.1 Median Opening

Road median is a physical separator of traffic lanes which serves to eliminate traffic conflicts from the opposite direction. Road medians are planned with the aim of improving traffic safety, traffic flow and comfort for road users and the environment. The road median functions as follows:

1. Separating two opposite directions of traffic
2. To block traffic turn right
3. Waiting booths for pedestrians

2.2 U-Turns

In order to maintain the road service in the U-turns, the capacity of the road due to the amount of traffic flowing in the direction of movement needs to be considered. The median facility which is the area of separation between straight-flow vehicles and reverse-flow vehicles needs to be adjusted to the conditions of the traffic flow, the geometric conditions of the road and the composition of the traffic flow (Heddy in Muh. Arif 2018).

2.3 Traffic Noise

Based on the Decree of the Minister of State for the Environment, noise described as unwanted sound from business or activity in a certain level and time which can cause human health disturbance and environmental comfort or all unwanted sounds originating from production process equipment and or work tools at certain levels that can cause hearing loss (Kep.Men48/MEN.LH/11/1996).

Traffic noise based on the nature and spectrum of the noise is included in the type of noise that is intermittent. Noise in traffic generally comes from motor vehicles generated from vehicle engines during combustion, muffler, horn, braking and wheel interaction with road in the form of friction. Most motorized vehicles in gear 2 or 3 gear produce 75 dbA noise with a frequency of 100–7000 Hz (Maitsa in Arlan, 2018). Noise level standard is the maximum level of noise level that is allowed to be released into the environment from businesses or activities so as not to cause health problems human and environmental comfort (Kep.Men LH No.48 of 1996).

2.4 Prediction Model Based on ASJ-RTN 2008

The method used in predicting traffic noise on elevated toll roads is the 2008 ASJ RTN model, which is a revised form from the previous form. The prediction model after the 1998 ASJ RTN was adopted comprehensively in the “Technical Method for Environmental Impact Assessment of Road” and is widely used for traffic noise prediction in Japan. The form of the ASJ RTN model is also used to design environmental maintenance measurements (measurement of noise reduction) and estimate the exact location of noise during environmental monitoring (regular observation). The experts worked on finding solutions to unresolved problems in the 2003 ASJ RTN model. After five years of research and examination, finally a new model of ASJ RTN 2008 was published (Yamamoto 2008).

3 Methodology

3.1 Time and Location

This reseach include literature studies, preliminary surveys, data collection and data processing. The data collection process was conducted in Thursday, March 21, 2019 on a U-turn in Jl. Urip Sumohardjo; Monday, March 25, 2019 on a U-turn in Jl. Sultan Alauddin; Monday, April 1, 2019 on the U-turn in Jl. Perintis Kemerdekaan; Thursday, April 12, 2019 on the U-turn in Jl. Tun Abd. Razak. Data was collected at 07.00–20.00 WITA for 10 min in each hours (Figs. 1 and 2).

3.2 Measurenment Equipment

Fig. 1 Noise measurenment equipment

1. Sound level meter tenmars TM-103 to measure noise in decibels (dB).
2. Tripod to keep the SLM stable.
3. Speed Gun to measure vehicle speed.
4. Counter to calculate traffic volume and number of horns.
5. The camera to take pictures or videos.
6. Laptop with Rev 01 sound level meter software to generate noise data from the TM-103 sound level meter tenmars
7. Stopwatch to measure measurement time.
8. Roll meter to measure the height and distance of the measuring instr

3.3 Measurement Method

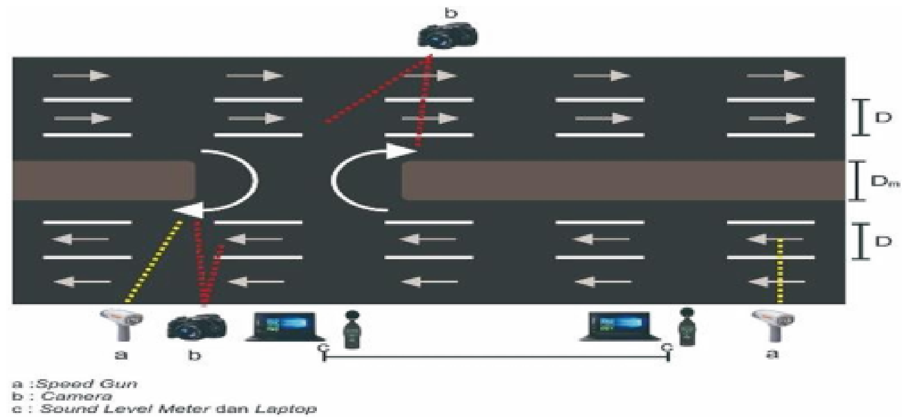

Fig. 2. Measurenment methode

The data collection stage is as follows:

Measurements were made simultaneously at 2 points of observation at each location, on U-turns and on the roadside of the street. The data was collected using 2 SLM tools, 2 speedguns, and 2 cameras. In each points it needs 2 operator to operate the SLM, speedgun and camera. In the u-turns there are two different directions of traffic flow, but the tool is only placed at one point because the SLM tool can read noise within the range of 50 m from the point of the tool. In addition, if there are two SLM tools placed close together, the readings will influence one another.

4 Results and Discussion

4.1 Noise Level Measurenment

The result for the noise level in U-turns can be seen in Table 1, it can be seen that for the maximum LAeq can be found on the Perintis Kemerdekaan observation point which is 81.27 dB and for the minimum LAeq can be found on the Sultan Alauddin observation point which is 80.23 dB. This value has exceeded the technical limits on the capacity of the road environment based on Ministry of Public Works Guidance No. 13 of 2003 which is equal to 63.2 dB–72.1 dB for the local-commercial road category, and 70.1 dB–76 dB for the main-commercial road category. For the LAeq segment, the maximum noise level can be found on the Perintis Kemerdekaan segment, while the minimum noise level is on the Tun Abdul Razak segment with 77.89 dB, this value still exceeds the technical limits on the capacity of the road environment. The average traffic noise level of all observation points is 80.39 dB.

The noise level in the U-turn is not always higher when compared to the noise in the segment which is caused by the queue of vehicles and the sound of horns that occurs more in a U-turn. The loudest noise level can be found on Jl. Perintis Kemerdekaan points. It occurs due to the variated building around the road such as office, schools, and hospitals.

Table 1. Noise level measurenment result

No	Measurement point	Noise level measurement (dB)	
		U-Turn	Road
1	S. Alauddin	80.4	80.6
2	Urip Sumoharjo	80.7	80.0
3	Perintis Kemerdekaan	81.2	81.5
4	Tun Abd Razak	80.8	77.6

4.2 Noise Level Prediction

Noise prediction is a method to find the model that is closest to the conditions in the field. This model will later be used to predict the level of traffic noise in reverse directions and sections with noise levels in the future. The prediction model used in this study is the 2008 ASJ-RTN. ASJ-RTN model 2008 is divided into two conditions, they are steady and unsteady.

4.3 Noise Level Prediction on U-Turn

This research using the 2008 ASJ-RTN model with unsteady conditions to predict the noise level, because the speed at U-turn is not constant. IT is caused by the queue of vehicles. In running the prediction model, it is operated using the Fortran 95 Programming Language. The variables needed as input data in Fortran 95 are road characteristic data in the form of the number of lanes (NL), the distance of the sound source to the prediction point (r), the width of the lane (D), median width (Dm), number of vehicles (N), vehicle speed (V), and measurement noise data for comparison to the output data. The results of noise level prediction on PBA can be seen in Table 2.

Table 2. Noise level prediction result on U-Turn

No	Measurement point	$L_{Aeq,day}$ (dB)	$L_{Aeq,day}$ (dB)	Difference
		Measurement	Prediction	
1	S. Alauddin	80.4	79.7	0.7
2	Urip Sumoharjo	80.7	78.4	2.3
3	Perintis Kemerdekaan	81.2	79.8	1.4
4	Tun Abd Razak	80.8	77.1	3.7

The predicted noise level using ASJ-RTN 2008 at each observation point is below the noise level measured. The difference in noise level at the measurement points of Urip Sumohardjo, Sultan Alauddin, and Perintis Kemerdekaan are not much different, while the measurement points of Tun Abdul Razak are much different. This is due to the number of vehicles. The 2008 ASJ-RTN prediction model predicts noise based on the number of vehicles and the number of horns. If based on the number of vehicles, the number of vehicles in u-turn considered low. However, the difference between the measurement results and the predicted results might due to other factors.

In calculating noise prediction with horns, there are several new variables added to the Fortran 95 input data, namely the number of horn sounds and horn power level. The power level of the horn used is the power level of the results of previous studies which is 107 dB (Arifin in Arfina, 2018). Comparison of the measurement noise level and the ASJ-RTN 2008 prediction noise level results with the sound of the horn can be seen in Table 3.

Table 3. Noise level prediction result on U-Turn with horn

No	Measurement point	$L_{Aeq,day}$ (dB)	$L_{Aeq,day}$ (dB)	Difference
		Measurement	Prediction	
1	S. Alauddin	80.4	79.8	0.6
2	Urip Sumoharjo	80.7	78.5	2.2
3	Perintis Kemerdekaan	81.2	79.8	1.4
4	Tun Abd Razak	80.8	77.2	3.6

The value of the predicted noise level ASJ-RTN 2008 with the addition of horn sound at each observation point is below the measurement noise level. Similar to the prediction results without a horn, at the measurement point of Urip Sumohardjo, Sultan Alauddin, and Perintis Kemerdekaan not much different, while the measurement point of Tun Abdul Razak is much different. This is due to the number of vehicles. Compared to the predicted noise value without the horn sound, the predicted noise value with the horn has the higher LAeq value.

Based on the 2008 ASJ-RTN, a model can be well accepted if the difference between the average measurement and prediction ≤ 3 dB. From Tables 2 and 3 it can be seen that the comparison of measurement results and the prediction of U-turns in Urip Sumohardjo, Sultan Alauddin, and Perintis Kemerdekaan are below 3 dB so that it can be said that measurement data and prediction models can be well received while the Tun Abdul Razak measurement point exceeds 3 dB. If based on theory, it can be said that measurement data and prediction models cannot be well received.

4.4 Noise Level Prediction on Road

This research using the 2008 ASJ-RTN model with unsteady conditions to predict the noise level, because the results of predictions using unsteady traffic produce noise level data higher than the results of measurement noise levels, which can indicate that the predicted value is invalid. And referring to previous studies that steady traffic is better for traffic noise prediction in Makassar City even though the speed is still low at 20 km/hr to 40 km/hr and the traffic flow is heterogeneous (Hustim in Arfina, 2018). Prediction results can be seen in Table 4

Table 4. Noise level prediction result on road

No	Measurement point	$L_{Aeq,day}$ (dB)	$L_{Aeq,day}$ (dB)	Difference
		Measurement	Prediction	
1	S. Alauddin	80.6	79.0	1.6
2	Urip Sumoharjo	80.0	78.4	1.6
3	Perintis Kemerdekaan	81.5	79.7	1.8
4	Tun Abd Razak	77.6	75.1	2.5

The value of the predicted noise level at each observation point is below the noise level measured. Difference in noise level at all observation points is not much different. In calculating the noise prediction with horn sounds, there are several new variables added to the Fortran 95 input data, namely the number of horn sounds and horn power level. The power level of the horn used is the power level of the results of previous studies which is 107 dB (Arifin in Arfina, 2018). The comparison of the noise level measured and the predicted noise level of ASJ-RTN 2008 with the sound of the horn can be seen in Table 5.

Table 5. Noise level prediction result on road with horn

No	Measurement point	$L_{Aeq,day}$ (dB)	$L_{Aeq,day}$ (dB)	Difference
		Measurement	Prediction	
1	S. Alauddin	80.6	79.0	1.6
2	Urip Sumoharjo	80.0	78.4	1.6
3	Perintis Kemerdekaan	81.5	79.7	1.8
4	Tun Abd Razak	77.6	75.1	2.5

The value of the predicted noise level ASJ-RTN 2008 with the addition of horn sound at each observation point is below the measurement noise level. Similar to the prediction results without a horn, the difference in the noise level at each point of observation is not much different. Compared to the predicted noise value without the horn sound, the predicted noise value with the horn has higher LAeq Day. Previous studies showed that the addition of the number of horns in the ASJ-RTN 2008 made only a small impact.

Based on the ASJ-RTN 2008, the model can be well accepted if the difference between the average direct measurement and prediction ≤ 3 dB. From Tables 4 and 5 it can be seen that the comparison of measurement results and the prediction results at all measurement points is below 3 dB so that it can be said that measurement data and prediction models can be well received.

5 Conclusion

Based on the analysis, the following conclusions are obtained: The average level of traffic noise from all observation points is 80.28 dB. This value has exceeded the technical limit of the specified environmental capacity of the road, which is between 63.2 dB to 76.0 dB (Ministry of Public Works Guideline No. 13, 2013). The noise level in U-Turn and Road almost same although number of vehicles are different.

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