An Investigation on the Sound Power Level of Vehicles in Makassar City

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Abstract: The present paper attempts to investigate and describe the sound power level of vehicles in Makassar City, Indonesia due to the sound power level of vehicles plays the important role on predicting the road traffic noise. The study measures the peak levels of A-weighted sound pressure level emitted from a single vehicle running, which converted into power levels at the some actual roads in Makassar City. The relationship between the power level and the speed for each vehicle type is statistically modeled using the single regression model. The results show that the relation between the power level and speed correlates significantly with the speed in each vehicle type. The results have revised the previous research of the first author. Then, the sound power level that achieved in this study is appropriate to use in Makassar's road traffic noise prediction in the further study.

Keywords: Sound Power Level, Vehicles, Road Traffic Noise, Makassar.

1. INTRODUCTION

Nowadays, the motor vehicles growth in developing countries such Indonesia has increased rapidly (Hustim and Ramli, 2013). This fact leads to several cities in the countries are facing traffic congestion problem in a critical level. In this situation the motor vehicles such passenger cars and motorcycles have made maneuvers and behaviors that are insufficient for the condition (Hustim and Ramli, 2013). The auto-cars and motorcycles have been conducting zigzag maneuvers, creeps up slowly to the front of queue when the signal are red, impedes traffic flow by disturbing the star of other vehicle behind, etc. (Chandra et al, 2003; Zakaria et al. 2011, Hustim et al., 2011). Also the vehicles have inconsistency or indiscipline to use their lane (Aly et al, 2011, 2012; and Hustim et al., 2011). Therefore, the motor vehicles behavior has changed from homogeneous situations to heterogeneous conditions. The last traffic behavior type has made more congested (Zakaria et al. 2011). In further, the motor vehicle pollutants, vehicle emission and traffic noise, have increased on the urban roads the cities (Aly et al, 2012; and Hustim et al., 2012).

Concerning to the road traffic noise (RTN) on the heterogeneous traffic condition in the developing countries, the first author has been conducted a survey on the RTN in Makassar City (Hustim, et all, 2011a; 2011b; 2011c). The results of the survey shows that the noise levels at roadside of main roads in the city was very high from morning until evening and it exceed the highest value of the Environmental Standard for Noise in Indonesian (1996). In addition, MCs dominate the traffic (67%) fleet in the city and contrary with the HVs (2%). As a result of such conditions, the average speed of the vehicles is less than 40 km/h, a low speed category. However, the traffic flow seems still in steady state condition.

Furthermore, by adopting the ASJ RTN-Model 2008 (ASJ-RTN, 2010), significant differences occurred between the measured *LAeq* and the predicted ones when the traffic is assumed to be non-steady. Regarding the heterogeneous traffic behavior on the roads in Makassar City, the author tried to consider the steady traffic flow and the effect of horn sound to predict the RTN. Here, the problem is about the power level of vehicle under heterogeneous traffic and horn sound. Because the ASJ RTN-Model 2008 does not consider the horn sounds utterly, the author imitated Asakura's method to predict the RTN in considering the vehicles horns (Asakura, et all, 2010). As a result, the author could make the predicted level of the RTN close to the measured value (Hustim and Fujimoto, 2011).

However to predict the RTN more precisely, to grasp precise power level of vehicle especially for all vehicle types and horn sound is needed. Until this step, the first author has measured sound power level of vehicles in Makassar City in a constraint condition to predict the RTN more precisely. Unfortunately, the results did not satisfy until a certain significant level. Further examination and survey to investigate the characteristics of the sound power level of vehicles in Makassar City is still needed. Therefore, this study attempts to grasp the sound power level of vehicle in Makassar City in order to revise the previous results of the author's study.

2. THE INVESTIGATION OF THE VEHICLE'S SOUND POWER LEVEL

2.1 The Measurement Method

The present study has measured the sound power level of each vehicle type in the three selected roads in Makassar City, i.e Tanjung Street, Baddoka Street and Hasanuddin University Street. The roads were fit to criteria for the measurement of sound power level of the vehicles, such as they were open and quiet areas to escape from the effect of another sound; ambient noise levels at the sites were less than 35dB; the roads were straight to allow the vehicle to pass through with a constant speed; and number of traffic is very small to enable us to measure each vehicle noise separately. Figure 1 shows the situation of the roads.

(a) Hasanuddin University Street (b) Baddoka Street (c) Tanjung Street

Figure 1. The State of the road for the sound power level measurement

The field scenario for the measurement is shown in Figure 2. In this regard, the markers were set at points A and B with the length of 20 m, and the measurement point was set in the center of AB. A sound level meter (SLM) was set at the position with the distance of 1.0 m from the road edge and height of 1.2 m above the ground. And A-weighted sound pressure level was observed when only one vehicle was passing through zone AB at the measurement point by SLM (RION NL-32) and LAmax (peak level while a vehicle is passing through zone AB) was measured. The speed of vehicle, V, in km/hour was measured by a speed gun, and the distance from the measurement point and the vehicle, d, were also measured for each vehicle running.

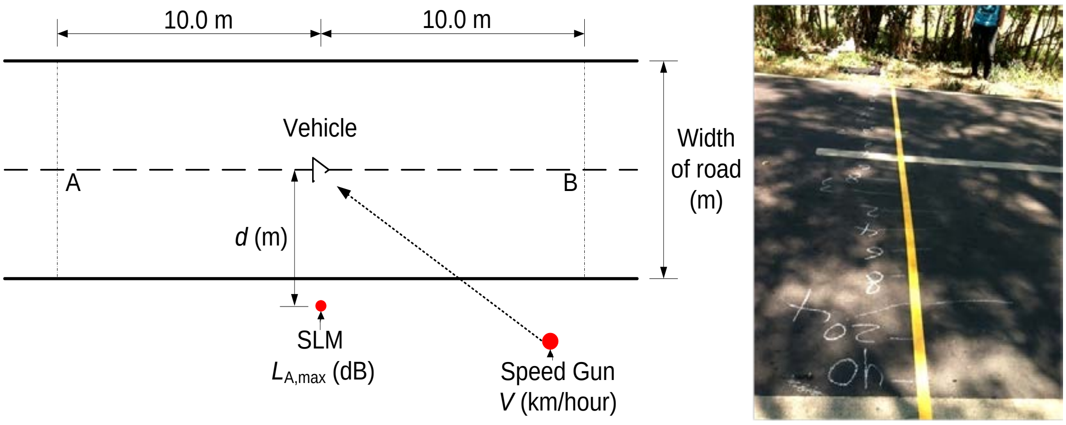


Figure 2. The field scenario of the vehicle sound measurement

2.2 Number of Data and the Calculation Method of the Vehicle Power Level

Table 1 and Figure 3 shows the number of data collected in the measurement. Based on the data, we found here, that the number of data for the speed vehicles between 20-30 km/h and 30-40 km/h are dominant than the others for the three vehicle types. In contrary, the data for more than 60 km/h are very small. This phenomenon shows the actual situation of road traffics in Makassar City, where the average speed of the vehicles is less than 40 km/h as the result of the author's previous survey.

Table 1. Number of data

Speed of vehicle (km/jam)	**Number of Data**		
	MC	**LV**	**HV**
10-20	8	-	-
20-30	99	89	79
30-40	123	121	121
40-50	67	41	37
50-60	18	7	5
60-70	2	-	-
Jumlah	317	258	242

Then, A-weighted power level of vehicle LWA is calculated by Equation (1)

$$L_{WA} = L_{Amax} + 20\log_{10} d + 8 \quad (1)$$

Where, *d* is the distance between a sound source and a measuring point.

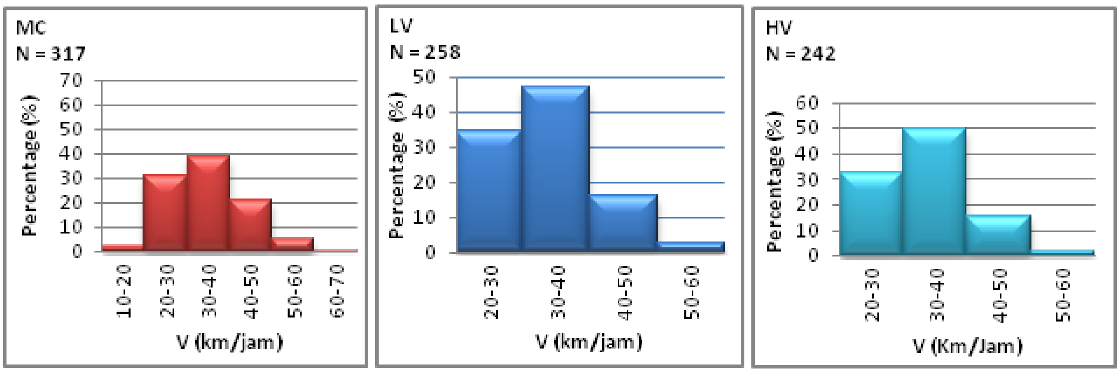


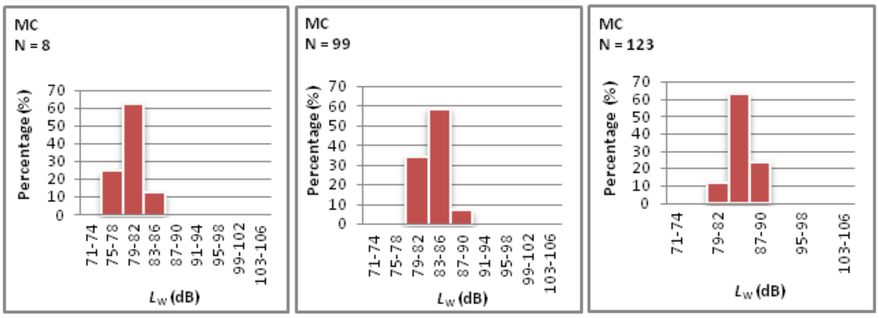
Figure 3. Number of Vehicle Data

3. THE SOUND POWER LEVEL OF VEHICLES IN MAKASSAR CITY

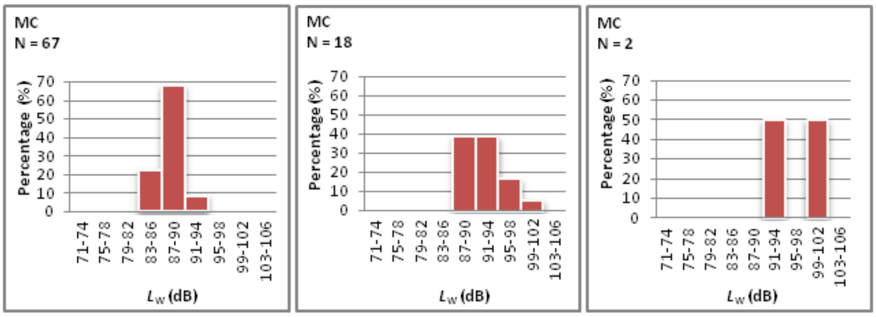
3.1 Number of Data and the Calculation Method of the Vehicle Power Level

After the calculation of the power level using Equation (1), we made the distributions of them for each 10 km/h interval in speed and for each vehicle type. Here, the MC data for the speed more than 60km/h, therefore the authors focus on the MC data with the speed between 10km/h until 70km/h.

Figure 4 shows the distributions of power level of MC particularly, while Figure 5 and Figure 6 shows the distributions of L_{WA} for each 10 km/h band in speed for LV and HV. Mostly figures show that it is clearly found that power level distributes widely in each speed band. Therefore, a selection of data is needed to make the data more precise. After some examinations, the authors resulted in adopting the data of 80% range as effective data for the subsequent analysis. Red bars show selected data for MC, LV and HV in Figure 4, Figure 5 and Figure 6, respectively.

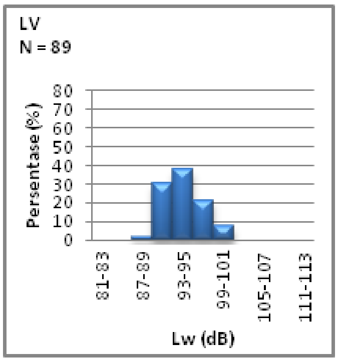


a. V = 10 – 20 km/h b. V = 20 – 30 km/h c. V = 30 – 40 km/h

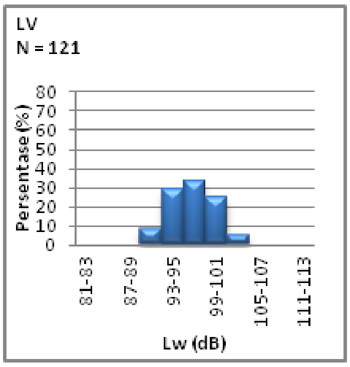


d. V = 40 – 50 km/h e. V = 50 – 60 km/h f. V = 60 – 70 km/h

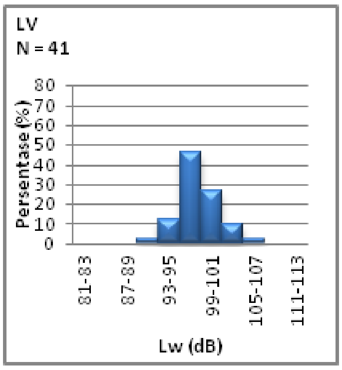
Figure 4. Distribution of MC's L_{WA}



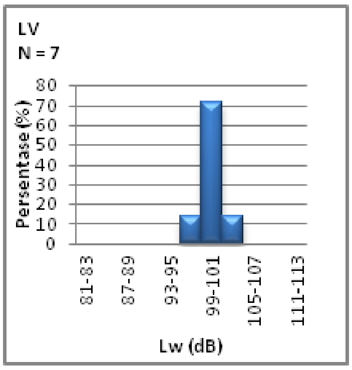
a. V = 20 – 30 km/h



b. V = 30 – 40 km/h

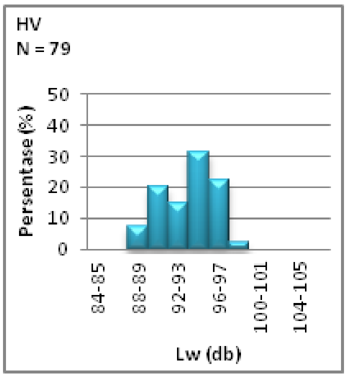


c. V = 40 – 50 km/h

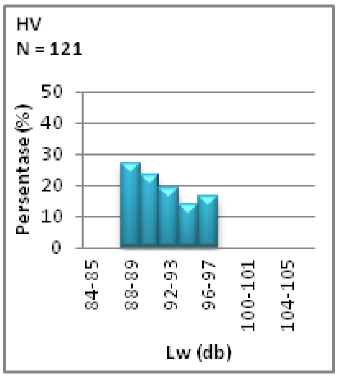


d. V = 50 – 60 km/h

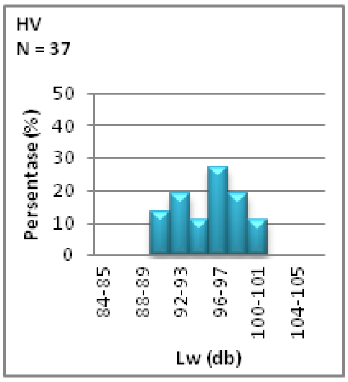
Figure 5. Distribution of LV's L_{WA}



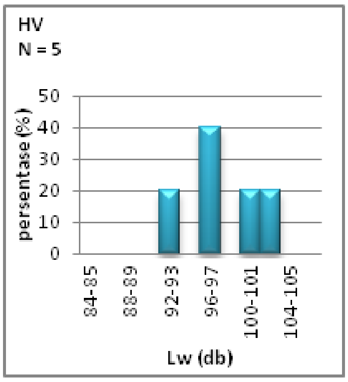
a. V = 20 – 30 km/h



b. V = 30 – 40 km/h



c. V = 40 – 50 km/h



d. V = 50 – 60 km/h

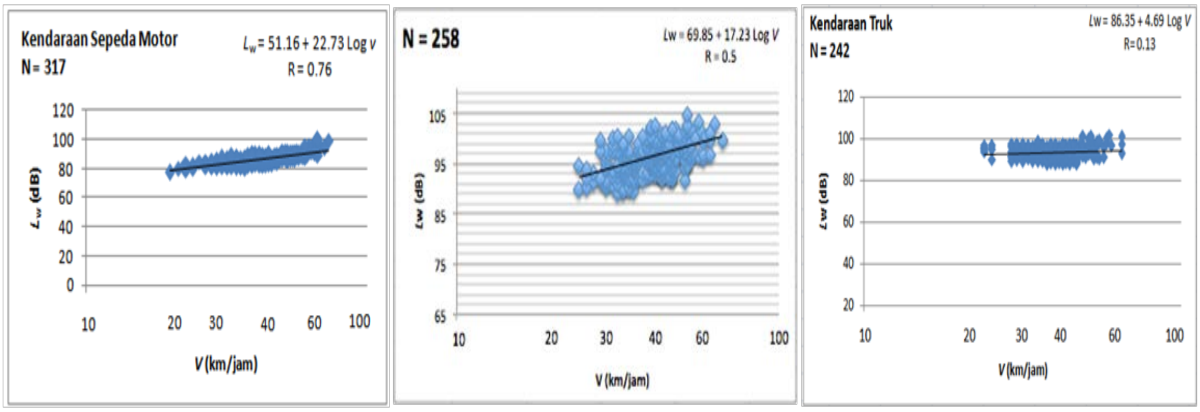
Figure 6. Distribution of HV's L_{WA}

3.2 The Relationship Model between the Power Level and the Vehicle Speed

Figure 7 shows the relationship model between vehicle power levels of the selected measurement data and vehicle speed in each vehicle type; MC, LV, and HV. The curve lines show the regression lines assuming that L_{WA} has a relationship of Equation (2) with V.

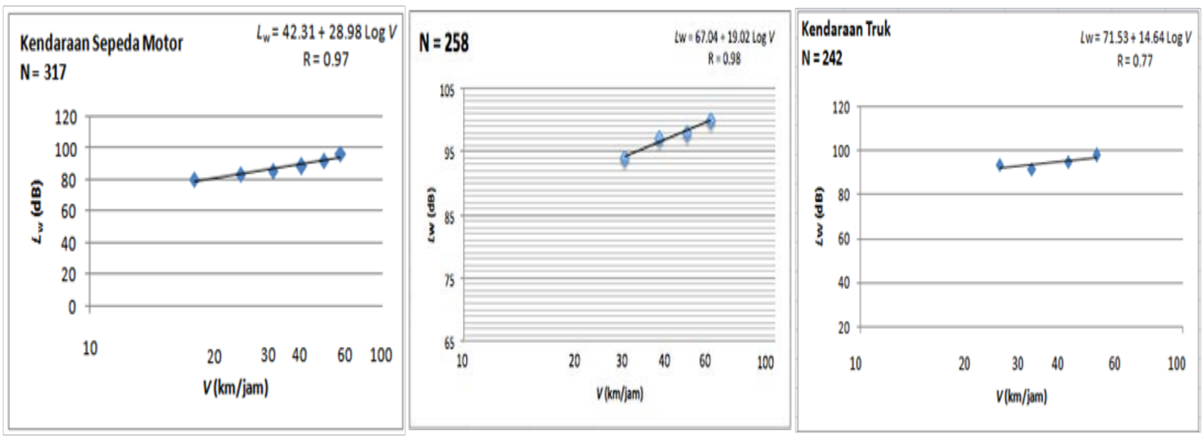
$$L_W = a + b \log V \tag{2}$$

In spite of the selected data, L_{WA} still distributes widely around the regression curve as found in Figure 7. Then, the energy-averaged levels in each speed band were calculated in each type of vehicle, and the relationship between averaged L_{WA} and V was analyzed again. The results were shown in Figure 8 and regression coefficients, a and b, were shown in Table 3. Further, Figure 9 shows the calculated L_{WA} using the relationship models. The results show that L_{WA} has a very good relationship with V of MC and LV though L_{WA} of HV is mostly static through all speed values.



a. MC b. LV c. HV

Figure 7. Relationship model between L_{WA} and V



a. MC b. LV c. HV

Figure 8. Relationship between Energy-Averaged L_{WA} and V

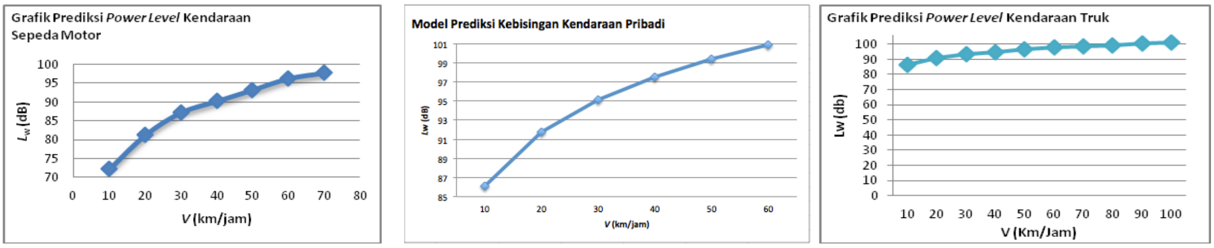
Overall, the power level of MC in Makassar City is appropriate when traffic is in steady condition. In contrary it is larger when the speed of the MC is lower than 30 km/hour. The phenomenon can be understood by considering that most of MCs in Makassar City have about

110cc of engine. As is well known, MC with low engine size produces small noise when the speed is low, and louder noise is generated as the speed increase. On the contrary, MC with high engine size produces high noise even the speed is low.

Table 3 - Coefficient *a* and *b* for Steady Traffic Flow

	MC		LV		HV	
	a	*b*	*a*	*b*	*a*	*b*
(i)	51.16	22.73	69.85	17.23	86.35	4.69
(ii)	42.31	28.98	67.04	19.02	71.53	14.64

(i): Individuals power level (ii): Average power level



a. MC b. LV c. HV

Figure 9. The calculated L_{WA}

4. CONCLUSSION

The present study has investigated A-weighted sound pressure level emitted from a single vehicle running at the actual road in Makassar City was measured and the power level is examined in order to describe the power level of vehicles more precisely in Makassar City. The relationship model between the sound power level and the speed was analyzed.

The results show that the relation between the power levels and speed correlates significantly to their speeds in MC, LV, and HV. However, the power level of HV is not significantly affected by the speed in comparing the others two. Briefly, the results coincides with the author can expect that the power level of vehicles resulted can be useful in predicting the RTN of Makassar City more precisely in further studies.

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