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A Vehicles Noise Traffic Model Development: Case Study In Pekanbarucity, Indonesia

Indra Hasan*[1] , Erwin Amiruddin[2] , Nofrizal[3] , Ikhwansyah Isranuri[4] , Abdul Khair Junaidi[5] , Wahyu Caesarendra[6]

[1,]Department of Mechanical Engineering,University of Muhammadiyah Riau,Pekanbaru,Indonesia

[2,]Department of Physic and Science, University of Riau, Pekanbaru, Indonesia

[3] Department of Doctor in Environmental Science, Postgraduate Coordinator, University of Riau,Pekanbaru

[4] Department of Industrial Engineering, InstitutTeknologi Perkebunan Pelalawan Indonesia (ITP2I)

[5] Faculty of Integrated Technologies, Universiti Brunei Darussalam, Jalan Tungku Link, Gadong BE1410, Brunei Darussalam

Abstract

Noise traffic is becoming a critical issues in many urban areas. The increasing of vehicle number each year is to be significant to the noise traffic intensity. Therefore, this requires an approach to predict noise traffic level which related to number of vehicle, speed and measurement distance. In this study aimed to develop traffic noise predictive model which based on Johnson model. The measurement of noise traffic was conducted in 8 location of main roads for time of 07.00-08.00, 12.00-13.00 and 16.00-17.00. The result showed that the comparison developed model to the actual traffic noise has similar pattern for 8 of measurement point on the main roads. The change of constant function (k) in the developed model equation refers to topography area of noise meas-urement. The range of constant function (k) is 1 – 1.5.

Keywords:noise, traffic, model.

Introduction

The World Health Organization (WHO) has documented seven categories of adverse health and social effects of noise pollution [1]. Traffic noise is one of critical issue in all large cities where the noise is originated from the traffic vehicles which include all type of vehicle. Traffic noise impact give rise to detriment effect to environment and living things around the highway [2]. Because of the rapid increase of vehicle growth yearly, the road noise has become an increasingly serious issue [3]. In urban administration and planning, noise mapping is required to mitigate environmental impacts and enabling the visualiza-tion of noise traffic in the urban landscape [4]. At this point, noise maps are an important tool to guide to local and global action plans [5]. Modelling of traffic noise have been de-veloped for environmental impact assessment and reducing noise annoyance. This study aim to develop prediction model of traffic noise which consist of three param-eters such traffic volume, vehicle speed and noise measurement distance.

The traffic noise models developed and adopted in various countries that may be dif-ferent approach for sound propagation model. Garg et al (2014) made a comparison of various traffic noise models which had been reviewed to ensure the use of numerical methods for solution [6]. Traffic noise model has correlation

with urban variable such as street location, urban land use, street geometry, road traffic control and public and private transport [7].

Research methods

2.1 Related Theory of Traffic Noise

Theoretical models of road noise were first reported in the Hand Book of Acoustic Noise Control [8] which formulated as follows:

$$L_{50} = 68 + 8.5 \log (Q) - 20 \log (d) \quad (1)$$

Where Q is number of vehicle that passing on the highway and d is distance of noise traffic measurement from the observation point to traffic lane.. Furthermore, the development of this theoretical model was further developed by Nickson et.al [9] by involving the same parameters as in equation below:

$$dB = C + 10 \, Log(Q/d) \quad (2)$$

The value of C (Constant) in the Nickson model equation has different values depending on the location of observations and measurements. This Nickson Theoretical Model was further developed by Johnson, et.al [10] by using the average speed of the vehicle (v) as a measuring parameter and the number of vehicles that pass per hour, the noise level can be written in the form of equation below:

$$dB = 3.5 + 10 \, Log\left(\frac{Qv^3}{d}\right) \quad (3)$$

2.2 Research Area

Area of study was carried out in the main streets of Pekanbaru city as the capital of Riau province, west Indonesia. This study is field experiment research that collecting data by measuring noise traffic level to obtain valid information regarding the characteristic of traffic noise level and environmental condition. The traffic noise levels of main roads were evaluated with two equipment of sound level meter (SL 4112).

The measurement of traffic noise level was conducted at 12 of measurement locations in the main streets of Pekanbaru city. Noise level measurement time was conducted during 10 hours that starts from 07:00-17:00 and classified the traffic noise for each hour. Data collection as carried out for a week which consists of Noise measurement, number of vehicle and average speed.

In this study proposed developed model of traffic noise in order to predict noise level to a certain number of vehicle and average speed according to Johnson's theory as equation 3, with the result that 12 of noise level measurement location had been validated by proposed model. The main road of Sudirman streets is to be sample of developed traffic noise model by comparing to the actual noise level.

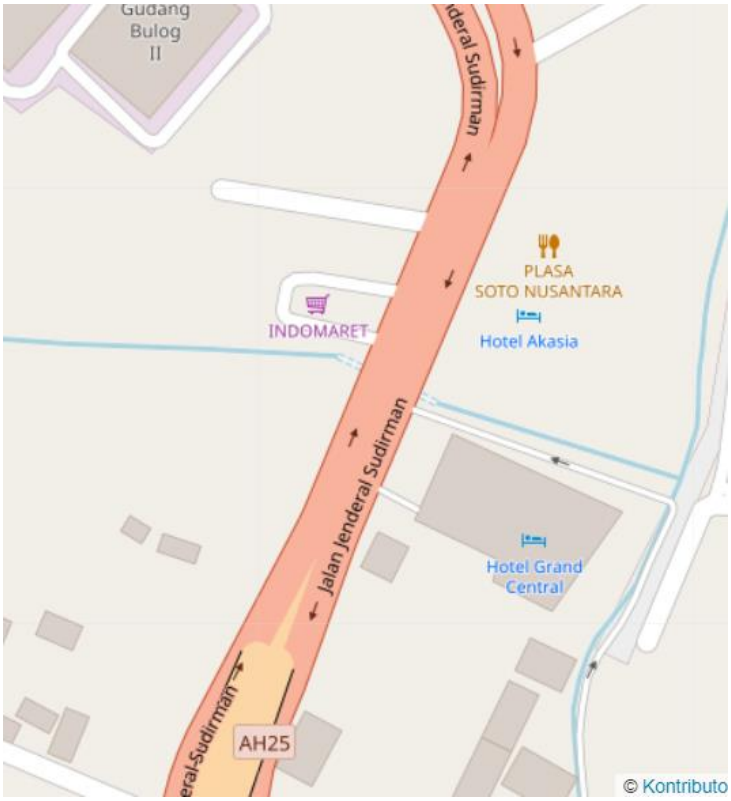

Figure 1. Map of Jend. Sudirman Street, Main road of Pekanbaru city

RESULTS AND DISCUSSION

Relationship between Number of Vehicle to the Average Speed

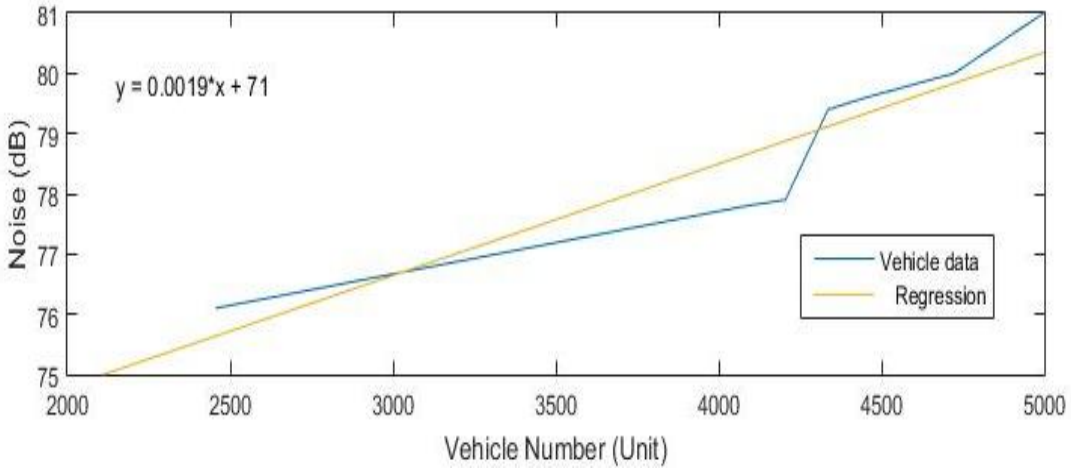

Figure 2. Comparison between Noise level to the number of vehicles start from Monday to Sunday.

In this study, regression modeling was considered to underline the functional relationship between noise and number of vehicle. Based on data collection, it indicated that the number of vehicle contributed the increased of noise traffic level linearly. Radam et al [11] reported that the traffic flow has a strong correlation level as a source of noise. The average noise change due to traffic activity fluctuation and indicating that it has

a strong relation to the hourly traffic flow, this condition might be a consideration to regulate traffic flow at a certain time.

Traffic Noise Level

Table 1. Traffic noise level measurement for a week at Jendral Sudirman Street.

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
07.00-08.00 (1)	79,4	80,0	80,3	80,1	78,6	76,7	75,1
08.00-09.00 (2)	81,0	79,7	80,4	80,5	79,6	77,1	75,7
11.00-12.00 (3)	80,0	77,9	79,7	78,1	78,2	77,2	75,7
12.00-13.00 (4)	76,1	78,1	79,6	77,6	79,1	75,9	76,0
15.00-16.00 (5)	77,9	78,0	77,8	79,4	79,3	77,4	76,5
16.00-17.00 (6)	77,8	77,8	78,0	78,7	78,7	76,9	76,3
17.00-18.00 (7)	79,6	80,0	79,8	80,3	79,2	77,2	76,1
Average	78,8	78,8	79,4	79,2	78,9	76,9	75,9

At the table 1, it shows the result of traffic noise measurement for a week at Jendral Sudirman street. Based on the above, the peak of traffic noise level fluctuate during work day. Traffic noise level that resulted from measurement is still above the threshold. According to the Regulation of the Indonesian Minister of Environment (1996), which amounted to 55 dB (A) [12]. Therefore, the negative effect of traffic noise on human health is indisputable. Thereby, advanced study should be conducted to determine the number of people suffering from noise-induced health problems. Marcin et al (2021) performed map of study regarding the effect of inhabitant health to the noise level that recommended to analyzed cities and a very well developed transport network and further studies are needed to characterize the effect of traffic noise on inhabitant health more accurately [13].

Table 2. Comparison of the noise level between the actual and the developed model at a speed of 64.8 km/h.

Day	Time	dB (Actual)	Q	d(m)	v km/hour	Developed Model
Monday	07.00-08.00 (1)	79.4	4336	10	43.2	78.94
	08.00-09.00 (2)	81.0	4998	10	43.2	79.55
	11.00-12.00 (3)	80.0	4454	10	43.2	79.05
	12.00-13.00 (4)	76.1	2455	10	43.2	76.47
	15.00-16.00 (5)	77.9	4087	10	43.2	78.68

	16.00-17.00 (6)	77.8	4723	10	43.2	79.31
	17.00-18.00 (7)	79.6	4205	10	43.2	78.80

Table 2 presents traffic noise level between actual and proposed model at the speed of 43.2 km/h. Average difference value of noise level between actual and proposed model is 1.48 dB. Rey Gozalo et al (2020) reported that the type of urban road contributed to noise prediction model which related to street location, urban land use, street geometry and road traffic control [14]. Refer to equation (3) as developed model of traffic noise, the value of constant (k) depend on lay out of road traffic characteristic which the noise prediction model is suitable. The value of constant (k) has range of 0<x<1.5.

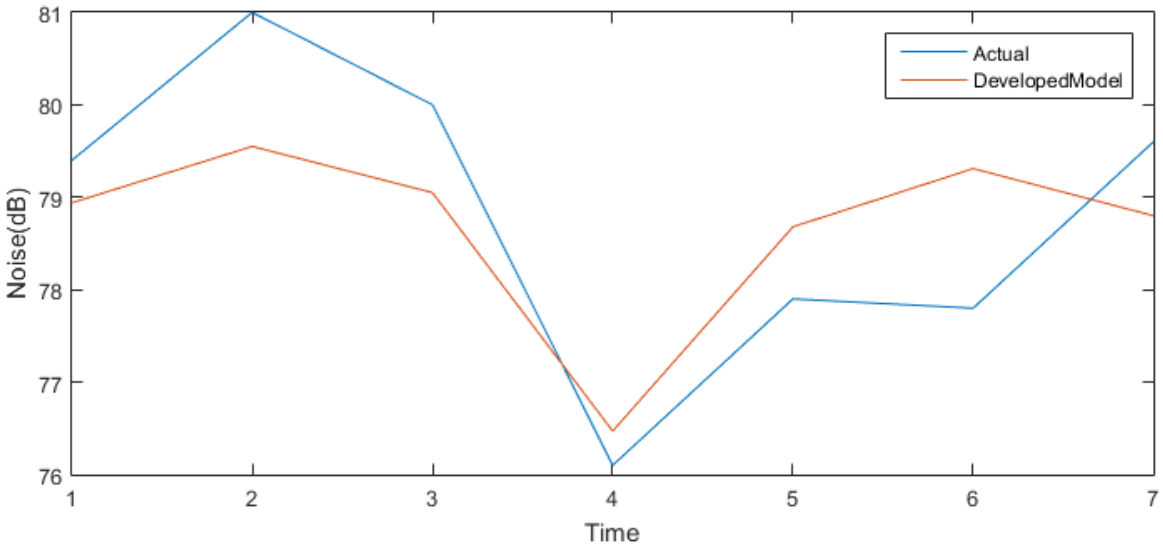

Figure 3. Comparison of traffic noise level between Actual and developed model at Jendral Sudirman Street.

Figure 3 shows the description of noise traffic comparison between actual and proposed model where the traffic noise level fluctuate during 10 hours for one day. As observed, there is no significant difference noise level in each time of period. However, the difference is observed in the traffic noise contour from morning and afternoon. In the morning, the proposed model of traffic noise is below the actual traffic noise. Whereas in the afternoon, the proposed model of traffic noise is over the actual traffic noise. This occurred due to classification of road traffic and difference round trip traffic [15].

Campbell (2000) has reviewed the prediction of the traffic noise model in which the road noise prediction model method refers to Nickson's theory in the Handbook of Acoustic Noise Control. This road noise prediction model was developed in the 1950s and 1960s. Based on this study, this road noise model prediction method is qualified to be used as a reference by the authorities to consider a rule so that this noise can be controlled [16].

CONCLUSION

Based on observation data for noise levels on the main streets of Pekanbaru City compared to the results of model development, it can be concluded that the proposed model can be applied in urban areas that have

regional topographic characteristics such as Pekanbaru. The spread of vehicle noise is strongly influenced by the contours of the ar-ea and buildings along the main road. So that in the development of the Johnson model, it is determined by the constant in the noise level equation function with a range of 0<x<1.5. the results of the development of this model have been simulated with the actual noise level on the main streets of Pekanbaru city which in principle has a difference in noise level of ± 2 dB.

CONFLICTSOFINTEREST

Theauthorshavenoconflictsofinteresttodeclare.

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