Traffic Noise Model for Urban Area Study Case Pekanbaru City

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Abstract. Traffic noise is a major problem in urban area that becoming complicated environment issues. The traffic noise has different characters in each of main road due to different size and weight of vehicles that go through the road in which resulted different noise intensity. In this study, the noise traffic measurement was conducted to get the data. The purpose of this study is to present the traffic noise model which compared to the actual traffic noise level that resulted from vehicle flow on the roads. The two models of predictive noise traffic have the similarities to the actual noise traffic.

1. Introduction

At present, the development of science and technology has driven the economic growth of Pekanbaru city especially in peoples and goods movement mobilization that evenly distributed. Furthermore, the rapid increase of population will affect to the increased demand for energy, transportation equipment, transportation infrastructure and social services.

Based on the data published by Central Bureau of Statistics, the population growth in Pekanbaru city reach to 4.8 % each year. Whereas the data resulted from the Department of Transportation of Pekanbaru explain that the number of vehicles in 2004 was 152,751 units and in 2016 there were 976461 units of vehicles. The rapid growth of vehicles in Pekanbaru due to the increase of population which will potentially be the main cause of high noise levels on the highway.

Traffic noise is inevitable in urban area such as Pekanbaru which is big city in the western Indonesia where the transportation is an important part and becomes a lifeline for the movement of people and goods. In this study, the measurement of noise traffic is located in the main street of Pekanbaru city because of high traffic density. Traffic noise has the different noise level which based on different parameters such as time, distance variable from the highway and number of vehicles. In this study, the research is related to the developed model in order to predict the traffic noise propagation which supported by surfer GIS (Geographic Information System) software package that used for noise mapping.

This study present an approach to predict the traffic noise model which is measured from the road to a certain distance of road side. In addition to describe traffic noise level as a noise contour by using analysis software simulation.
2. Literature Study

2.1. Noise Definition
Noise can be defined as unwanted sound. The noise has the different level of annoyance to the hearing. Road traffic is the main source of noise that disturbs most people. Sound generated by traffic is a sound that is not constant in its sound level [25]. Noise pollution can be defined as an unwanted and disturbing sound to humans. Noise is one of the pollution which is now increasingly out of control. As of small or soft the sound is heard, if it is not desirable it will be called noise. The instrument of noise measurement is Analog Sound Level Meter (SLM) SL4112, which can measure three types of frequency response characters, which are shown on the A, B, and C scales. A scale is found to best represent the limits of human hearing and ear response to noise, including traffic noise, and noise that can cause interference hearing A scale is expressed in units of dBA.

Theoretical model of traffic noise on the highway was first reported by Anno, in the Hand Book of Accustic Noise Control as follows:

\[ L_{50} = 68 + 8.5 \log(Q) - 20 \log(d) \]  

Where \( Q \) is the vehicle's number per hour that pass through in the highway and \( d \) is the noise measurement distance. The development of this theoretical model was further developed by Nikson et al [18], involving the same parameters as equation (1) with the result that equation as follow:

\[ L_{50} = C + 10 \log \left( \frac{Q}{d} \right) \]  

Afterward, another noise model by the French institution "Center Scientific Engineering Technique du Batiment" (CSTB), developing a theory about noise levels on the highway based on the average acoustic value (\( L_{50} \)), which can be written with the following equation:

\[ L_{eq} = 0.65 L_{50} + 28.8 \text{ [dBA]} \]  

Where \( L_{eq} \) is equivalent noise prediction model.

2.2. Relevant Result of Research
The noise model predictions for heterogeneous traffic conditions have been carried out by Agarwal et.al [1] where the main purpose of the research is to obtain an empirical model of noise levels caused by traffic activities. This research was conducted in the city of Jaipur, which is one of the major cities in India. Research conducted by Agarwal et.al concluded that traffic noise is directly affected by the type of traffic on the highway such as traffic density and type of vehicle. Furthermore, the traffic noise model has also been investigated by Carvalho da Paz et.al [6] who took place in the southern regions of Brazil. This study produced four groups of mathematical models that were adjusted for experimental data. These four noise level models have characteristics that distinguish models developed with existing models. These characteristics are linearity and group intervals. Linearity represents that the noise model in this city is not complex and group intervals represent a heterogeneity of traffic on the highway.

Noise level mathematical modeling due to traffic activity that has accelerated and decelerated the rate of vehicles has been developed by Rajakumara et.al [14]. In this study vehicles on the highway that experience acceleration and deceleration due to congestion are considered to be realistic conditions that need to be developed mathematical models for this case. The previous mathematical model only assumed the vehicle did not experience acceleration or deceleration due to congestion. However, in this study the model of noise due to vehicles experiencing acceleration and deceleration was also investigated to represent realistic traffic conditions. The results of research conducted by Rajakumara in the City of Bangalore India contributed mathematical modeling to the condition of
accelerated vehicles and vehicles that were experiencing a slowdown due to congestion on the highway.

The results of the latest research on modeling noise levels due to traffic activities can be seen from the research conducted by Panchal et al. [22]. An analytic model has been developed to predict noise levels on vehicle-intensive highways in the City of Delhi India. This study uses linear regression analysis to predict noise as a function of vehicle density on the highway, the percentage of heavy vehicles, and the average speed of the vehicle. Regression analysis carried out in this study was carried out with the help of SPSS software. Then the model that has been developed is validated with measurement data on the highway. This research provides suggestions to improve the accuracy of the noise model by providing more data from various road locations and from various types of vehicle density on the highway.

Gallo et al. presented a model for predicting the level of road traffic noise [8]. This model is applied to evaluate the level of general traffic noise in big cities. This highway traffic noise level model is validated with survey data in the city of Benevonto. Previously, Schenone (2012) made a precision tool for analyzing noise propagation using numerical techniques to simulate the behavior of outdoor acoustic waves or open environments [23]. This numerical technique proved that this could be applied effectively in a number of different situations such as main roads in urban, railways, airports, seaports and industries.

Based on the results of research on noise level modeling due to previous traffic activities, in this dissertation a new mathematical model will be developed that can represent noise levels in Pekanbaru City. The modeling that will be developed is based on noise level models for major cities in the world, of which Pekanbaru is also one of the major cities in Indonesia. So that the mathematical model for major cities in the world that had previously been developed can and is suitable as a basis for the development of new mathematical models for the city of Pekanbaru.

3. Material and Method
In this study, the measurement of noise level was conducted in the Sudirman street as main road of Pekanbaru city. The measurement time is based on the ISO R-2006 Standard in 3 ways, namely in the morning, the highest level of activity during the interval from 07:00 - 09:00 WIB and during the daytime activities in the interval 11:00 - 13:00 WIB then in the afternoon before evening with a time interval of 15: 00-18:00 WIB.

The instruments used for measuring noise are the sound level meter (SLM). It is important to understand the calibration, operation and reading the instrument that used. In this study, the traffic noise level is measured by using two pieces of SLM simultaneously in order to obtain the more accurate data. The traffic noise level measurement is conducted with three different measurement point which measured from the edge of highway. The measurement point consist of 10m, 15 m, 20m and 25m. Due to noise level fluctuate over a wide range with time, the sound level meter records the data during one hour to obtain the average noise level.
Figure 1. Research Flowchart

Figure 2. Map of Noise measurement in Jendral sudirman Street. (Openstreetmap.org)
4. Result and Discussion

4.1 Traffic Noise Model
In the Figure 3 below illustrates the comparison of noise levels with the number of vehicles. The increased of vehicle number causes an increasing of noise levels linearly. In general, it can be said that there are 2 stages of increasing the noise level to the increase in the number of vehicles, namely the number of vehicles at 07.00 - 08.00 a.m resulted 79.4 dB and at 17.00 - 18.00 p.m resulted 79.6 dB with the number of vehicles 4205 unit and 4336 unit.

![Figure 3. Noise Level Comparison Chart with the number of vehicles](image)

In the figure 5 illustrates the speed of vehicles passing on Jalan Sudirman that starting at 7:00 a.m. to 6:00 p.m. in the afternoon. The speed of vehicles varies for every hour. The vehicle velocity starting from 28.8 km/hr to 64.8 km/hr which resulted noise level above 80 dB.

![Figure 4. Noise Level Comparison Chart with the vehicle velocity](image)

In figure 4, in the form of linear line equations which describe the relationship vehicle speed and noise level, the linear line equation can be written as follows:

\[ y = 2.52 x + 65.48 \]  

(4)

if the speed of vehicle \( v \) = 0 (zero) then the noise level still get the result as below:

\[ dB = 2.52 (0) + 65.48 = 65.46 \text{ dB} \]

The result indicated that if the vehicle speed is zero \( v=0 \) or the vehicle stopped then the noise still get the result of 65.46 dB.
Figure 5. Comparison of two noise level model to actual noise level

Figure 5 shows the two noise level models and actual noise level. The actual noise level is measured directly as a function of time. Predictive noise model of Nickson presented the fluctuation of noise level. In the morning, the noise level model of Nickson is below the actual noise level whereas in the afternoon the noise level of Nickson is above the actual noise level. The different noise level value reached to 2 dB.

Secondly, predictive noise level of Johnson presented the noise level fluctuation which is below the actual noise level line. The different value is about 3 dB to the actual noise level. Figure 5 shows also the difference between Nickson’s model and Johnson’s model which applied vehicle speed as a parameter. Figure 6 illustrates where the Nickson model when compared to the Johnson model shows clearly that the Nickson model and the Johnson model have the same characteristics.

5. Conclusion
In this study, the traffic noise models are presented to compare with the actual noise level. These models are developed to ensure the noise traffic prediction. Either Nickson’s model or Johnson’s model have the same characteristic to the actual noise traffic level model. The difference of noise level between Nickson’s model and Johnson’s model are about 2 dB to the actual noise traffic level. These two models could be used for noise prediction in other roads which to be a consideration to develop urban area.

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