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RELATIONSHIP MODELS OF TRAFFIC VOLUME Vs NOISE LEVEL IN ARTERIAL AND COLLECTOR ROADS

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ABSTRACT

The research aimed at analyzing relationship pattern of vehicles volume and noise level, especially on arterial and collector roads in Kendari City. Analytical approach with descriptive statistic method is using scatter plots. The results show that vehicles volume has significant relationships with noise. Noise level variability could be explained by vehicles volume of 75.2% at arterial and 77% collector road. In these case, heavy vehicles with a composition 4% has a significant role in influencing to noise on arterial road. While at the collector road with a composition 3% is not significant to noise fluctuation. The noise more dominant influenced by motorcycles and light vehicles reached 97% composition.

INTRODUCTION

The rapid growth of motor vehicles from year to year produced problem transportation. The problem manifest in a disturbed transportation system such as congestion and a decrease in environmental quality such as noise polution. In general, motor vehicles is one main source of a very significant to noise emission in urban areas with contribution of 55% of the total noise(Banerjee *et al*, 2008; Nirjar *et al*, 2003). Noise characteristics of a road definite different from the others. The difference is causeddue to traffic noise levels determined by many factors, such as the passing through motor vehicle, include: total vehicles per hour, ratio of vehicles type, average speed (Mediastika *et al.,* 2005). High traffic volume usually occurs at the arterial and collector roads. Traffic volume proportional with the noise level. It means, the higher of traffic volume then noise level will be greater. Prediction models and traffic noise simulation based on the vehicles group that is divided into 8 groups, bus, car, double cabin taxi, jeep, truck, motorcycle, three wheeled vehicles, and van. But the model only be used for stable condition with assumption that the traffic flow free from zebra cross or traffic lights. The noise value for each vehicle as dependent variable, distance and speed as independent variable.

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The measuring distance is selected perpendicular to the traffic line, that is 2.5m (L_1), 5m (L_2), 7.5m (L_3), 10m (L_4), 12.5m (L_5) and 15m (L_6). Speed in range from 20 km/h to 80 km/h (Sooriyaarachchi *et al.,* 2008). Predictive models of traffic noise can be used effectively suitable with cities condition in Iran. The used variables included vehilcle total volume, speed, truck presentation, length and width of road, gradient, and observation distance. Where the noise measuring distance from the road side, that is 3m. The produced prediction model has the least difference value, that is in average -0.24 dB and -0.77 dB for Teheran city and Hamadan city if compared by using several other models (Golmohammadi *et al.,* 2009).

Motor vehicles data in Jaipur (India) consist of two wheeled vehicles 72%, car/jeep 15%, three wheeled (12%), and the remain is bus dan truck 1%. Although the two wheeled vehicles volume was higher but from the analysis results, it was found that the light vehicles are the main sources of noise in cities. The new factors, equivalent amount of light and heavy vehicles are entered to calculate Leq value, and make comparison between L_{eq}(o), Leq(Lv), and L_{eq}(Hv). Model with L_{eq}(Lv) gave higher correlation coefficient and can be implemented to calculate the traffic noise with disturbed flow condition at urban road of India (Agarwal *et al.,* 2011).Simple and multiple regression models of the local traffic influence to the noise level for arterial road in Bali with locus By-Pass NgurahRai and Sunset Road by using the independent variables of traffic volume (MC, LV, HV), speed (MC, LV, HV), and distance from the observation point to the nearest

and the furthest road center lines. From the simple linear regression showed that motorcycle influenced dominantly 26,7% to noise level, followed by the light vehicles 20,8%, and heavy vehicles 5,7%. Thus the higher of motorcycle volume then noise level will be greater. Where, composition of motorcycle on the two streets between 55 – 72% (Wedagama *et al.,* 2012).

However, the noise model based on local traffic characteristics in the developing countries, still develop yet (Pamanikabud and Vivitjinda, 2002). Traffic conditions and vehicle characteristics in developed and developing countries is different. So toovercome this, many models are developed to predict noise level that relate with the traffic volume. Because of its reality, the traffic noise level in the developed country is not suitable to use in the developing country such as in Indonesia. Kendari city is the center of economic, industrial, trading, or educational activities in Southeast Sulawesi Province. Thus, even though still classified the medium city category, but in the last five years showed high vehicles growth, in average 19% per year (BPS Kendari, 2013). Because of that, the research aimed at analyzing the relationship pattern among three vehicles (MC, LV, HV) with traffic noise and also build the relationship models for arterial and collector road that possible to use for heterogeneous traffic of medium city.

MATERIALS AND METHODS

The research was done in Kendari City. Form 49 points sample, 35 points at the arterial road and 14 points at the collector road. Determination of sample points using incidental sampling technique by considering function and land use at the road side. In one road segment can consist of several observation sample, depend on variation or the characteristic change at one of factors. Survey of noise and traffic volume simultaneously during 10 minutes at each observation sample. Microphone SLM (Wohler SP-22) is placed at 1 m distance from the edge of pavement with Tripod height of 1, 2 m from land surface. The noise calculation using simple statistic method by creating histogram area equation L_1, L_{10}, L_{50}, and L_{90}. While to get equivalent continuous noise level (Leq) was calculated by equation (Chunnif, 1977; Mediastika, 2005):

$$L_{eq} = L_{50} + 0{,}43\ (L_1 - L_{50}) \quad \ldots.(1)$$

Where:

L_{eq} = equivalent continuous noise (dBA)
L_{50} = noise exceeded 50% (dBA)
L_1 = noise exceeded1% (dBA)

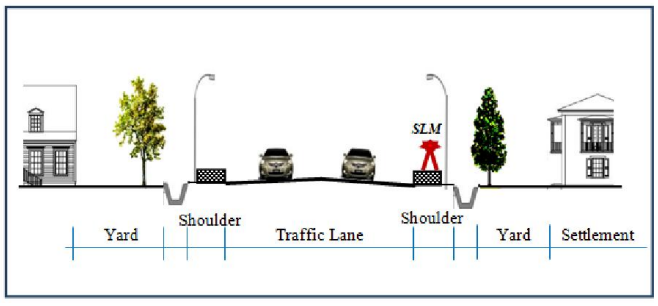

Fig. 1. SLM Placement Scheme

RESULTS

Traffic Volume

Observation is done to three types of vehicles, motorcycle, light vehicles, and heavy vehicles. Based on the observation results at 35 points at arterial road and 14 points at collector road, then obtained vehicles volume per hour as shown in Figure 2 and 3.

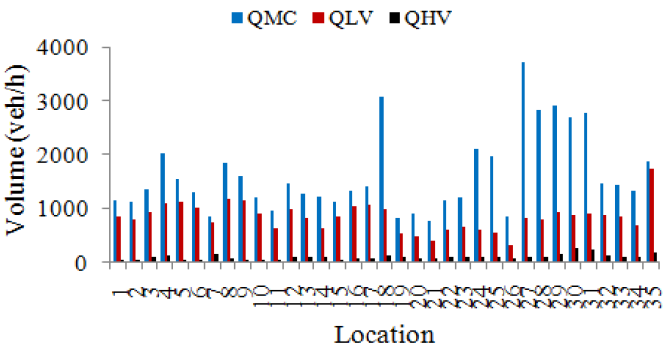

Fig.2. Traffic Volume (Arterial roads)

Figure 2 showed that the traffic at arterial road very fluctuated from 1242 to 4632 veh/h. The highest volume in average at the road segment for trading and services. If compared between primary and secondary arterial roads, the volume was higher at secondary arterial road. It was because the road for by-pass ring road that connects periphery areas with center of social activities, such as trading, office complex, and services in the downtown. So it is not surprising if the number of heavy vehicles passing through averages above 100 veh/h.

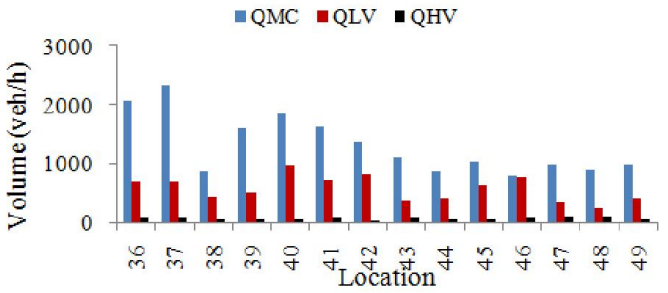

Fig. 2. Traffic Volume (Collector roads)

Figure 3 showed that the traffic volume at collector road fluctuated from 1218 to 3090 vehicles/jam, lower than arterial road. The highest volume in average at the primary collector road, at the education area. It was because the road segment was the main road to one of university and also connector from the periphery area to the downtown. The number of heavy vehicles passing through in this lane average under 100 veh/h. The use of motor vehicles in Kendari city is dominated by motorcycle than other vehicles. The vehicles composition at the arterial road, namely: motorcycles 63%, light vehicles 33%, heavy vehicles 4%. While at collector road, motorcycles 68%, light vehicles 29%, heavy vehicles 3%. Composition of motorcycle at collector road is higher than arterial road.

Table 1. Noise level in Arterial and Collector Roads

Location Number	N_L (dB)	Location Number	N_L (dB)	Location Number	N_L (dB)	Location Number	N_L (dB)
1	75.6	14	74.6	27	78.6	40	77.6
2	73.4	15	74.6	28	75.7	41	74.4
3	74.3	16	75.5	29	78.0	42	74.0
4	75.6	17	75.8	30	79.4	43	70.6
5	76.8	18	76.7	31	77.8	44	70.0
6	75.1	19	74.1	32	75.7	45	73.7
7	74.1	20	73.8	33	75.2	46	70.8
8	76.1	21	71.4	34	75.5	47	71.4
9	75.7	22	75.5	35	77.8	48	72.3
10	75.3	23	75.4	36	75.3	49	73.4
11	74.0	24	75.5	37	77.9		
12	76.0	25	76.6	38	72.6		
13	73.0	26	71.9	39	74.9		

Description: N_L = Noise Level

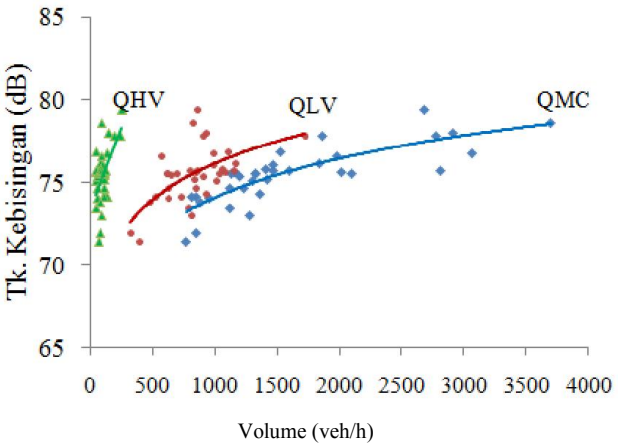

Fig.4. Volume Vs Noise (Arterial road)

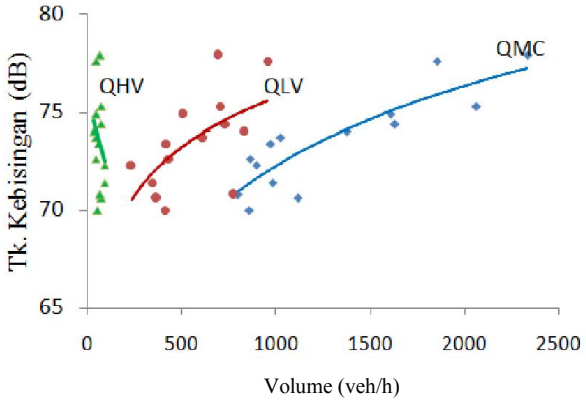

Fig. 5. Volume Vs Noise (Collector road)

Traffic Noise Level

The obtained noise level from the field observation was fluctuating value. So to get representative value, it should be got the equivalent continuous noise level (L_{eq}). The analysis results can be seen Table 1, number 1 to 35 were the noise level at arterial road while number 36 to 49, the noise at the collector road. Table 1 showed that the noise level has surpassed quality standard if refer to the allotment threshold for settlement area (NAB_1 = 55 dB) or for trading and services (NAB_2 = 70 dB). Where entirely, the average noise level at the arterial road was 75, 4 dB while at collector road Was 73,5 dB.

The pattern of relationship between two variables based of function the way, as shown in Figure 4 and 5.

Table 2. Relationship Models

No	Model	p-value	R^2	Description
1	$N_L = 48{,}01 * Q_{Tot}^{0{,}058}$	0,000	75,2	Arterial
2	$N_L = 67{,}1 + 0{,}003 Q_{Tot}$	0,000	76,9	Collector
3	$N_L = 34{,}89 + 5{,}18 . \ln(Q_{Tot})$	0,000	75,4	Combination

N_L = Noise level, Q_{Tot} = Total traffic volume

DISCUSSION

Relationship plots between the volume (Q_{MC}, Q_{LV}, Q_{HV}) with noise level (N_L) at arterial roads formed positive non-linear relationship, either motorcycles, light vehicles, or heavy vehicles with the noise. It means that each addition of volume from the three types of vehicles will increase the noise level of traffic. Based on the correlation analysis results which was the determination coefficient roots, obtained the relationship of Q_{HV} with noise (strong, R= 0,55), Q_{LV} with noise (strong, R = 0,62), and Q_{MC} with noise (very strong, R = 0,83). Among the vehicles types, motorcycle was most dominant 68,1% followed by light vehicles 38%, and heavy vehicles 30,3%.It was relevant if looked at from the vehicles that passing through the arterial road, around 63% used motorcycles. While the relationship between vehicles volume (Q_{MC}, Q_{LV}, Q_{HV}) with noise level N_L) at collector roads, motorcycles and light vehicles made positive non-linear relationship, means each addition of motorcycles and light vehicles will increase the noise.

While for the heavy vehicles, made negative linear relationship, the more heavy vehicles the lover noise. In this case the heavy vehicles composition only 3%, so the increase or decrease of heavy vehicles volume did not influence significantly to the noise, noise fluctuation is more influenced by motorcycles and light vehicles, whose composition reached 97%.It can be proven from the correlation value of each vehicles. Based on the correlation analysis, obtained the relationship of Q_{HV} with noise (weak, R = 0,28), Q_{LV} with noise (strong, R = 0,62), and Q_{MC} with noise (very strong, R = 0,88). Among the three vehicles types, motorcycles the most dominant influencing the noise level, that was 76,6% followed by light vehicles 38,2%, and heavy vehicles 8,1%. It was relevant if looked from the passing through vehicles at the collector road about 68% used motorcycles. Motorcycle is

the most influencing factor for the noise in Kendari city compared with other vehicles. It also occurs in Bali, where the motorcycle volume influenced most dominantly 26,7% to the nose level (Wedagama, 2012).

If look at the vehicles composition in arterial road in Bali (By-Pass NgurahRai and Sunset Road) and compare it with Kendari city, it can be assumed that if the composition of motorcycle more than 60%, then the noise level dominantly caused by motorcycle. But the research results in the developing countries showed the light vehicles are the main sources of noise pollution, although the two wheeled vehicles reached 72% compared with car/jeep (15%), three wheeled vehicles (12%), and the remain is bus and truck 1% (Agarwal 2010). It could be occurred because of the different characteristic of vehicles or speed. The predictive model of relationship between vehicles volume and noise should be developed because actually each country has specific characteristic. The differences include; vehicle physical characteristic, speed, road physic, and environmental condition. From several alternatives of Statistical test results, it was obtained the relationship model of vehicles volume and noise on arterial road, collector road, and arterial-collector combination.

Conclusion

Vehicles volume has significant relationship with the noise. The variability of noise level could be explained by vehicles volume explained by vehicles volume of 75.2% at arterial road and 77% at collector road.Heavy vehicles with a composition 4% had a significant role in influencing the noise on arterial road. While at the collector road with a composition only 3% is not significant to the noise fluctuation, where the noise more dominant influenced by motorcycles and light vehicles reached 97% composition.

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