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Assessment of Traffic Noise Pollutions Outside School, Residential, Hospital and Commercial Areas along Jalan Kluang, Batu Pahat, Johor

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Abstract: The increasing numbers of vehicles are the major factor that contributes to the noise pollution. Some of the residential areas and schools near busy traffic road were built many years before the development took place. Major effects of traffic noise pollution include interference with communication, sleeplessness and reduced efficiency. In Malaysia, a guideline for environmental noise limit has been set by Department of Environment (DOE) in order to minimize traffic noise pollution. The aim of this study is to assess the traffic noise pollution occurred in residential, school, hospital and commercial areas along Jalan Kluang, Batu Pahat, Johore, Malaysia. Traffic noise measurement consists of 9 survey locations were carried out using data logger Type RS-322 along with traffic volume. The assessments were carried out during peak hours which covered morning peak hours (7.00 a.m. to 9.00 a.m.) and evening peak hours (5.00 p.m. to 7.00 p.m.). Traffic noise indicators of L_{Aeq}, L_{10}, L_{90}, Traffic Noise Index (TNI) and Noise Pollution Level (LNP) were estimated in the present study. Besides, the recorded noise levels were also compared with the permissible limit that has been set in Malaysian legislation. The overall traffic noise assessments for all 9 locations along the Jalan Kluang were beyond the standard limit set by DOE during daytime. The noise produced by the traffic along the Jalan Kluang, Batu Pahat is considerably high and could lead to serious impact to the quality of life.

Keywords: Traffic Noise, Urban Noise, Noise Pollution

1. Introduction

The development of cities or countries contributes to the increasing number of vehicles especially on ground transportation. This is due to rise of population and many people use vehicles to go to their work or destinations. When the vehicles on road are increasing, it will lead to higher traffic noise levels and become one of the urban pollutions [1]. In Asia, developing countries such as China, India and Vietnam are facing the serious problem of traffic noise pollution occur in their major cities [2].

The major sources of this urban pollution come from ground transportation networks. Noise pollution from road traffic also gives negative impacts to the urban communities and surrounding environment [3]. If the noise level of these areas exceeds the permissible limit, the sleeping, resting, health, studying and communication among population nearby

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the traffic roads will be affected. With the large volume of traffic, the traffic noise forms annoying sound from the road and give disturbing noise to the residents nearby. This is due to the fact that traffic noise was produced from the friction between vehicle's tires and the surface of the road [4].

According to the European Environment Agency (EEA) noise assessment report, urban noise is a major environmental health treats in Europe. From the report, road traffic is the significant source of environmental noise with an estimated 125 million people affected by noise levels greater than 55 decibels dBA [5]. Malaysia as one of the developing countries also cannot be excluded from this problem due to the development pace that constantly occurs with the increasing number of road transportation networks in supporting the development process. The main contributors to road traffic noise are motor vehicles, aircrafts, and train [6].

Similar to other developing countries, Malaysia is also facing noise pollution problem. The Star Online, (2016) stated that a total of 132 noise pollution complaints have been reported to the Department of Environment, Malaysia in 2015. The majority of the complaints were reported due to the noise from the commercial and construction sites. Other noise pollution complaints were reported regarding the noise that came from industrial and transportation system. Although traffic noise annoyance was not the major source of nuisance, but the expert has highlighted that road traffic noise is the most pervasive noise pollution over the world [7].

Therefore, from this study, the external noise level of noise sensitive areas (school and hospital), residential areas and non-sensitive areas (business and commercial) along busy road of Jalan Kluang were investigated. The assessment of traffic noise pollution at these areas also were compared with the noise limit and control that has been set by Malaysian Department of Environment.

2. Traffic Noise Limits

Traffic noise is globally recognized major problem in that affects the quality of life in urban cities [1]. According to the World Health Organization (WHO) safe sound levels are below 55-65 dBA. About 40% of the populations at European countries are exposed to the noise pollution with an equivalent sound pressure level exceeding 55 dBA. Noise levels beyond this value are classified as noise pollution.

The noise pollution problem is more pronounced in big cities. In Malaysia, the issue of noise pollution is not a new issue. The noise pollution problem received the attention of the authorities in Malaysia in 1979. This situation shows that Malaysians are increasingly aware of the situation and problems of noise pollution faced mainly in large urban areas [8]. Based on the environmental control set by the Malaysian Department of Environment (2007), at suburban and residential areas, the maximum permissible noise level outside the low density residential areas should not exceed 55 (dB) in order to protect community from this urban noise as shown in Table 1 [9].

Table 1 - Traffic noise exposure limits set by Malaysian legislation [9].

Receiving Land Use Category	Day Time	Night Time
Noise Sensitive and Residential areas (Low Density)	55 dBA	50 dBA
Suburban Residential (Medium Density)	60 dBA	55 dBA
Urban Residential (High Density)	65 dBA	60 dBA
Commercial, Business	70 dBA	60 dBA
Industrial	75 dBA	65 dBA

Every place in the world are tending to be exposed by noise pollution. However, not every place can tolerate with noisy environment especially noise sensitive location such as school and residential area. World Health Organization (WHO) and other guidelines which have outlined the noise limit recommendations for the activities conducted during daytime or at night. According to WHO noise level for residential areas indoor and outdoor varies from 30 to 55 dBA. Critical effects from noise pollution mainly contribute to annoyance and sleep disturbances. In addition, Table 2 shows noise limit among selected countries which classified into daytime and night time noise level [10], [11].

3. Study Areas and Measurements

The methodology of this study comprises of step to step chronology, which is shown in Fig. 1. The noise assessment of this study includes residential, school, hospital and commercial areas related to traffic noise was conducted along Jalan Kluang Batu Pahat. Jalan Batu Pahat – Kluang- Mersing or Federal Route 50 is a main federal road in the state of Johore, Malaysia which connect Batu Pahat in the west to Jemaluang in the east of Peninsular Malaysia. The starting point of

this federal route or kilometer zero is located at Batu Pahat of Jalan Kluang. This road is also a main route to North-South Expressway Southern Route via Ayer Hitam Interchange. There are schools, residential buildings, hospital and commercial buildings located next to this federal route.

Table 2 - Recommended noise level standard and guidelines by WHO and selected countries [10], [11]

Noise Level Limit	Noise level, L_{eq}	
	Dayti	Night
WHO	55	45
Germany (Noise level guidelines)	45	35
Australia (Recommended outdoor background noise level)	45	35
Japan (Environmental quality standards)	45	35
Korea (Environmental quality goal)	50	45
Philippines (Environmental quality noise standards)	50	40
Iran		
(Residential area)	55	45
(Commercial area)	65	55
(Industrial area)	75	65

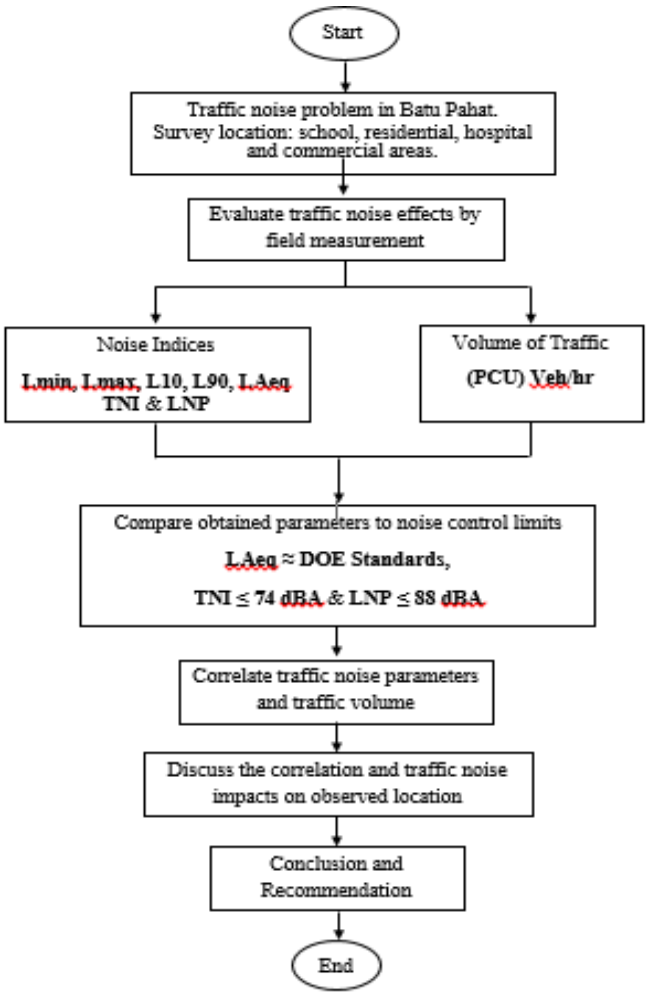


Fig. 1 - Methodology chart of the present study

From the data by Transport Statistic Malaysia (2015), there are 41632 numbers of vehicles using Jalan Kluang every day. In the morning, the Jalan Kluang, becomes busier as many people living around this area using this road toward Batu Pahat and Kluang directions to their destinations. A total of nine sampling points were selected in this study to evaluate the traffic noise effects to the population surrounding as shown in Table 3. Four of the measurement sites represented school environment while one site be regarded as hospital environment which all of these points were considered noise sensitive receiver areas. The rapid urbanization of Batu Pahat town made this area categorized as urban area. In this study, three urban residential areas and a commercial area was chosen for the traffic noise investigation. All sampling sites are located near the roadside along Jalan Kluang, Batu Pahat.

Table 3 - Measurement locations.

No	Area	Location	Coordinates
1	School	SK Pintas Puding	1.8571° N 103.1000° E
2		SK Pintas Raya	1.8477° N 103.0717° E
3		SJK(C) Kong Nan	1.8664° N 103.1168° E
4	Residential	SK Bukit Soga	1.863216ºN 102.955564ºE
5		Kampung Istana	1.863159ºN 102.958450ºE
6		Taman Koperasi Bahagia	1.859886ºN 102.949631ºE
7		Wisma Yatim	1.855333ºN 102.947356ºE
8	Hospital	Pantai Hospital	1.86117ºN 102.951229ºE
9	Commercial	Old Town Street	1.862844ºN 102.953091ºE

The sound data logger Type RS-322 was used as main equipment of this study to measure the external noise level as shown in Fig. 2. The traffic noise measurements were conducted according to the guidelines that has been set by Malaysian Department of Environment [9]. A-weighted sound levels were adopted in the present study which corresponds to the inverse of equal-loudness curve for the human ear.

The traffic noise assessments were conducted on weekdays taken between Sunday and Thursday. Noise surveys were taken during the peaks hours which cover morning peak hours (7-9 am) and evening peak hours (5-7 pm). The observations were carried out with minimum of 2 days and maximum up to 3 days per site.

In addition, traffic counts also were performed during the noise levels assessments. The traffic volume was done manually by counting the vehicles that passed through observation site. The types of motor vehicles were classified into four categories, namely, motorcycles (1), cars (2), van or medium lorries (3) and heavy vehicles (4) that include buses, lorries and trailers. The results of traffic counts were recorded in form of the total traffic volume. The number of vehicles was calculated to see the relationship between the numbers of vehicles passed by and the traffic noise level obtained at the measurement sites.

Fig. 2 - On-site traffic noise measurement at SK Pintas Puding (school environment).

Equivalent continuous level, L_{Aeq} is a single number descriptor that commonly used for environment noise. This parameter most often use is $L_{Aeq,T}$ which is sound pressure level of the steady sound that would result same energy being produced over a certain period of time, T as shown in Equation (1). The duration of present study for each measurement was 2 hours and the sound pressure levels were logged every minute during the observations. Thus, for each sampling site, a total of eight hours measurements which two in the morning (AM) and two in the evening (PM) for at least two different days. Fig. 3 shows the variation of equivalent continuous traffic noise levels for different time intervals. Altogether, there are 4320 measurement data for analysis. From the figure, it can be seen that the equivalent continuous traffic noise data was quite steady during measurements. The $L_{Aeq,2hrs}$, $L_{Aeq,1hr}$ and $L_{Aeq,30mins}$ are between 65.5 to 66 dBA for both measurements, thus only data with 1 hour equivalent continuous level, $L_{Aeq,1hr}$ were presented for the rest of this paper.

$$L_{eq} = 10 \log_{10} \left[\frac{1}{N} \sum_{i=1}^{N} \left(a_i \log_{10} \right) \right] \quad (1)$$

Besides, traffic noise index (TNI) and noise pollution level (LNP) also were adopted in the present study to evaluate the traffic noise pollution levels at the studied areas [12-13]. The TNI and LNP values were obtained by calculation based on measured noise indices such as L_{Aeq}, percentiles of L_{10}, and L_{90}. The traffic noise index of TNI can be derived as shown in Equation 2. The noise variability in L_{10} is quite un-linear so the TNI derived to make respective allowance [14]. Thus, the TNI values should not be more than 74 dBA to maintain healthy noise environment especially to location near to residents. Noise pollution level, LNP can be derived by combining noise indices L_{Aeq}, L_{10}, and L_{90} as shown in Equation 3. LNP is considered as the variations in sound signal that serves as a better indicator of environment pollution [15]. It is also considered as good indicator of physiological and psychological impact of noise where the permissible limit of LNP is 88 dBA.

$$TNI = 4 (L_{10} - L_{90}) + L_{90} - 30 \quad (2)$$

$$LNP = L_{eq} + (L_{10} - L_{90}) \quad (3)$$

4. Results and Discussion

The overall results of the traffic noise assessments and traffic noise indices of $L_{Aeq\ 1hr}$, L_{10}, L_{90}, TNI, LNP were shown in Table 4. Besides, the total traffic volume with different categories of vehicles also were presented in the same table. The A-weighted equivalent continuous levels for all measurement sites except at commercial area were exceeded the permissible noise limit of Malaysian legislation. Even the background noise level, L_{90}, for all sensitive receiver areas (school and hospital environments) were exceed the noise limit that has been set by DOE, Malaysia. This indicated that the traffic levels in the ambient condition of school and hospital surrounding of studied areas were already serious.

From the table, it can be noticed that the TNI values for all the measured school areas and residential area of Kg Istana were greater than 74dBA. This indicated that the population at these sampling locations were affect by the noise from the traffic roads. The teaching and learning process in the schools may interrupt by the urban traffic noise while the residents at Kg Istana may annoying with the traffic noise nearby. The noise pollution level (LNP) at school area of SK Bukit Soga and residential area of Kg Istana have been exceeded the limit of 88dBA. Although LNP at other sites do not exceed the permissible limit, the values of most the studied areas that obtained were more than 80dBA. Precaution actions should be taken in order to reduce the noise pollution impacts to the population in Batu Pahat especially located next to the heavy traffic road of Jalan Kluang.

SK Bukit Soga show the highest volume of vehicles as the school was located near the four way intersection which illustrates more vehicles that coming thru and forth from all four direction. In addition to that, at SK Bukit Soga and SK Pintas Puding there were speed breaker with traffic signal located at the intersection. SK Pintas Raya and SJKC Kong Nan has no any road furnishes in front of the schools. That means, vehicles might speed in front SK Pintas Raya and SJKC Kong Nan compare to SK Bukit Soga and SK Pintas Puding which near the traffic signal that might slow down the vehicles. Noise levels increase as the number of vehicles and average speed increases.

Overall traffic noise on working days at Hospital Pantai outside is around (~) 66 dBA during both peak hours. Hospital Pantai recorded the lowest traffic noise levels among the nine selected location. This may due to the fact that the distance of sound data logger was set up 5m from the main road of Jalan Kluang and there was a slope that separated the busy traffic road with the hospital.

The average value of LAeq at commercial building shop also shows higher levels of traffic noise. LAeq value on working days at commercial building is nearly 70 dBA. Old town street is located on a busy street same as Kampung Istana and SK Bukit Soga. This situation caused a less traffic noise level because of the traffic light nearby makes speed of vehicles quite slow at the station. Speed of traffic flows passing through are mostly contributed the traffic noise level at commercial building quite less than Kampung Istana and SK Bukit Soga. The traffic noise level at this location does not exceed the standards outlined by the World Health Organization (WHO) and Department of Environment (DOE) for day time of 70 dBA.

Fig. 4 shows the average noise levels at different sampling locations compared to the permissible limit set by Malaysian Department of Environment. The noise levels at the school areas were higher than noise limit of ~ 20 dBA. This condition will definitely affects the communication and teaching and learning activities in the schools. Noise level shown might interfere the learning process in the school as the schools has two learning sessions held in the morning and evening. However, all schools involved in observation exceeded the standard set by DOE which is 55 dBA. There was about 10 dBA of noise level at Pantai Hospital that over the noise limit. For the residential areas, the recorded traffic noise levels were higher than DOE limit from ~ 2dBA to ~11 dBA. Higher noise levels recorded at the area of Kg Istana.

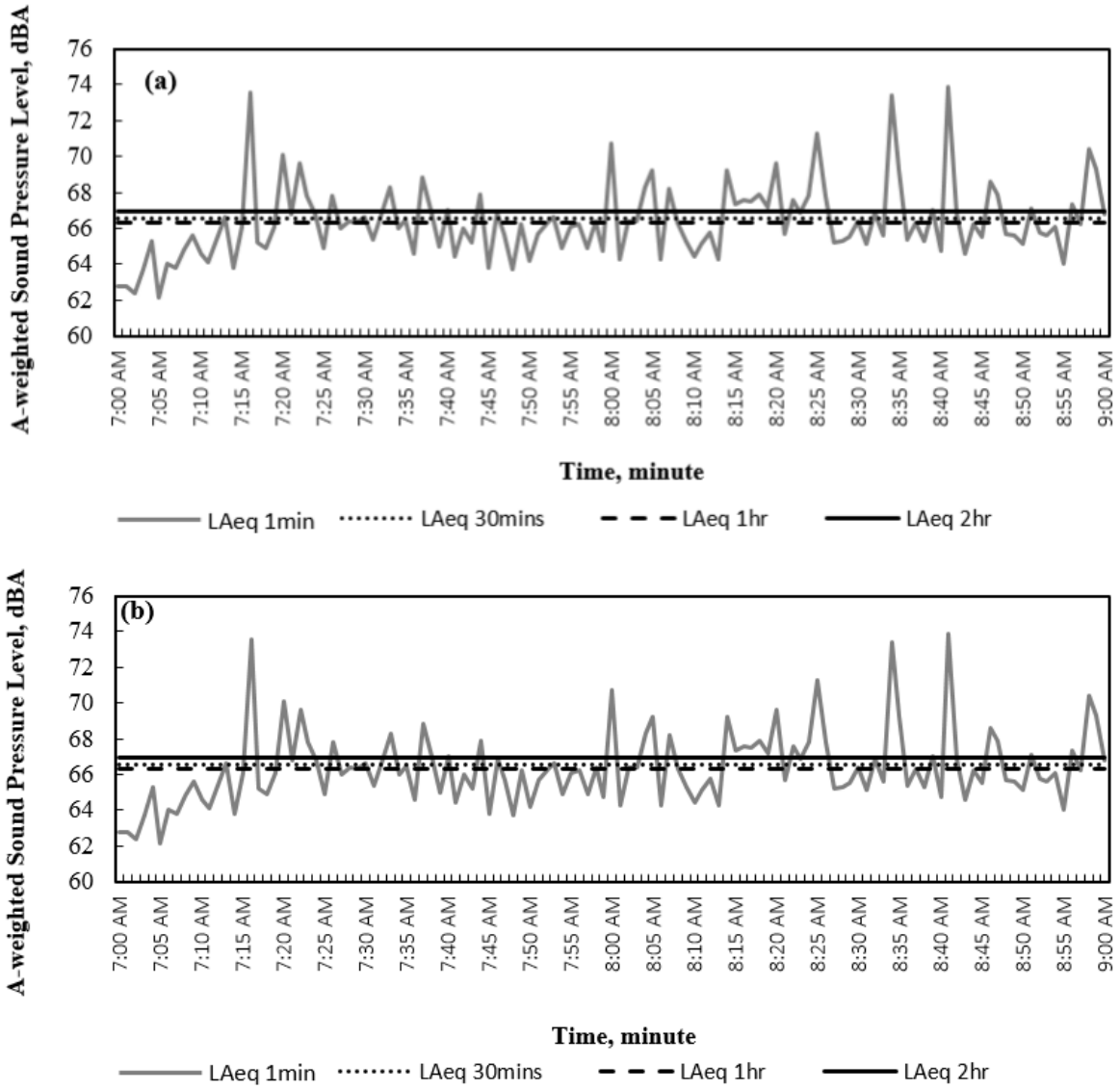


Fig. 3 - Variation of A-weighted equivalent continuous noise level for 2 hours, 1 hour and 30 minutes (a) Morning peak hours; (b) Evening peak hours

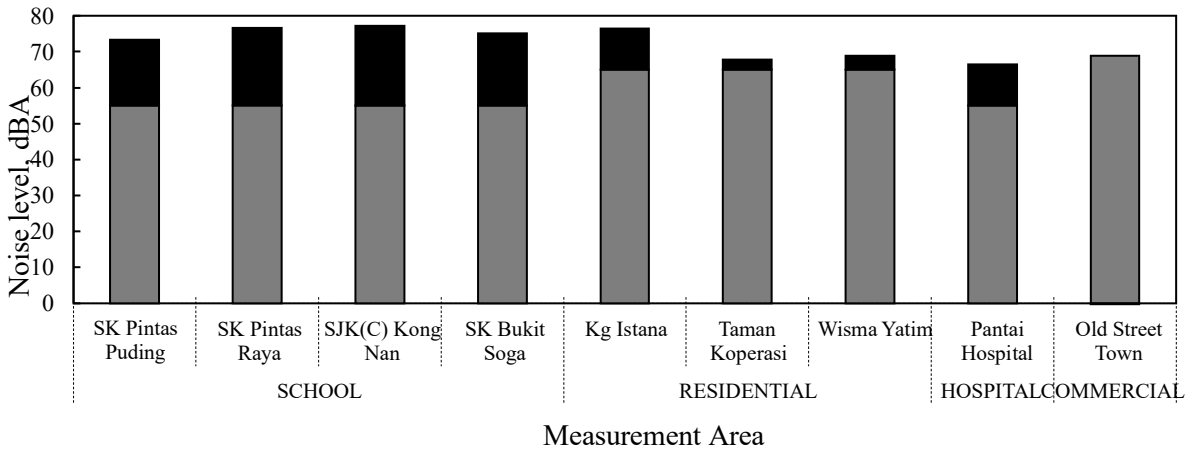


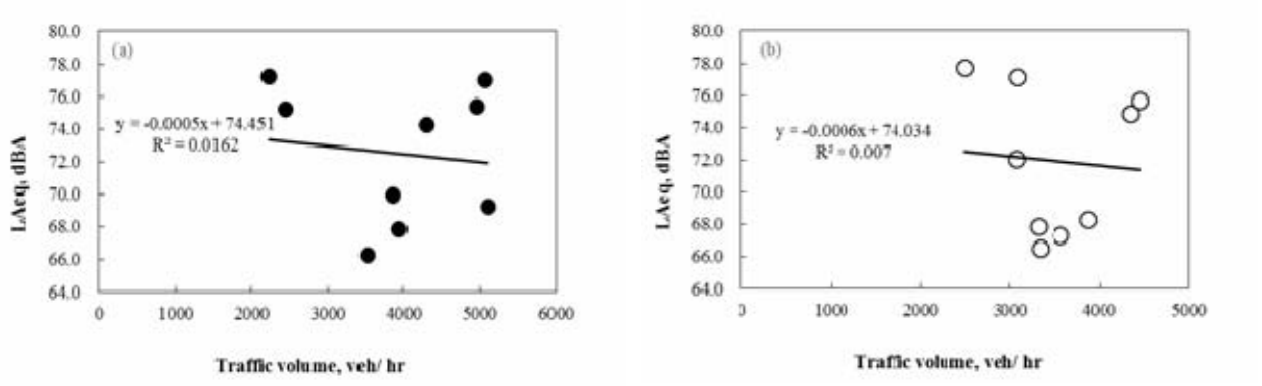
Fig. 4 - Average noise levels at different sampling locations. Dark colored areas indicate that the noise levels exceeding the permissible limit set by Malaysian Department of Environment

Areas	Malaysian noise limit	Locations	Measurement time	LAeq 1br	L10	L9o	TNI	LNP	Vehicle Class 1*	2*	3*	4*	Total Traffic Volume
School	55dBA	SKPintas Puding	AM	74.3	77.3	65.8	81.8	85.3	1343	2434	341	169	4287
			PM	72.1	74.9	60.9	87.1	86.1	641	2031	167	239	3077
		SK Pintas Raya	AM	75.2	78.2	67.5	80.3	85.1	706	1523	141	76	2446
			PM	77.7	80.3	71.1	78.1	86.8	723	1559	136	78	2497
		SJK(C) Kong Nan	AM	77.2	80.4	69.6	83.1	87.9	684	1296	143	101	2224
			PM	77.1	80.1	69.8	81.0	87.6	910	1853	182	139	3084
Residential	65dBA	SK Bukit Soga	AM	75.4	78.3	67.5	80.8	86.9	1356	3319	206	74	4955
			PM	74.9	77.4	64.2	86.9	88.1	839	3154	273	85	4351
		Kg Istana	AM	77.0	79.8	68.9	82.5	88.4	1376	3440	140	113	5069
			PM	75.7	78.0	68.2	77.6	86.3	705	3616	91	41	4453
		Taman Koperasi	AM	67.8	70.1	62.6	62.8	76.5	1116	2601	179	41	3937
			PM	67.9	70.7	62.0	66.9	77.3	731	2390	139	54	3314
		Wisma Yatim	AM	70.0	70.6	61.6	67.9	78.5	965	2731	140	26	3862
			PM	67.3	69.0	58.6	70.4	78.9	414	3086	53	16	3569
Hospital	55dBA	Pantai Hospital	AM	66.3	67.8	63.8	49.9	71.0	1305	1967	158	89	3519
			PM	66.5	69.5	63.1	58.8	72.4	689	2423	163	57	3332
Commercial	70dBA	Old Street Town	AM	69.3	72.0	65.5	61.7	76.4	1392	3497	157	62	5108
			PM	6R.3	70.7	62.3	66.0	76.6	762	2R57	119	132	3R70

Vehicle Class'–!': Motorcycles; 2': Cars; 3: Van or medium lorries; 4': Heavy vehicles (buses, lorries and 1hailers)

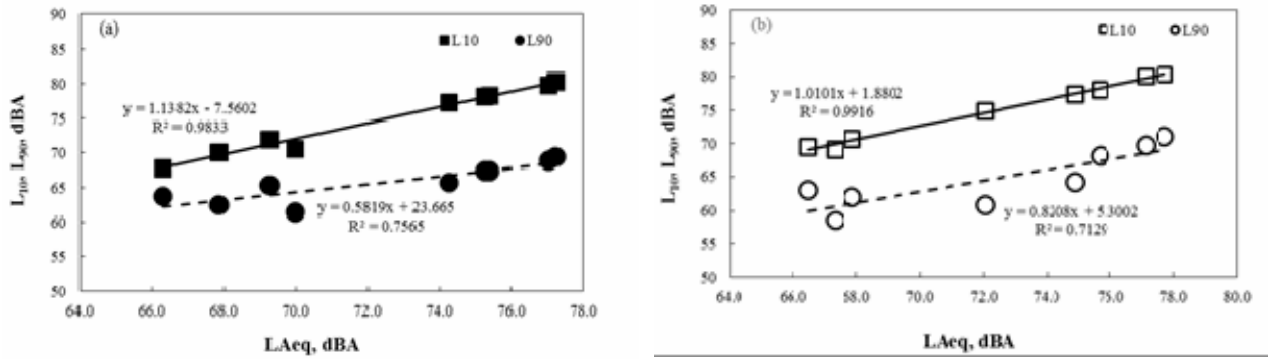
According to standards set by DOE and WHO all observed stations recorded noise levels above the noise limit which indicates seriousness of noise pollution rate in residential, school, respective commercial and hospital areas along the Jalan Kluang Batu Pahat. All locations are along the Jalan Kluang but the variation among the traffic volume clearly associate with road condition, design and furniture's play main role to manipulate the noise level. Fig. 5 shows the relationship between average traffic noise levels and traffic volume of the studied areas. From the graphs, there are negative gradients for both morning and evening observation peak hours. Although graphs indicated negative relationship between L_{Aeq} and traffic volume but the R^2 values are too small which means the traffic volume of Jalan Kluang has no significant effect on average traffic noise levels of $L_{Aeq\ 1hr}$. Other factors such as distance from the road, speed of the vehicles and the pavement conditions may affects the traffic noise levels.

Linear realtionship between L_{10} and L_{90} with L_{Aeq} were observed in the Fig. 6. The measurement points of L_{10} were in a good fitted with L_{Aeq} which the correlation coefficient R^2 = 0.98 and 0.99 for morning and evening peak hour measurements, respectively. Thus, the prediction of L_{10} can be made and it was realiable after the equivalent continuous noise level, L_{Aeq} is known. The correlation between L_{90} and L_{Aeq} is not good as than observed between L_{10} and L_{Aeq} . This similar trends were also found in study of Mirhossaini and Pourzamani [11].



(a) (b)

Fig. 5 - Relationship between traffic noise levels and traffic volume (a) Morning peak hours; (b) Evening peak hours



(a) (b)

Fig. 6 - Correlation between the percentile level L_{10}, L_{90} with LAeq. (a) Morning peak hours; (b) Evening peak hours

5. Results and Discussion

Field measurements on traffic noise assessments were carried out in the present study. The aim of this study was to evaluate the urban noise levels along Jalan Kluang respective residential, school, hospital and commercial areas to identify the seriousness of traffic noise pollution in Batu Pahat. In conclusion, traffic noise levels at all measurement locations except commercial area were exceeded the permissible limit set by Department of Environmental, Malaysia. The traffic noise pollution at Jalan Kluang must be taken seriously to enhance acoustical environment in Batu Pahat. Several noise indices including LAeq, L_{10}, L_{90}, TNI and LNP have been evaluated in order to determine the traffic noise pollution to the population nearby. The results showed that Kampung Istana were recorded the highest traffic noise

pollution problem among the residential areas been observed at Jalan Kluang Batu Pahat. Furthermore, results proven that the selected schools been observed along Jalan Kluang suffered from traffic noise pollution.

The traffic volume of this road is found to be insignificantly affects the noise levels of the measured areas. The difference in noise levels are due to the several factors such as the vehicle speeds and the conditions outside the sampling points. Since Jalan Kluang is the main road that connecting Ayer Hitam, Parit Raja and Batu Pahat, the drivers tend to speed their vehicles especially toward Parit Raja where the road is straight and wide. More detailed studies in the future are necessary to identify the extent to which factors affects the level of traffic noise along this busy road. Besides, other factors that may affects the communication, sleepless disturbance, teaching and learning environment in these areas also are needed.

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