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STUDY ON ENVIRONMENTAL NOISE POLLUTION AT THREE DIFFERENT PRIMARY SCHOOLS IN KUALA TERENGGANU, TERENGGANU STATE

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Abstract: Most of schools in Malaysia are located near the roadside, thus facing problems of noise pollution. Children exposed to elevated noise level had significantly decreased attention, social adaptability and increased opposite behavior relation to the other people. The increasing number of motor vehicles is among a trigger factors contributing to the noise pollution. This paper reports the level of traffic induced noise pollution at three primary schools in Kuala Terengganu with different surrounding activities i.e. industrial, commercial and residential. Noise levels were measured over six days at each schools comprising of three school and three non-school days from 0700 hours to 2200 hours every day. Noise measurement parameters analyzed were L_{max}, L_{Aeq}, L_{min}, L_{10} and L_{90}. Results showed that noise level at each location is significantly different ($P<0.05$), and at all locations, the noise level exceeded the acceptable limit. Principal Component Analysis (PCA) showed that the classes of motor vehicles that significantly contribute to noise level were motorcycles, passenger cars and small lorries. Highest noise level was recorded at school located within the industrial area, followed by commercial and residential area respectively.

Keywords: Noise pollution, motor vehicles, primary schools, sound level meter, Malaysia.

Introduction

The success achieved by the developed countries in terms of economic development, social and cultural has created noise problem. This is due to combination of factors including the scarcity of habitable land, the economic growth and a concentrated road transport network to support the economic growth. Malaysia is no exception from this problem due to the development pace that constantly occurs with the increasing number of road transport in supporting the development process. Traffic noise is one of the major environmental noise problems of which the main contributors are motor vehicles, aircrafts and trains (Mehdi *et al*., 2011).

Excessive noise level at school areas can affect psychology and physiology of both teachers and students. This is due to the development process, especially development near the school areas. It can effects focus on study, communication and more extremes can default hearing. Research shows that primary school children are able to hear and answered their teacher in a bit noisy environment, but younger children, age 6-7 years are difficult to cope rather than older children, age 11-12 years in same situation (Shield & Dockrell, 2004). Children exposed to elevated noise level had significantly decreased attention, social adaptability and increased opposite behavior relation to the other people (Ristovska *et al*., 2004). The chronic noise level exposure could impair cognitive development in children, specifically reading comprehension (Stansfeld *et al*., 2005). The age of primary school children in Malaysia is within the range of 6 to 12 years old. The extreme noise level could disrupt learning process of children, especially in primary schools.

Therefore, considering these points, we decided to evaluate the environmental noise level at three primary school areas having different surrounding activities of industrial, commercial and industrial areas as most of schools are located near the road sides, thus be affected by traffic noise problems. Apart from that, Principal Component Analysis (PCA) will be utilized to determine classes of motor vehicles that contribute significantly to the noise pollution. Statistics from the Road Transport Department of Malaysia (2013) indicate that there is an increasing trend of motor vehicles registered in Malaysia from year 2008 till 2013 by 30% as shown in Table 1.

Table 1: Total registered motor vehicles

Year	Total Registered Motor Vehicles
2008	17, 971, 901
2009	18, 760, 878
2010	20, 188, 565
2011	21, 401, 269
2012	22, 702, 221
2013 (as of 30th June)	23, 376, 716
Total	124, 401, 550

Source: Road Transport Department, Malaysia (2013)

Table 2: Location of study areas

Primary Schools	Surrounding Activities	Latitude & Longitude
Sekolah Kebangsaan Gong Badak	Industrial	5º23'49.6494" 103º4'25.9716
Sekolah Kebangsaan Paya Bunga		18, 760, 878
Sekolah Kebangsaan Tok Jembal		20, 188, 565

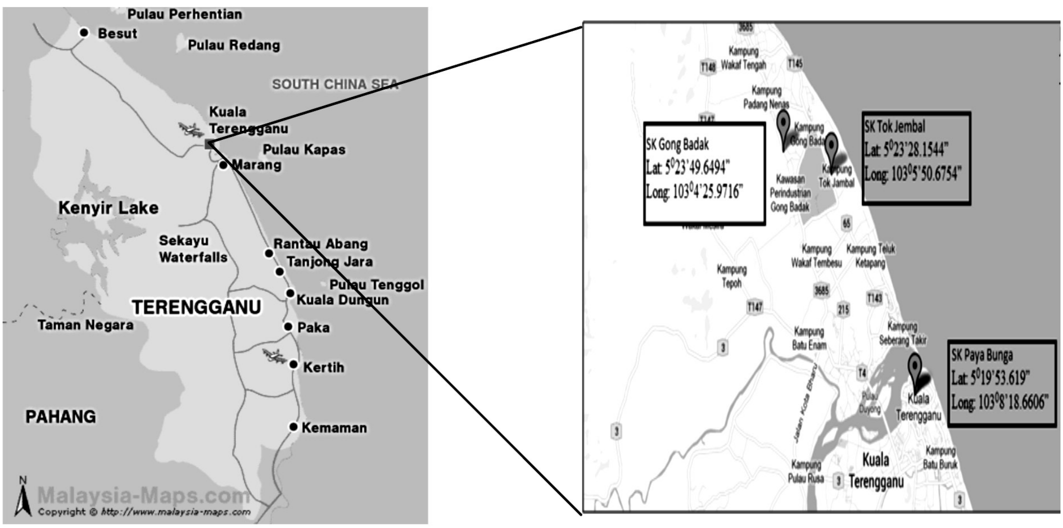

Figure 1: Map of the study areas

Material and Methods

Study Area

Three schools with different surrounding activities representing residential, industrial and commercial areas were selected for this study (Figure 1 and Table 2). Sekolah Kebangsaan Tok Jembal (SKTJ) which represents residential area is located within the vicinity of Seberang Takir and covered an area of 39388 acres with total population of 3,636 peoples. Hence, this residential area is classified as "low density residential areas" since the population is less than 75 persons per acre (Planning Guidelines for Environmental Noise Limit and Control, 2007). Sekolah Kebangsaan Tok Jembal (SKTJ) representing industrial area is located within the locality of Gong Badak Industrial Area, which comprises of mixed industries such as electronics, transportation and food processing. Meanwhile, Sekolah Kebangsaan Paya Bunga (SKPB) representing commercial area is located in the Kuala Terengganu city center. Commercial activities surrounding the SKPB encompass of shop lots, entertainment centers, hotels, food and beverage centers and wet market (Urban and Regional Planning Department of Kuala Terengganu, 2010).

Sampling Activity

Noise measurement was performed according to Planning Guidelines for Environmental Noise Limit and Control, 2007, using Sound Level Meter (SLM) which complies with IEC 61672 Class 1 Standard while wind speed was measured via hot wire anemometer (Kanamox Climomaster). Microphone was placed on a tripod stand at a height of 1.5m above ground at an angle of approximately 70 degrees to the source noise, at least 1m from any reflecting surface; and no noise reading were measured when the wind speed exceeds 5 m/s. The parameters measured were L_{eq}, L_{max}, L_{min}, L_{10} and L_{90}. Measurements were taken from 0700 hours to 2200 hours daily for 6 days at each school, comprising of 3 school and 3 non-school days. The types and number of motor vehicle passing through the area as classified in Appendix A were also recorded based on Malaysian Standard developed by SIRIM Berhad (The Classification and Definition Of Power-Driven Vehicles and Trailers).

Data Analysis

L_{eq} was calculated using Equation 1.0 which expressed in dB (A) units.

$$L_{eq} = 10 \log \sum_{i=t}^{i=n} (10)^{Li/10} (t_i) \quad \text{Equation 1}$$

Where, n = the total number of samples taken

L_i = the noise level in dB (A) of the *i*th sample

t_i = fraction of total sample time

L_{max} and L_{min} are highest and lowest values measured by the sound level meter over a given period of time respectively. The noise data were then tabulated in a spreadsheet in ascending order. L_{10} and L_{90} were calculated in Microsoft Office Excel 2010 by entering the following command; [= PERCENTILE (array, k)], select array from the tabulated noise data and insert k=0.9 for calculating L_{10} (k=0.1 for L_{90}).

Analysis of Variance (ANOVA) was performed to determine the significance different of noise level at the three different primary schools during school and non-school days. Meanwhile, Statistical Package for Social Science (SPSS®) software extracted factors with Eigen values greater or equal to 1 as a principle component or factor was used for estimating the motor vehicle classes contributing to the noise load. Factor analyses proceed in the following 3 steps:

i. Correlation matrix for all the variables are computed,
ii. Factor extraction and
iii. Factor rotation between the original values and the extracted factors.

In addition, classes of motor vehicle which are principally significant were extracted and inserted in the SPSS® Editor for multiple linear regression analysis to establish the relationship between noise level and traffic volume.

Results and Discussion

Noise Level Evaluation

Average noise level at each site with different surrounding activities on both school and non-school day were shown in Figure 2 and Figure 3 respectively. The results showed that receptors at schools were exposed to equivalent noise level (L_{eq}) ranged from 63.7 dBA to 66.4 dBA on school day and 64.7 dBA to 68.4 dBA on non-school day. For both school and non-school day, it can be seen that the L_{max} is higher at school located at industrial area rather than school located at commercial and residential area. This is mainly because there were many motor vehicles passing by in front of this school's main road and sometimes dominated by heavy trucks such as lorries and trailers.

Relationship between Traffic Volume and Noise Level

Based on Figure 4, noise level, L_{Aeq} during non-school day was higher than during school day. This is expected due to higher traffic volume during non-school days, and L_{Aeq} varies linearly with traffic volume increment. For example, on Day 1 for non-school day, the traffic volume was 4864 units with L_{Aeq} of 69.9 dBA and for the same day, for non-school day, the traffic volume

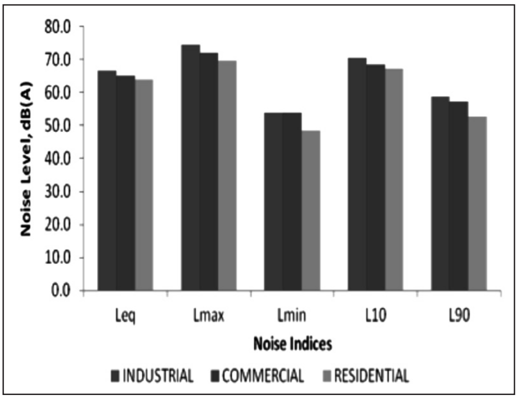

Figure 2: Average noise level at the daytime

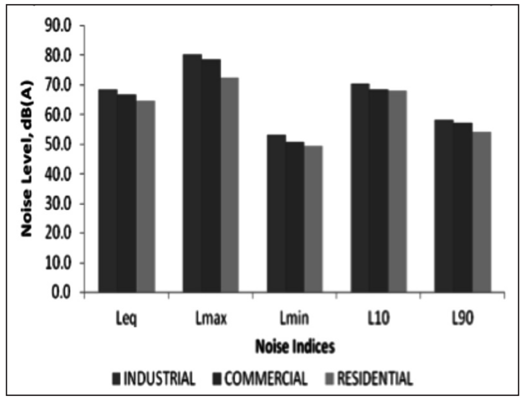

Figure 3: Average noise level at the on school day daytime on non-school day

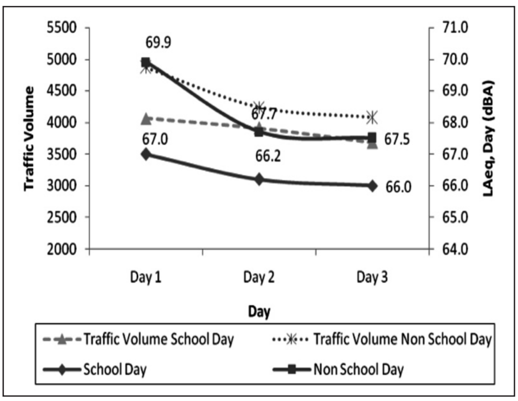

Figure 4: Relationship between traffic volume and noise level at industrial area

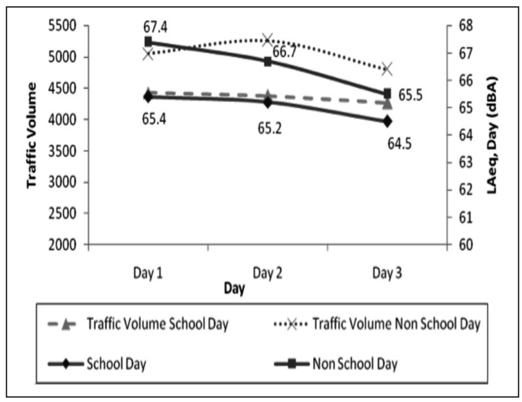

Figure 5: Relationship between traffic volume and noise level at commercial area

was 4064 units with L_{Aeq} of 67.0 dBA. During non-school day, there was a slight different in the L_{Aeq} on Day 1 as compared with Day 2 and Day 3. This was because; the sampling day for Day 1 was conducted on Saturday while Day 2 and Day 3 were on Friday. Usually private sector workers are working on Saturday and off on Friday. Therefore, at industrial area, it was expected that during the off day, there was less of motor vehicles pass through the sampling site especially the heavy vehicles such as in Class N, O and T.

Figure 5 shows the relationship of traffic volume and noise level, L_{Aeq} at commercial area. Based on the Figure 5, L_{Aeq} during non-school day was higher than during school day. During school day, the L_{Aeq} varies linearly with traffic volume. During non-school day, take Day 1, the traffic volume was 5051 units, and L_{Aeq} of 67.4 dBA. Although Day 2 has higher traffic volume than Day 1, its L_{Aeq} was lower due to the difference in the traffic volume in Class N motor vehicle. Class N was considered as power driven vehicles having at least four wheels and used for the carriage of goods such as small lorries. Traffic volume of Class N in Day 1 was 178 units while on Day 2 was 38 units. According to Priede (1971), the heavy trucks show different noise emitting behavior resulting from their larger number of sources than automobiles. For this reason, the L_{Aeq} for Day 1 was high although the traffic volume was low.

Figure 6 shows the relationship between traffic volume and noise level, L_{Aeq} at the residential area. Based on Figure 6, it shows that the L_{Aeq} for non-school day was higher than

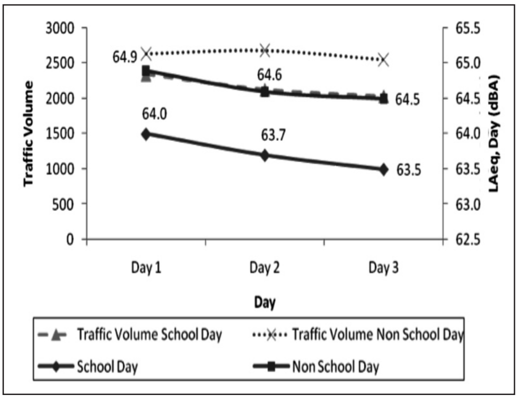

Figure 6: Relationship between traffic volume and noise level at residential area

during school day for the all three days of data collection. The L_{Aeq} for the school day varies linearly with the traffic volume. For the non-school day, on Day 1, the traffic volume was 2636 units, with L_{Aeq} of 64.9 dBA. That traffic volume in Day 1 was lower than Day 2 (Traffic volume = 2684 units). As the same case that had happened in commercial area, there was a difference in the number of Class N and Class O for these two days. The number of Class N and Class O motor vehicles on Day 1 was 94 units and 3 units respectively compared to the number of Class N and Class O on day 2 that was 27 units and 1 unit respectively. Therefore, there was higher noise level in day 1 although it has lower traffic volume than Day 2.

Trend of Noise Level at the Three Site Locations

Trend of noise level, L_{Aeq} for the industrial, commercial and residential areas were shown in Figure 7 and Figure 8 for school and non-school days respectively. Statistically, there exist significant different ($P<0.05$) between these study areas whereby L_{Aeq} was higher at the industrial, followed by commercial and residential areas due to traffic volume on each sampling site. This finding is in tandem with study by Singal (2005) where the environmental noise level of primary school located at industrial area was found to be higher than commercial area with school located at residential area lowest among the three. The noise limit (L_{Aeq}) enacted by DOE (Table 3) for day time (0700 hours to 2200 hours) at

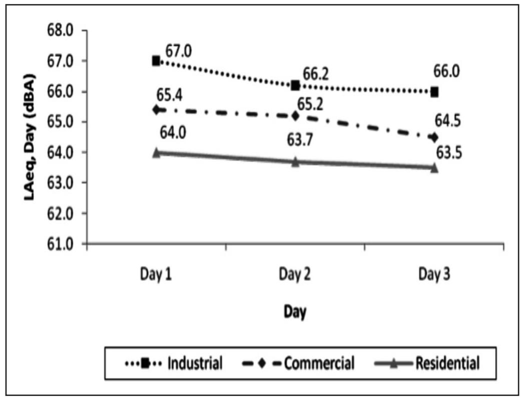

Figure 7: Trend of noise level at each sampling site during school day

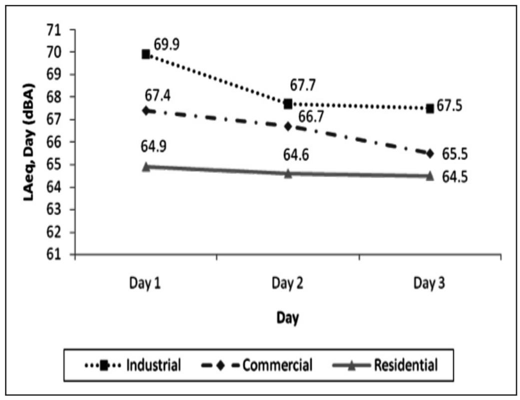

Figure 8: Trend of noise level at each sampling site during non-school day

school area is 55.0 dBA since school and other public institution are categorized as sensitive areas. The values of L_{Aeq} for all the study areas exceeded the limit with minimum value of 64.5 dBA recorded at residential area's school. The noise level was higher during non-school days due to accumulation of motor vehicles during weekend. People went out to fulfill their leisure time with family and cars were used rather than motorcycle because they bring along their families. Meanwhile, motorcycles were used for going to and fro the workplace. Cars have larger engines than motorcycles which subsequently contribute to higher noise level. This was shown in the principal component analysis (PCA) whereby Class M and L were dominant classes of motor vehicles extracted.

Table 3: Guidelines for limiting sound level (L_{Aeq}) from road traffic (for proposed new roads or redevelopment of existing roads) from the planning guidelines for environmental noise limit and control (2007) by the malaysian department of environment

Receiving Land Use Category	Day Time 7.00 am - 10.00 pm	Night Time 7.00 am - 10.00 pm
Noise Sensitive Areas Low Density Residential Areas	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

Table 4: Extracted classes of motor vehicles using PCA

Area	Industrial	Commercial	Residential
School Day	M and L	L, M, N and O	M, L and N
Non-School Day	M, L, N and O	L, M and N	M, L and N

There were additional factors that contribute to high noise level at these study areas beside motor vehicles. At the industrial site, there is a road hump in front of the school and upon reaching the hump, vehicles will brake then accelerate after crossing it, and this braking and acceleration process contribute to higher noise level. According to Mitchell (2009), the acceleration and braking influence the overall noise pollution and both these processes accounted for 10% of the total traffic noise. Meanwhile, at the residential site, the adjacent roads were painted with yellow strips to ensure that vehicles passing by slowing down but most of the drivers did not adhere it, instead, they speed up their vehicles. This contributes to higher noise level due to the interaction of vehicle's tire and the yellow strips.

Extracting Factors from Principal Component Analysis (PCA)

Table 4 shows the items or classes that have been extracted by using the PCA. Interestingly, the variation occurred at the commercial area in which the Class L motor vehicles, namely motorcycles have higher correlation value than the others. This was due to the lack of parking space as people were willing to use motorcycles because it was easy to park and avoid traffic congestion as the site for commercial area was in the middle of Kuala Terengganu city center.

Multiple Linear Regression (MLR)

Results showed that three out of four independent variables were significantly contributing to the noise level i.e. Class M (β = .170, $p < .05$), Class L (β = .207, $p < .05$) and Class N (β = .138, $p < .05$). These three independent variables contribute 15.3 percent (r = .392) variance change in noise level [F (3,783) = 47.259, P < .05]. Significantly, Class M [F (1,785) = 101.881, p < .05] contributes 11.5 percent variance (R^2 = .115) in frequency of noise level. This means Class M (β = .170, $p < .05$) was the main factor that contributes to noise level. The combination of Class M and Class L increased to (13.5-11.5) or by 2.0 percent to variance (R^2 = .135) in the frequency of dependent variable, noise level [F (2,784) = 61.381]. The combination of Class M, Class L and Class N contribute significantly 15.3 percent (R^2 = .153) variance change in noise level [F (3,783) = 47.259, p < .05]. Based on the multiple regression analysis, it can be concluded that Class M, Class L and Class N of motor vehicles were the factors that contributed to noise level at the sampling sites as follows:

$$\text{Noise Level (dBA)} = 0.030M + 0.66L + 0.286N + 58.847 \quad \text{Equation 2}$$

where,
M = Number of motor vehicles in Class M
L = Number of motor vehicles in Class L
N = Number of motor vehicles in Class N

Conclusion

ANOVA test showed that these three study areas were significantly different ($p<0.05$) among each other with the highest noise level observed at the industrial area, followed by commercial and residential area. Between the three study areas, the school located at residential area was found to be more conducive from the perspective of noise pollution as compared to schools located at industrial and commercial areas. However, the noise level at these three study areas exceeded the limit set by DOE, Malaysia. Therefore, we proposed some recommendations to minimize the noise level received by the receptor (primary school children and teachers). Firstly, relocate classes near the road side to room further away and convert current classes to wet or dry laboratories where less time will be spend by the children and thus reduce the noise received. Next, plant trees around the school boundaries especially those adjacent to the road side. Plant species such as *Putranjva roxburghi wall* and *Azadirachata indica A.Juss* were scientifically proven able to reduce noise intensity. Finally, forbid motor cycles, buses, lorries and good vehicles that significantly contribute to noise level from passing by the school area during school hours.

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APPENDIX A

The Classification of Power- Driven Vehicles and Trailers

Category L:
Motor vehicles with less than four wheels

Moped

Motorcycle

Tricycle

Category M:
Power-Driven vehicles having at least four wheels and used for the carriage of passengers

Passenger Cars

Station Wagon

Multipurpose Vehicle

Buses

Category N:
Power-Driven vehicles having at least four wheels and used for the carriage of goods

Goods Vehicles

Category O:
Trailers, including semi-trailers

Category O:
Trailers, including semi-trailers

Source: Malaysian Standard (MS 1882: 2005)