ENVIRONMENTAL NOISE POLLUTION AT SELECTED PRIMARY SCHOOLS WITH DIFFERENT POPULATION DENSITY IN MALAYSIA

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Abstract - Majority of primary schools in Malaysia are located near the roadside, thus facing problems of noise pollution. Children exposed to high noise level significantly diminished their concentration in class, social flexibility and intensify inverse relationship with other people. The increasing number of motor vehicles is among the triggering factors that contribute to the noise pollution. This study investigate the level of traffic induced noise pollution at three primary schools in Kuala Terengganu with different population density of low, medium and high. Noise levels comprising of L_{max}, L_{Aeq}, L_{min}, L_{10} and L_{90} were measured over six days at each schools, i.e. three school days and three non-school days from 0700 hours to 2200 hours each day. Results showed that noise level at each location is significantly different ($P<0.05$), and at all sites, the noise level exceeded the permissible limit. Principal Component Analysis (PCA) showed that the classes of motor vehicles that significantly contribute to noise level are from Class L, M, N and O. Highest noise level was recorded at school located within the high density area, followed by medium density and low density area respectively.

Index Terms - Malaysia, motor vehicles, noise pollution, primary schools, sound level meter

INTRODUCTION

The accomplishment achieved by developed countries in terms of economic, social and cultural development has created noise problem due to a blend of sources including increased in industrial development, concentrated street transport system with growing number of motor vehicles, construction activities and household chores especially in area having shortage of tenable land. 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 [1].

Excessive noise level at school areas can affect psychology and physiology for all human, especially children. The extreme noise level could disrupt learning process of children, especially in primary education where the students aged from 6-12 years [2]-[3]. It can effects focus on study, communications and for the more extremes can default hearing especially to primary school children [4]. Children exposed to high noise level significantly diminished their concentration in class, social flexibility and expanded inverse relationship with other people [5]. Furthermore, chronic noise level exposure could impair debilitate psychological advancement in children, particularly in reading activities [6]-[7]. Therefore, in view of this, we decided to evaluate the environmental noise level at three primary school areas located near the road sides, thus highly possible to be affected by traffic noise problems. Apart from that, Principal Component Analysis (PCA) was utilized to determine classes of motor vehicles that contribute significantly to the noise pollution

II. MATERIALS AND METHODS

A.Site Description

Three schools with different population density namely; high, medium and low were selected for this study as presented in Table 1 and Figure 1. Sekolah Kebangsaan Mengabang Telipot (S1), representing low density area is located within the vicinity of Seberang Takir, covering an area of 39,388 acres with total population of 3,636 peoples. Hence, this residential area is classified as low density residential area since the population is less than 75 persons per acre [8]. Sekolah Kebangsaan Tok Jiring (S2) is define as medium population density whereby the population is between 75 to 200 persons per acre. Meanwhile, Sekolah Kebangsaan Tok Jembal (S3) is representative of high population density area because the adjacent area consists of more than 200 persons per acre.

B.Sampling Activity

When you submit your final version, after your paper has been accepted, prepare it in two-column format, including figures and tables. Noise measurement was performed by Planning Guidelines for Environmental

Noise Limit and Control, 2007, using Sound Level Meter (SLM) as per IEC 61672 Class 1 Standard whereas wind speed was measured via hot wire anemometer (Kanamox Climomaster).

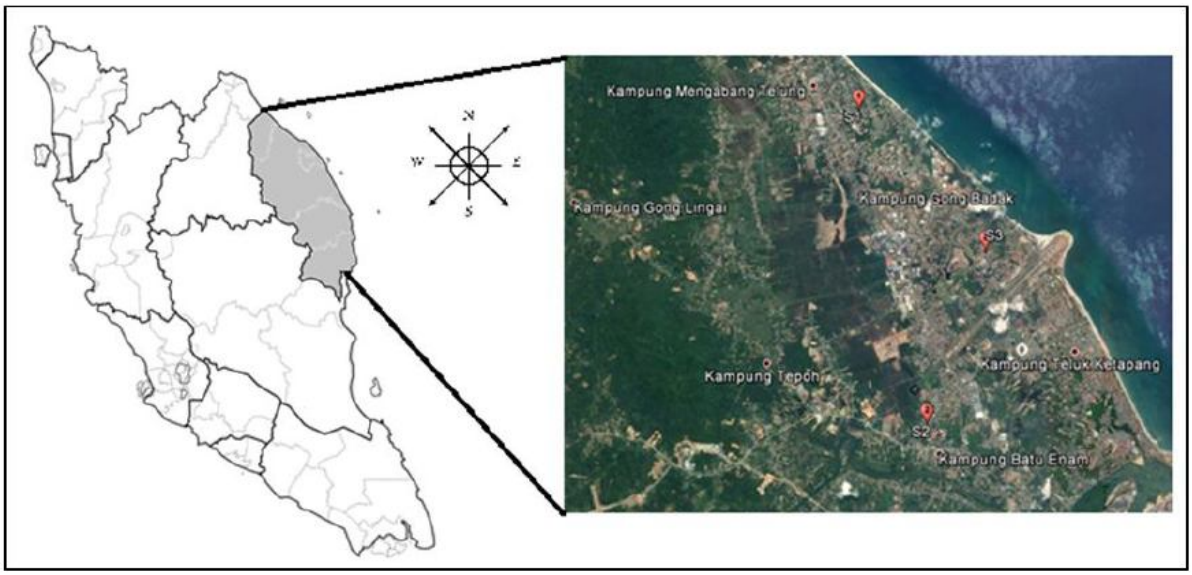


Figure 1. Map of study areas

Site	Location	Classification of Population Density	Latitude, Longitude
S1	Sek. Keb. Mengabang Telipot	Low	N 05° 25.404 E 103° 04.013
S2	Sek.Keb. Tok Jiring	Medium	N 05º 21.149 E 103º 5.072
S3	Sek. Keb. Tok Jembal	High	N 05º 21.149 E 103º 5.072

Table 1. Location of study areas

Microphone was placed on a tripod stand at a height of 1.5m above ground at an angle of 70 degrees to the source noise, and at least 1m from any reflecting surface. No noise reading were measured when the wind speed exceeded 5 m/s. Measurements of noise level (dBA) was performed from 0700 hours to 2200 hours daily for 6 days at each school, comprising of 3 school and 3 non-school days. Number of motor vehicles were calculated by means of tally system and classified accordingly based on Malaysian Standard developed by SIRIM Berhad (The Classification and Definition of Power-Driven Vehicles and Trailers) [9], comprising of 5 classes of motor vehicles namely Class L, M, N, O and T. Class L is define as motor vehicles with less than four wheels such as moped, motorcycle (solo), motorcycle with sidecar, motorcycle (tri-cycle). Class M is known as power-driven vehicles having at least four wheels and used for the carriage of passengers such as passenger car, saloon, hatchback, station wagon, coupe, convertible, multi-purpose vehicles and buses. Class N is define as power-driven vehicles having at least four wheels and used for carriage of goods such as small lorries. Class O is known as trailers which including semi-trailers, full trailers and centre-axle trailer. Lastly, Class T is define as agricultural and forestry tractors such as land tractors.

C.Data Analysis

L_{eq} was calculated using Equation 1 expressed in dB (A) units.

$$L_{eq} - 10\,log \sum_{i-1}^{i=n} (10)^{L_i/10}\ (t_i) \quad (1)$$

Where,

n= The total number of samples taken

L_i=The noise level in dBA of the $_i$th sample

t_i=fraction of total sample time

The data were organized in Microsoft Office Excel 2013® by ascending order. L_{max} and L_{min} are the highest and lowest values measured by the sound level meter over a given period of time respectively. L_{10} and

L_{90} were calculated 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}). The L_{10} is the noise level in dBA, exceeded only by 10% of the time or Peak Sound Level and also known as traffic noise. Meanwhile, L_{90} is the noise level in dBA, exceeded 90% of the time or otherwise known as background or residual noise level.

Analysis of variance (ANOVA) was performed to determine the significance difference of noise level at these three study areas. Then, principal component analysis (PCA) was executed to emphasize variation and bring out strong patterns in the dataset. PCA is a statistical technique that employ orthogonal transformation to convert a set of observations of possibly correlated variable into a set of values of linearly uncorrelated variables known as principal components (PCs) [10]. Prior to implementation of PCA, the dataset must meet the requirements of Kaiser-Meyer-Olkin (KMO) Sampling Adequacy and Bartlett's Test of Sphericity with value of greater than 0.50 and less than 0.001, respectively. The transformation is portrayed such that the first principal component has the biggest possible variance and each succeeding component thus has the most noteworthy difference plausible under requirement that is orthogonal to (i.e. uncorrelated with) the former parts. In general, PCA is written as:

$$PC_i = l_{1i}X_i + l_{2i}X_2 + \ldots + l_{ni}X_n \qquad (2)$$

Where PC_i is the ith principal component and X_{ij} is the loading of the observed variable X_i

III. RESULTS AND DISCUSSION

A. Noise Level Evaluation

It was found that, there exists statistically significant different ($P<0.05$) of noise level at the three study areas of S1, S2 and S3. Noise indices of L_{Aeq}, L_{90}, L_{10}, L_{min} and L_{max} were calculated and depicted in Figure 2 and Figure 3 for all the study areas. The study areas were exposed to different noise level ranging from 66.5 to 67.9 dBA during weekdays and 63.6 to 67.9 dBA during weekends. L_{90} is highest at S2 during both weekdays and weekends with 61.2 dBA and 60.7 dBA, respectively followed by S3 and S1. The highest traffic noise, $L_{10,}$ was observed during weekdays at S3 (64.9 dBA), while the highest L_{10} during weekends is at S2, followed by S3 and S1. In addition, the highest reading of L_{max} during weekdays is at S1 with value of 69.6 dBA, followed by S3 (66.7 dBA) and S2 (66 dBA), correspondingly. However, during weekends, the L_{max} reading was higher at S2, which is 66.7 dBA, followed by S3 and S1. L_{min} during weekdays ranged between 54.6 dBA to 59.9 dBA while during weekends, L_{min} noise level is 49.9 dBA to 56.9 dBA. Dissimilar population densities will contribute different noise level especially at the populated areas which are known in having high influence of traffic [11]. It was proven that disparate noise level for each study area was due to different types of motor vehicles and traffic volume passing by in front of the schools [12]

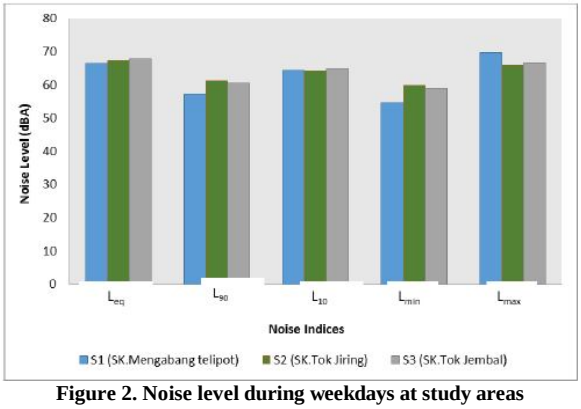


Figure 2. Noise level during weekdays at study areas

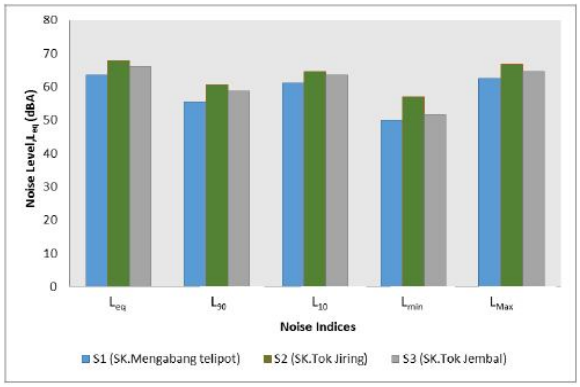


Figure 3. Noise level during weekends at study areas

B. Relationship between traffic volume and noise level

Each school is having different number of traffic that pass by in front of the schools. Figure 4 demonstrate the relationship between traffic volume and noise level at S1. During weekdays, L_{Aeq} for S1 was 66.5 dBA having traffic volume of 5620 units; consisting of motor vehicles from Class L, M, N and O. 2746 units are from Class L and 2733 units from Class M whilst the rest are from class N and O, respectively. However, traffic volume during weekends is higher than weekdays which accounted for 7022 units. It comprises of Class L (3301 units), Class N (131 units) and Class O (6 units). The L_{Aeq} for both weekdays and weekends exceeded the limit of 55 dBA stipulated by DOE. Obviously, residents at low density area use motor vehicles from Class L, especially motorcycles, to travel from one place to another for meals and goods, recreation and also for working purpose [13]
Figure 5 shows the traffic volume at S2 for both

weekdays and weekends with L_{Aeq} of 67.3 dBA and 67.9 dBA, respectively. The L_{Aeq} for both weekdays and weekends exceeded the noise limit of 60 dBA as specified by DOE. Number of motor vehicle from Class M is higher than motor vehicle from class L. Number of motor vehicles from Class N during weekdays is 401 units and the trailers are in Class O is 131 units, however on weekends, motor vehicles from Class N is 220 units and 86 units for Class O. Therefore, at medium population density area, there are scores of heavy vehicles passing through the sampling area especially during weekdays. The increasing noise level at this area is contributed to the increasing number of Class N and Class O including heavy trucks that induce the noise level [14]

The numbers of traffic during weekdays for S3 from Class M is 10308 units followed by Class L, N and O (Figure 6), while Class M (10286 units), Class L (3958 units) during weekends. The number of heavy motor vehicles for Class N and O during weekends (248 units) is less compared to weekdays (182 units). S3, located near to an institutional area which is Universiti Malaysia Terengganu, experience higher traffic volume during weekdays comparative to weekends. L_{Aeq} for both weekdays (67.9 dBA) and weekends (66.2 dBA) also exceeded the limit (65 dBA) stipulated by DOE.

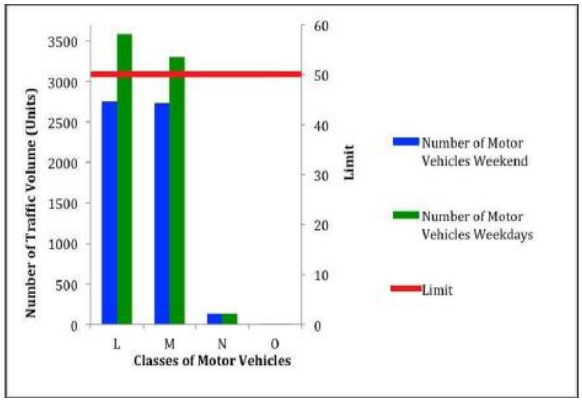


Figure 4. Number of Traffic Volume and Classes of Motor Vehicles (S1)

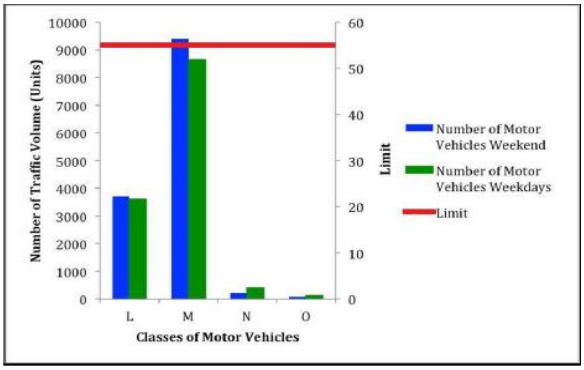


Figure 5. Number of Traffic Volume and Classes of Motor Vehicles (S2)

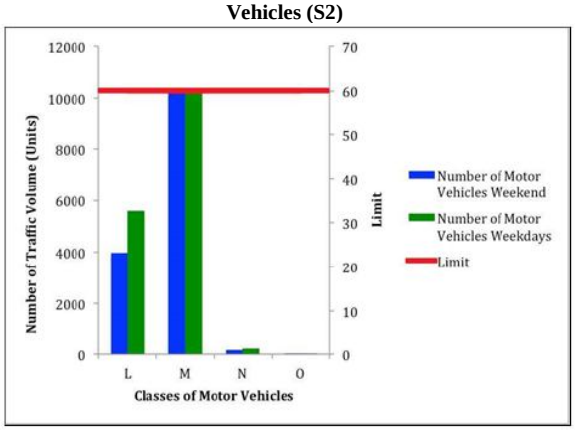


Figure 6. Number of Traffic Volume and Classes of Motor Vehicles (S3)

C. Principal Component Analysis (PCA)

Table 2 illustrated the eigenvalues related to each linear component during extraction and rotation for all sites together with its percentage of variance explained. PCA extricates all factors with eigenvalues more than 1, yet for this study at S2, the 2nd factor has eigenvalue closed to 1, consequently be included as a factor too [15]. Using 2 factors, the percentage variability is about 73% for S1. Before rotation, factor 1 accounted for considerably more variance than factor 2 with 45.30% and 27.40%, respectively. However, after extraction, it accounts for only 45.18% and 27.52% correspondingly. S2 has the percentage variability of 64%. Before rotation, factor 1 accounted for considerably more variance than factor 2 with 39.43% and 24.87% respectively. However, after extraction, it accounts for only 32.52% and 31.78% respectively. S3 has the percentage variability of 62%. Before rotation, factor 1 accounted for considerably more variance than factor 2 with 36.69% and 25.80% correspondingly. However, after extraction, it accounts for only 36.67% and 25.83% respectively.

Rotated matrix rotation using varimax with Kaiser Normalization is shown in Table 3 encompassing the loading of each variable onto each factor, where values less than 0.4 are suppressed from the output [16]. The loading factor of more than 0.5 is considered as strong, range of 0.4 – 0.49 is considered as moderate whereas value less than 0.3 is considered as weak [17]. Interestingly, although the sites were having different population density, all sites recorded the same components in each PC-1 and PC-2. PC-1 composed of the strong contribution of motor vehicles from Class L and M; referred as light motor vehicles. PC-2 is associated with strong contribution of motor vehicles from Class N and O or better known as heavy motor vehicles.

Site 1									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.812	45.297	45.297	1.812	45.297	45.297	1.807	45.178	45.178
2	1.096	27.401	72.697	1.096	27.401	72.697	1.101	27.520	72.697
3	.893	22.319	95.017						
4	.199	4.983	100.000						

Site 2									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.577	39.427	39.427	1.577	39.427	39.427	1.301	32.517	32.517
2	.995	24.871	64.298	.995	24.871	64.298	1.271	31.781	64.298
3	.789	19.714	84.012						
4	.640	15.988	100.000						

Site 3									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.468	36.694	36.694	1.468	36.694	36.694	1.467	36.672	36.672
2	1.032	25.804	62.499	1.032	25.804	62.499	1.033	25.827	62.499
3	.973	24.322	86.821						
4	.527	13.179	100.000						

Table 2. Total Variance Explained

S1			S2		S3	
	Component		Component		Component	
	1	2	1	2	1	2
L	.937		.878		.854	
M	.943		.717		.855	
N		.729		.793		.691
O		.747		.728		.736

Table 3. Rotated Component Matrix

CONCLUSION

ANOVA test showed that noise level at these three study areas were significantly different ($p<0.05$) among each other with the highest noise level observed at the high density area, followed by medium and low density area. Between these three study areas, the school located at low density area was found to be more conducive from the perspective of noise pollution as compared to schools located at medium and high density 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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REFERENCES

[1] MR. Mehdi, M. Kim, JC. Seong, MH. Arsalan, "Spatio-temporal patterns of road traffic noise pollution in Karachi, Pakistan," Environment International, vol. 37. pp. 97-104, 2011

[2] Y. Avsar, MT. Gonullu, "A map preparation for outdoor noises of educational buildings in Fatih District of Istanbul," International Symposium on Noise Control & Acoustics for Educational Buildings. Istanbul/Turkey: Yildiz Technical University, pp. 69–76, 2000

[3] M. Kamal, R. Abdallah El-Rahman, S. Tawfiq, "Evaluation of noise levels affecting schools in Cairo Egypt," Proceedings of ISMA2010 including Leuven, Belgium., pp. 1811–20, 2010

[4] B. Shield, J. Dockrell, "Children's perception of their acoustic environment at school and home," Journal of Acoustical Society of America, vol. 115(6), pp. 2964-2973, 2004

[5] G. Ristovska, D. Gjorgjev, NP. ordanova NP, "Psychological effects of community noise: cross sectional study of school children in urban center of Skopje, Macedonia," Croation Medical Journal, vol. 45(4), pp. 473-476, 2004

[6] SA. Stansfeld, C. Clark, RM. Cameron, T. Alfred, J. Head, MM. Haines, I. van Kamp, E. van Kampen , I. Lopez-Bario I," Aircraft and road traffic noise exposure and children's mental health, " Journal of Environmental Psychology, vol, 29, pp. 203-207, 2009.

[7] P. Lercher, GW. Evans, M. Meis, "Ambient noise and cognitive processes among primary school children," Environment Behaviour, vol. 35, pp. 725-735, 2003

[8] Department of Environment, "The planning guidelines for environmental noise limits and control," Sasyaz Holding Sdn. Bhd, Putrajaya, Malaysia, 2007

[9] SIRIM Berhad, "Classification and definition of power-driven vehicles and trailers. Department of Standards, Malaysia" 2005.

[10] SA. Abdul-Wahab, CS. Bakheit, SM. Al-Alawi, "Principal component multiple regression analysis in modelling of

ground-level ozone and factors affecting its concentrations," Environmental Modeling and Software, vol. 20, pp. 1263-1271, 2005

[11] L. Steg, A. Vand Den Berg, J. De Groot J,"Environmental psychology: An introduction (1st ed.)," John Wiley & Sons Inc.: West Sussex, 2013

[12] M. Ismail, S. Abdullah, FS. Yuen, "Study on environmental noise pollution at three different primary schools in Kuala Terengganu, Terengganu State," Journal of Sustainability Science and Management, vol. 10(2), pp. 103-111, 2015

[13] M. Ismail, S. Abdullah, FS. Yuen, "Study on environmental noise pollution at three different primary schools in Kuala Terengganu, Terengganu State," Journal of Sustainability Science and Management, vol. 10(2), pp. 103-111, 2015

[14] T. Priede T, "Origins of automotive vehicle noise," Journal of Sound Vibration, pp. 61-73, 1971

[15] S. Abdullah, M. Ismail, SY. Fong, AMAN. Ahmed, "Evaluation for long term PM_{10} concentration forecasting using multiple linear regression and principal component regression models," EnvironmentAsia, vol. 9(2), pp. 101-110, 2016

[16] SA. Abdul-Wahab, CS. Bakheit, SM. Al-Alawi, "Principal component multiple regression analysis in modelling of ground-level ozone and factors affecting its concentrations," Environmental Modeling and Software, vol. 20, pp. 1263-1271, 200

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