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Noise of traffic ranking in several countries

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Abstract: In this paper, traffic noise was measured at two locations: Bukit Mertajam, a developing town in Malaysia, and Erbil City, the regional capital of Iraqi Kurdistan. Field measurements were taken simultaneously with traffic volume measurements in Bukit Mertajam, and then validated using various models. The NAISS model represented the field measurements better than did the other models used. The noise level was higher during peak hours, particularly during evenings when there were increased traffic volumes and a higher percentage of heavy vehicles. The average noise level exceeded the guidelines set by the Malaysian government. The sound pressure levels (SPLs) for Erbil City were higher during mornings, and decreased as distance increased. The correlation coefficient obtained for SPL and the distance between the sound source and receiver indicates a good relationship.

Key words: Traffic Noise; Pollution; Sound Pressure

1. Introduction

Road traffic has become an important factor in societal development, specifically in terms of living comfort and economic progress. With increasing number of vehicles in countries such as Malaysia and Iraq, traffic noise represents the most pervasive source of community noise (Morillas et al., 2002; Zannin et al., 2003). Exposure to noise can cause health problems, disturbance, and annoyance to individuals; under certain conditions, it can also affect work efficiency and quality of life. For instance, sleep disturbance is generally associated with low noise levels, and levels higher than 70 dB(A) can induce hearing impairment and ischemic heart diseases (Nijland and Wee, 2005). Ranked highest in terms of the severity of noise sources in many countries, traffic noise is the most diffused in nature with the most significant effect. Motorcycles constitute more than 40% of the total number of vehicles and are regarded as a major source of noise pollution in Malaysia. Carrying out research on many aspects of traffic noise necessitates traffic noise data, covering information obtained during the planning stage and findings collected through investigations of specific or local traffic noise problems. The source of noise in Malaysia and Iraq are usually vehicles, construction activities, and industry activities.

Traffic noise is produced by vehicular flow on roads. Many factors influence noise emission from vehicles, including vehicle density, road type and road surfaces, vehicle speed, gradient, junctions, ratio of Lorries on the road, climate, and building deflection. Davis and Cornwell (2008) reported that for most automobiles running below ~55 km/h, exhaust noise constitutes the main source of noise pollution. Although tire noise is less of a problem in automobiles than in trucks, it is a main noise source of noise pollution at speeds above 80 km/h. Although not as noisy as trucks, automobiles collectively contribute a significant amount of noise pollution by virtue of their large numbers on the road. Motorcycle noise is highly dependent on the speed of the vehicle; noise primarily stems from the exhaust. The noise spectra of two-stroke and four-stroke engines are slightly different. Two-stroke engines exhibit more high-frequency spectral energy content than do four-stroke engines.

A number of traffic noise pollution studies have been published in the past few years in various countries (Abo-Qudais and Alhiary, 2007; Agarwal and Swami, 2010; Al-Mutairi et al., 2011; Barros and Dieke, 2008; Doygun and Gurun, 2008; Jamrah et al. 2006; Ma et al., 2006; Phan et al. 2010). However, the highly limited data on noise emission from vehicles in Malaysia and Iraq have restricted the effective implementation of noise control measures in these countries. Given the increasingly international orientation of our society, the comparison of noise levels in international locations can provide useful information on regulatory trends. It can also enable comparative analysis of field data. The objectives of this work are to 1) study the trend of roadside noise generated from vehicle movement

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during peak hours at Arumugam Pillai and Permatang Batu Roads in Bukit Mertajam, Malaysia (different models were used to examined the relationships among noise level, traffic volume, traffic composition, traffic speed, and predicted potential levels of noise caused by vehicular emissions); 2) study noise generated from vehicular movements for Kirkuk, Shaqlawa, Peshawa Qazi, Koysinjaq, Kurdistan, and Barzani Namr Roads in Erbil City, Iraq; and 3) compare the noise levels measured in Bukit Mertajam with those obtained for Erbil City, Iraq. To the best of our knowledge, this kind of research has not been conducted.

2. Materials and methods

This study was conducted in Bukit Mertajam, Penang, Malaysia and Erbil City, Iraq. Two intersections in Bukit Mertajam—Arumugam Pillai and Permatang Batu Roads— were chosen. Bukit Mertajam is a developing town surrounded by many factories; such a location is characterized by heavy vehicle movement because of product transport. To measure the potential effects of traffic noise, data on traffic volume, including types of vehicles and roadside sound levels, were collected and interpreted using various models. Sound level meters, a manual hand counter, a stopwatch, a radar gun, and portable measurement instruments were used to obtain the required data. Data analysis was conducted using Microsoft Excel and SPSS. Traffic volume (composition and flow) and speed were measured at three time periods per day for Bukit Mertajam. These time periods were the morning peak hour (07:15–09:15 AM), the daytime peak hour (12:15–14:15 PM), and the evening peak hour (16:15–18:15 PM). Traffic characteristics and noise levels were measured simultaneously during each of the three time periods at each location. The volume and composition of traffic were measured for 15 min during each peak period. Traffic composition was determined on the basis of the presence of light vehicles (cars, taxis), light Lorries and vans, heavy Lorries (truck trailer > 3.5 tons), buses, and motorcycles.

On the basis of the policy of the Malaysian Public Works Department (PWD), we converted the number of vehicles obtained to its equivalent passenger car unit (PCU). Spot speed was measured using a Kustom Falcon radar gun with a speed range of 15–199 mph. Fifty samples were collected with the radar gun. Vehicle speed was measured at one point and the average of the data was taken as the value of traffic speed flow. Data on the geometric dimensions of road sections, as well as the number of lanes and their widths, were also collected. Sound level measurements were performed using a sound level meter (GA 204/Castle Type 2 IEC 651 BS 5969 ANSI S1-4). Traffic noise was measured using the sound pressure level (SPL) index with an A-weighted scale expressed in decibel units, which convert the SPL value into Leq. The data were then clarified with a sound level meter (model 1800). The SPL was calculated using the following equation (Davis and Cornwell, 2008):

$$SPL = 10\log\left({Pres^2}/{refpres^2}\right) \qquad (1)$$

Where

pres = sound pressure, refpres = reference sound pressure.

For Erbil City, noise level measurements were carried out at Kikuk, Shaqlawa, Peshawa Qazi, and Koysinjaq Roads between 8 AM and 6 PM. The traffic noise level was also determined for Barzani Namar and Kurdistan Roads for 0, 10, and 20 m to assess the differences in traffic noise at various distances.

2.1. Measurement procedure

The sound level meter was mounted on a tripod closest to the noise source, and the microphone was positioned 70 m from the traffic light, at a height of 1.2 m above the ground level corresponding to the ear level of an individual of average height (Onnu, 2000) and a reference distance of 7.5 m (ISO 362); 70 m was adopted with the assumption that most vehicles in the traffic stream had already reached steady speed (Burgess, 1997). Measurements were taken on one side of the road and data were averaged to represent the results for each location. The microphone was calibrated before and after each noise sampling session. Results with a variation higher than 0.5 dB (A) were disregarded.

2.2. Prediction models

Traffic noise prediction models are designed to facilitate planning for new roads or account for changes in traffic noise conditions. Most mathematical models adopt L_{eq} as the most representative physical variable that quantifies noise emissions. L_{eq} corresponds to the sound pressure of a fictions stationary noise that emits acoustic energy similar to that emitted by a non-stationary source (Cvetković et al., 1997). The equivalent continuous noise level in A-weighted decibels (dBA) is widely recognized as a stable descriptor of motor vehicle noise (Cvetković et al., 1997). Mathematical models for the prediction of traffic noise usually extract the functional relationship between noise emissions and measurable traffic and road parameters. The classical functional relationships based on data measured through semi-empirical models, typically regression analyses, are shown below.

$$L_{eq} = 55.5 + 10.2\log Q + 0.3P - 19.3\log(\frac{L}{2}) \quad \text{Burgess (1997)} \quad (3)$$

$$L_{eq} = 10\log(N_c + N_m + 8N_v + 88N_b) + 33.5 \quad \text{Fagotti and Poggi (1995} \quad (4)$$

$$L_{eq} = 10\log(N_c + 11.7N_{hv} + 3.1N_b) + 44.3 \quad \text{Cvetković et al. (1997)} \quad (5)$$

Where

L_{eq} = equivalent continuous noise level (dBA), p = percentage of heavy vehicles (%), L = road width (m), Q = total number of vehicles per hour, N_c = number of light vehicles per hour, N_m = number of motorcycles per hour, N_{hv} = number of heavy vehicles per hour, N_b = number of buses per hour.

3. RESULTS AND DISCUSSION

3.1. Traffic volume, composition, and noise level

The intensity of traffic noise changes significantly with variations in traffic composition. A single heavy vehicle (weight > 3500 kg) can produce a noise level equivalent to that generated by 9.12 cars (Li et al., 2002). Traffic volume data were collected according to vehicle type, and manually monitored at intervals of 15 min every 2 h during peak periods. Data were collected in units of vehicle per hour. The results of the counting were converted into equivalent PCU by calculating the PCU factor and applying this factor to vehicle volume, as suggested by the Malaysian PWD (PWD, 1986). The results of traffic composition for both locations are shown in Figs. 1a and 1b.

Higher traffic flow and volume in the studied areas were observed because the data collected were based on peak hours. Traffic composition was grouped into five types of vehicles. The highest PCU volume was recorded during the evenings. For both Arumugam Pillai and Permatang Batu Roads, the PCU volumes of cars and motorcycles was higher than those of the other vehicles, except for lorries during the evenings, during which the PCU volume was almost similar to that of the motorcycles (Figs. 1a and 1b). The buses showed the lowest PCU value followed by the vans. Because the heavy vehicles exhibited higher noise levels, an analysis of the number and percentage of heavy vehicles was carried out. The results are presented in Figs. 1c and 1d for Arumugam Pillai and Permatang Batu Roads.

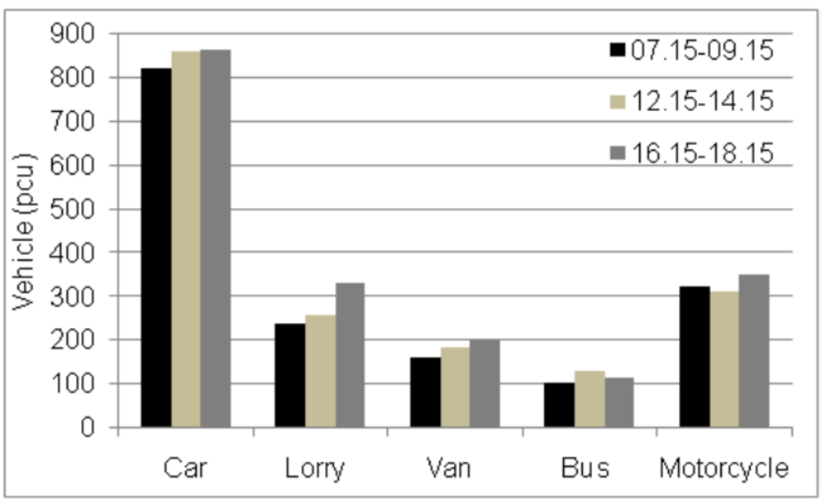

Fig. 1a. Traffic composition at Arumugam Pillai Road

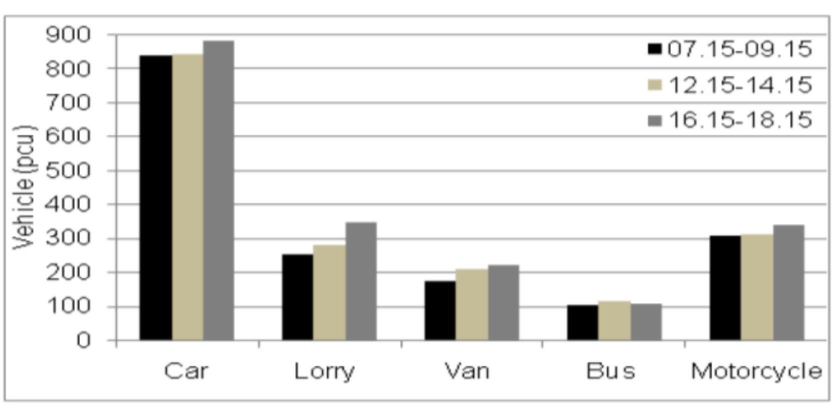

Fig. 1b. Traffic composition at Permatang Batu Road

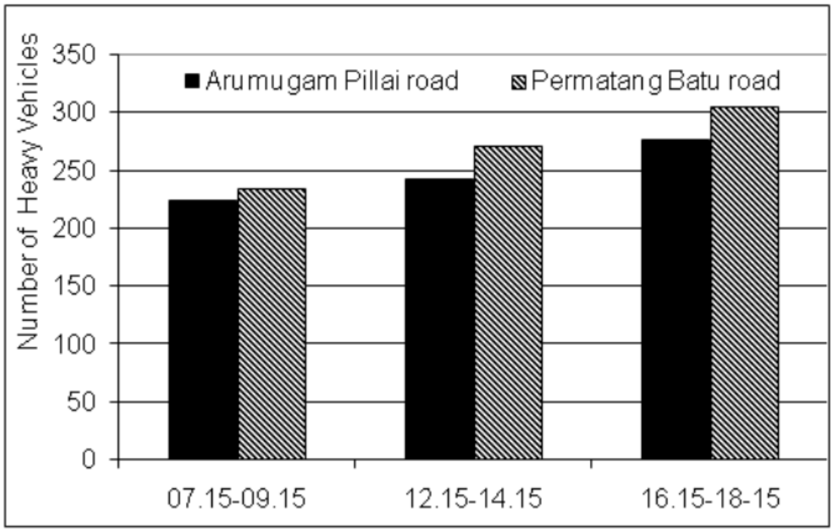

Fig. 1c. Number of heavy vehicles for Arumugam Pillai and Permatang Batu Roads

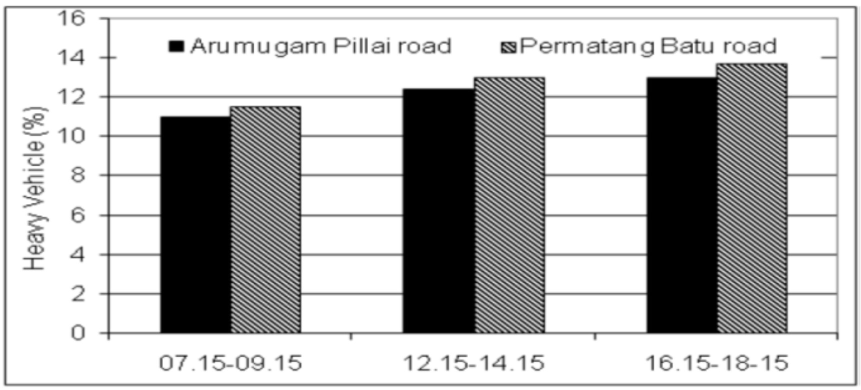

Fig.1d. Percent heavy vehicles for Arumugam Pillai and Permatang Batu Roads

Light lorries (vans), lorries, and buses are classified as heavy vehicles by the Highway Planning Unit of Malaysia (1994). Heavy vehicles are those designed for a gross weight of more than 3.5 tons and predominately powered by 4-stroke diesel engines. As seen in Fig. 1d, the percentage of heavy vehicles was higher during evenings for both studied areas. Noise level measurements were carried out during peak hour periods. Noise level in Leq at Arumugam Pillai and Permatang Batu Roads varied between 74 and 76 dB(A), as shown in Figs. 2a and 2b, respectively. The average background noise level for both locations was between 60 and 65 dB(A).

The average noise level exceeded the guidelines of the Malaysian Department of Environment (DOE), which states that the Leq for urban areas should not exceed 55 dB(A) at daytime and 45 dB(A) at night. Not much difference was observed between the noise levels at each peak hour period, but the noise level in the early evenings between 16:15 and 18:15 PM was higher than those in the mornings and afternoons. A relatively higher noise level during the evenings can be attributed to the higher number of heavy vehicles passing the roads. Higher traffic noise levels due to heavy vehicles have also been reported in literature (El-Fadel et al., 2002; Filho et al., 2004; Ma et al., 2006). Although the noise levels at Arumugam Pillai Road were higher than those at Permatang Batu Road, these were relatively less variable.

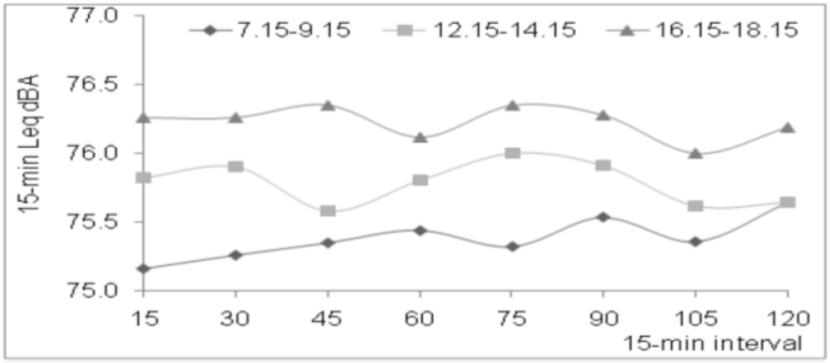

Fig. 2a. Trend noise level at Arumugam Pillai Road

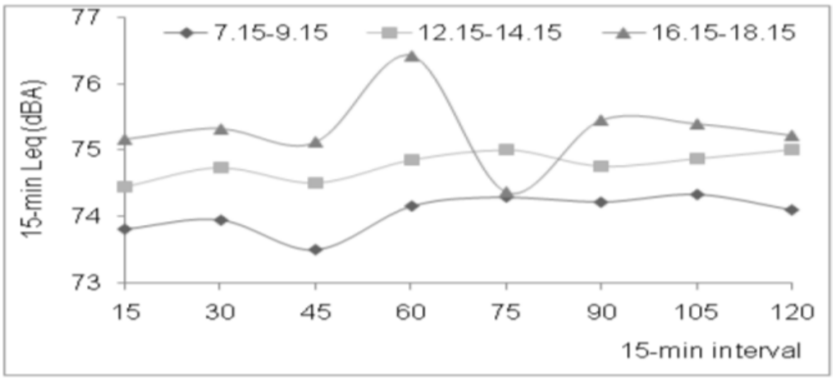

Fig. 2b. Trend noise level at Permatang Batu Road

3.2. Analysis of traffic speed

According to Li and Tao (2004), traffic noise level is influenced by traffic flow and speed. The average speed of traffic volume flow was obtained by taking 50 samples from the data collected using a radar gun. The radar gun was aimed at vehicles at one point to determine their speed. The data average was taken as the value of traffic speed flow. The data on spot speed are presented in the form of histograms in Figs. 3a and 3b. The spot speed was within 35.4 and 70.8 mph for both roads. From the spot speed data, the size of the class interval was determined by substituting the highest and lowest values of speed obtained for 50 observations for both roads. Sturges (1926) suggests the following equation for estimating the size of class intervals.

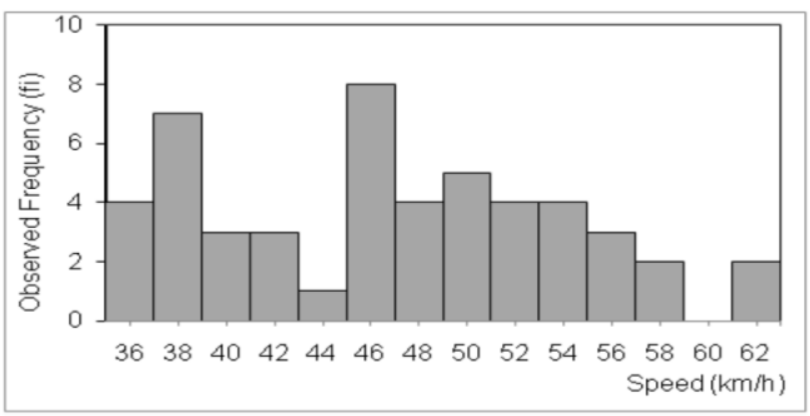

Fig. 3a. Histogram of spot speed data for Arumugam Pillai Road

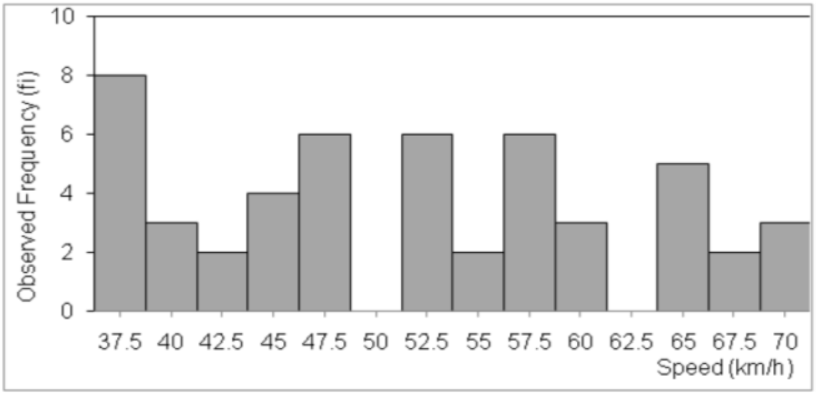

Fig. 3b. Histogram of spot speed data for Permatang Batu Road

$$I = \frac{R}{1 + 3.322 \log n} \tag{6}$$

Where

I = size of a class interval, R = total range (largest observed value minus smallest observed value), n = number of observations, Eqs. (7) and (8) show the sizes of the class intervals for Arumugam Pillai and Permatang Batu Roads, calculated as 4 and 5, respectively.

$$I = \frac{61.2 - 35.4}{1 + 3.322 \log 50} \tag{7}$$

$$= 3.875 \approx 4$$

$$I = \frac{70.8 - 37.01}{1 + 3.322 \log 50} \tag{8}$$

$$= 5.087 \approx 5$$

As calculated from the data shown in Figs. 3a and 3b, time mean speeds (average speed) were 46.7 and 52 km/h with standard deviations of 7.26 and 10.40 for Arumugam Pillai and Permatang Batu Roads, respectively. The cumulative distributions of spot speed data at Arumugam Pillai and Permatang Batu Roads are plotted in Figs. 4a and 4b. The 85th percentile was 54.5 km/h for Arumugam Pillai Road and 64 km/h for Permatang Batu Road.

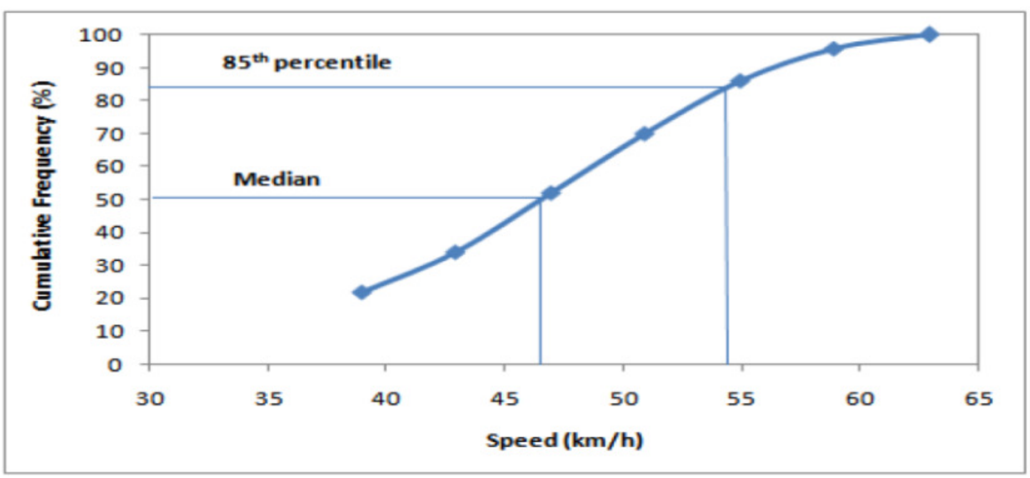

Fig. 4a. Cumulative distribution of spot speed data at Arumugam Pillai Road

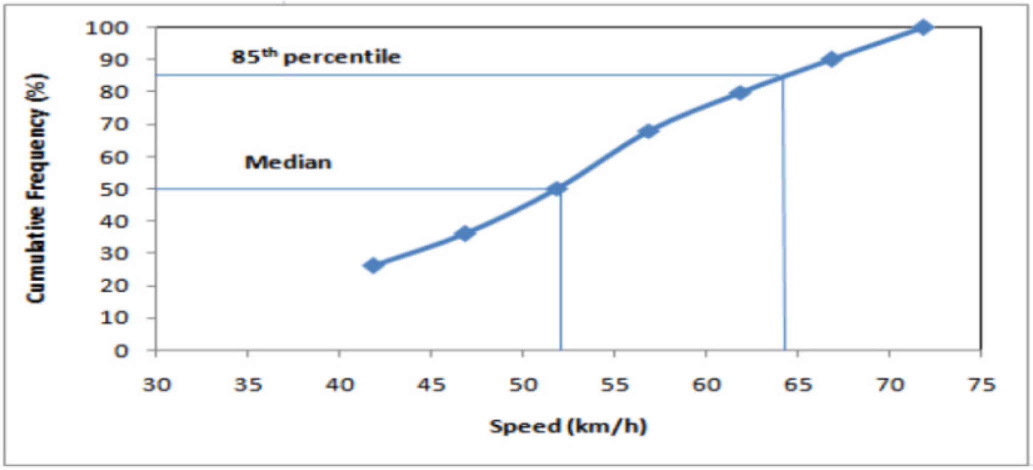

Fig. 4b. Cumulative distribution of spot speed data at Permatang Batu Road

3.3. Noise prediction model

Three prediction models, namely Burgess, Fagotti, and NAISS, were used. Data analysis was carried out using Eqs. (3), (4), and (5) for each model, respectively. Fig. 5a shows that that the Leq value measured was between 75.8 and 76.3 dB(A), whereas the Leq values predicted by the Burgess, Fagotti, and NAISS models were 71–74, 71.5–73.5, and 75–76 dB(A), respectively, for Arumugam Pillai Road.

For Permatang Batu Road (Fig. 5b), the predicted Leq values ranged between 73.8 and 74.9. Those determined by the Burgess, Fagotti, and NAISS models were 69.7–71, 69–70, and 74.9–75.9 dB(A), respectively. The results of the comparison of the different models show that the NAISS model is more suitable for both locations because the measured traffic noise values more accurately corresponded to the values determined by the NAISS model than to the other empirical relationships.

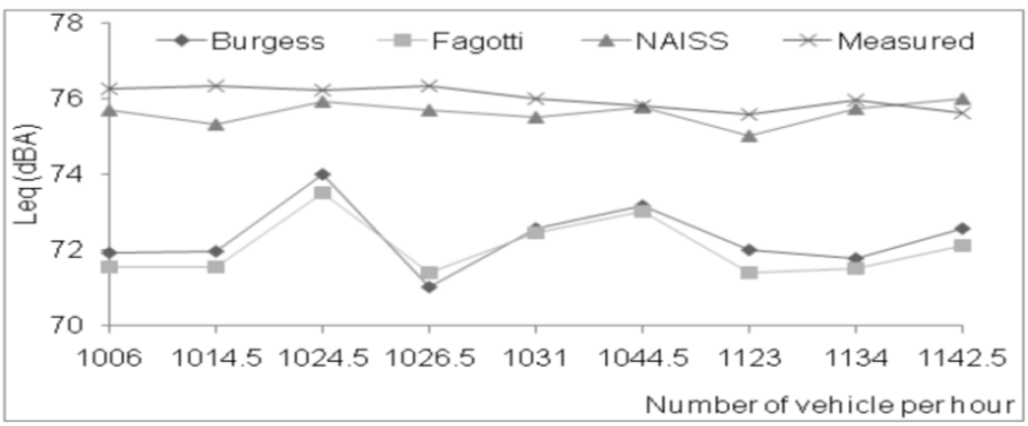

Fig. 5a. Leq comparison between different variants of traffic noise prediction model for Arumugam Pillai Road

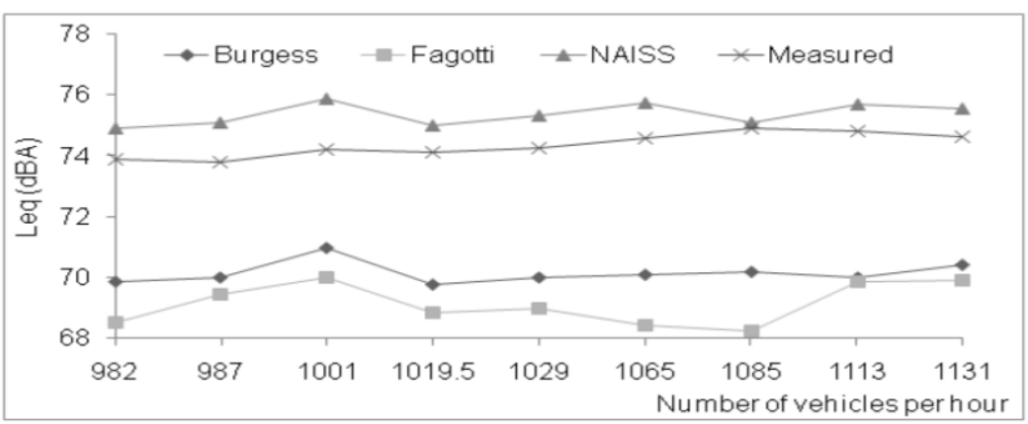

Fig. 5b. Leq comparison between different variants of traffic noise prediction model for Permatang Batu Road

3.4. Noise level in Erbil City

Fig. 6a shows the SPL measurements for Kirkuk and Shaqlawa Roads. The SPL values were higher during the peak hours particularly during the mornings, and then decreased gradually until 11 AM. This decrease continued until 1 PM for Kirkuk Road and 2 PM for Shaqlawa Road. From 2 to 3 PM, the SPL increased and then gradually decreased for both roads (Fig. 6a). Fig. 6b shows an almost similar trend for Peshawa Qazi and Erbil Koysinjaq Roads, where the highest SPL was recorded during the morning followed by a decrease in mid-day hours. A sudden decrease in SPL was observed for Peshawa Qazi Road after 12 PM. From 1 PM onwards, the increasing SPL trend was similar to that observed for Erbil Koysinjaq Road.

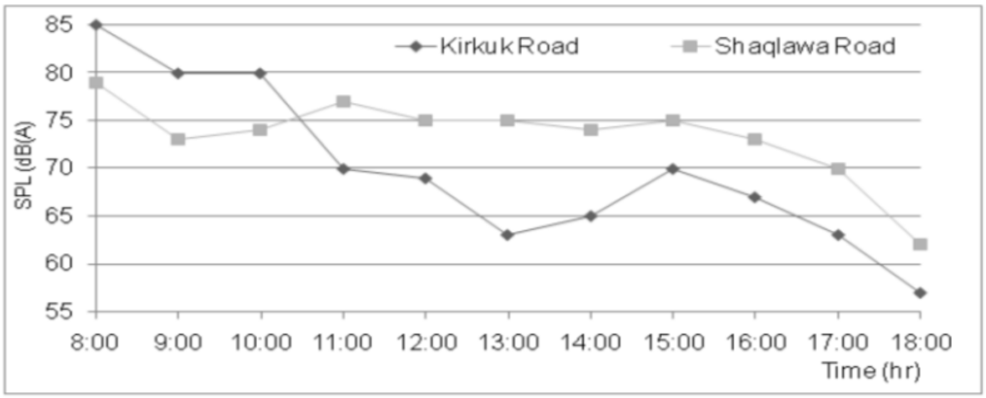

Fig. 6a. Variation of SPL for Kirkuk and Shaqlawa Roads

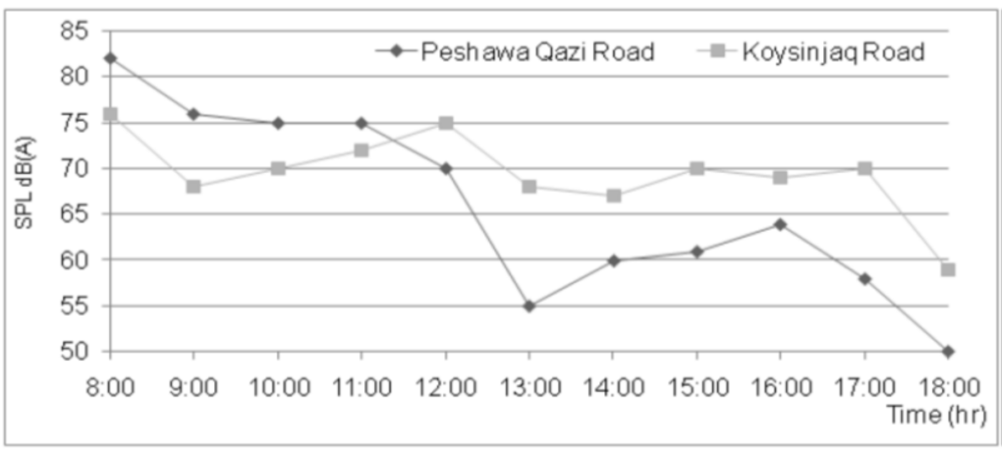

Fig. 6b. Variation of SPL for Peshawa Qazi and Koysinjaq Roads

At the edge of the roads, SPL values of 50–85 dB were recorded. This result agrees with the average value 85 dB mentioned by Davis and Cornwell (2008) and Kiely (1997). To observe the changes in SPL level with distance, the noise level was measured at 0, 10, and 20 m for two nearby roads, namely, Kurdistan and Barzani Namr Roads. Figs. 7a and 7b show the effect of distance on SPL for these roads. The increase in distance between the sound source and receiver decreased the SPL value. Correlation models can be used to describe the variations in SPL values with distance. A mathematical model was derived to represent the relationship of SPL and the distance between the sound source and receiver (m).

$$SPL(dB) = 106.87D^{-0.1328} \quad (9)$$

Where D is the distance between the sound source and receiver (m). The coefficient of determination (r^2) for the mathematical model was 0.9846, indicating a good relationship.

3.5. Comparison of the noise levels of Bukit Mertajam and Erbil City

The traffic noise levels for Bukit Mertajam were relatively lower than the values measured for Erbil City in the mornings. The L_{eq} values obtained for Arumugam Pillai and Permatang Batu Roads (Figs. 2a and 2b) showed little variability in the peak hours compared with those of Kirkuk, Shaqlawa, Peshawa Qazi, and Koysinjaq Roads (Figs. 6a and 6b). The noise levels measured for evenings in Bukit Mertajam were highly variable than were the corresponding values for Erbil City. The Leq values observed for Erbil City showed a decreasing trend, whereas those for Bukit Mertajam were at their maximum during the evening hours.

4. CONCLUSION

For both Arumugam Pillai and Permatang Batu Roads, traffic flow and volume were high during the peak periods, and the highest PCU value was recorded during the evenings. Time mean speeds were 46.7 and 52 km/h with standard deviations of 7.26 and 10.40 for Arumugam Pillai Road and Permatang Batu Road, respectively. The corresponding 85th percentile values were 54.5 and 64 km/h. The noise level in Leq for the studied locations varied between 74 and 76 dB(A), while the average background noise level was between 60 and 65 dB(A), which exceeds Malaysian DOE guidelines.

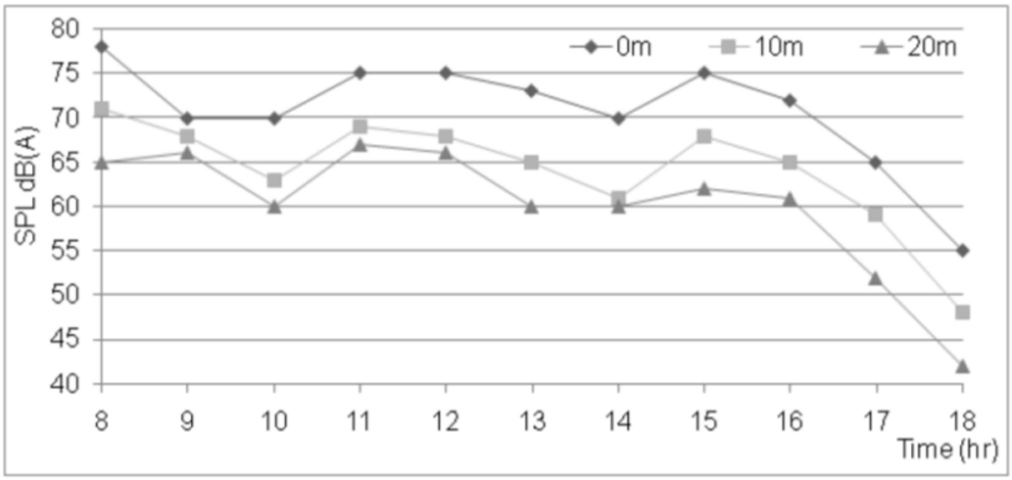

Fig. 7a. Variation of SPL for Kurdistan Road at different distances

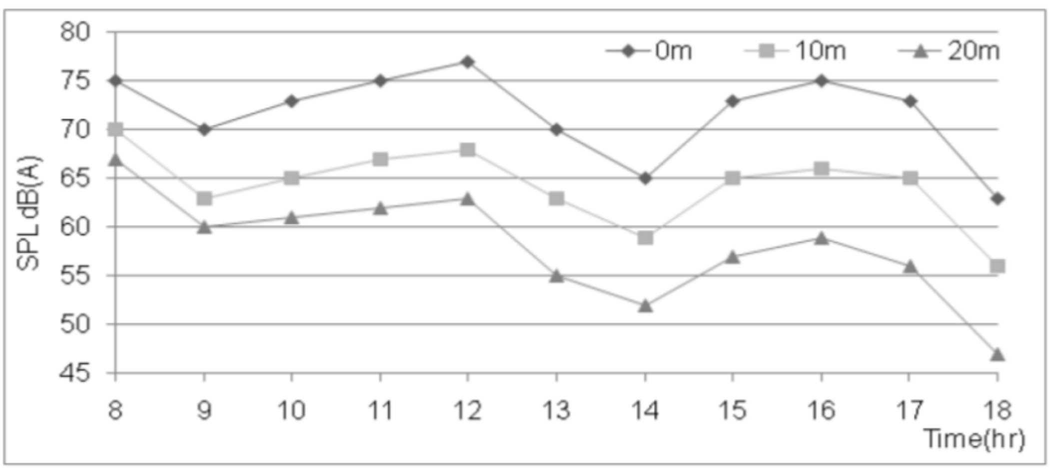

Fig. 7b. Variation of SPL for Barzani Namr Road at different distances

Among the three models used in this study for noise level measurements, the NAISS model proved more accurate followed by the Burgess and Fagotti models. The SPL was generally higher in the mornings for Erbil City. A drastic decrease was observed during the early afternoons followed by a gradual increase between 2 and 4 PM. In the early evenings, the SPL decreased. The noise levels measured at various distances showed a decreasing tendency with increasing distance from the receiver. Noise level can be reduced by designing vehicle enclosures for engines and producing better-designed mufflers. Reductions in speed limit can also be considered because noticeable decreases also occur at reduced vehicle speeds.

References

Abo-Qudais S, Alhiary A (2007). Statistical models for traffic noise at signalized intersections. Building and Environment, 42: 2939–2948.

Avsar Y, Gonullu MT (2005). Determination of safe distance between roadway and school buildings to get acceptable school outdoor noise level by using noise barriers. Building and Environment, 40: 1255–1260.

Ballesteros MJ, Fernańdez MD, Quintana S, Ballesteros JA, Gonzaĺez I (2010). Noise emission evolution on construction sites. Measurement for controlling and assessing its impact on the people and on the environment. Building and Environment, 45: 711–717.

Barros CP, Dieke PUC (2008) Choice valuation of traffic restrictions: Noise, pollution, and congestion preferences. A note. Transportation Research Part D, 13: 347– 350.

Cabrera IN, Lee MHM (2000). Reducing Noise Pollution in the Hospital Setting by Establishing a Department of Sound: A Survey of Recent Research on the Effects of Noise and Music in Health Care. Preventive Medicine, 30: 339 – 345.

Davis ML, Cornwell DA (2008). Introduction to environmental engineering. Fourth edition. McGraw-Hill International Edition.

Jadan K.S, El-Ezzy RM, Salman H (1997). Magnitude of and solutions to traffic noise levels in residential areas. First Jordanian conference on traffic engineering and environment. Amman, Jordan.

Kiely G (1997). Environmental engineering. First edition. Mc Graw – hill publishing company.

Mehdi MR, Kim M, Seong JC, Arsalan MH (2011). Spatio-temporal patterns of road traffic noise pollution in Karachi, Pakistan. Environment International, 37: 97–104.

Phan HYT, Yano T, Sato T, Nishimura T (2010). Characteristics of road traffic noise in Hanoi and Ho Chi Minh City, Vietnam. Applied Acoustics, 71: 479–485.

Rahmani S, Mousavi SM, Kamali J (2010). Modeling of road-traffic noise with the use of genetic algorithm. Applied Soft Computing, 11: 1008–1013.

Shaheen EI (1974). Environmental pollution: Awareness and control. First edition. Engineering technology, INC.

Travel Iraqi Kurdistan (2012). http://www.joaoleitao.com/iraqikurdistan/map-erbil-google-map-iraq-erbil-map-hawler/ [Accessed on 5 January].

Waly RB (1990) The effect of fluid flow rate on noise emission due to pipe fittings. M. Sc. Thesis. University of Technology, Iraq.

Zaheeruddin, Jain VK (2008). An expert system for predicting the effects of speech interference due to noise pollution on humans using fuzzy approach. Expert Systems with Applications, 35: 1978–1988.

Zannin, P.H.T., Diniz, F.B., Barbosa, W.A. Environmental noise pollution in the city of Curitiba, Brazil. Applied Acoustics 2002; 63: 351–358.