Measurement and Assessment of Traffic Noise Levels on Bangkok Streets

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Abstract.

Measurements of the noise level emission from vehicular traffic in Bangkok were performed on different types of motor vehicles. A monitoring program was also conducted to evaluate the traffic noise levels at various traffic zones of the Bangkok Metropolitan Area. Four noise monitoring sites were strategically established to cover the Bangkok Metropolitan Area (BMA). Traffic noise levels in these study areas were hourly measured during the day/night times and weekday/weekend. Both traffic volume counting and traffic noise level monitoring were determined simultaneously over 24-hour period and were used to identify the peak and non-peak periods. The study was carried out over a period of 6 months. Traffic noise levels at each monitoring site were measured by using a precision integrating sound level meter. The characteristic of traffic noise on Bangkok streets is discussed in term of monitoring, generation, measurement and societal effects. The average noise measurements taken at various traffic zones the Bangkok Metropolitan Region (BMR) during the peak hour period were found to be 72.8 ± 1.70 to 83.0 ± 3.14 dB (A) which is a prime concern of the Pollution Control Department, Thailand (PCD, 1997). The noise data collected during the monitoring period can be used to assess traffic noise situations on Bangkok streets and are therefore interesting for both local and overseas scientific communities.

Key words: motor vehicle noise, noise pollution, traffic zone, traffic volume, Thailand.

1. Introduction

Bangkok, the capital city of Thailand has a registered population of 6.5 million, [1] and is experiencing fast growth in annual vehicle registration, due to rapid industrialization and expanding urbanization. As a result of the increase in number of vehicles in the Bangkok Metropolitan Area (3.9 million vehicles registered in 2001), the intensity of noise pollution on Bangkok streets has been increasing over the past few years. There are many types of vehicles in Bangkok such as passenger cars, motorcycles, trucks, buses, taxis and motor-tricycles which can give rise to a large number of noise sources with low to moderate levels of noise. Horn-honking, tire noise at high speeds and defective mufflers are the major sources of noise in urban areas. In addition, noise transmitted by motors and exhaust systems of large trucks at low speeds provides a potential noise hazard to the driver as well [2]. In the city, traffic noise can be augmented by narrow streets and tall buildings, which can produce a canyon effect. Noise pollution caused by vehicular traffic has long been identified as the most common form of community annoyance [3]. It can develop noise-induced hearing loss and adverse effects can be cumulative with prolonged or repeated exposure [4]. Persons exposed to high noise levels are having more social conflicts at home and at work [5].

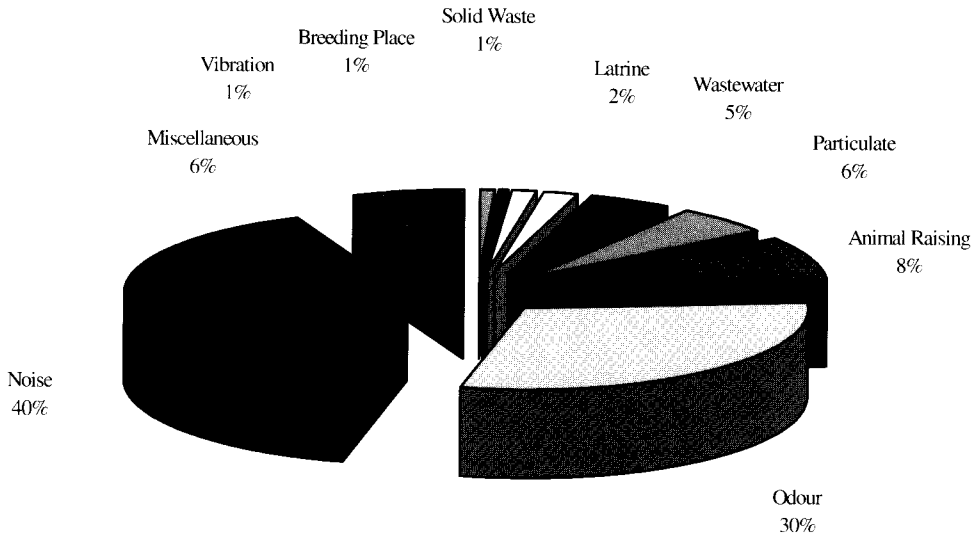

Figure 1. Proportion of noise problems categorized by environmental nuisance in Bangkok
Source: Environmental Health Division, Health Department, BMA, 2000

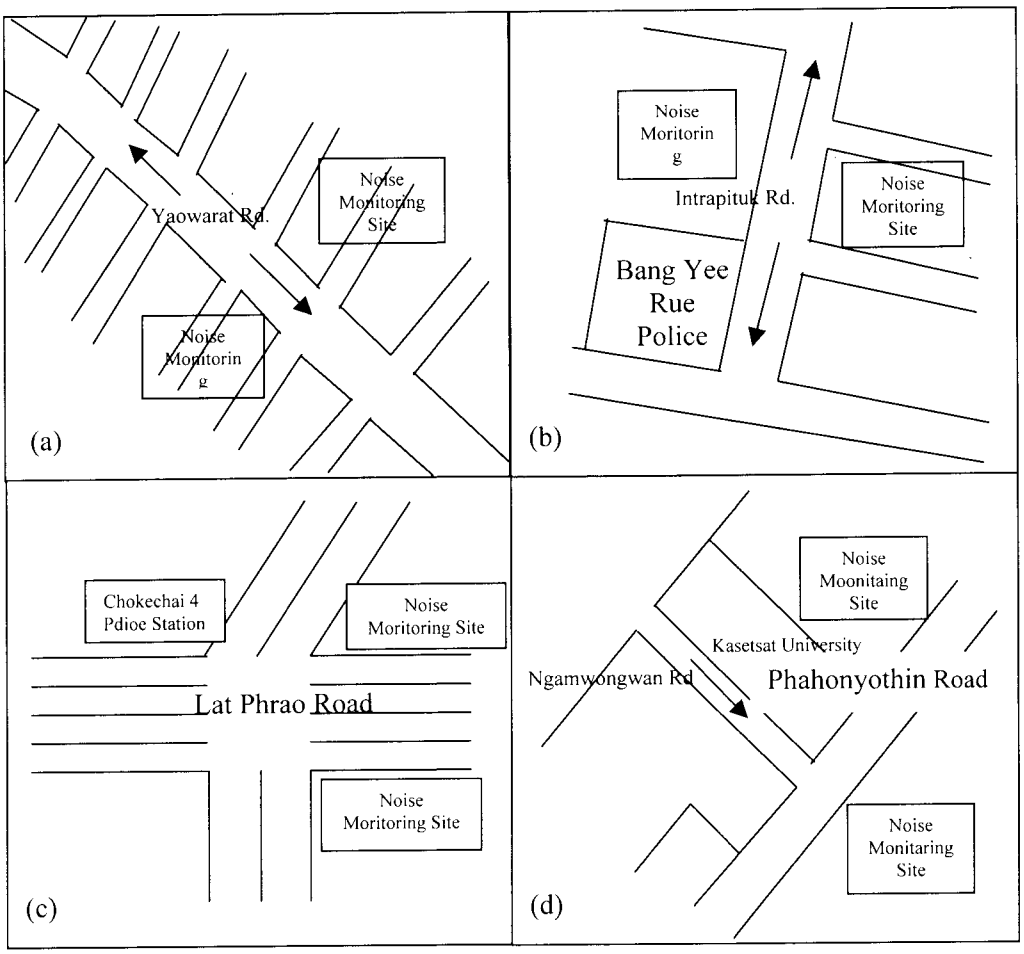

Figure 2. Locations of noise monitoring stations at the study area

Although subjective opinions on the noise pollution problems in Bangkok streets are frequently voiced (Figure 1), few data on the traffic noise pollution situation in Bangkok have been available to provide a basis for planning noise pollution control. It was the purpose of the present study to provide a quantitative data-base for traffic noise levels on Bangkok streets which might prove useful in the management of noise pollution in Bangkok.

2. Materials and Methods

2.1 Description of Ambient Noise Monitoring Stations

Four noise monitoring sites were established in the Bangkok Metropolitan Area (BMA), based on traffic density and flow conditions in that particular traffic zone. The descriptions for individual location of the monitoring stations are indicated in Table 1 and Figure 2, respectively.

Table 1. Description of monitoring stations at the study area

Station	Traffic Zones	Location	Vehicles/h (Peak hr)	Traffic Noise Leq. dB(A)	Population (persons km^{-2})
N1	Inner Core	Yaowarat Road	7,053.5	83.0 ± 3.14	26059
N2	Inner, Section I	Intrapituk Road	16,403.2	76.1 ± 2.70	18910
N3	Inner, Section II	Lat Phrao Road	13,661.0	79.2 ± 1.80	13426
N4	Middle	Phahonyothin Road	94,442.7	72.8 ± 1.70	5188

2.2 Motor Vehicle Noise Measurements

Motor vehicle noise measurements strictly followed the procedure of the Pollution Control Department, Ministry of Natural Resources and Environment, Thailand [6]. A motor vehicles with noise level lower than 85 dB (A), is measured at 7.5 m from the exhaust pipe or 100 dB(A) at 0.5m from the exhaust pipe. During measurement, the motor vehicle is stationary and engine conditions vary according to type of engine below:

a) Diesel engine: maximum rotating speed.
b) Gasoline engine: no-load acceleration at ¾ of maximum rotating speed.
c) Motorcycle: If maximum rotating speed is more than 5,000 rpm, the measurement is done at ½ of maximum rotating speed. If maximum rotating speed is less than 5,000 rpm, the measurement is done at ¾ of maximum rotating speed. The test was performed twice. The highest level at which the difference of noise levels between both tests was not more than 2 dB (A), was used.

2.3 Ambient Noise Monitoring and Measurement

Noise levels at each monitoring site were measured by using a precision integrating sound level meter (RION, NL-14, Japan) conforming to the International Electrotechnical Commission Recom-mendations, [7]. The microphone (RION, UC-53) used was of the precision condenser microphone type and can be directly recorded by a recorder. Each day before starting a measurement, acoustic calibration is performed using the pistonphone (RION, NC-72) or sound level calibrator NC-73. The sound level meter can simultaneously calculate the Leq (equivalent continuous sound pressure level). L_E (sound exposure level), L_{max} (maximum sound pressure level), and L_x (percentile sound pressure levels). The Leq processing was carried out in 10 ms intervals (100 samples per second). All measurements were made with the sound level meter set to the slow response and placed 1.2 m above the ground for measuring roadside noise levels. When the filter unit NX-05 is installed, 1/1 octave band or 1/3 octave band frequency analysis results can be recorded. By connecting the AC output of the sound level meter to the level recorder LR-06, the sound pressure level changes over time can also be recorded. The bar graph indication has a resolution of 1 dB and a range of 60 dB. The indication is updated every 0.1 seconds. The numerical reading has a resolution of 0.1 dB and is updated every second. Environmental parameters, such as ambient temperature, relative humidity and wind velocity were recorded together with the sound measurements. Noise levels were measured at various distances of 20, 50 and 100 m from the

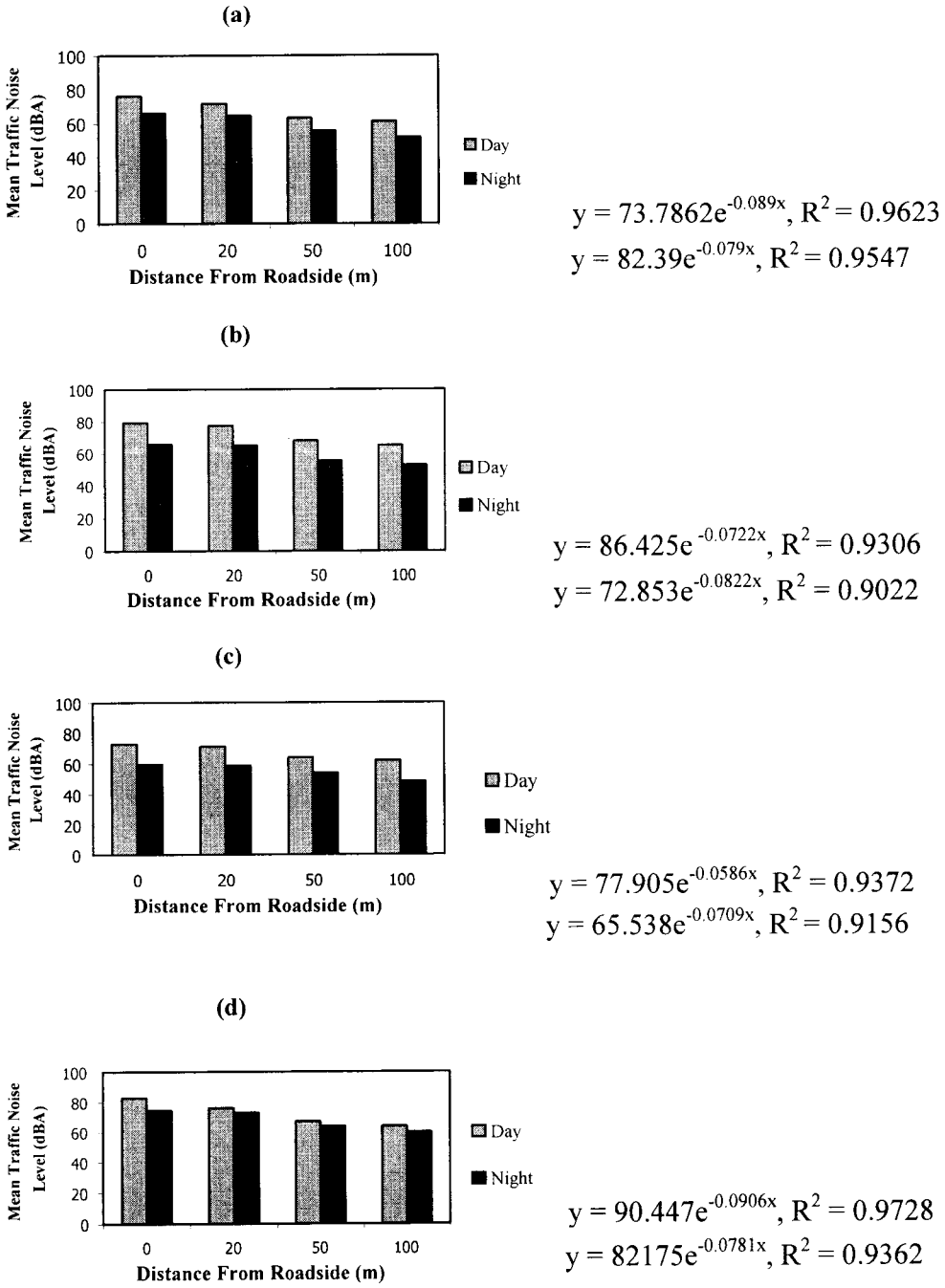

Figure 3. Mean Traffic Noise Levels during Day and Night Times and Distance from Roadside at a) Station N1 (Yaowarat Road), b) Station N2 (Intrapituk Road), c) Station N3 Lat Phrao Road) and d) Station N4 (Phahonyothin Road).

edge of road at the particular studied site. Noise monitoring was taken over a period of six months (from January to June, 2002). On each day at each distance, 8 measurements were made; 4 of which were during the day time and 4 were at the night time. Throughout the monitoring period at different distances, the same monitor was used on different days. The noise level measurements were made at the following time intervals of the day and night (Table 2):

Table 2. The noise level measurements for the specified times during day and night at each distance site.

Day time	Night time
0600 – 0700 hr	1800 – 1900 hr
0900 – 1000 hr	2000 – 2100 hr
1200 – 1300 hr	2300 – 2400 hr
1500 – 1600 hr	0100 – 0500 hr

A 24-hour noise monitoring pattern was carried out at each site to cover the fluctuations due to traffic during weekday and weekend. The average A-weighed noise level was measured hourly. Both traffic flow counting and ambient noise monitoring were determined simultaneously to identify the peak and non-peak noise levels over a 24-hour period. The 24 hour noise monitoring is most useful in giving the average values of noise level to be expected by day and night.

3. Results and Discussion

3.1 Average Noise Levels for Bangkok Motor Vehicle

Table 3 gives results obtained from noise measurements for various types of motor vehicle in Bangkok.

Table 3. Mean noise levels for Bangkok motor vehicles

Motor Vehicle Types	Mean Noise Level, dB (A)	Standard Derivation
Ten-wheel truck	96.1	5.75
Motor-tricycle (Samlor)	91.8	5.61
Truck	88.5	4.81
Motorcycle	87.9	5.11
Van	87.2	3.96
Taxi	87.1	3.41
Bus	86.8	3.80
Car	84.5	4.50

Note: Standard derivation is an output of the SPSS and 95% confidence interval of the estimated Leq. Z statistics are greater than 0.05. The distribution is normal.

The noise levels presented in Table 3 are for stationary vehicles. When the vehicles are moving noise levels will increase, due to actual noise generated from tires, engines and exhaust pipes. In some cases, noise from trucks can be higher than noise from motor-tricycles. Likewise, the noise from cars can be higher than noise from normal motorcycles. Measurement results of noise emissions from stationary motor vehicles show that noise levels of trucks and motorcycles are higher than buses and private cars. The average noise level of a ten-wheel truck is 96.1 dB(A). It is observed that noise levels generated by large diesel trucks can be significantly higher than the allowable noise level set at 85 dB(A) by the Royal Thai Police Department [6]. In general, noise from motors and exhaust systems of large trucks provides a potential noise hazard to the driver as well.

In Bangkok, motorcycles are considered to be a prominent contributor to traffic noise because of their growing population and higher average noise level than taxis and passenger cars. As a result of severe traffic congestion problems, motorcycles are becoming a popular mode of transportation. More

than 1.7 million motorcycles are registered in the Bangkok Metropolitan Region [8]. Motorcycles generate a wide range of noise levels, due to the extensive variation in muffling practices. In many cases, motor-tricycles are often singled out as special nuisances because of their unusual high noise level and their frequent penetration in residential areas.

3.2 Average Traffic Noise Levels on Bangkok Roads

3.2.1 Traffic Noise Levels at Various Monitoring Stations and Distances from Roads

Figure 3a gives the result at station N1 which shows that traffic noise levels during daytime, at the road edge was 83.00 dB(A) and decreased to 64.00 dB(A) at 100 m, at station N1. Similar trends were also observed at stations N2, N3 and N4. (Figure 3b to 3d). Noise level decreases, as the monitoring point is moved further away from the roadside. The monitoring result indicated that traffic noise levels in Bangkok were generally below established standards at locations away from streets. But at curbside monitoring stations, noise levels during rush hours were much higher, exceeding Thai noise level standards, which has set the 24- hour A-Weighted Equivalent Continuous Noise Level to be 70 dB(A). Throughout the monitoring period, the noise levels at some sites warrant serious concern, particularly at Yaowarat Road, Intrapituk Road, and Lat Phrao Road. These locations accumulate high noise levels due to heavy traffic, crowded areas, and dense activities nearby the measuring sites and tall buildings on both sides of the street, especially Yaowarat Road (station N1) which is a one way street with frequent traffic jams, low speed, braking, accelerating and so on. Hence, if traffic flow is 'stop and go driving', noise level will also be maximum. Similarly, Intrapituk and Lat Phrao Roads (sites N2 and N3) with frequent decelerating at intersections have also shown high traffic noise levels. In addition, diesel buses, taxis and three wheeler vehicles at these sites appear to increase the traffic noise level. In general. the noise levels at these three sites vary from 79 dB(A) to 83 dB(A) during day hours and 60 dB(A) to 74.5 dB(A) during night hours (18.30-05.30). Noise levels were highest during the daytime, particularly during rush hours (07.00-09.00 and 16.00-18.00) and on some occasions, it exceeded the 24- hour A-Weighted Equivalent Continuous Noise Level of 70 dB(A), set by the Pollution Control Department of Thailand. Hence these areas are not generally suitable for residential purposes. On the other hand, lower traffic noise level is expected on Phahonyothin Highway (site N4) which is a 8 lane-two way highway providing stable traffic movement. Daytime noise levels vary from 62 dB(A) to 72.8 dB(A) and night time noise levels vary from 45 dB(A) to 59.5 dB(A). Hence, this area was found to be more suitable for residential purposes.

3.2.2 Weekday and Weekend Variations

The maximum hourly Average Equivalent Energy Continuous noise levels (Leq) on weekdays and weekends, for all the monitoring sites during the sampling time period (0100-2400) are presented in Table 4. During weekdays, there are two peaks for traffic noise levels, one in the morning at approximately 9 am and one in the evening around 7 pm (Figure 4). The morning peak was linked with the morning commuter rush and a similar rush hour was observed for the evening peak. Fluctuation of traffic noise levels between weekday and weekend were investigated. There was only a small difference in noise levels observed between weekdays. However, a moderate decrease in noise level is recorded during weekends. A lower noise level resulted from a decreased traffic activity on Sunday, since offices and government departments were closed during the weekend. When comparing the 8-hour A-weighted noise level during daytime in Bangkok urban areas with the international noise standards proposed by NIOSH [9], (85 dBA), AGGIH [10], (85 dBA) and OSHA [11], (90 dBA), it was found that the intensity does not exceed the 8-hour noise exposure limit. The traffic noise levels in some study areas are currently below the established standards, however, annual traffic noise levels are increasing, and is a health concern as well.

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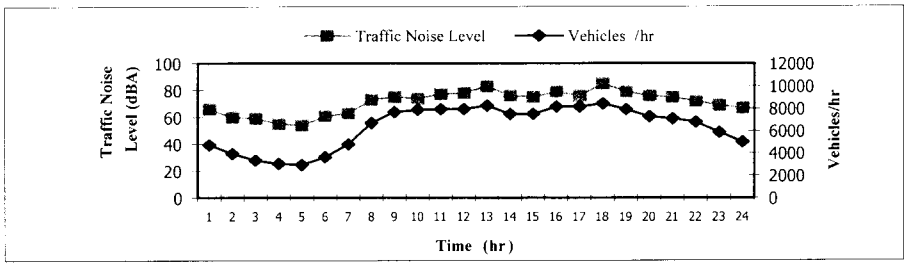

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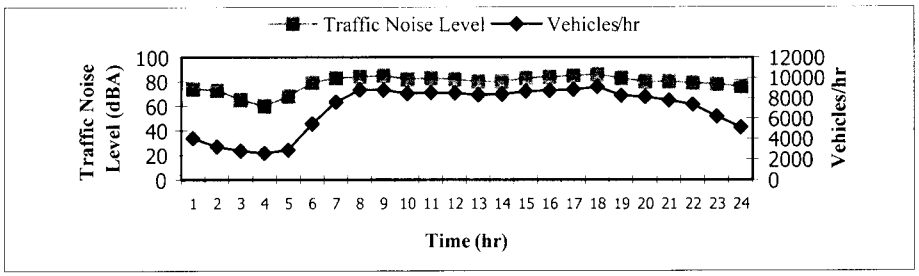

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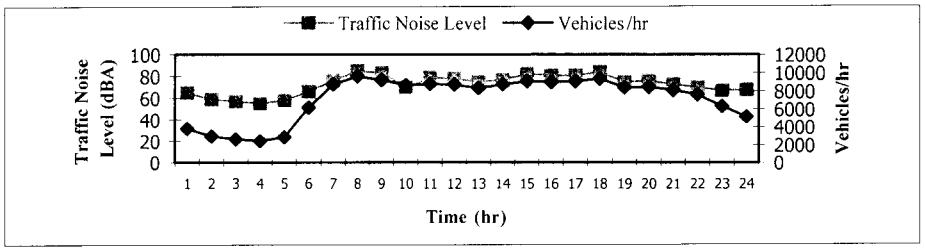

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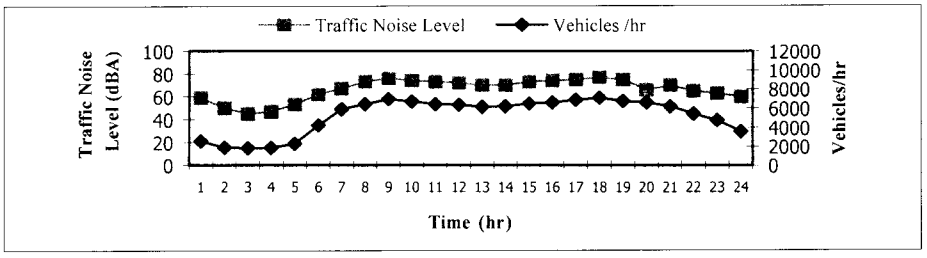

Figure 4. Relationship between Traffic Noise Levels and Traffic Volume at (a) Station N1 (Yaowarat Road), (b) Station N2 (Intrapituk Road), (c) Station N3 (Lat Phrao Road) and (d) Station N4 (Phahonyothin Road).

Table 4. Maximum hourly average Leq during weekday and weekend at various monitoring stations, January-June, 2002.

	Maximum Hourly Average Leq, dB(A)		
Station	Weekday	Saturday	Sunday
N1 (Yaowarat Road)	83.00 (7.1)	76.35 (5.3)	74.45 (5.9)
N2 (Intrapituk Road)	76.10 (3.4)	74.75 (6.2)	64.45 (3.1)
N3 (Lat Phrao Road)	79.20 (3.9)	75.05 (4.9)	68.25 (4.8)
N4 (Phahonyothin Highway)	72.80 (4.7)	70.45 (2.2)	64.25 (6.2)

Note: Standard deviation is in parenthesis.

3.2.3 Relationship between Traffic Noise Levels and Traffic Volume

Figures 4a to 4d show the variation of noise level with traffic volume, at various monitoring stations. A comparison was performed between the traffic noise level and traffic number for a 24 hour period (01:00-24:00). It is seen that there is a gradual increase in traffic noise level reaching a maximum during morning peak hour (07:00-09:00) and evening peak hour (16:00-18:00). Thereafter, a slight decrease in traffic noise level is observed at non peak hours (11:00-13:00). During peak hours, more vehicles are expected on the road resulting in frequent congestion on major roads in the city. Similarly, significant differences in traffic noise levels and traffic volume were also noticed between day and night times. Noise levels were highest during the daytime which was predominantly attributed to road traffic at rush hour conditions and decreased gradually during the night time (18.30-05.30). In Figure 4, it is revealed that noise levels at night time are not significantly reduced, even though tremendous decreases in traffic volumes appear in the night times. This can be explained by the police regulation to allow ten-wheel trucks to enter the city after 9.30 p.m., especially the major roads leading to the city. Elevated levels of noise were found in those areas which were characterized by poor traffic flow particularly at station N1, Yaowarat Road (7,053.5 vehicles/hour). In general, the highest hourly average noise levels were found curbside at several busy main roads with higher traffic volume while lower levels were found among roadside stations with lower traffic volumes.

4. Conclusions

Unlike other forms of pollution such as air, water and solid waste, noise pollution problems have been receiving lesser attention by Bangkok city dwellers. In Bangkok, surveys show that some significant differences in traffic noise effects among different social classes of people. Home dwellers are more likely to be bothered by traffic noise than street vendors at each site. Apartment dwellers are frequently annoyed by traffic noise, when the building is not properly insulated and constructed [12]. However, with increasing traffic noise levels in the Bangkok Metropolis, at certain intensities will produce different degrees of hearing loss and speech interference [13]. Sources of traffic noise exceeding legal noise limits can be controlled through enforcement of legislation and policy and planning [14]. Local pollution control departments should also implement a comprehensive study of various options to reduce traffic noise pollution.

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