Journal of Civil Engineering
The Institution of Engineers, Bangladesh
Vol. CE 29, No. 1, 2001

TRAFFIC INDUCED NOISE POLLUTION IN DHAKA CITY

Md. Jobair Bin Alam[1], A.F.M.A. Rauf[1] and M.F. Ahmed[1]

ABSTRACT: Along with the increasing degree of air and water pollution, noise pollution is also emerging as a new threat to the inhabitants of Dhaka City. Exposure to high level of noise may cause severe stress on the auditory and nervous system of the city dwellers, particularly the children. Motorized traffic is one of the major sources of noise pollution in urban areas. The paper reports the level of traffic induced noise pollution in Dhaka City. For this purpose noise levels have been measured at thirty-seven major locations of the city from 7AM to 11PM during the working days. The data have been analyzed to calculate various noise parameters such as L_{eq}, L_{10}, L_{50} and L_{90}. It is observed that at all the locations, the level of noise remains far above the acceptable limit for all the time. The paper suggests that vulnerable institutions like schools and hospitals should be located about 60m away from the roadside unless any special arrangement to alleviate sound is used. A model has also been developed for the prediction of noise level on the basis of traffic volume, mean speed and distance.

KEYWORDS: Sound Level, Traffic, Noise Mitigation.

INTRODUCTION

Noise can be defined as the level of sound which exceeds the acceptable level and creates annoyance. Frequent exposure to high level of noise hampers physical and mental peace and may cause damage to the health. Along with the increasing degree of air and water pollution, the inhabitants of Dhaka City are being exposed to high level of noise pollution. The level of noise pollution is very closely related with urbanization and motorization. Although there are many sources of noise which include industries, construction works and indiscriminate use of loud speakers, motorized traffic is the principal source of noise in urban areas. During the 70s and early 80s, noise pollution was not a major concern for the dwellers of Dhaka City. With the increase of in the number of motorized vehicles in the city, the hazard of noise pollution has increased and exceeded the level of tolerance.

Exposure to high level of noise causes severe stress on the auditory and nervous system. Ahmed (1998) reports that the hearing ability of the inhabitants of Dhaka City has reduced during the last ten years. About five to seven percent of the patients admitted to the Bangabandhu Sheikh Mujibar Rahman Medical University, Dhaka are suffering from permanent deafness due to noise pollution. Disturbances created by noise may cause hypertension, headache, indigestion, peptic ulcer, etc (OECD, 1995).

---

[1] Department of Civil Engineering, BUET, Dhaka-1000, Bangladesh

The paper aims at studying the level of noise pollution in Dhaka City and analyzing its level of severity. It analyses durinal variation of noise near the roadside and its relationship with traffic volume. In this regard, noise related parameters such as L_{eq}, L_{10}, L_{50} and L_{90} have been estimated from field observations of noise levels. A noise prediction model has also been calibrated to estimate noise level at any location on the basis of traffic volume, mean traffic speed and distance. This paper also suggests several strategies to control the level of noise pollution in the city.

METHODOLOGY

Measurement of Noise

Noise is characterized by its sound level, its frequency spectrum and its variation over time. Although the level of noise largely depends on the subjective perception of the hearer about the loudness, the term sound level refers to a physical measure which is a function of the magnitude of the pressure fluctuations. The most common measures of sound level are sound intensity and sound pressure.

Sound intensity (also called sound power density) is the average rate of sound energy transmitted through a unit area perpendicular to the direction of sound propagation, typically measured in pico-watts per square meter. Since no instrument is available to directly measure the power level of a source, sound pressure is employed as a measure in this regard. Sound pressure is usually proportional to the square root of sound power. Because of dealing with large range of numbers, a logarithmic measure called decibel (dB) is used to describe sound level.

The sound level in decibel is defined as follows:

$$Sound\ Level, L\ (dB) = 10Log_{10}\left(\frac{P}{P_0}\right)^2 = 20Log_{10}\left(\frac{P}{P_0}\right) \quad (1)$$

Where, P= Root-mean-sq. sound pressure (Newton per sq. meter)
P_0= Std. reference pressure (20 micro-Newton per sq. meter)

For practical purpose, the decibel scale ranges from zero, the threshold of hearing, to about 140 dB, the onset of pain. For every three-decibel increase in sound level, the apparent loudness of sound doubles.

In order to account for the ear's response to different levels of noise, weighing filters are used while measuring the sound level. The A-weighted sound level is devised to represent a person's subjective response to the variation of sound more accurately. In this case the level of noise registered by the microphone of the measuring instrument is filtered and adjusted in the same way that the human ear filters and adjusts the sound level it receives. The A-weighted sound level, measured in decibel (dBA), is the generally accepted scale for measuring sound level in highway transportation.

In this study, noise levels have been measured by a sound level meter which consists of a microphone that converts the pattern of sound pressure fluctuations into a similar pattern of electric voltage, amplifiers and a voltage meter that is normally calibrated to read in decibel.

Noise Parameters

Noise levels generated by transport facilities show a good amount of variability with respect to time. It is, therefore, necessary to establish meaningful statistical noise measures that describe the magnitude of the problem while capturing the variability. The parameter universally used in discussions of noise pollution of environment is L_{eq}, the energy equivalent continuous noise level expressed in dB(A) which is the average rate at which energy is received by the human ear during the period mentioned (Papacostas and Prevedouros, 1993). This parameter can be obtained by direct objective measurement with an integrating type of sound level meter; or can be computed from a sample record of variation of noise level with time during a specified period. Mathematically it can be expressed as follows,

$$L_{eq} = 10\ Log_{10}\left[\frac{1}{T}\int_0^T \frac{f^2}{f_0^2}dt\right] = 10\ Log_{10}\left[\frac{1}{N}\sum_i 10^{(L_i/10)}\right] \tag{2}$$

Where T is the period of measurement and L_i is the average noise level during interval i.

Another parameter, termed as Noise Pollution Level (L_{np}), is also used to express varying level of noise (Rao and Rao, 1991). It can be computed from the time varying noise level using following equation.

$$L_{np} = L_{50} + \frac{(L_{10} - L_{90})^2}{60} + (L_{10} - L_{90}) \tag{3}$$

Where L_{10}, L_{50} and L_{90} indicate the levels exceeded for 10%, 50% and 90% of time respectively in a set of records of noise level in a given interval of time. Lnp is expressed in the units of dB(A).

Leq provides the energy equivalent sound level received by the ear and hence an indicator of the physiological disturbance to the hearing mechanism. Lnp takes into account the variations in sound signal and hence serves as better indicator of noise pollution in the environment for physiological and psychological disturbance of the human system.

Traffic Noise Index (TNI) is another parameter which indicates the degree of variation in a traffic flow. This is also expressed in dB(A) and can be computed by using the following equation.

$$TNI\ \ in\ \ dB\,(A) = L_{90} + 4\,(L_{10} - L_{90}) - 30 \tag{4}$$

Noise climate (NC) provides the range over which the sound levels fluctuate in an interval of time and is given by the following equation.

$$NC\ \ in\ dB\,(A) = (L_{10} - L_{90}) \tag{5}$$

Noise Prediction

Noise prediction methods have been developed in various countries for the assessment of traffic noise levels. Noise prediction methods have been adopted by the public authorities responsible for land-use planning design with the objective of locating various types of land-uses in areas with acceptable noise levels. These agencies are also responsible for reduction of noise level as well as design and implementation of noise abatement technologies. The noise prediction methods, characterized by different levels of detailing and reliability, can be classified into three basic groups which include analytic equations and nomographs, physical models and computerized simulation models. The last two approaches incorporate highly detailed reproductions of very complex spatial situation and are highly expensive. Computer simulation models are usually used for large-scale projects to evaluate acoustic propagation, reflection and absorption phenomena. Analytical equations are widely used for quick prediction of expected noise levels in the developed countries like USA, UK, Austria, Finland, France, Japan (OECD, 1995). In these models the expected level of noise is forecasted on the basis of traffic volume, speed, distance and percentage of heavy vehicles.

STUDY DESIGN

Noise levels have been measured at nineteen locations in Dhaka City during 7AM to 11PM on workdays. The study incorporates most of the major locations of the city, which include Gulistan, Motijeel, Science Laboratory, Dhanmondi, Mohakhali, Gulshan, Banani and Uttara. Noise levels have been measured at the roadside as well as at distances away from the roadside. This is done to analyze the effects of distance and existing roadside barriers on the reduction of noise level. All the measurements were made on 'A-weighting' scale and the Sound Level Meter (SLM) was switched to fast response position. During each hourly interval, sound levels have been measured for 10 minutes for a couple of times. The average values of these measurements have been recorded as the sound level for the corresponding location and time interval. From the recorded values of noise level, noise parameters have been estimated using the procedure described above. At the same locations, traffic data was recorded by video imaging. Later the video data was extracted to measure traffic flow and speed in the Traffic Engineering Laboratory of BUET. Then, a relationship between noise and traffic flow, speed and distance was developed.

ACCEPTABLE LEVELS OF NOISE

Various standards are being used in different countries regarding the acceptable levels of noise depending on the situation. Limits of acceptable noise level established by different organizations are given in Table 1.

Table 1: Acceptable Noise Level (dBA)

Description of Area	Noise Level dBA		
	DOE	FHA	AASHTO
Sensitive Areas such as parks, schools, hospitals and mosques	45	60	55-60
Residential Area	50	70 (Interior max. 55)	70 Exterior 55 Interior
Mixed Area	60	70	70
Commercial Area	70	75	75
Industrial Area	75	75	75

Source: OECD (1995), Davis and Cornwell (1998) and Ahmed (1998)

RESULTS OF THE STUDY

City Wide Aggregate Noise Level

From the study it is observed that the average noise level in the road side in Dhaka city is about 78 dB(A) which far exceeds the acceptable limit of 60 dB(A) set by the Department of Environment (DOE), Bangladesh considering the road side as mixed area. Table 2 and Fig. 1 show the average noise levels and their variations with distance away from the roadsides. Fig. 1 also shows that the noise level reduces to acceptable limit at about 60m away from the roadside.

Table 2. Average Level of Noise (Leq) in Dhaka City

Time Interval	Distance From Road Side (meter)						
	0m	15m	30m	45m	60m	75m	90m
7am-11am	78.55	74.04	69.33	65.09	60.19	55.27	50.17
11am-3pm	77.24	72.54	67.91	63.19	58.05	63.24	48.20
3pm-7pm	79.09	74.38	69.65	65.00	59.71	54.94	49.78
7pm-11pm	77.45	72.99	68.05	63.18	58.36	53.41	48.33

Noise Level at Different Locations

From Table 2 it is observed that the noise level remained almost constant during the sixteen hours of measurement. During this time traffic composition also remains similar. Table 3 presents the variation of noise level near the road at some of locations where it has been measured and Fig. 2 depicts the relationship between traffic volume and noise level.

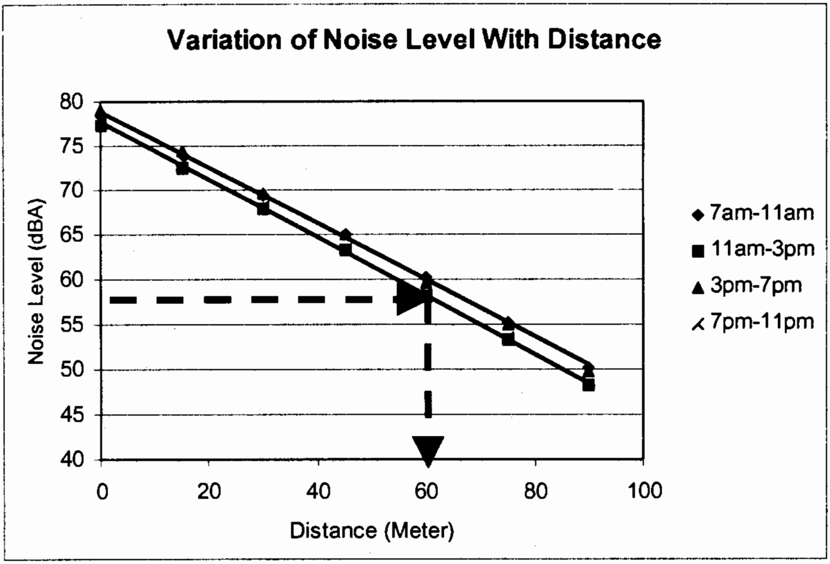

Fig 1. Variation of Noise level with Distance

Table 3. Noise Level (Leq dBA) near Road

Time Interval	Locations						
	Gulistan	Sc. Lab	Saydabad	F.gate	Dhanm.	Gulshan	Uttara
Land-use	Comm.	Mixed	Comm.	Comm.	Res.	Res.	Res.
7am-11am	80.08	75.24	83.27	80.07	75.87	76.16	76.25
11am-3pm	79.34	78.19	83.89	78.86	74.38	74.83	74.81
3pm-7pm	81.13	79.23	84.37	81.96	75.21	76.11	76.81
7pm-11pm	78.52	75.32	82.08	80.28	74.30	74.31	73.36

From Table 3 it is observed that even in residential areas, the level of noise pollution is very severe for the household near the roadside. Most of the schools and hospitals, which are particularly vulnerable, are located near the roads.

Noise level reduces linearly with distance unless any noise-reducing barrier is used. It also depends on traffic flow and speed. The following model is calibrated to estimate the effect of these variables on noise. Using this model, noise level at a particular location as well as desirable positions for locating the vulnerable institutions can be obtained.

$$L_{eq}(dBA) = 20.63 + 10.98\log(Q_{LV} + EQ_{HV}) + 15.76\log V - 8.39(D + w/2) \quad (6)$$

$$(R^2 = 0.69)$$

Where, Q_{LV} and Q_{HV} are the volumes of light and heavy vehicles respectively, E is factor of acoustic equivalence between light vehicle (<3.5 Ton) and heavy vehicle (>3.5Ton), V is speed in km/hr, D is distance from roadside (m) and w is the width of the roadway. The equivalence factor E depends on road type and gradient (OECD, 1995).

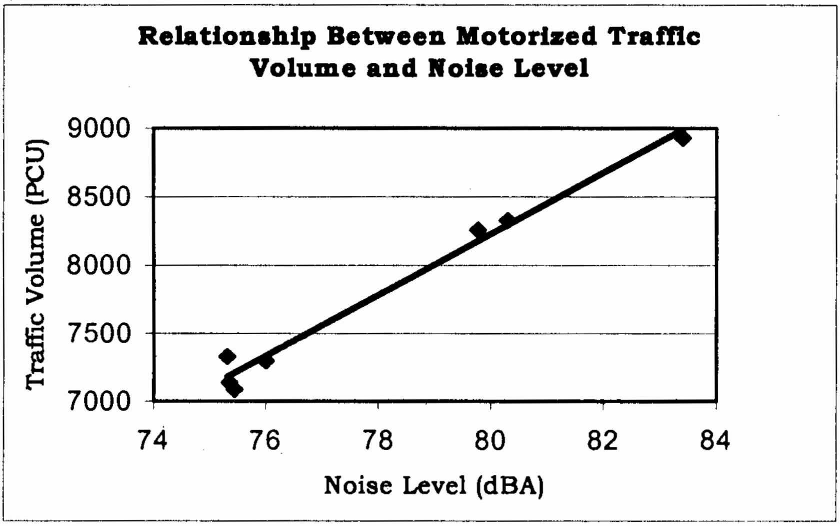

Fig 2. Variation of Noise Level with Traffic

Noise Parameters at Different Locations

Typical values of the noise parameters described earlier are shown in Table 4 for some particular locations. It is observed that the average level of noise and its degree of fluctuation, as implied by L_{eq}, L_{np} and TNI, are high in both residential and commercial areas. In the residential areas the range of variation in noise level is much higher as implied by the values of Noise Climate (NC). Such variations of noise create shock wave which severely affect patients of heart disease.

Table 4 Noise Parameters near Road at Different Locations

Noise Parameter	Location		
	Sayedabad	Science Laboratory	Dhanmondi
L_{eq}	82.86	78.83	75.23
L_{np}	89.62	82.10	80.23
TNI	87.23	81.06	77.23
NC	6.23	10.61	19.20

NOISE PROPAGATION AND MITIGATION STRATEGIES

Once generated at a source, unshielded noise spreads out spherically as it travels through the air away from the source. Consequently, the intensity of sound diminishes with distance from the source. In addition to these losses in intensity due to spreading, absorption losses also take place as the sound energy is transferred between air particles. When sound waves encounter natural and manufactured solid objects, they undergo diffraction and reflection, the degree of which depends on the characteristics of the object. Trees and other vegetation, for example, tend to reflect sound wave in a diffused pattern and are considered to be as interceptors of noise. Dense plantation will have some effect on noise reduction.

The approaches to combat noise can be divided into three categories: source controls, noise path controls and receiver side control. Source control includes vehicle control devices, vehicle maintenance practices, traffic controls and geometric as well as construction design controls. Noise path controls include erection of appropriately designed noise barriers that reflect and diffuse noise and provision of buffer zones between transportation facility and the population to provide a distance over which noise can be attenuated. Noise control strategies at the receptor site include public awareness programs and building design practices.

Source control is the task of traffic law enforcing authorities and road designers. Realizing the grave situation, the law enforcing authorities should consider the issue seriously and develop rules accordingly. The engineers should design the geometric features in a way to control noise.

CONCLUSION

Noise is undesirable or unwanted sound. Extended exposure to excessive sound has been proved to produce physical and psychological damage. Because of its annoyance and disturbance implications, noise adds to mental stress and hence affects the general well being of those exposed to it. Noise is a major source of friction among individuals.

Transportation operations are major contributors to noise in modern urban areas. Here noise is created by the engine and exhaust system of vehicles, aerodynamic friction, interaction between the vehicle and road system, and by the interaction among vehicles.

The results of this study show that the level of noise pollution in Dhaka city far exceeds the acceptable limits set by the Department of Environment, Bangladesh. Even in the residential areas and vulnerable institutions like schools and hospitals, noise level is much higher than the acceptable limit. This has serious implication on the general health and well-being of the inhabitants of the city. It is also observed that noise level is closely related with the number of motor vehicles. Urgent measures should be taken to control the level of noise pollution in the city.

To reduce noise pollution, several measures can be implemented which include proper maintenance of vehicle and roadway, plantation of trees and construction of sound barriers. Solid boundary walls are expected to have a positive effect on attenuation of noise level. In this regard, it is worthwhile to mention that there is a tendency to construct grilled fences in the roadside for decorative purpose. These should be avoided in the major roadsides. Special measures should be taken to design and construct roadside faces of buildings.

REFERENCES

Ahmed, K. (1998), "A Study on Noise Pollution in Dhaka City", Department of Environment, Bangladesh.

Kadiyali, L.R. (1997), "Traffic Engineering and Transportation Planning", Sixth Edition, Khanna Publishers, India.

Papacostas, C.S. and Prevedouros, P.D. (1993), "Transportation Engineering and Planning" Second Edition, Prentice Hall Publishers, USA.

Ahmed, F. (1999), "Study on Noise Pollution Caused by Road Traffic in Dhaka City", B.Sc. Engineering Thesis, Department of Civil Engineering, BUET, Dhaka.

OECD (1995), Road Side Noise Abatement, Road Transport Research, Organization for Economic Cooperation and Development, Publication Services, OECD, France.

Rao, P.R. and Rao, M.G. (1991), Urban Traffic Intensity and Prediction of (L_{eq}) Noise Level, Indian Journal of Environmental Health, National Environmental Engineering Research Institute, India.

ABBREVIATIONS

DOE	Department of Environment Bangladesh
FHA	Federal Highway Agency
AASHTO	American Assoc. of State Highway and Transportation Officials
Comm.	Commercial Area
Mixed	Mixed Land-Use Area
Res.	Residential Area