Asian Journal of Water, Environment and Pollution, Vol. 13, No. 3 (2016), pp. 67–72.
DOI 10.3233/AJW-160028

Environmental Pollution by Traffic Noise in the City of Colombo, Sri Lanka

Nandika S. Nagodawithana*, Arunasalam Pathmeswaran[1], Ananda S. Pannila[2], Ananda R. Wickramasinghe[1] and Nalini Sathiakumar[3]

Ministry of Health, Colombo, Sri Lanka
[1]Department of Public Health, Faculty of Medicine, University of Kelaniya, Sri Lanka
[2]Industrial Technology Institute, Colombo, Sri Lanka
[3]Department of Epidemiology, School of Public Health, University of Alabama at Birmingham, USA
✉ nnagodawithana@yahoo.com

Received January 16, 2015; revised and accepted June 17, 2016

Abstract: Traffic noise levels in most cities of the world are higher than the recommended levels. Exposure to high levels of noise may cause adverse health effects such as ischemic heart diseases and noise induced hearing loss. We conducted a cross-sectional study to determine road traffic noise levels at 60 selected locations in the city of Colombo, Sri Lanka. On randomly selected days we measured equivalent continuous sound pressure level (LA_{eq}) for six hours during the day. From these measurements LA_{eq} for eight hours were calculated and used as the average noise level of a particular location. LA_{eq} (8 hrs) within Colombo ranged 76.6 to 84.0 dB; well above the Sri Lankan recommendation of 63.0 dB (an increase of 13.3 to 21.0 dB), and the WHO recommendation of 55.0 dB (an increase of 21.6 to 29.0 dB). These levels translate into increase of sound pressure level by 21.4 to 794.3 times above the recommendations on the logarithmic scale of dB. Thirty-eight of 60 locations recorded levels more than 80.0 dB. Road traffic noise levels in Colombo were well above the recommended levels. Though the increase in measured decibels might not appear to be too high, in reality this translates into an increase manifold times in the sound pressure level that reaches the ear.

Key words: Road traffic noise, noise pollution, Colombo, Sri Lanka.

Introduction

Sound is the sensation that we experience when we perceive the vibrations of air particles on our ear drums. Sounds with the frequencies between 20 and 20,000 Hz are audible to the human ear (Berglund and Lindvall, 1995). Noise is unwanted or undesirable sound which can be either environmental or occupational. Noise emitted from traffic (transportation) is one of four main sources of environmental noise, the others being noise from construction and building services, domestic and leisure activities, and industries (Berglund et al., 1999).

Noise causes several adverse health effects. These include: auditory effects (noise induced hearing loss, tinnitus); cardiovascular effects (increased blood pressure, ischemic heart disease); and psychological effects (nervous complaints, anxiety, emotional stress, effects on residential behaviour and annoyance). Most of these effects may occur at exposure to noise levels of more than 70 dB (Berglund et al., 1999).

According to the equal energy principle, the effect of a combination of noise event is related to the combined sound energy of those sounds, and is measured as equivalent continuous sound pressure level (LA_{eq} T).

*Corresponding Author

The LA_{eq} T is then summed up over a specific time period yielding the average sound level over that time period (ISO, 1987a, b cited in Berglund et al., 1999). Acoustic parameters such as sound are measured by using a logarithmic unit called decibel (dB). Because of the logarithmic scale of decibel, a 3 dB increase in sound level represents a doubling of the power of the sound reaching the ear. However, a 3 dB increase is subjectively only just noticeable. A 10 dB increase in sound level represents a tenfold increase of the power of the sound reaching the ear, but subjectively it will "sound" only about twice as loud to the exposed person (Walls, 1994).

As per the World Health Organization (WHO), the maximum day time recommended noise level for an outdoor living area is 55 dB (Berglund et al., 1999). Most countries have adopted rules and regulations on noise pollution. However, their implementation is poor. Traffic noise levels in most cities in the developed as well as developing world is more than the levels recommended by the environmental regulatory legislations in these countries (Li et al., 2002; Piccolo et al., 2005; Sampath et al., 2004). About 40% of the population in European Union (EU) are exposed to road traffic noise with an equivalent sound pressure level exceeding 55 dB(A) during daytime, and 20% are exposed to levels exceeding 65 dB(A). It is estimated that more than a half of the population in EU countries are living in zones where environmental noise levels due to transportation is higher than the recommended levels.

According to the estimates made in 1981, 25.1% of the 200 million (non-farm) population in the United States of America were exposed to road traffic noise levels in the range of 55-60 dB, and 13.7% were exposed to road traffic noise levels in the range of 60-65 dB (Simpson and Bruce, 1981). Noise pollution is even more problematic in developing countries, and the main source in these countries is from traffic. Equivalent continuous A-weighted sound pressure levels (LA_{eq}) for 24 hours, alongside the densely travelled roads can reach up to levels of 75 to 80 dB(A) (Berglund et al., 1999).

Sri Lanka is a lower middle income island nation situated in the Indian Ocean having an approximate land area of 65,610 km^2 (25,330 square miles); Colombo is the commercial capital of the country. The population in Sri Lanka was 20,277,597 in 2011 (Department of Census and Statistics, 2012). The country is undergoing rapid industrial development. The National Environmental Regulations No. 01 1996 of The National Environmental Act, No. 47 of 1980 has set forth regulation for noise control. These regulations have set permissible limits for noise by time of day according to area (low, medium, high and silent) as shown in Table 1 (Ministry of Transport, Environment and Women's Affairs, 1996). However, these regulations are not enforced routinely, and no data have been collected on noise pollution in the city of Colombo. A preliminary study conducted recording of traffic noise about 40 km away from Colombo found a level of 74 dB, a level much higher than the maximum permissible limit (Kalansuriya, 2010). We, therefore, conducted a study to determine daytime traffic noise levels measured at selected locations in the city of Colombo.

Table 1: Noise areas and maximum permissible noise levels according to the National Environmental Act, Sri Lanka

Area	*Maximum permissible noise levels (LA_{eq} T)*	
	Day time (dB)*	*Night time† (dB)*
Low noise Pradeshiya Sabha (rural) areas	55	45
Medium noise Urban Council or Municipal Council (urban) areas	63	50
High noise areas (Any export processing zones established by Board of Investment or Industrial estates under National Environmental Authority)	70	60
Silent areas within a distance of 100 m from the boundary of courthouse, hospital, public library, school, zoo, sacred areas and areas set apart for recreation or environmental purpose	50	45

*Day time: 6.00 am to 6.00 pm. †night time: 6.00 pm to 6.00 am.

LA_{eq} T = Equivalent continuous sound level pressure over a time interval (T).

Materials and Methods

Study Setting

We conducted a cross-sectional study in the city of Colombo located in the Colombo district of Sri Lanka. Colombo district is the most populous district of Sri Lanka with a population of 2,323,826 (11.5% of country population) and population density of 3438 persons per square kilometre. The city of Colombo covers an approximate area of 37 km^2 and has a resident population of 555,152 (about 2.7% of total population of Sri Lanka); it is estimated that approximately 400,000 commuters travel the city every day (Department of Census and Statistics, 2012). The city is divided into 15 postal divisions, designated from Colombo 01 to Colombo 15.1

Identification of Locations

We identified locations with high traffic density by using two data sources: the Colombo City Traffic Division (CCTD) of Department of Police, Sri Lanka; and the Traffic Laboratory of the Department of Civil Engineering, Faculty of Engineering, University of Moratuwa. Locations with high traffic density were selected to measure the noise levels as these locations were more likely to have high levels of noise pollution. Sixty locations met with above criteria (four from each postal division of city). Purposive selection of places with high traffic density for measurement of noise levels in cities have been used in similar studies as this approach is considered as an efficient way of utilizing limited resources (Gaja et al., 2002; Piccolo et al., 2005; Ozer et al., 2009).

Noise Measurements

We measured the noise levels on randomly selected week-days (Monday to Friday except public holidays). According to the CCTD, there are three peak periods of traffic during a week day: 7.00 am to 9.00 am in the morning (office and school traffic); 1.00 pm to 2.30 pm in the afternoon (school traffic); and 4.00 pm to 7.00 pm in the evening (office traffic). For each of the selected locations, we measured LA_{eq} for one hour during each period of peak traffic. Sampling interval was set to five minutes. Three sessions were undertaken during peak traffic periods and another three sessions were undertaken in off peak traffic periods. A total six sessions of one hour each were conducted from 6.00 am to 6.00 pm per day. Using these data, we calculated LA_{eq} (8 hrs): average noise level for that location. In addition, we obtained L_{10}, L_{50} and L_{90} measurements; these measurements represent the level of noise that is present 10%, 50% and 90% of time during the measuring period, respectively. We avoided rainy and windy days to ensure the accuracy of measurements.

We used a Rion NL-52 Class I sound level meter (SLM) to perform all measurements. The SLM was placed at least 3.5 m away from any reflecting surface other than ground and it was set at 1.5 m height from the ground using a tripod as specified in the ISO 1996/1-1982(E) standards. Calibration of the SLM was done every day before taking the measurements using the standard calibrator which comes with the machine. All measurements were conducted by a trained research assistant. Training included theoretical aspects of the physics of sound, its measurements and handling of instruments (SLM and calibrator). Practical sessions on environmental noise measuring at field level were also included. Experts from the Industrial Technology Institute (ITI) of Sri Lanka conducted the training at the ITI.

Institution Review Board

We obtained the ethical clearance from Ethical Review Committee of Faculty of Medicine, University of Kelaniya, Sri Lanka.

Analysis

We performed descriptive statistics including univariate analysis on the measured noise levels. Data were analyzed using SPSS.

Results

During the day time, noise levels (LA_{eq} 8 hrs) ranged from 76.6 dB to 84.0 dB in the city of Colombo with a median value of 80.9 dB (Table 2). For peak hours, the values ranged from 76.6 dB to 83.6 dB with a median of 80.9 dB. For off-peak traffic hours, the values ranged from 76.2 dB to 84.4 dB with a median of 80.4 dB. All of these values were well above the country's recommended 63.0 dB value for a Municipal Council area during day time and the WHO recommended 55.0 dB value for a residential area during day time. Compared to the maximum permissible level by Sri Lankan National Environmental Act, the LA_{eq} (8 hrs) values were higher by 13.3 dB to 21.0 dB in different locations of Colombo city. Due to logarithmic ratio of the decibel scale, a 13.3 dB increase translates to an increase of sound pressure level (this is the component of sound which affects the hearing) by 21.4 times and

Table 2: Noise levels for selected locations in the city of Colombo, by peak and off-peak hours

Noise parameter		*Range (dB)*	*Median (dB)*
LA_{eq} (8 hrs)		76.6 - 84.0	80.9
Peak hours	LA_{eq} (8 hrs)	76.6 - 83.6	80.9
	L_{10}	78.2 - 86.4	83.1
	L_{50}	72.8 - 81.5	76.5
	L_{90}	68.7 - 77.6	71.9
Off-peak hours	LA_{eq} (8 hrs)	76.2 - 84.4	80.4
	L_{10}	76.6 - 87.0	82.4
	L_{50}	72.5 - 82.7	76.2
	L_{90}	68.2 - 76.9	71.6

LA_{eq} (8 hrs) = equivalent continuous sound level pressure for eight-hour duration.
L_{10} = The level of noise that is present 10% of time during the measuring period.
L_{50} = The level of noise that is present 50% of time during the measuring period.
L_{90} = The level of noise that is present 90% of time during the measuring period.

21.0 dB increase translates to an increase of sound pressure level by 125.9 times. When same LA_{eq} (8 hrs) values compared with WHO recommended values it was higher by 21.6 dB to 29.0 dB. This translates to an increase of sound pressure level by 144.5 to 794.3 times.

L_{10} values for peak traffic hours ranged from 78.2 dB to 86.4 dB while L_{10} values for off-peak traffic hours ranged from76.6 dB to 87.0 dB. For peak traffic hours, the L_{50} and L_{90} values ranged 72.8 dB to 81.5 dB and 68.7 dB to 77.6 dB, respectively. For off-peak traffic hours, the L_{50} and L_{90} ranges were 72.5 dB to 82.7 dB and 68.2 dB to 76.9 dB, respectively. Difference in noise levels between peak traffic hours and off-peak hours were unremarkable.

The distribution of LA_{eq} (8 hrs) values among the 15 postal divisions of the Colombo is shown in Figure 1. Thirty-eight of 60 locations (63%) had LA_{eq} (8 hrs) levels of 80.0 dB or more. The lowest value of 76.6 dB

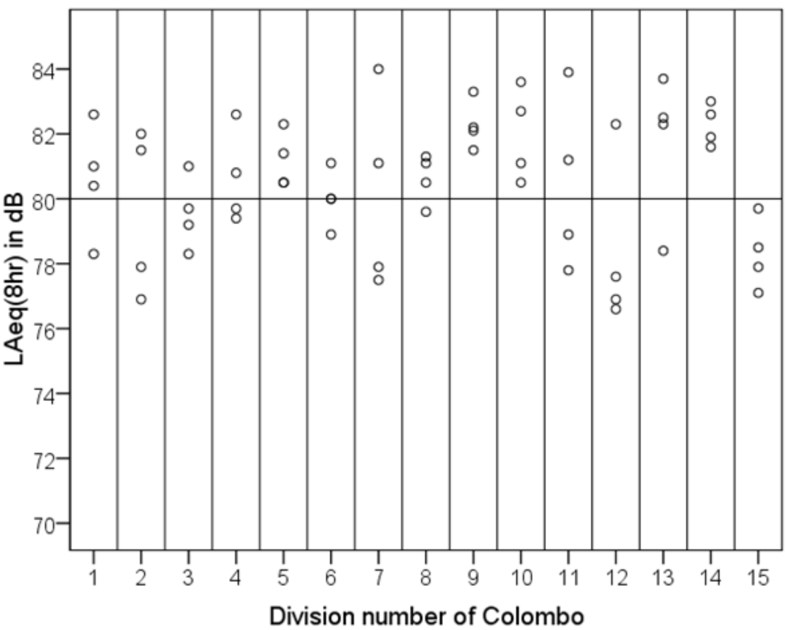

Figure 1: Distribution of LAeq (8 hrs) in selected 60 locations in the city of Colombo.
LAeq (8 hr) = Equivalent continuous sound level pressure for eight-hour duration
Numbers in X axis represents the postal divisional numbers of Colombo. Each dot in the plot represents the level of traffic noise of each selected place for noise measurement in the city of Colombo.

was recorded at Bank of Ceylon circle, a specific area in Colombo 12, where the Supreme Court Complex and other lower courts are located. The highest value of 84.0 dB was recorded at Lipton circle, a specific area in Colombo 07, where the National Hospital of Sri Lanka is located. All 16 measurements in Colombo 05, 09, 10 and 14 areas were more than 80.0 dB. Colombo 01, 06, 08 and 13 recorded only single value per area less than 80.0 dB. Although all of the recorded measurements in Colombo 15 were less than 80.0 dB (ranged 77.1 dB to 79.7 dB), they were still beyond the recommended values. Of the four lowest LA_{eq} values, three were recorded in Colombo 12 area including the lowest value of 76.6 dB.

Discussion

This is the first study in Sri Lanka to quantify traffic noise levels in a major city of the country. We found that day time traffic noise levels were well above the recommended noise levels by the National Environmental Act of Sri Lanka and the WHO. The highest value was recorded around the National Hospital of Sri Lanka at Colombo 07, while the lowest value was recorded around the Supreme Court Complex of Sri Lanka at Colombo 12. Both of these areas are considered as silent zones. It appears that implementation of law near a court house is probably more efficient than other silent zones. The traffic noise produced in the city poses a high risk for noise-related illnesses among the people. Vulnerable groups include residents of the city, people who are working on the roads of the city, children who are studying in schools situated in the city, vendors and travellers. Health effects due to excessive noise can range from mild effects such as annoyance to more serious effects such as noise-induced hearing loss and ischemic heart diseases.

Our study results are consistent with studies from both developed and developing countries in that traffic noise levels are higher than the country's recommended levels. A direct comparison between the studies was not possible as the measurement of noise, the time interval and the time of day differed across studies.

A study conducted in the city of Tokat, Turkey, found that average traffic noise levels ranged from 49.1 to 81.6 dB. Most places recorded average noise levels more than 65.0 dB which is the maximum recommended level of noise set by Turkey noise control regulations (Ozer et al., 2009). It was reported that LA_{eq} (24 hrs) in Valencia, Spain, were 73.0-74.0 dB over a five-year period (Gaja et al., 2002). The noise levels of major cities in Kerala, India, were higher than the recommended levels of Indian Ministry of Environment and Forest. In Thiruvananthapuram, an average noise level of 81.3 dB in commercial areas and 78.7 dB in silent areas were recorded. These levels were higher than the permissible noise levels set by the government of India; 65.0 dB for commercial and 50.0 dB for silent areas, respectively (Sampath et al., 2004). A study conducted in eight cities of South-Eastern Nigeria found that road traffic noise level (LA_{eq}) was 84.6 dB while residents were exposed to instantaneous levels of road traffic noise as high as 110.0 dB. The government recommended maximum noise level for residential areas in Nigeria is 55.0 dB (Onnu, 2000).

The main limitation of our study was that measurements were limited only to the day time. Thus, a measure of the traffic noise at night time could not be assessed. Availability of this data would have allowed us to gauge the magnitude of noise pollution at night times. We also selected only locations with high traffic density; thus, providing the maximum estimates.

Conclusions and Recommendations

Road traffic noise levels of the city of Colombo are higher than the values recommended in The National Environmental Act of Sri Lanka. Though an increase by 13.3 dB to 21.0 dB from the Sri Lankan recommended value of 63.0 dB or an increase by 21.6 dB to 29.0 dB from the WHO recommended value of 55.0 dB might appear to be not too high, in reality this translates to a manifold increase in the sound pressure level that reaches the ear. Difference in noise levels between peak and off-peak hours of traffic were not substantial.

We recommend that attempts should be made by environmental regulatory authorities to identify effective strategies to lower noise levels in the city of Colombo. Implementation of rules and regulations, which have already been enacted in the country, is recommended. Lowering of noise levels to 63.0 dB in a city may be an unrealistic target. An interim upward revision may help in the practical implementation of rules and regulations. Input from the scientific community on health end points will aid in these decisions.

Acknowledgement

The present work was supported by the University of Alabama at Birmingham International Training and Research in Environmental and Occupational Health programme, Grant Number 5 D43 TW05750, from the National Institutes of Health-Fogarty International Center (NIH-FIC). The content is solely the responsibility of the authors and do not necessarily represent the official views of the NIH-FIC.

References

Berglund, B. and T. Lindvall (1995). Community Noise. Archives of the Center for Sensory Research, Stockhalm.

Berglund, B., Lindvall, T. and D.H. Schwela (1999). Guidelines for community noise. World Health Organization, Geneva.

Department of Census and Statistics (2012). Census of population and housing 2011. Population of Sri Lanka by Districts. [Accessed 04 April 2013] http://www.statistics.gov.lk/PopHouSat/CPH2011/Pages/sm/CPH%202011_R1.pdf

Gaja, E., Gimenez, A., Sancho, S. and A. Reig (2002). Sampling techniques for the estimation of the annual equivalent noise level under urban traffic conditions. *Applied Acoustics*, Elsevier, **64(1):** 43-53.

Kalansuriya, C.M. (2010). Community perception and assessment of transportation noise. MPhil. Faculty of Science, University of Colombo, Sri Lanka.

Li, B., Tao, S. and R.W. Dawson (2002). Evaluation and analysis of traffic noise from the main urban roads in Beijing. *Applied Acoustics*, Elsevier, **63(10):** 1137-1142.

Ministry of Transport, Environment and Women's Affairs (1996). National Environmental (noise control) Regulations No. 1, 1996. Colombo, Sri Lanka.

Onnu, M.U. (2000). Road traffic noise in Nigeria: Measurements, analysis and evaluation of nuisance. *Journal of Sound and Vibration*, Elsevier, **233(3):** 391-405.

Ozer, S., Yilmaz, H., Yesil, M. and P. Yesil (2009). Evaluation of noise pollution caused by vehicles in the city of Tokat, Turkey. *Scientific Research and Essay*, Academin Journals, Nigeria, **4(11):** 1205-1212.

Piccolo, A., Plutino, D. and G. Cannistraro (2005). Evolution and analysis of the environmental noise of Messina, Italy. *Applied Acoustics*, Elsevier, **66(4):** 447-465.

Sampath, S., Murali Das, S. and V. Sasi Kumar (2004). Ambient noise levels in major cities in Kerala. *The Journal of Indian Geophysical Union*, National Geophysical Research Institute, Hydrabad, India, **8(4):** 293-298.

Simpson, M. and R. Bruce (1981). Noise in America: The extent of noise problem. EPA Report No. 550/9-81-101. [Accessed 09 November 2012] http://www.nonoise.org/epa/Roll6/roll6doc7.pdf

Walls, C. (1994). Noise induced hearing loss of occupational origin: A guide for medical practitioners. Occupational Safety and Health Service, Department of Labour, Wellington, New Zealand.