International Journal of Structural and Civil Engineering Research

ISSN 2319 – 6009 www.ijscer.com
Vol. 3, No. 2, May 2014

Research Paper

TRAFFIC NOISE STUDIES ON ARTERIAL AND COLLECTOR ROAD IN DELHI, INDIA

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Traffic noise is always irritating to the people living along the road. High growth of vehicles and lack of public transport system is responsible for high traffic noise. The traffic noise standards are evolved in various countries as well as in India. It is observed in Delhi that the traffic noise levels at different categories of roads are above prescribed limit by Ministry of Environment and Forest (MoEF), Govt. of India. In this paper, effort has been made to appreciate the traffic noise characteristics on Arterial and Collector Road in Delhi, India. Efforts are also made to review few research works carried out in India and abroad to understand the effects of traffic noise. International comparison of noise standards are also carried out in this paper.

Keywords: Traffic Noise, Noise Standards, Arterial Road, Collector Road

INTRODUCTION

Urbanisation is increasing at a very fast rate in our country; road length and its conditions are also improving. Therefore, the number of vehicles is increasing at alarming rate of more than 10.8% per annum. During the period of 60 years from 1951 to 2011, the number of vehicles has increased from 0.3 million to 142 million. The vehicles in Delhi have grown at the rate of 7.41% per annum between 2003 and 2010. Number of private vehicles has increased substantially from 3.98 million to 6.52 million during that period.On an average, there are about 1000 cars added to the roads of the capital city of Delhi on a daily basis.This has led to traffic congestion on roads and noise pollution. The transportation sector is one of the major contributors to noise in an urban area. Road traffic noise is most irritating pollution which has a major concern on communities living in the vicinity of highway corridor. Studies have shown that some of the most pervasive source of noise in our environment today is those associated with transportation. Traffic noise tends to be a dominant noise source in our urban as well as rural environment.

REVIEW OF RESEARCH STUDIES

There are a number of studies carried out with respect to traffic noise measurement and

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understand effect of traffic noise in India and abroad. Few research works carried out in the area of traffic noise are discussed below:

The study carried out by Thancanamootoo S (1987) is concerned with the development of Noise Annoyance Model (NAM) from the operation of urban railways (Metro).

The Study carried out by Goran Belojevic *et al*. aimed to determine principal factors for high noise annoyance in an adult urban population and to assess their predictive value. A cross-sectional study was performed on 3097 adult residents of a downtown municipality in Belgrade. Logistic regression model identified increased risk for a high level of noise annoyance with regard to: orientation of living room/bedroom toward the street, duration of stay at apartment during the day, noise sensitivity and night time road-traffic noise level.

The Study carried out by Kin-Che Lam *et al*. shows that annoyance is largely determined by noise disturbance and perceived noisiness. Personal noise sensitivity, attitudes towards different means of transport and perceived quality of the living environment are secondary contributing factors. Policy implications of such results on how to minimize noise-annoyance response are discussed in the study.

The Study carried out by Katarina Paunovic *et al*. (2009) aimed to assess the predictive value of various factors on noise annoyance in noisy and quiet urban streets. Equivalent noise levels were measured during day, evening and night times in all of the streets of a central Belgrade municipality. A cross-sectional study was performed on 1954 adult residents, aged 18–80 years. Noise annoyance was estimated using a self-report five-graded scale.

The study undertaken by Mohammed Ahmed Ali (2001) aims at investigating the road traffic noise, the bus transit noise and the noise perception in urban area. In this study Modelling of Traffic Noise (Modelling perception of road traffic noise, Modelling rider perception of bus transit noise), Traffic Noise prediction model for medium size urban area in India and mitigation measures are presented.

The study carried out by Rajesh Rohatgi (1994) aims to assess traffic noise characteristics and develop relationship between traffic noise and stream flow variables. Passenger Car Noise Equivalences (PCNE) has been established in this study.

The study carried out by Sharma V P (1978) brings out the importance of traffic noise in environmental area planning. Author finally concluded that noise level in grid iron type layouts are considerably high and are unacceptable.

The research work by Surender Mohan *et al*. had emphasised that by installing traffic calming measure such as mini roundabout with cushions, magnitude of noise energy per 24-hour day decreased by 857 Kw-hrs (~5dBA), alongside cushions by 864 Kw-hrs (~7dBA), near the raised junction by 821 Kw-hrs (~4dBA) and between cushions by 857 Km-hrs (~5dBA) approximately. The study recommends implementing of specific traffic calming measures at different traffic situations prevailing at Indian roads.

Mina *et al*. (2004) discussed procedure for combing noise level, sound level environment

and parameters influencing noise. Traffic noise control by noise reduction at source, streamlining traffic flow, landuse control, improving road structure viz. noise barriers, buffer zones, poros asphalt pavement, designing building with sound insulation are also describe in the study.

The research work by Filho J M A *et al*. (2004) analysed effect of traffic composition on the noise generated by typical Brazilian roads.The percentile level L_{10} and the equivalent L_{eq} were measured. These levels were plotted against the composition of the traffic and empirical expressions were obtained with reasonably good correlation indexes.

In the research work carried out by Patricia Galilea *et al*. (2005) stated preference experiment is used to estimate the willingness-to-pay for reducing noise levels in a group-based residential location context. Multinomial and mixed logit models are estimated based on a consistent microeconomic framework, including non-linear utility functions and allowing for various stratifications of the data.

The study carried out by Barbara Lebiedowska analysed interaction between noise and transport noise in urban space. A new classification of city soundscape is proposed. This relative classification is based on two principal sources of noise in urbanised areas; background and transport noise. Five types of urban soundscape are proposed from very quiet area to very loud area.

The study carried out by Kjartan Saelens mind estates that environmental problems related to urban traffic can be valued by Stated Choice method. This study points the fact that considerable uncertainty remains with regard to the area of validity of results.

The study carried out by Surender Mohan *et al*. discussed noise damage risk criteria to hearing impairment on the basis of physical sound pressure level and duration of exposure to noise for Indian Community. The various options for controlling noise have also been recommended for the group of workers working at different work places.

The study carried out by Umesh Sharma *et al*. indicates that noise levels in commercial areas exceeded permissible levels. A correlation model of noise level with traffic characteristics has been proposed. The model could be used as an effective tool in traffic management, land use planning and pollution control.

The study carried out by Kumar Vimal found that there is useful correlation between traffic parameters like traffic volume, average speed of the traffic stream, distance from pavement edge etc. and noise parameters like Leq. The various model to predict noise level are also presented.

The Study carried out by Goran Belojevic *et al*. observed that heart rate was significantly higher (2 beats/min on average) in children from noisy residences, compared to children from quiet residences ($p<0.05$). Multiple regression, after allowing for possible confounders, showed a significant correlation between noise exposure and children's systolic pressure ($B=1.056$; $p=0.009$).

The study conducted by Vinita Pathak *et al*. revealed the fact that noise levels have reached an alarming level. The result of the study indicated the fact that 85% of the people

were disturbed by traffic noise, about 90% of the people reported that traffic noise is the main cause of headache, high BP problem, dizziness and fatigue.

Sandrock S *et al*. (2007) conducted two studies, the first study reveals that The noise of a tram was judged to be equally annoying as the noise of a bus with a 3 dBA lower level, which corresponds to the calculated loudness difference. In the second study, noises of a tram and of a bus were superimposed onto a 2-h realistic road traffic scenario. Performance data did not differentiate between the noise conditions, but the participants were again less annoyed by the scenario with the tram, suggesting a possible bonus for the tram.

The study conducted by Tang U W et al. (2007) shows that the urban forms in historical areas with narrower roads, complex road networks and a higher density of intersections lead to lower traffic volumes and thus lower noise pollution. However, the greater street canyon effects in these historical urban areas lead to higher carbon monoxide (CO) concentrations.

Anita Gidl¨of-Gunnarsson *et al*. find out that in the process of planning health-promoting urban environment, it is essential to provide easy access to nearby green areas that can offer relief from environmental stress and opportunities for rest and relaxation, to strive for lower sound levels from road traffic, as well as to design “noise-free” sections indoors and outdoors.

PyoungJik Lee *et al*. found that parapets of the balcony were more effective in reducing exterior noise than lintels. Based on the measurements of the parapet used for this study and the absorptive materials in the scale model, a maximum noise reduction of 23 dB was obtained. A computer simulation was conducted in order to predict the noise reduction level of lintels and parapets. The results of the simulation were compared to the results of the scale model test. The results indicate that this method of exterior noise reduction can be useful in high-rise buildings where tall barriers cannot be built.

This study carried out by Ashish Bhaskar *et al*.discusses the areawide Dynamic Road traffic NoisE (DRONE) simulator, and its implementation as a tool for noise abatement policy evaluation. DRONE involves integrating a road traffic noise estimation model with a traffic simulator to estimate road traffic noise in urban networks. The output from DRONE is linked with a geographical information system for visual representation of noise levels in the form of noise contour maps.

Inferences of Literature Review

The above studies carried out has been very comprehensive in nature and discussed ways and means to evaluate noise levels, impact assessment, annoyance, etc. Though these studies are interesting and a step forward to evaluate and model the noise levels as well as to account of various traffic parameters. But these studies are silent with respect to evolving noise level acceptability for any predominant landuse activity or with respect to any category of urban road.

COMPARISON OF NOISE STANDARDS FOR VARIOUS CATEGORIES OF ZONES IN INDIA (M.O.E.F. NOTIFICATION)

Ambient Air Quality Standards with respect to Noise for various categories of areas/zones

in India (MOEF Notification) are presented in Table 1.

Table 1: Ambient Air Quality Standards w.r.t. Noise in India: MOEF Notification

Area Code	Category of Area/Zone	Limits in dB(A) Leq.	
		Day Time	Night Time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	42

Note:
- Day Time- 6.00 a.m to 10:00 p.m.
- Night Time- 10:00 p.m. to 6:00 a.m.
- Silence zone is defined as area comprising not less than 100 metres around hospitals, educational institutes and courts
- dB(A) - time weighted average of the level of sound in decibles on scale A, which is relatable to human hearing
- "A" in dB(A)Leq. Denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear
- Leq. – Energy mean of the noise level. Over a specified period

There are no different noise standards for existing and planned roads India as in other countries of World. The variation of noise standard for residential and industrial zone is high i.e. 20 dB(A).

Though there is a broad classification for noise standards with respect to different types of landuse as recommended by MoEF, noise standard with respect to different types of roads has never been prescribed by any agency so far. This is of paramount importance primarily because most of the people in urban areas do not like to be exposed near the high traffic arterial roads. In the contrary, this major section of people prefers to be lactated in residential area other than high trafficked arterial roads. This has necessitated having a re-look on the perception on the effect of traffic noise in different categories of road in urban areas.

INTERNATIONAL COMPARISON OF NOISE STANDARD

In general, noise standards are set too high and enforcement is weak. At three European countries (Switzerland, Netherlands and Germany), there is a huge gap between the admissible noise emission levels for existing transport infrastructure and sustainable level for health. Standards of noise level for existing transport infrastructure in all three courtiers are 70dB(A), which is perceived to be at higher level as presented in Table 2.

Table 2: Noise Emission Standards for Different Countries for Residential Zones

Leq, T (dB(A)) Country/Organisation	Existing Roads		B/N	Planned Roads		B/N
	Day	Night		Day	Night	
Germany	70	60	N	59	49	B
Netherlands	70	60	B 2010	50 (45)	40	B
Switzerland	70	65	B 2010	55	45	B
Japan	70	65	B 2009	60	55	B
OECD EST (until 2030)	55	45	N	55	45	N
WHO	55 (50)	45	N	55 (50)	45	N

Note: B- Binding and year if binding in the future, N-not binding.
OECD EST- Organization for Economic Co-operation and Development (30 countries) project on Environmentally Sustainable Transport

On the other hand, recent noise legislation in the countries has focused on the construction of new transport infrastructure and residential areas. In these cases, stringent noise emission limits that meet the requirements of protecting the human health and avoid annoyance to the population within their residential areas are brought into force. The new legislation is consistent with the recommendations of international organisations like OECD or WHO.

It can be seen from the table that Netherlands, Switzerland and Japan has set their noise standard for residential zones which are binding up to 2010 and 2009 respectively, while OECD and WHO does not have any binding with respect to any specific year. It is worth mentioning that noise emission standards in the above countries on the planned roads for residential zones during night time ranges between 45-50dBA.

APPRECIATION OF TRAFFIC NOISE CHACTEISTICS IN DELHI

Study Area

Delhi, capital city of India is one of the fastest growing cities in India as there are number of opportunities concentrated within an area of 1483 km^2. As a result, the need for travel has grown leaps and bounds, which has given rise to high volume of traffic on most of the roads on urban road network. Due to high growth of traffic on these corridors, traffic noise has become major concern to the residents living along the roads.

Following two categories of roads are selected for appreciation of traffic noise:

i. Arterial Road

ii. Collector Road

Primary Surveys

Following primary surveys were conducted to appreciate the traffic noise along arterial and collector roads in Delhi:

i. Classified Traffic Volume Count- 1 Day (24 Hours)

ii. Noise Monitoring - 1 Day (24 Hours)

Arterial Road

Under this category, Soami Nagar residential area along Outer Ring Road has been selected. Soami Nagar is located between Chirag Delhi Flyover and August Kranti Flyover along Outer Ring Road, please refer Photos 1 and 2. The carriageway is 6-lane divided.

Photo1: Soami Nagar, Outer Ring Road, Arterial Road

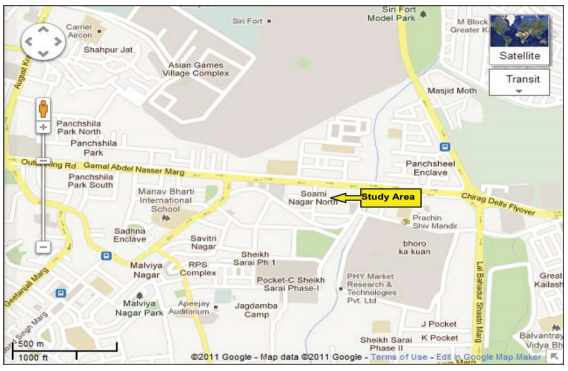


Photo 2: Soami Nagar, Outer Ring Road, Arterial Road

Service road of intermediate lane is also provided along with 2 m wide footpath. The landuse along the road is pre-dominantly residential and houses are directly exposed to traffic noise.

Traffic Volume

Classified traffic volume survey was carried out for 24 hours in a working day at Soami Nagar. Observed Average Daily Traffic (ADT) was 1,96,414 Passenger Car Unit (PCU) (Table 3) with peak hour traffic of 8.2% at 10:00-11:00 hrs. (Figure 1).This is the highest traffic in two survey locations. The share of cars was observed maximum of the order of 51.5% followed by two-wheeler and autorickshaw of the order of 32% and 8.1% respectively (Figure 2).

Traffic Noise

Traffic Noise monitoring was carried out for 24 hours in a working day simultaneous with traffic volume survey at Soami Nagar. L_{eq} (Day) and L_{eq} (Night) at road side was observed very high of the order of 78.8 dB(A) and 74.9 dB(A) respectively (Table 4). It is above the prescribed limit by MoEF of 55 dB(A) and 45 dB(A) in day and night respectively. Variation of equivalent traffic noise w.r.t. motorised traffic, passenger traffic, goods traffic and buses are presented in Figures 3, 4, 5 and 6 respectively.

It is observed that the trend in the hourly variation of equivalent traffic noise is similar to the trend in thehourly traffic volume of motorised traffic, passenger traffic and buses. However, the trend of hourly variation of equivalent traffic noise does not reflect the same trend w.r.t. hourly variation of goods traffic as described above. It might happen due to reason that goods traffic is heavy in night time and at that time other traffic is less.

Collector Road

Under this category, Chitranjan Park residential area along ISU Darshan Munjal Marghas been selected. Chitranjan Park residential area is located south of Outer Ring Road, please refer Photos 3 and 4. The carriageway is 4-lane divided with 2 m wide footpath. The landuse along the road is pre-dominantly residential with few shops at ground floor. Houses are directly exposed to traffic noise.

Table 3: Traffic Volume at Soami Nagar

Time Band	Pass.	Goods	NMT	Total Veh.	Total PCU
06-09	17868	524	838	19230	19786
09-12	37645	485	737	38867	39605
12-16	43933	2502	462	46897	49368
16-22	61046	2107	1682	64835	64273
22-06	14998	3912	151	19061	23382
Total	175490	9530	3870	188890	196414
% Share	92.9%	5.0%	2.0%	100.0%	-

Figure 1: Hourly Variation of Traffic at Soami Nagar

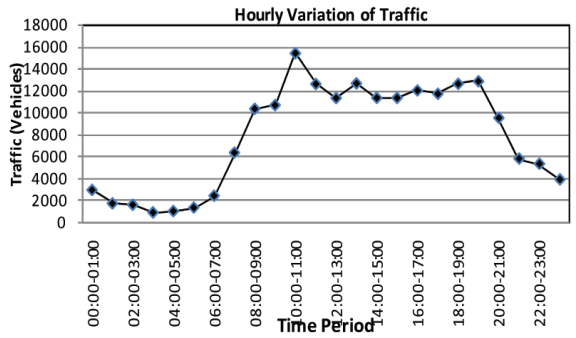


Figure 2: Traffic Composition at Soami Nagar

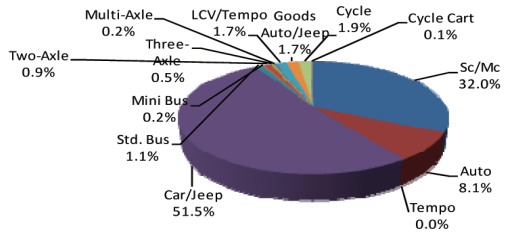


Figure 3: Variation of Leq with Motorised Traffic at Soami Nagar

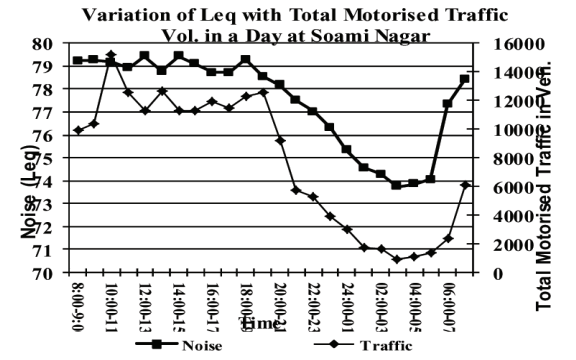


Figure 4: Variation of Leq with Passenger Traffic at Soami Nagar

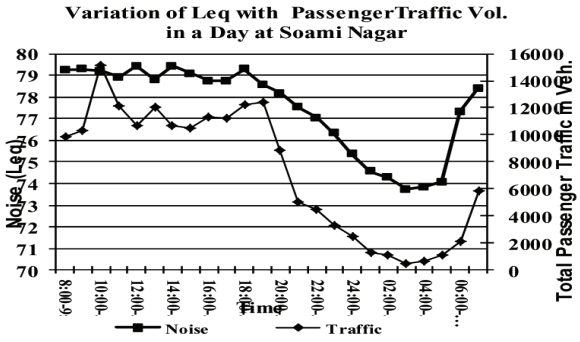


Table 4: Traffic Noise at Soami Nagar

Time Band	Leq, dB(A)-at Road	Leq, dB(A)-at Residence
06-09	78.3	67.7
09-12	79.1	68.5
12-16	79.2	68.5
16-22	78.5	67.8
22-06	74.9	64.2

Figure 5: Variation of Leq with Goods Traffic at Soami Nagar

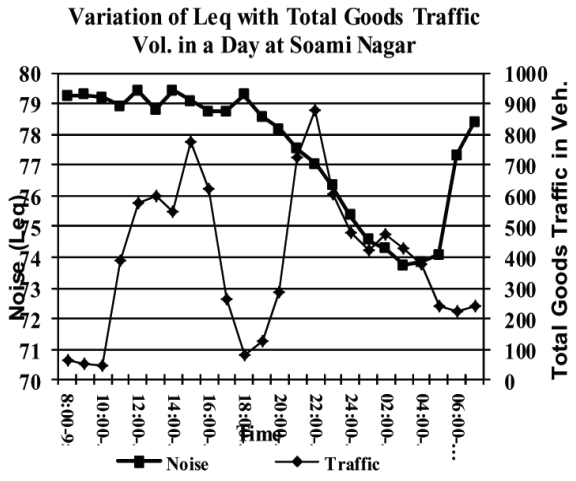


Figure 6: Variation of Leq with Bus Traffic at Soami Nagar

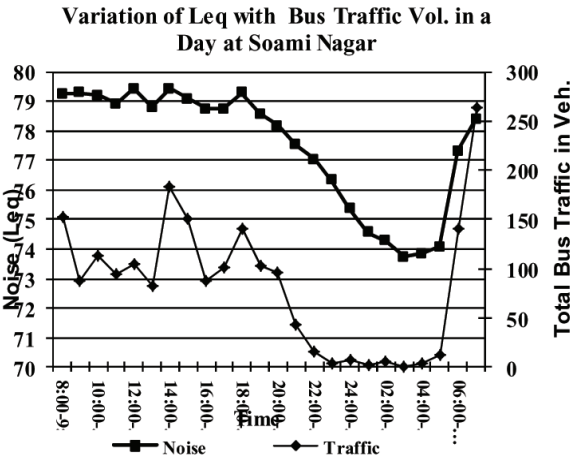


Photo3: Chitranjan Park (CR Park), ISU Darshan Munjal Marg, Collector Road

Photo4: Chitranjan Park(CR Park), ISU Darshan Munjal Marg, Collector Road

Traffic Volume

Classified traffic volume survey was carried out for 24 hours in a working day at CR Park. Observed Average Daily Traffic (ADT) was 31,505 PCU (Table 5) with peak hour traffic of 8.7% at 18:00-19:00 hrs. (Figure 7). The share of cars was observed maximum of the order of 45.6% followed by two-wheeler and autorickshaw of the order of 34.8% and 11.6% respectively (Figure 8).

Traffic Noise

Traffic Noise monitoring was carried out for 24 hours in a working day simultaneous with traffic volume survey at New Friends Colony. L_{eq} (Day) and L_{eq} (Night) at road side was observed high of the order of 72.2 dB(A) and 53.2 dB(A) respectively (Table 6). It is above the prescribed limit by MoEF of 55 dB(A) and 45 dB(A) in day and night respectively. Variation of equivalent traffic noise w.r.t. motorised traffic, passenger traffic, goods traffic and buses are presented in Figures 9, 10, 11 and 12 respectively.

Table 5: Traffic Volume at CR Park

Time Band	Pass.	Goods	NMT	Total Veh.	Total PCU
06-09	2496	35	185	2716	2818
09-12	5877	75	270	6222	6383
12-16	7508	173	359	8040	8320
16-22	11490	92	680	12262	12439
22-06	1408	29	67	1504	1546
Total	28779	404	1561	30744	31505
% share	93.6%	1.3%	5.1%	100.0%	-

Figure 7: Hourly Variation of Traffic at CR Park

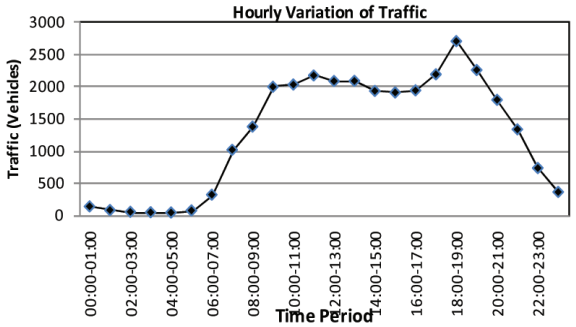


Figure 8: Traffic Composition at CR Park

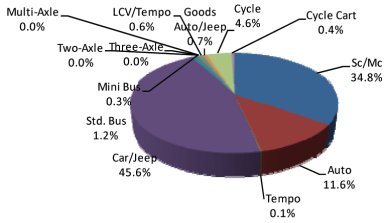


Table 6: Traffic Noise at CR Park

Time Band	Leq, dB(A)-at Road	Leq, dB(A)-at Residence
06-09	72.2	61.2
09-12	72.5	61.5
12-16	73.5	62.5
16-22	72.4	61.4
22-06	53.2	42.2

Figure 9: Variation of Leq with Motorised Traffic at CR Park

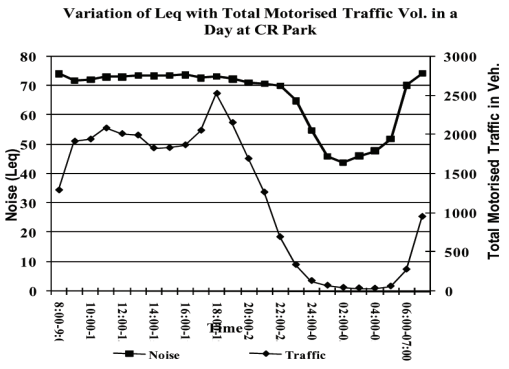


Figure 10: Variation of Leq with Passenger Traffic at CR Park

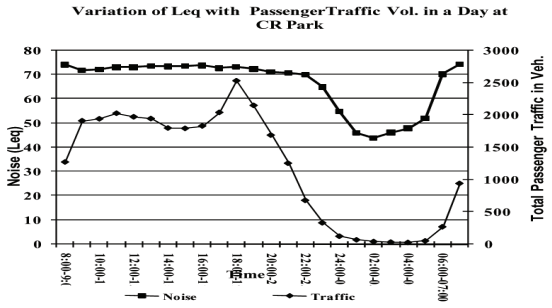


Figure 11: Variation of Leq with Goods Traffic at CR Park

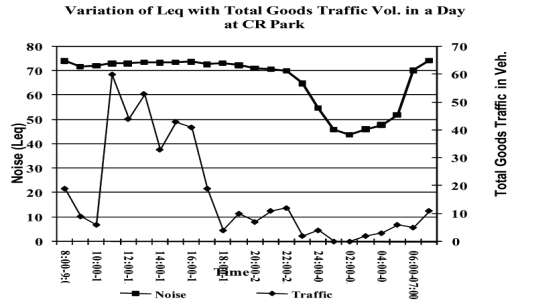
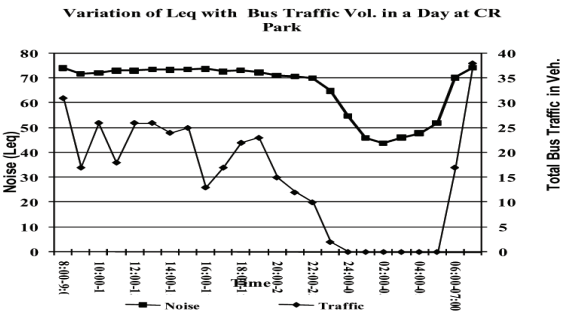


Figure 12: Variation of Leq with Bus Traffic at CR Park



It is observed that the trend in the hourly variation of equivalent traffic noise is similar to trend in the hourly traffic volume of motorised traffic, passenger traffic, buses and goods traffic.

NEED FOR DEVELOPING NOISE ACCEPTABILITY FOR DIFFERENT CATEGORIES OF URBAN ROADS

Residential areas in most of the cities are

badly affected due to generation of high traffic noise by vehicular traffic. This has led to serious effect of health hazard to the people in general and residential community in particular.

Various studies carried out in past have been primary concerned with either the development of traffic noise modelling or the prediction of traffic noise but there is no study available dealing with the development of noise acceptability for different categories of urban roads.

In view of this, it is felt that there is a need to develop acceptability for traffic noise for the residential areas located along various categories of roads by considering the impact of traffic noise on the health of the people.

The available studies have many dimensions carried out through simple analytical model as developed by various researchers for noise prediction. Conventional models may not be much useful for developing noise standards. Innovative techniques such as fuzzy set theory can be explored to measure the subjectivity of the responses of the effect of traffic noise on the people living in different activity zones, so as to establish the noise acceptability for different types of urban roads.

CONCLUSION

Residential areas in most of the cities are badly affected due to generation of high traffic noise by vehicular traffic. This has led to serious effect of health hazard to the people in general and residential community in particular.

The study also reveals that even during the night time at arterial road between 24 hrs. to 6 hrs., equivalent traffic noise is quite significant. It varies between 63dB(A) to 66.7B(A). This is primarily due to continuous movement of truck traffic, which becomes primarily the predominant mode during the night time. This aspect is one of the major concerns to be addressed in the design of alleviating the traffic noise on such an arterial road.

The limited study reveals that traffic noise on arterial as well as collector roads is continuous to pose serious problem to the residents living along the corridor. This was also reflected from the opinion survey of the residents living along the corridor.

The traffic noise at study areas in Delhi is very alarming. Its values are more than the prescribed limit by Ministry of Environment and Forest (MoEF), Govt. of India and World Health Organisation (WHO). The WHO describes limits of traffic noise as 55dB(A) and 45 dB(A) for day and night respectively. People are very much annoyed due to traffic noise and they are facing various health problems.

REFERENCES

1. Anita Gidl¨of-Gunnarsson *et al.* (2007), "Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas, Landscape and Urban Planning", Vol. 83, pp. 115–126,
2. Ashish Bhaskar *et al.* (2007), "Development and implementation of the areawide Dynamic Road traffic Noise (DRONE) simulator", *Transportation Research Part D,* Vol. 12, pp. 371–378.
3. Barbara Lebiedowska (2005), "Acoustic Background and Transport Noise in Urbanised Areas: A Note on the Relative Classification of The City Soundscape",

Transportation Research Part D, Vol. 10, pp. 341-345.

4. BrankoJakovljevic, Katarina Paunovic and Goran Belojevic (2009), "Road-traffic noise and factors influencing noise annoyance in an urban population", *Environment International,* Vol. 35, pp. 552–556.
5. Filho J M A (2004), "Effect of Traffic Condition on Road Noise: a Case Study", *Transportation Research Part D,* Vol. 9, pp. 75-80.
6. Goran Belojevic et al.(2007), "Urban road-traffic noise and blood pressure and heart rate in preschool children", *Environment International,* Vol. 34, pp. 226–231.
7. Katarina Paunović, BrankoJakovljeviæ and Goran Belojeviæ(2009), "Predictors of noise annoyance in noisy and quiet urban streets", *Science of the Total Environment,* Vol. 407, pp. 3707–3711.
8. Kin-Che Lam, Pak-Kin Chan, Tin-Cheung Chan, Wai-Hong Au and Wing-Chi Hui (2009), "Annoyance response to mixed transportation noise in Hong Kong", *Applied Acoustics,* Vol. 70, pp. 1–10.
9. KjartanSaelensminde (1999), "Stated Choice Valuation of Urban Traffic Air Pollution and Noise", *Transportation Research Part D,* Vol. 4, pp. 13-27.
10. Kumar Vimal (1997), "Analysis of Urban Traffic Noise", M.Tech. Thesis, University of Roorkee.
11. Mina H L *et al*. (2004), "Road Traffic Noise Pollution and Control", *Indian Highways*, Vol. 32, No. 6.
12. Mohammed Ahmed Ali (2001), "Urban Transport Noise: Magnitude, Perception and Modelling", Ph.D. Thesis, Regional Engineering College Warangal .
13. Patricia G alilea *et al*. (2005), "Valuing Noise Level Reduction in a Residential Location Context", *Transportation Research Part D* , Vol. 10, pp. 305-322.
14. PyoungJikLeea *et al.* (2006), "Effects of apartment building fac-ade and balcony design on the reduction of exterior noise", *Building and Environment,* Vol. 42, pp. 3517–3528.
15. Rohatgi Rajesh (1994), "Traffic Noise Characteristics in a Metropolitan City, Case Study-Delhi", M Planning Thesis, School of Planning and Architecture.
16. Sandrock S *et al*. (2007), "Experimental studies on annoyance caused by noises from trams and buses", *Journal of Sound and Vibration.*
17. Sharma V P (1978), "Traffic Noise: A Consideration in Planning", M. Planning Thesis, School of Planning and Architecture.
18. Surender Mohan *et al*. (2008), "Noise Pollution in work Environment and its Health Impacts in Indian Conditions", *Highway Research Journal,* Vol. 1, No. 1 .
19. Surinder Mohan *et al.* (2005), "Traffic Calming measures for the Reduction of Noise Energy Impacts", *International Conference on Structural and Road Transportation Engineering* (START 2005).

20. Tang U W *et al*. (2007), "Influences of urban forms on traffic-induced noise and air pollution: Results from a modelling system", *Environmental Modelling & Software,* Vol. 22, pp. 1750-1764

21. Thancanamootoo S (1987), "Impact of Noise from Urban Railway Operations", Ph. D. Thesis, University of New Castle upon Tyne

22. Umesh Sharma *et al*.(2008), "Studies on Traffic Related Noise Pollution in Commercial Areas of Chandigarh (India)", *Indian Highways Journal,* Vol. 36, No. 10.

23. Vinita Pathak *et al.* (2007), "Evaluation of Traffic Noise Pollution and Attitudes of Exposed individuals in working place", *Atmospheric Environment*.