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PEDESTRIAN RESPONSE TO ROAD TRAFFIC NOISE FOR MEDIUM SIZE CITY IN INDIA

Pritikana Das[1], Manoranjan Parida[2], Vinod Kumar Katiyar[3]
[1] *Centre for Transportation Systems, CTRANS, IIT Roorkee, India*
[2] *Department of Civil Engineering CTRANS, IIT Roorkee, India*
[3] *Mathematics Department, IIT Roorkee, India*

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Abstract: Level of vehicular noise pollution is one of the major factors to choose pedestrian mode of transportation among other modes of transportation. Transportation systems and their related outcomes are responsible for ensuring safe travel options, including walking people of all ages and different abilities. This study will provide an opportunity to quantify the environmental impact in terms of noise level for future development and planning of pedestrian infrastructure in India. It will also help in modal shifting towards walking, improvements in energy efficiency, and the impact of specific contaminants on health. Exposure of high noise level can cause annoyance and severe stress on auditory and nervous system of pedestrians. Most of the Indian cities have noise level above than acceptable limits because of rapid urbanization with increasing number of vehicular traffic. The objective of this study is to study response of pedestrians towards noise pollution in Roorkee at different locations based on different land use. Roorkee is a medium size city with a population of 2.73 lakhs (Roorkee Metropolitan areas, 2011 census), situated in Uttarakhand, India. It is a city with large number of educational institutions and sizable numbers of student population. Noise level study has been carried out at ten locations on NH-58 near Indian Institute of Technology Roorkee. Noise data was collected at an interval of 30 seconds. Design implications for future improvement of pedestrian infrastructure have been presented in this paper considering traffic noise as an environmental factor. It is expected that the study outcome shall be useful in understanding positive effect of low traffic noise encouraging increased usage of pedestrian facilities within urban transport network.

Keywords: pedestrian response, equivalent noise level, traffic noise index.

1. Introduction

Noise is defined as unwanted sound, produces direct and cumulative adverse effects that impair health and that degrade residential, social, working, and learning environments with corresponding real (economic) and intangible (well-being) losses (Marathe, 2012). Environmental noise pollution is more severe, widespread and increasing in magnitude because of population growth and urbanization with sustained growth in highway, rail, and air traffic. Nelson (1982) mentioned that noise is a continuous variable and optimal level can be chosen individually at the margin. He provided the range of noise level about 25 decibels (50 to 80 decibels) from empirical studies. Wolf et al. (2002) observed most of the sources for noise associated with urban development such as transportation, industrial and recreational noise. Schmidt

[1] Corresponding author: pritidce@iitr.ac.in

(2005) stated that the exposure to harmful noise levels is greater in developing countries because of ineffectual planning and the poor construction of buildings. Sustained growth in traffic increase noise level which is a major source of environmental noise (Schell et al., 2006). As stated by Rahmani et al. (2011) traffic noise basically affected by traffic volume, composition, speed, road surface, and its gradient.

As per FHWA guidance (December 2011) basically highway traffic noise depends on volume of traffic, speed of the traffic and the number of trucks in the flow of traffic. Highway noise consists of total noise produced by all the moving vehicles on the highway which depends on the individual vehicles, type of the vehicle, mode of operation, characteristics of the vehicle flow and the relative proportions of the vehicle types included in the flow (Subramani et al., 2012). Traffic is a major source of noise pollution in Delhi and was surveyed by Singh and Davar (2004) using questionnaire survey. The design of urban noise surveys should take into account that the underlying structure of urban noise is largely determined by the disposition of transportation, and in particular, road traffic, noise sources (Brown and Lam, 1987).

Effect of traffic noise can be classified into three categories such as subjective effect (annoyance, disturbance, dis-satisfaction and noisiness), behavioral effect (interference with sleep, speak or any general task) and physiological effects (fright phenomena). For a long period of exposures to noise may produce deafens and further continuous noise causes cardiovascular effects, increases blood pressure and heart rates (Marathe, 2012). Pathak et al. (2008) studied that 85% of the people were disturbed by traffic noise and 90% of the people reported that traffic noise is the main cause of headache, high BP problem, dizziness and fatigue.

Noise pollution is a form of air pollution and it should be control to improve policies and procedures in Health Impact Assessment (HIA). Noise control measures should consider acoustic performance, costs, effectiveness, durability, visual intrusion and safety. HIA is a tool to improve decision-making, to weigh the policy options in different sectors (Kumar et al., 2011). It's a challenge to incorporate health into the capacity of planners and engineers to work with health professionals to conduct HIAs. Few criteria of policies and procedures were met Bangladesh, India, and Nepal likely 26 to 50% and Indonesia, Sri Lanka and Thailand met 51 to 75% (Caussy et al., 2003). Sharma et al. (2010) studied that the noise barrier and green belt can be designed to check the propagation of the noise due to traffic, industry and any new development and construction activities. Based on the existing noise level, Mishra et al. (2010) suggested for installation of barrier at BRTS corridor to reduce noise level.

Proposed construction plans for pedestrian infrastructure in most of the cities require noise control measures such as barriers, absorbing road surfaces, restriction on vehicular access or separate pedestrian walkways. In this study, selected NH-58 is shared by pedestrians and vehicular traffic. Signals, markings and foot over bridge (FOB) or subway are not provided for crossings at the selected location.

2. Survey Methodology and Analysis

Ten locations were identified within Roorkee city along National Highway-58 for noise

survey. In this study, Noise Level Meter Type 2240 was used for noise data collection. Details of study locations are given in Table 1. Survey was done in the presence of a continuous flow of traffic during 15 minutes duration with 30 s interval. Traffic volume data were collected during 4 hours study on NH-58 near main gate of IIT Roorkee to provide demographic composition of motorized vehicles. Noise level data was measured at a distance of 10 m from the centre line of road and at 1 m height from the ground level.

Table 1

Details of Study Locations

Sl. No.	Locations	Land Use	Designation
1	Sinchai Vibhag (Tiraha)	Commercial	L1
2	V-Mart Intersection	Commercial	L2
3	Swami Ram Nagar	Residential	L3
4	Infront of Praksh Hotel	Commercial	L4
5	Century Gate Intersection	Commercial	L5
6	Near to IIT Main Gate (174.8 km from Delhi)	Residential	L6
7	Infront of IIT Roorkee Main Gate	Mixed	L7
8	Near Roorkee Bus Terminal	Transport Terminal	L8
9	SDM Intersection	Commercial	L9
10	BEG Intersection	Commercial	L10

Standard noise level was established by ARAI are given in Table 2. The good dose-response relation is one of the explanations for using the $L_{Aeq,24}$ as a simple description of road traffic noise (Bendtsen, 1999). A survey was carried out by Mishra et al. (2008) in Roorkee city and they reported major sources for noise pollution is traffic (87%) in Roorkee. In this study, 79.55% pedestrian responded that traffic / automobiles are major source of noise pollution at selected locations. A questionnaire survey was done using rode-side interview technique and home-interview technique to quantify effect of annoyance on pedestrians. Survey was designed to measure dissatisfaction level due to noise. A major source of noise pollution identified from respondent survey is motorized vehicles as presented in Fig. 1. Effects due to annoyance for pedestrians are shown in Fig. 2.

Table 2

Ambient Air Quality Standards in Respect of Noise (CPCB) Under the Noise Pollution (Regulation and Control) RULES, 2000

Area Code	Category of Area / Zone	Limits in dB (A) Leq*	
		Day Time	Night Time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence Zone	50	40

Source: The Noise Pollution (Regulation and Control) RULES (2000)

*Leq = An energy mean of the noise level over a specified period

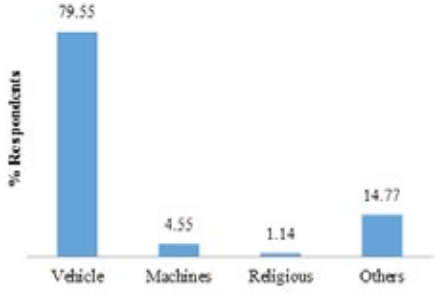

Fig. 1.
Sources for Noise Pollution

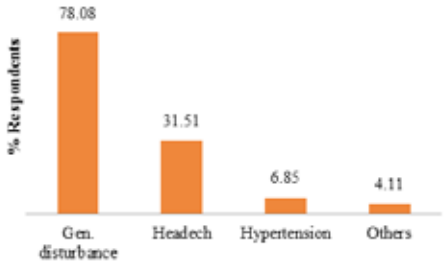

Fig. 2.
Effect of Noise on Pedestrians

A typical distribution of traffic flow on NH-58 near main gate of IIT Roorkee for 3-h period in each direction for different type of motorized vehicle is given in Table 3. Demographic composition of mixed traffic is shown in Fig. 3. Due to more number of vehicles and regular congestion on NH-58, it increases environmental pollution in city. An emission from vehicles mainly contains CO_2, HC, NO_x, PM, VOCs. These hazardous pollutants cause bad effects on pedestrian's health. Diesel fumes cause an increase in lung cancer (Higgins, 1984).

Table 3
Categorized Hourly Traffic Volume Data to Delhi and to Haridwar

Direction of Traffic	Car/Jeep/Van	Mini Bus/ Bus	Scooter/M.Cycle	Truck/Tractor/ Trailer	Auto Rickshaw
To Delhi	226	65	536	70	22
	191	65	450	68	11
	326	67	802	67	13
To Haridwar	162	65	361	47	15
	220	72	642	46	14
	287	94	578	62	10

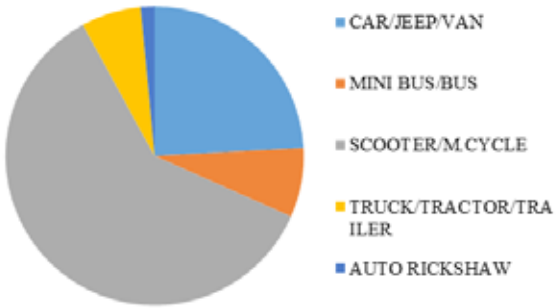

Fig. 3.
Demographic Composition of Vehicles on NH-58

To quantify impact of noise on pedestrians at various locations, noise indicators such as equivalent traffic noise level (Leq), L_{10}, L_{50}, L_{90}, standard deviation of noise level, traffic noise index and noise pollution level was analyzed in this study (Marathe, 2012). These are discussed in the next section.

3. Results and Discussion

The percentage of respondent pedestrians about annoyance by traffic noise has shown in Fig. 4. From the qualitative survey (questionnaire) 36.36% pedestrians have observed that areas where they have to walk for leisure / shopping trips are very noisy. It can be seen from the Table 4 that the proportion of individuals exposed to environmental noise levels exceeding the standard values in most of the selected study locations during day time. From this study, it was observed that at residential area, noise level varied from 67.7 dBA to 77.1 dBA which should not exceed 55dB (A) as per Indian standard. As previously stated that the guideline value above have recommended by ARAI in India, noise emissions should not exceed 65 dBA during daytime in commercial area but in this survey this value reaching maximum up to 87.4 dBA and Leq is 82.3 dBA. There is need to control noise pollution in Roorkee.

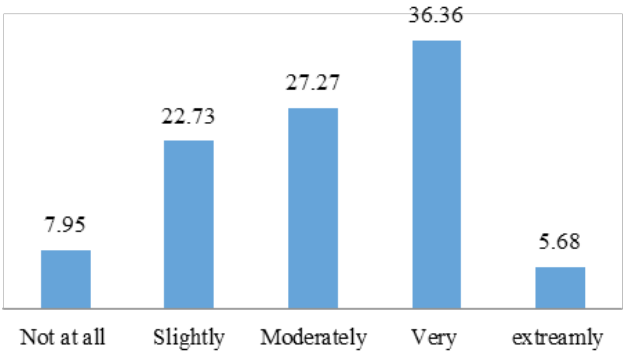

Fig. 4.
Percentage of Response for Scaling Noise Level

Table 4
Observed Noise Data

Location	L_{eq} dBA	Maximum dBA	Minimum dBA
L1	79.1	83.8	65.8
L2	78.6	95.6	67.6
L3	81.5	83.2	69.7
L4	72.9	81.1	68.9
L5	79.0	86.3	68.0
L6	74.7	77.1	67.7
L7	72.6	87.4	67.4
L8	73.7	85.5	68.8
L9	80.4	83.7	68.6
L10	82.3	83.6	68.3

Spatial variances of road traffic noise were analyzed to observe diversity of traffic noise and analyzed values are given in Table 5. L_{10} and L_{90} are the A-weighted decibel levels exceeded 10% and 90% of the time respectively (the peak and ambient levels respectively). Near residential area L_{10} is 79.8 dBA and at intersection L_{10} was 85.45 dBA. Traffic Noise Index (TNI) and Noise Pollution Index (NPL) (Langdon and Scholes, 1968; Robinson, 1971) have been calculated at different locations and values are provided in Table 5. For distance measured less than 10 meter acceptable TNI should less than 70 dBA (Langdon and Scholes, 1968) but in the selected locations TNI values exceed the acceptable limit. Standard deviation of noise level was calculated for each of the locations.

Table 5
Analysed Values from the Observed Data

Location	L_{10} dBA	L_{50} dBA	L_{90} dBA	Leq dBA	SD dBA	TNI dBA	NPL dBA
L1	80.2	74.1	68.35	76.6	4.74	85.75	88.74
L2	80.35	73.37	67.85	76.16	5.61	87.85	90.52
L3	79.81	75.33	71.25	76.64	3.33	75.49	85.16
L4	78.81	73.2	68.62	75.05	4.1	79.38	85.55
L5	85.71	75.95	68.65	81.15	7.3	106.89	99.84
L6	79.8	71.7	64.67	75.79	6.16	95.19	91.56
L7	81.51	73.91	65.37	78.56	6.48	99.93	95.15
L8	84.21	76.35	70.11	79.90	5.71	96.51	94.52
L9	80.25	75.54	71.31	76.97	3.53	77.07	86
L10	81.63	75.72	70.56	77.91	4.54	84.84	89.53

To control traffic noise pollution, following steps can be followed for reducing noise effects on pedestrians in Roorkee as well as other medium sized cities in India:

1. Identification of the sources of noise pollution,
2. Understanding of various adverse impacts of noise pollution,
3. Quantify the noise levels,
4. Methodologies to control noise pollution,
5. Information collection about the standard noise limits for different land use in India.

Noise can be controlled by three techniques mainly as control at source (reducing the noise levels from domestic sectors, maintenance of automobiles, control over vibrations, maintenance of vehicles/machines), control in the transmission path (installation of barriers, green belt development) and providing protective equipment at the roadside (exposure reduction, hearing protection). In Roorkee city, separate pedestrian path ways can be provided like skywalk or subway for pedestrians to reduce exposure to traffic noise.

4. Conclusions

It can be concluded from the pedestrian response study that traffic noise is the major source of environmental pollution in Roorkee. From the qualitative survey (questionnaire), it was observed the 36.36% of pedestrians consider that locations where they are walking are very noisy. The evaluated values of different noise indicators (Leq, standard deviation of noise level, traffic noise index and noise pollution level) shows the noise level is more than the standard noise level. From the evaluated result and its comparison with other health standard, it can be noticed that traffic noise affect the health of pedestrians and in future it may lead to hearing damage. Due to increasing trends of traffic in future, the noise level will certainly increase and pedestrians will suffer by adverse effect of noise as they are more exposed to noise annoyance. Calculated TNI value provided dissatisfaction would be greater than 60% as per Langdon and Scholes (1968). TNI values at every location exceed the acceptable limit, so noise level should be controlled using optimized noise control techniques. Hence there is need to improve pedestrian facilities through provision of barriers to control noise pollution in the city.

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