International Journal of Applied Science and Engineering
2009. 7, 2: 159-168

Noise Annoyance under Interrupted Traffic Flow Condition for Jaipur City

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Abstract: Motorized road vehicles are the major source of noise; always responsible for creating annoyance among people. The present study is aimed to investigate the correlation between annoyance level and different noise indices and its impact on residents/community in terms of annoyance index. Noise and attitudinal response of local population were carried out at ten commercial road networks of the city. To define the noise annoyance quantitatively, a new point scale [i.e. Mean Dissatisfaction Score)(MDS)]has been used in the present study , a strong correlation was observed between percentage highly annoyed and various noise indices.

Keywords: Noise percentile levels; Noise annoyance; Traffic congestion; Noise annoyance index.

1. Introduction

Noise annoyance is a feeling of displeasure-irritation or disturbance, gives a negative effect on community or individual [1]. It is a feeling of displeasure-irritation or disturbance, gives a negative effect on community or individual [2-4]. According to the World Health Organization (WHO)[5] noise pollution is nowadays the third most hazardous environmental pollution and is almost one of the harmful agents which adversely affects the human health as well as environment [6-8]. Kiernan [9] (1997) reported that noise may cause hypertension; disturb sleep and a hinder cognitive development in children. Exposure of high level noise can cause severe stress on auditory and nervous system of human beings [10]. Griffiths et al. [11] found that the annoyance is the most commonly encountered human response to traffic noise in major cities. To focus the behavior of human beings exposed to traffic noise carried out in two French cities by Lambert et al. [12] and Bluhn et al. [13].It was found that even at low levels, traffic noise exposure was associated with annoyance and sleep disturbance. However, on a community scale, annoyance is more uniform so that estimating community annoyance is possible through the use of established dose response curves [14]. The relationship between day-night sound level (Ldn) and the percentage of an exposed population highly annoyed by any transportation noise source was first given by Schultz [15](1978). The term “highly annoyed” refers to a response to a social survey question on noise annoyance with in the top 27% to 29% on a

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Accepted for Publication: April 29, 2010,

numerical scale. Further, Miedema and Oudshoorn [16] established a relationship between traffic noise annoyance and day night level (DNL) index. Other studies [17-21] have also established correlations between traffic noise pollution and annoyance [22-24]. The criteria for assessing annoyance caused by traffic noise have also been developed. Scholes [25] found that the A-weighted equivalent sound pressure level LAeq and a traffic Noise Index (TNI) based on the A-weighted 10 and 90 percentile levels, L10 and L90 correlate satisfactorily with human annoyance. The use of percentile levels as the noise criteria was further investigated by Langdon and Griffiths [26].

In India, the problem of noise pollution is wide spread. Motorized road vehicles are the major responsible source of noise pollution in urban areas, contributing 55% of the total noise in the environment [27-28]. Several studies reported that noise levels in the mega cities exceeded specified standard limits [29-31].However, there is a paucity of information on Jaipur in the state of Rajasthan, India, which is one of the most important tourist places. Whatever study has been conducted is limited and confined to a few specific functional regions [32-33] and the entire city has never been covered. Like many other cities in the world, increased urbanization and industrialization have turned Jaipur too into a very noisy place. Agarwal et al., [34]

Jaipur is one of the large metropolitan cities situated in the western region of India. The city has not been expanded according to the provision of master plan, creates narrower, overcrowded and medium to heavy congested road networks conditions. The annual growth rate of the motorized vehicles shows an increasing trends in the past ten years (1999-2008) shown in Figure 1. It clearly due to the lack of proper public transportation availability which develops tendency of own vehicle ownership among people. Besides this, the heterogeneous nature of traffic, continuously plying on roads develops the interrupted traffic flow condition and responsible for creating traffic congestion and annoyance among exposed people.

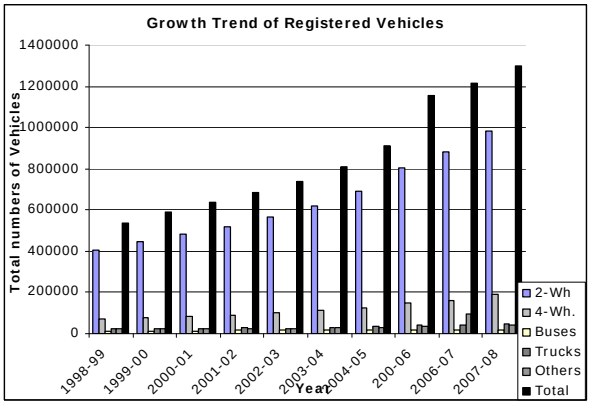

Figure 1. Growth trends of registered vehicles in Jaipur city

In earlier studies noise pollution levels had been evaluated by several ways for the Jaipur city [35-36].No research has been done to evaluate noise annoyance levels quantitatively and correlate the noise pollution levels with the attitudinal responses of exposed people of the city. Therefore, the present study is aimed to investigate the relationship between measured traffic noise levels with the attitudinal responses of exposed population.

2. Material and Method

Ten selected intersections covering all the four major directions of the city, having medium to heavy traffic flow conditions, as per different land uses, were selected for the present study. The selection of locations for the measurement of noise of any traffic situation was entirely random without any consideration of collecting the incidences of dominance of any type of vehicles. A brief introduction of each selected location is given in Table 1 while, Figure 2 shows the identified stretches for the present study. The various contemporary modes of vehicles have been observed and counted manually for both of the directions of the road section. At each of these lo-

cations, traffic related data were taken when there was a reasonable traffic activity (in general from 8 a.m. to 8 p.m.), while, different noise indices were recorded from 8 a.m. to 8 a.m. Noise is measured by a sound level meter, which is an instrument, responds to sound in approximately the same way as the human ear and gives reproducible measurements of sound level [37]. The equivalent noise level (Leq) is defined as the constant noise level that expands the same amount of energy as the fluctuating level over the same period [38] Leq is measured for traffic noise along with the statistical levels L10, L50,L90 which are the noise levels exceeded 10%,50% and 90% of the time; respectively, [39-41]. Various .noise indices like Ldn (Day-night noise level), TNI (Traffic Noise Index) and Leq (Equivalent Noise Level) have been used by various people in India and world wide to quantitatively evaluate annoyance [42]. Assessment of traffic noise and development of an MDS (Mean Dissatisfaction Score) was done by Rao and Rao (1992) [43]. It is a point scale which correlates observed Leq with different noise parameters and resulted noise annoyance level. On this scale firstly difference has been calculated between the observed noise indices and the values given in the score table. After that, all difference values for each of the noise indices were combined collectively and one mean values have been calculated for each of the selected locations shows the mean dissatisfaction level. The point scale is shown in Table 2.

Table 1. Brief description of all selected locations

S. No.	Name	Land use	Traffic condition	Type of road	Road geometry		
					No of Lane	Details of Median	Width of road (m)
1.	Bus Station	Commercial	Heavy, Congested	bituminous	4	Absent	15
2.	Gopal pura Mod	Commercial	Heavy, Congested	bituminous	4	Present	15
3.	Govt.Hostel	Commercial	Heavy, free flow	bituminous	6	Present	22.5
4.	JDA Circle	Institutional	Heavy, free flow	bituminous	6	Present	22.5
5.	Khasa kothi Circle	Commercial	Medium, Congested	bituminous	4	Present	15
6.	PaniPaich	Institutional	Medium, Congested	bituminous	4	Present	15
7.	Queen's road	Residential	Medium	bituminous	4	Present	15
8.	Railway Station	Commercial	Heavy, Congested	bituminous	4	Present	15
9.	Sodala	Commercial	Medium, Congested	bituminous	4	Absent	15
10.	Transport Nagar	Commercial	Heavy, Congested	bituminous	6	Present	22.5

Table 2. Upper limits of noise levels for desirable and prohibited levels of environmental traffic noise indices

Noise Index	Upper limits for noise levels in dBA			
	Desirable		Prohibitive	
	Dissatisfaction	Dissatisfaction	Dissatisfaction	Dissatisfaction
	Score 2	Score 3	Score 4	Score 5
L_{10}	64	74	82	93
L_{50}	58	67	75	85
L_{90}	52	61	70	79
L_{Aeq}	58	68	76	89
L_{NP}	69	82	97	111
L_{DN}	60	70	78	86
Lmax	63	69	81	87
TNI	61	76	87	98

(Source: Rao and Rao, 1991)
Where,
Score 2: represents slight uncomfortable feeling
Score 3: represents mild disturbance
Score 5: represents upper limit of any allowable sound on this score.

Figure 2. The map of the city indicating all selected locations

The objectives of the present study were to assess the non-audiometric impact (annoyance) due to road traffic parameters, different noise indices and attitudinal response. A comprehensive, yet briefly structured questionnaire was made to find information about traffic noise traits and its effects on exposed individuals. 45-55 individuals were selected at each site for Random Sampling Questionnaire and total 450 individuals were interviewed at ten selected locations the questionnaire addressed individual attitudes toward traffic noise and the inference of noise with daily activities such as work, relaxation, talking, telephoning, eating, sleeping, reading and watching television. A set of Regression equations were developed between mean noise index (Leq, $L_{10,}$ L_{max} $L_{dn,}$ and TNI) and percentage of the person highly annoyed and mean dissatisfaction score. Using Microsoft excel, the equation for best fit curve (Y= A+B X) was developed to show the relationship between the extent of annoyance and exposure to traffic noise at ten traffic junctions in the city of Jaipur.

3. Result and Discussion

Figure 3 shows that the public awareness has been increased very high. It demonstrates that 60% people were disturbing by noise and were aware adverse health effects of noise pollution. Whereas, figure 4 shows the increment in noise level in the city. It clearly indicated that 80% people felt an increase in noise levels. It may be due to the continuously increase in traffic activities on the roads.

The results of attitudinal survey are shown in Table 3. It summarizes the number of interviews conducted at each site, different noise indices and traffic characteristics. It indicated that at all the selected locations except one (i.e Sodala) The equivalent noise levels showed positive relationship with noise annoyance levels, The reason could be that most of the locations had medium to heavy congested traffic flow conditions., The location of sodala is having mixed nature of residential and commercial land uses. However, at this site the traffic volume was lesser as compared to other selcted locations but a good number of cyclists, pedestrians and slow moving vehicles like, cycle rickshaw, hand cart etc were also plying on the road along with the fast moving vehicles. Beside this, road encroachments by the shopkeepers also create traffic congestion on the road. Therefore, the equivalent noise levels were lower but the annoyance level among residing residents was higher as compared to the other selected locations. It was observed that value of Leq ranged between 72.6-83.9 dBA with mean values of 78.42 dBA for most of the selected locations. TNI is a method used to estimate annoyance responses due to traffic noise. It was exceeded by 70 dBA. The TNI had mean value of 79.15 dBA with range varying between 73.3-88.6 dBA. It indicated mild disturbance to the high annoyance level in the city. All average noise descriptors i.e., L10, L50, L90, Leq, TNi and Ldn were compared with annoyance index scale. It was found that all descriptors were fallen between low disturbance to upper limit of any allowable sound .It indicated that it may start causing physiological and psychological damage to human system.

Table 3. Results of the attitudinal survey at all the selected location

S.No.	Location	Percent highly annoyed (%HA)	Mean dissatisfaction score (MDS)	Noise Indices dBA				
				L_{10}	Leq	L_{max}	Ldn	TNI
1.	Bus Station	17.07	5.95	88	83.9	105.7	84	88.6
2.	Gopal pura Mod	27.22	1.14	81.1	76.3	104.3	74	76.6
3.	Govt.Hostel	34.33	1.59	81.6	74.7	96.8	73	79.4
4.	JDA Circle	32.26	2.29	79.1	76.7	96.3	77	78.2
5.	Khasa kothi Circle	30.25	3.66	86.2	81	106.6	79	84.5
6.	PaniPaich	29.8	3.39	84.4	82.3	103.8	81	77.3
7.	Queen's road	28.92	1.71	84.2	78.3	99.3	76	76.2
8.	Railway Station	39.69	2.08	77.3	72.6	87.7	70	73.3
9.	Sodala	35.06	3.32	78.8	74.6	88.6	73	76.5
10.	Transport Nagar	26.39	5.84	87.7	83.8	98.2	84	80.9

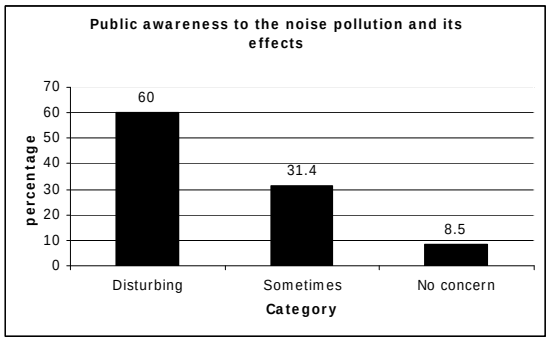

Figure 3. Public awareness to the noise pollution ant its health effects among people

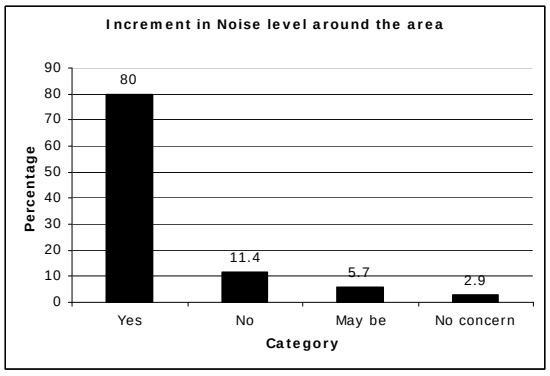

Figure 4. Increment in Noise pollution level in the city

To determine the relationship between %HA, MDS and various noise indices (L_{10}, Leq, Lmax and TNI) XY scatter plot was drawn between %HA Vs MDS and %HA Vs noise indices and best fit line was generated (figure 5-10). It was found that the value of R^2 was ranged between0.50 to 0.74 (as presented in figures 5-10), were not very good, but if the same study was applied to the individual sites, it would give better R^2 value. Since the main aim of this study was to develop a generalized correlation between annoyance levels and different noise indices, which can be applied for the whole city, hence a big dataset was taken by clubbing together the observations at all the ten selected locations in order to develop a common relation. As there were huge differences among road geometrical dimensions, road conditions, traffic characteristics and population density at all investigated locations, big data set gave lesser R^2 values (ranges between 0.50-0.74) for all the parameters.

It can be observed that there is a good correlation between various noise descriptors and %HA. It predicts that as the different noise parameters increases, the annoyance level among people also increases which directly affects the health of the individual person and whole environment as well.

4. Conclusion

Vehicular road traffic is the major source of noise pollution and creates annoyance among people. The present study highlights the relationship between attitudinal responses of the individual person and different noise indices. It indicated that the noise annoyance (psychological term) can correlate with different mathematical noise parameters. It was found that as the road traffic volume increases; the Leq levels and noise annoyance levels also increases, simultaneously.

The present investigation can be used to correlate the attitudinal behavior of the respondents to the noise descriptors. Noise annoyance level among people and itsadverse affects on human health can also be predicted by the present study.

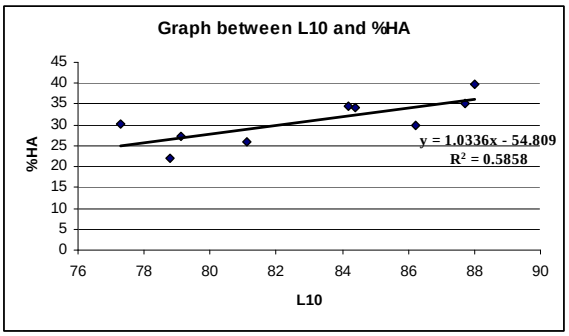

Figure 5. Relationship between L_{10} and %HA

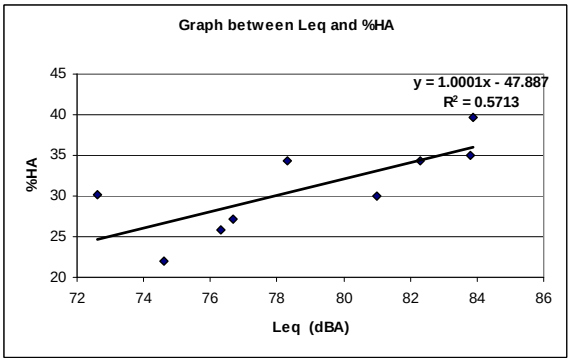

Figure 6. Relationship between L_{eq} and %HA

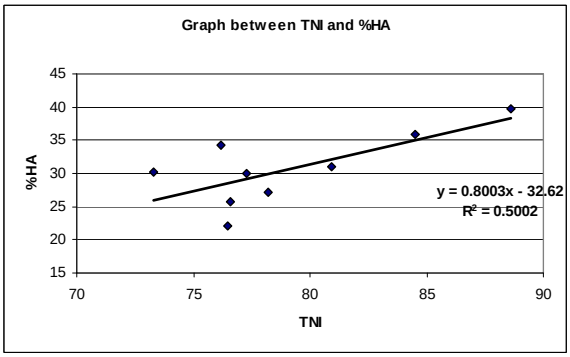

Figure 7. Relationship between TNI and %HA

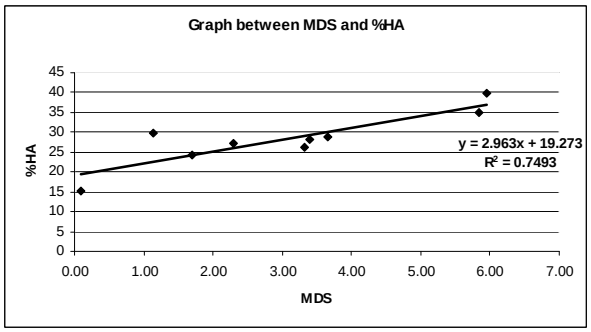

Figure 8. Relationship between MDS and %HA

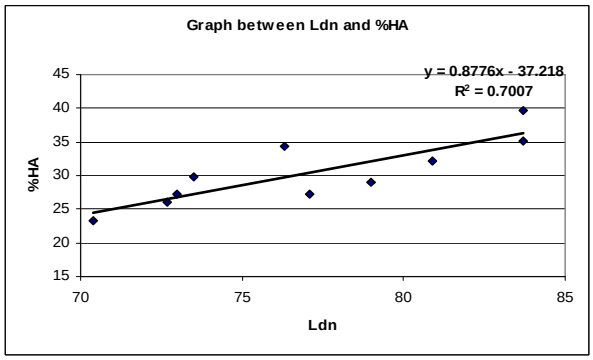

Figure 9. Relationship between L_{dn} and %HA

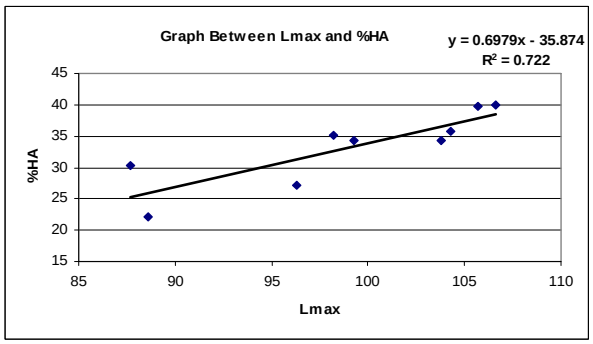

Figure 10. Relationship between L_{max} and %HA

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