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Study on the effects of traffic noise on human health

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ABSTRACT

This study analyses the physiological effects of traffic noise on the people living in the vicinity of roads in Delhi city. A questionnaire based survey at ten selected locations was carried out in the city. Ambient noise level data were also recorded at each location. It was observed that noise level was above the prescribed limits at all the selected locations. Results of the study demonstrate that vehicular road traffic is the major source of noise pollution which creates annoyance among people. Regression analysis was performed between day night noise level ( ) and percentage of highly annoyed (%HA) population which shows a strong correlation between them.

Keywords: Noise annoyance, Noise level, Human health.
I-INCE Classification of Subject Number: 62, 63

1. INTRODUCTION

Noise generated from vehicular traffic is a major source of environmental pollution. Despite attempts to regulate it, noise pollution has become an unfortunate fact of life worldwide. It will continue to increase in magnitude and severity because of population growth, urbanization, and the associated growth in the use of increasingly powerful, varied, and highly mobile sources of noise. It will also continue to grow because of sustained growth in highway, rail, and air traffic, which remain major sources of environmental noise (Goines and Hagler, 2007). Noise pollution is a growing problem that remains unaddressed as for as the case of developing countries is concerned. Unlike other pollutants noise leaves no waste, society ignores noise the way it ignored the use of tobacco products in the 1950s. Noise induces social and behavioral effects, notably annoyance and sleep disturbance; from a medical point of view, the effects of noise on human health are also well known: hearing impairment, speech intelligibility, physiological dysfunctions, mental illness, performance reduction, and cardiovascular diseases (Kim et al., 2012; WHO, 2011).
With urbanization and corresponding increase in number of vehicles in metropolitan cities, pollution is increasing at an alarming rate. Main areas of concern are related to air and noise pollution. More than 70% of total noise in our environment is due to vehicular noise (Calixto et al., 2003). Noise levels are showing an alarming rise and infact, noise level exceeds the prescribed levels in most of the land uses in the Indian cities (CPCB, 2000). Investigations in several countries in the past decades have shown that noise has adverse effect on human health, living in the close proximity of busy roads and highways (Babisch et al., 2001; Lujenberg and Neely, 2007; Ouis, 2001; Pirrera et al., 2010; Rylander, 2004).
Delhi, the capital of India, is located at 28.61°N 77.23°E, and lies in Northern India. It stands on the west bank of river Yamuna bounded by Uttar Pradesh and on the north, west and south by Haryana. Delhi is spread over an area of 1483 sq. kilometers, therefore making it the largest city in terms of area in the country. It has a length of 51.9

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km and a width of 48.48 km. It has an average elevation of 200-250 m above mean sea level. Delhi is the biggest city of India in terms of population also. The city is expanding at a faster rate to manage with increasing population. The steady growth in industries, new institutions, roads, and several construction activities have led to rapid expansion of the city. This development has resulted in fast urbanization and unprecedented traffic growth, which is the most common scenario in many Indian cities. This has added to noise levels significantly causing environmental noise pollution. Digital hearing app founders Mimi Hearing Technologies GmbH created the Worldwide Hearing Index (Mimi Healthy Hearing Index, 2018). Delhi was found the second worst city for noise pollution, followed by Cairo, Mumbai, Istanbul and Beijing.

2. LITERATURE SURVEY

During past two decades extensive research has been carried out by various researchers to study the effect of road traffic noise exposure and human health, sleep disturbance, impaired task performance, hypertension, high blood pressure and cardiovascular problems. Apart from monitoring, modeling and sleep disturbance studies in laboratory and field type, most of the studies report use of social surveys questionnaires to analyze the harmful effect of traffic noise on social communities. It is well documented that environmental noise affects health and well-being by disrupting basic activities such as sleep, rest, communication, concentration and cognition; and it may also lead to a general feeling of annoyance (Berglund et al., 1999; Muzet, 2007; Stansfeld et al., 2005; Pirrera et al., 2010). Exposure of high level noise can cause annoyance and severe stress on auditory and nervous system of human beings (Dratva et al., 2010; Fyhri and Klaeboe, 2009; Ljungberg and Neely, 2007; Ouis, 2001; Rylander, 2004). Noise exposure for a long period of time during the night leads to both sleep disturbances and activation of the sympathetic nervous system, thus increasing the risk of cardiovascular disease in the long run. After years of noise exposure may lead to dysregulation and permanent physiological changes that increase the risk of cardiovascular disease. Some studies dealing with noise exposure and cardiovascular effects have been reported (Babisch, 2000; Babisch, 2003; Babisch et al., 2005; Babisch, 2008; Fyhri and Klaeboe, 2009; Fyhri and Aasvang, 2010). International Commission on Biological Effects of Noise (ICBEN) promotes a high level of scientific research concerning all aspects of noise-induced effects on human beings and animals. ICBEN team chairs and co-chairs (Basner et al., 2015) presented a detailed review summarizing relevant findings, publications, developments, and policies related to the biological effects of noise, with a focus on the period 2011-2014. Review result demonstrate that noise is a prevalent and often underestimated threat for both auditory and nonauditory health and that strategies for the prevention of noise and its associated negative health consequences are needed to promote public health. Dzhambov and Dimitrova (2018) presented a systematic review and meta-analysis of analytic studies published in the period 2011-2017 concerning road traffic noise and hypertension. In conclusion, residential road traffic noise was associated with higher risk of hypertension in adults, but the risk was lower than previously reported in the systematic review literature.

A systematic review on the effects of road traffic noise on health was given by Brown (2015) along with measures to control environmental noise. Most recent studies reported by Barcelo et al. (2016) described long term effects of traffic noise on mortality whereas Camusso and Pronello (2016) studied relationships between traffic noise and annoyance for different urban site typologies. Two detailed review articles

given by Baliatsas et al. (2016) and Recio et al. (2016) described health effects from low-frequency noise; infrasound in the general population and road traffic noise effects on cardiovascular, respiratory, metabolic health respectively. It was found from the results that noise in the everyday environment constitutes an issue that requires more research attention, particularly for people living in the vicinity of relevant sources. Munzel et al. (2018) presented a critical review focusing on the mechanisms and the epidemiology of noise-induced cardiovascular diseases which provides novel insight into the mechanisms underlying noise-induced vascular damage. Two interesting review articles, one dealing with noise exposure and diabetes (Sakhvidi et al., 2018) and other focusing on chronic noise exposure and adiposity (An et al., 2018) were reported. Sun et al. (2018) studied the effect of interaction between attention focusing capability and visual factors on road traffic noise annoyance. The interaction between these factors provides additional evidence to support the role of audiovisual attention in the emergence of noise annoyance.

Banerjee (2012) presented a systematic review on road traffic noise and human health in India covering all the important studies which were carried out from 1991 to 2012. His review search and analysis observe that very little studies were available relating to traffic noise and its health impacts in India. All of them were subjective response studies and only a small portion of them quantify the exposure-effect chain and model the noise index with annoyance. Finally, it was concluded that the road traffic noise is a cause for annoyance to a variety of degree among the respondents. After that few more studies were reported dealing with noise exposure and its impact on human health (Banerjee, 2013(a and b); Mondal et al., 2014; Banerjee et al., 2014; Solanki et al., 2016; Ravindra et al., 2016).

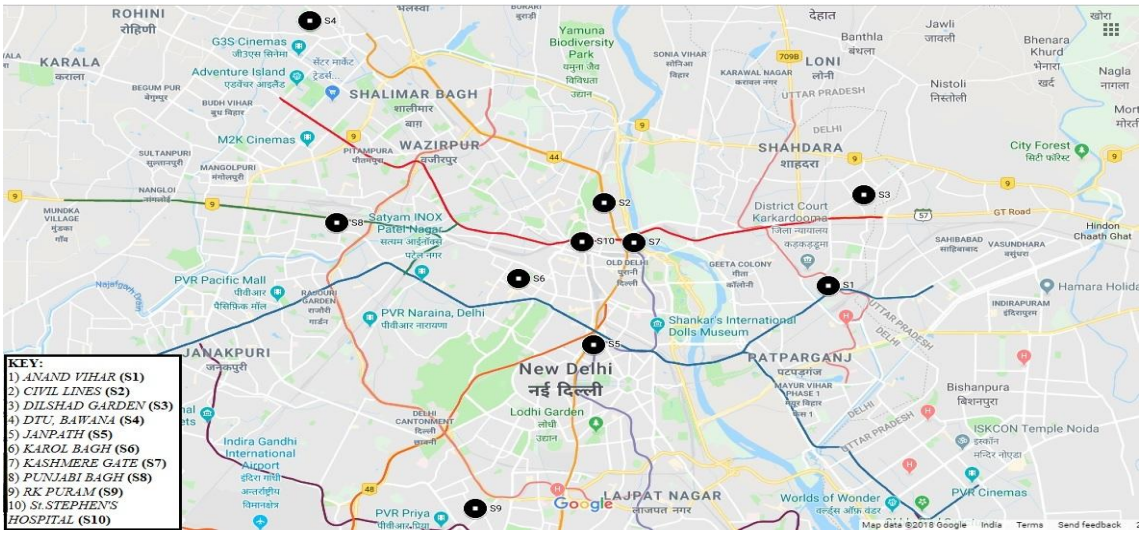

Figure1 Selected locations for study in Delhi (Source: Google maps)

3. METHODOLOGY OF THE STUDY

3.1 Study Sites/Locations identification

Ten locations were selected in the city for study purpose (Figure 1). Out of these 10 locations 5 are in commercial zone, 2 in residential zone and 3 silence zone. General features of the selected locations, along with traffic flow characteristics are presented in Table 1. These sites represent residential and commercial road stretches, having medium to heavy traffic flow, and covering major intersection points of the city.

Table1 General features of selected locations

S. No.	Name of location	Location type	Geographical coordinates
1	Anand Vihar (S1)	Commercial	28º38'51.22"N 77º18'57.02"E
2	Civil Lines (S2)	Commercial	28º40'55.97"N 77º13'25.75"E
3	Dilshad Garden (S3)	Silence Zone	28º40'53.76"N 77º19'6.2"E
4	Delhi Technological University (DTU), Bawana (S4)	Silence Zone	28º44'44.49"N 77º5'1.56"E
5	Janpath (S5)	Commercial	28º37'30.22"N 77º13'9"E
6	Karol Bagh (S6)	Commercial	28º38'42.77"N 77º11'18.84"E
7	Kashmere Gate (S7)	Commercial	28º39'59.91"N 77º13'44.3"E
8	Punjabi Bagh (S8)	Residential	28º40'12.83"N 77º7'54.14"E
9	RK Puram (S9)	Residential	28º33'46.23"N 77º11'12.4"E
10	St. Stephens Hospital (Near Tis Hazari Court) (S10)	Silence Zone	28º40'0.58"N 77º12'52.46"E

3.2 Questionnaire items

As the first step a questionnaire need to be developed to collect relevant information. Literature survey was carried out to develop the questionnaire (Levine 1981; Fields et al. 1997; Fields et al. 2001; ISO/TS 15666 (2003)). Developed questionnaire was divided in three parts (Part A, B and C). First part of the questionnaire is related to personal information of the respondents such as age, sex, educational background, distance of house from the road edge and annual income. In the second part questions like do you understand noise pollution, time period in your present house, major sources (i.e. road vehicles, electrical machines/industry/construction work, animals, religious places, house hold items like washing machines and grinders, and fire work/loud speaker etc) of noise pollution and what time of day/night you experience noise pollution at all the selected locations were incorporated in the questionnaire. Each respondent was also asked about to rate his/her residential area as quiet, noisy, very noisy or extremely noisy. Third part of the questionnaire is based upon the health problems (i.e. disturbance, irritation, headache, hypertension, loss of sleep, stress, increase or decrease in blood pressure and increase or decrease in heart/pulse rate) of the individual residents affected by noise pollution. All respondents were asked to respond to the questions, i.e., with respect to the yes, no, sometimes or not sure respectively. To measure respondents annoyance reaction two questions with same wording and instructions as in Fields et al. (2001) and ISO-TS 1566 (2003) were used. First question was "Thinking about the last (..12months or so..), when you are here at home, how much does noise from (..noise source..) bother, disturb, or annoy you; Extremely, Very, Moderately, Slightly or Not at all" and second "Thinking about the last (..12 months or so..), what number from zero to ten best shows how much you are bothered, disturbed, or annoyed by (..source..) noise?". Actually second question was a zero to ten point opinion scale for how much (..source..) noise bothers, disturbs or annoys you when you are here at home. If you are not at all annoyed choose zero, if you are extremely annoyed choose ten, if you are somewhere in between choose a number between zero and ten. Respondents were also asked to suggest the measures to control the noise pollution in their areas.

3.3 Questionnaire surveys and noise level data measurement

A questionnaire based survey in the Delhi city was carried out at ten selected locations. During this empirical study total 520 respondents were interviewed by direct interview method. 52 respondents were randomly selected at each of the identified locations. The samples represent a cross – section of different age groups, sex, educational levels and income levels of respondents. Central Pollution Control Board (CPCB), New Delhi, has initiated a National Ambient Noise Monitoring Network (NANMN) comprising 70 noise monitoring stations spread over seven metropolitan cities of India which include Bangalore, Chennai, Delhi, Hyderabad, Kolkata, Lucknow and Mumbai with an objective of collecting real-time noise monitoring data. Noise level data used in this study has been taken from CPCB website (CPCB, 2017) for the six locations Anand Vihar, Civil Lines, Dilshad Garden, Delhi Technological University, Punjabi Bagh, RK Puram and for the remaining four locations Janpath, Karol Bagh, Kashmere Gate and St. Stephens Hospital (Near Tis Hazari Court) ambient noise level data have been collected using a Noise Level Meter SA-29 for duration of 24 hours.

Table 2 Socio-demographic characteristics of population in the study area

Factors		Percentage of different factors at selected sites									
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**
Sex	Male	94.23	73.08	96.15	51.92	88.46	86.54	86.54	34.62	48.08	100
	Female	5.77	26.92	3.85	48.08	11.54	13.46	13.46	65.38	51.92	0
Age	15-30	53.85	36.54	44.23	100	36.54	25	38.46	21.15	36.54	30.77
	30-45	28.85	25	42.31	0	26.92	48.08	30.77	19.23	28.85	51.92
	45-60	17.31	32.69	13.46	0	32.69	21.15	26.92	42.31	30.77	17.31
	>60	0	5.77	0	0	3.85	5.77	3.85	17.31	3.85	0
Annual Income (in lacs)	<2	32.69	7.69	13.46	0	23.08	36.54	42.31	17.31	5.77	11.54
	2-4	7.69	0	7.69	0	19.23	5.77	15.38	5.77	3.85	7.69
	4-6	0	3.85	3.85	0	19.23	25	15.38	0	3.85	0
	6-8	0	19.23	0	0	0	0	0	0	0	0
	Not revealed	59.62	69.23	75	100	38.46	32.69	26.92	76.92	86.54	80.77
Education	10	38.46	36.54	44.23	0	32.69	36.54	34.62	23.08	15.38	44.23
	10+2	32.69	19.23	23.08	23.08	11.54	25	23.08	19.23	17.31	17.31
	UG	13.46	21.15	13.46	67.31	51.92	34.62	28.85	40.38	28.85	26.92
	PG	1.92	9.62	5.77	9.62	1.92	3.85	5.77	9.62	25	0
	Ph.D.	13.46	13.46	13.46	0	1.92	0	7.69	7.69	13.46	11.54
	Other	38.46	36.54	44.23	0	32.69	36.54	34.62	23.08	15.38	44.23
Time period of stay in current house or work period in shop (in years)	0-5	67.31	25	63.46	100	40.38	36.54	38.46	13.46	42.31	51.92
	5-10	21.15	26.92	21.15	0	32.69	15.38	11.54	15.38	19.23	25
	10-15	5.77	15.38	5.77	0	13.46	15.38	15.38	3.85	13.46	5.77
	15-20	1.92	15.38	5.77	0	5.77	11.54	17.31	19.23	17.31	5.77
	>20	3.85	17.31	3.85	0	7.69	21.15	17.31	48.08	7.69	11.54

4. DATA ANALYSIS

Data analysis has been carried out with the help of percentages and cross classifications on sources of noise, reaction to noise and suggestions to control noise in terms of age as well as sex. Socio-demographic characteristics of the studied population are shown in Table 2. The percentage of interviewed persons for the age group 15-30 years and 30-45 years combined was more than 60% for all locations except Punjabi

Bagh which is in tune with the fact that out of 10 study locations, 6 were of commercial type. People generally hesitate to share information about their annual income/gross salary due to various reasons. Except for Janpath, Karol Bagh and Kashmere Gate more than 59% respondents were not willing to share the information about their annual income/gross salary. Education background of the respondents also reveal an strange fact that around more than 55% respondents were educated up to 10+2 only except for the locations DTU, Janpath, Punjabi Bagh and RK Puram.

It was found that about 36% people were living/staying/working about <5 years in their current houses/commercial locations except for Civil Lines and Punjabi Bagh. It is also evident from the table that percentage of people living/staying/working more than 10 years in their current location is less than 50% at all locations except Punjabi Bagh (Table 2). Figure 2 shows the major sources of noise pollution in a particular community/location/area. It is clear that traffic i.e. vehicles are the main source of noise pollution followed by electrical machines/industry. Data analysis reveals that more than 80% noise comes from vehicular sources.

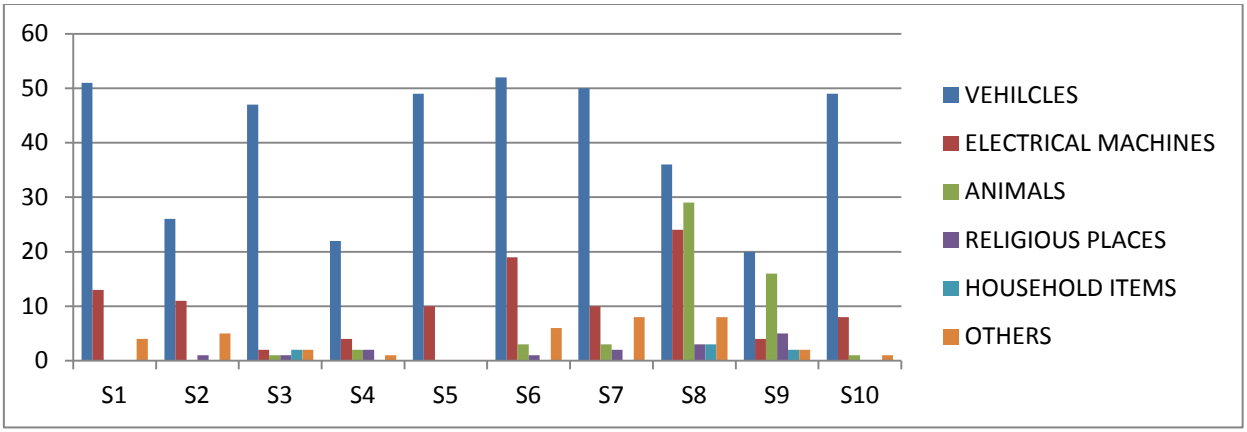

Figure 2 Contribution of major sources of noise pollution at different locations

Respondents were asked to answer about the health problems faced by them due to noise pollution. They were asked to answer in four categories: Yes, No, Sometimes and Not Sure. Following paragraph describe the results obtained by data analysis of the responses collected through questionnaire from the residents/respondents on the selected locations about the effects of noise pollution on them.

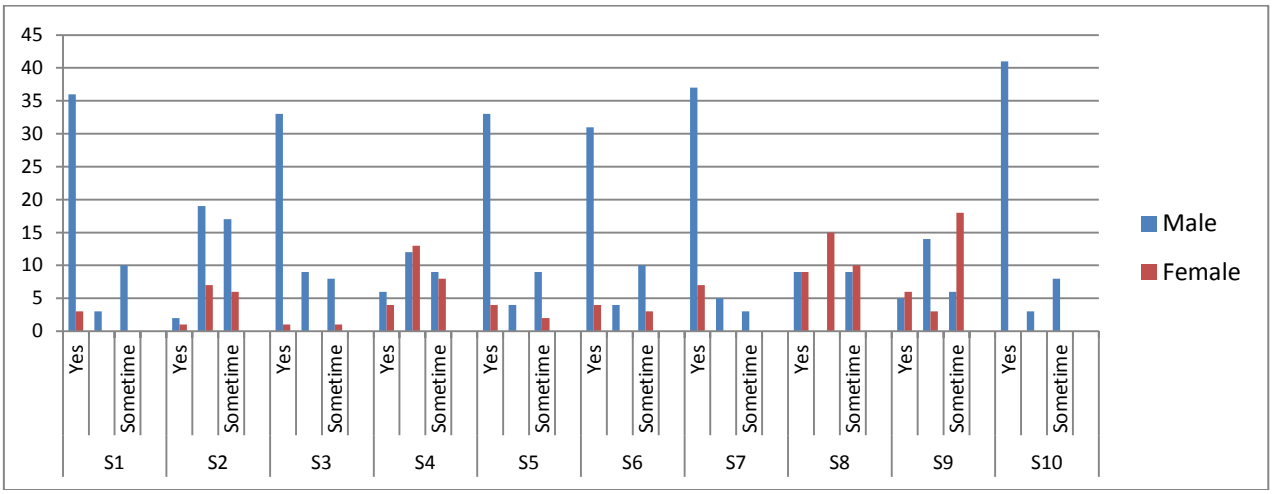

Figure 3 Disturbance due to noise pollution reported by respondents

Disturbance is a common and most obvious problem faced by higher noise level exposure for a longer period of time. Figure 3 shows the disturbance due to exposure of noise pollution faced by residents/respondents at the surveyed locations. It is obvious form the figure that at six locations respondents replied in majority in "Yes" i.e. disturbance due to noise is faced by them in general for a longer period of time. Only at the four locations Civil lines, DTU, Punjabi Bagh and RK Puram response was mixed with answers like Yes, No and sometimes i.e. respondents/residents were less affected in terms of disturbance caused by noise pollution but they also feel it sometimes.

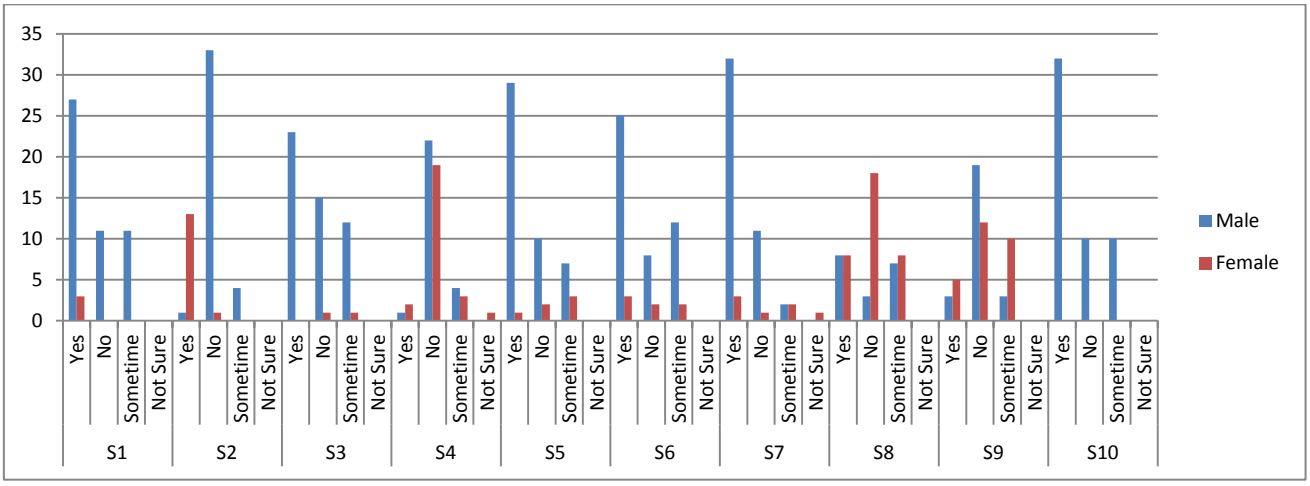

Figure 4 Irritation due to noise pollution reported by respondents

Like disturbance, irritation is another general problem faced due to noise pollution. Figure 4 shows the irritation due to exposure of noise pollution faced by residents/respondents at the surveyed locations. It is obvious form the figure that at six locations respondents replied in majority in "Yes" i.e. irritation due to noise is faced by them in general for a longer period of time. Only at the four locations Civil lines, DTU, Punjabi Bagh and St. Stephens Hospital response was mixed with answers like Yes, No and sometimes i.e. respondents/residents were less affected in terms of irritation caused by noise pollution but they also feel it sometimes. At Civil lines females replied majority in "Yes" whereas at Punjabi Bagh males replied majority in "Yes" i.e. at these locations responses were totally different given by either of the gender.

Due to persistent exposure of higher noise levels, headache is another common problem faced by residents/respondents. Table 3 shows that overall 21.52% male and 12.8% female respondents reported headache due to noise exposure. Other problems due to noise exposure to the people are presented in the Table 3. It is clear from the table that loss of sleep, hypertension and stress were reported from male respondents by 3.55, 3.46, and 4.33% respectively. While in case of increase or decrease in blood pressure and heart rate only 1.53 and 0.77% male respondents replied in "yes". It is also obvious from the Table 3 that the percentage ratio of female respondents affected by noise exposure was significantly lower as compared to male respondents. It was found that 5.04, 0, 1.6% females reported loss of sleep, hypertension and stress respectively due to the noise-generating sources. While in case of increase or decrease in blood pressure and heart rate no female respondents replied in "yes". The reason behind the higher number of male population affected by traffic noise is due to the fact that the numbers of male working population are sufficiently higher in commercial areas than the females in the city and due to continuously living in particular surroundings they have to face noise exposure daily for longer time period as compared to females.

Another reason behind this is that commercial sites are too near to the highway as compared to residential areas.

Table 3 Health problems due to noise exposure

Health Factor	Male				Female			
	Yes	No	Sometimes	Not sure	Yes	No	Sometimes	Not sure
Disturbance	58.98	18.48	22.53	0	31.2	30.4	38.4	0
Headache	21.52	61.27	16.71	0.51	12.8	72	15.2	0
Irritation	45.82	35.95	18.23	0	30.4	44.8	23.2	1.6
Loss of sleep/Insomnia	3.55	92.13	4.06	0.25	5.04	89.08	5.88	0
Hypertension	3.46	95.1	1.15	0.29	0	98.4	1.6	0
Stress	4.33	92.37	3.05	0.25	1.6	98.4	0	0
Increase/decrease in blood pressure	1.53	97.46	0.76	0.25	0	99.2	0.8	0
Increase/decrease in heart (pulse) rate	0.77	98.97	0.26	0	0	100	0	0

4.1 Noise Annoyance

Annoyance can be defined as a general feeling of displeasure or adverse reaction triggered by the noise (Ouis 2001). The degree of annoyance triggered by traffic noise is determined by the duration and intensity of noise level. The higher the level, the more people are annoyed and the greater the severity of perceived annoyance (Goines and Hagler 2007). Several researchers have attempted to establish the relationship between noise exposure and % of highly annoyed (%HA) people (Schultz 1978; Fidell et al. 1991; Fields 1994a). Exposure-response relationships for transportation noise were investigated by Miedema and Vos (1998). Synthesis curves for aircraft, road traffic, and railway noise were presented. Miedema and Oudshoorn (2001) presented a more accurate relationship between day night noise level and day night evening noise level versus %HA using third-order polynomial for aircraft, road and railway noise.

In this study two questions were used in the questionnaire to assess noise annoyance of respondents. In the first question, respondents were asked to respond to annoyance from noise exposure by either of the five categories i.e. Extremely, Very, Moderately, Slightly or Not at all. Second question was a zero to ten point opinion scale. Respondents were instructed to choose zero value if they were not at all annoyed , if they were extremely annoyed choose ten and if they were somewhere in between choose a number between zero to ten. A person was considered as highly annoyed if he or she chooses ‘Very’ or extremely in first question and value of ‘8’ or above eight in second question. All other combinations were discarded while counting the persons which are highly annoyed.

Table 4 Noise level and highly annoyed population at selected locations

S. No.	Name of location	Percentage of Highly Annoyed (% HA) Population	L_{dn} in dB(A)
1	Anand Vihar	46.15	72
2	Civil Lines	11.54	68.4

3	Dilshad Garden	42.31	70.4
4	DTU, Bawana	9.62	59
5	Janpath	28.85	71.2
6	Karol Bagh	38.5	71.4
7	Kashmere Gate	36.54	72.8
8	Punjabi Bagh	15.38	62.4
9	RK Puram	13.5	64.4
10	St. Stephens Hospital (Near Tis Hazari Court)	40.38	72.4

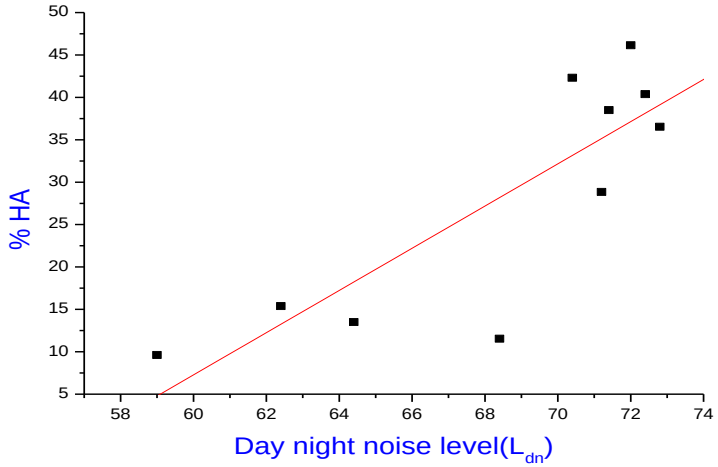

Figure 5 Relationship between percentage of Highly Annoyed population and L_{dn}

5. RESULTS AND DISCUSSION

Table 4 summarizes the percentage of highly annoyed (%HA) population, as well as L_{dn} at different locations. The mean L_{dn} (Day–Night Noise Level) value was 68.44±4.82 dB(A) and ranged between 62.4–72.8 dB(A). Graph between %HA and L_{dn} is shown in Figure 5 along with linear fitting. Value of coefficient of correlation between %HA and L_{dn} was found 0.837 with standard deviation 8.3, which shows a strong correlation between them. It is obvious from the measured values that the noise level is above the prescribed standards by CPCB, India (2000), at all the selected locations. Respondents were also asked to suggest measures to control the noise pollution in their locality. It was found that most of the respondents suggested that there should be ban on the pressure horns commonly used in the heavy vehicles and strict restrictions should be imposed on driving speed limits. Other suggestions to control noise were construction of bye pass, tree plantation, noise barrier construction and special acoustical treatment of building façade.

6. LIMITATIONS OF THE STUDY

One of the major drawbacks of this study is that out of ten selected locations only at four locations female respondents were available in sufficient number for interview. It happened, since survey locations which were dominated by commercial land use. A large amount of interviewed candidates were not of good educational level due to which

they were unaware of the harmful effects of traffic noise and some of them were even unaware about noise pollution. In this survey it was noticed that not only low educated people but also high educated people were not aware about noise pollution and its harmful effects and also about the rules and regulations about noise pollution in India.

7. CONCLUSIONS

A questionnaire survey was carried out in the city to investigate the ill effects of traffic noise on exposed individuals. Disturbance, headache and irritation were the main problems reported by respondents. It was found that about 70 % people opined that vehicular road traffic was major source of noise pollution which creates annoyance among individuals. Linear relationship between L_{dn} and noise annoyance (%HA) was derived using regression analysis. A strong correlation was observed between day night noise level (L_{dn}) and percentage of highly annoyed (%HA) population. It can be concluded that as the noise levels increases the level of annoyance also increases.

8. ACKNOWLEDGEMENTS

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