

Dynamics of road traffic noise in Bhadrak city, India

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Abstract

Road traffic noise assessed in 13 different squares of major intersection points in Bhadrak city during four different specified times i.e. 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m.. Road traffic was found to be the most important source of community noise at the studied sites. The noise levels of all the 13 squares were found to be beyond the permissible limit [70 dB (A)] during day time. Leq (equivalent noise level) values ranged from 93.4 to 100.5; 91.5 to 100.6; 95.1 to 107.3 and 97.3 to 106.3 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m. respectively. LNP values range from 115.7 to 127.7; 114.2 to 129.8; 118.2 to 138.2 and 120.7 to 135 dB, while TNI values range from 134.3 to 154.7; 130.7 to 157.9; 136.7 to 168.2 and 137.2 to 165 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m. respectively. Reprehensibly, even minimum LNP and TNI values are more than 114 and 130 dB respectively. Analysis of variance also computed for investigated squares at the peak hour i.e. 7-10 p.m. to infer the level of significance. The observed value of F (0.47) was less than the tabulated values and was not significant at both 5 and 1% levels of significance. Thus, the noise levels of different squares did not differ significantly at their peak hours. A preliminary public health survey carried out based on questionnaire method amongst 202 local inhabitants reveal the degree of annoyance due to road traffic noise.

Key words

Road traffic, Noise pollution, Noise descriptors, Health survey, Bhadrak

Introduction

Prolonged exposure to traffic noise can be both annoying and damaging to hearing (Agarwal and Swami, 2009b). In addition, stress of noise pollution can lead to sleepless nights, anxiety, higher blood pressure and even increased chances of heart failure (Ouis, 2001; Muzet, 2007).

Millions of people are affected by constant traffic noise. In India, some studies on the traffic noise monitoring have been carried out at different cities like Delhi (Prakash *et al.*, 2006), Mumbai (Naik, 1998), Aurangabad (Bhosale *et al.*, 2010), Amravati (Patil *et al.*, 2011), Dehradun (Ziaudin *et al.*, 2007), Lucknow (Kisku *et al.*, 2006), Varanasi (Pathak *et al.*, 2008), Jaipur (Agarwal *et al.*, 2009), Kolkata (Chakraborty *et al.*, 2002), Asansol (Banerjee *et al.*, 2008;

2009), Bolpur (Padhy and Padhi, 2008), Burdwan (Datta *et al.*, 2006), Visakhapatnam (Rao and Rao, 1992), Anantpur (Ravindranath *et al.*, 1989), Chennai (Kalai Selvi and Ramachandriaiah, 2009), Thiruvananthapuram, Kochi, Kozhikode (Sampath *et al.*, 2004), Jharsuguda (Patel *et al.*, 2006) and Balasore (Goswami, 2009) etc. and the average noise levels in these cities have been found to be higher than the recommended value. Improper stoppage of buses at locations rather than desired bus stoppage, improper parking of four wheelers along the road cause traffic jams (Agarwal and Swami, 2011; Goswami *et al.*, 2011). In Odisha, the number of vehicles on roads is increasing at a faster rate, which has led to noise pollution. An attempt has been made in this study to record the road traffic noise levels at 13 different squares (major intersection points) to assess the extent of vehicular noise pollution around the Bhadrak

city. Leq represents the equivalent energy sound level of a steady state and invariable sound. It includes both intensity and length of all sounds occurring during a given period (Piccolo *et al.*, 2005; Ozer *et al.*, 2009; Ghatass, 2009). Thus, the noise levels of different squares in different time intervals were predicted along with their equivalent noise levels (L_{eq}). As L_{eq} is an insufficient descriptor of the annoyance caused by fluctuating noise; Noise Pollution Level (LNP), which takes into account the variations in the sound signal and hence serves as better indicator of the pollution in the environment for physiological and psychological disturbance of the human system, was also assessed in the present study.

Materials and Methods

The Bhadrak city is located at 21° 06' N latitude and 86° 50' E longitude. The noise levels were measured following standard procedure using calibrated sound level (dB) meter (Model LUTREN, SL-4010) from January to April, 2011 at thirteen squares/ road sections (Aparti Bindha, Bank square, Charampa square, Bus stand, Kacheri square, Town-hall square, Rajghat square, Aradi square, Thana square, Banth square, Bypass road square, Dahanigadia/ Chhapulia square, College square) of Bhadrak. Sixty measurements were made within one hour duration (i.e. at 1 min interval) during four specified times (7-10a.m., 11a.m.-2p.m., 3-6p.m. and 7-10p.m.). Noise descriptors such as L_{10} , L_{50} , L_{90} , Leq, Traffic Noise Index (TNI), Noise Pollution Level (LNP) and Noise Climate (NC) were assessed to reveal the extent of noise pollution due to heavy traffic in this city.

Noise descriptors such as L_{10} , L_{50} , L_{90} are also assessed to calculate the value of L_{eq} using the following formula of Robinson (1971).

$$L_{eq} = L_{50} + (L_{10} - L_{90})^2 / 56,$$

where L_{10} : The level that were exceeded during 10% of the measuring time in dB(A),

L_{50} : The level that were exceeded during 50% of the measuring time in dB(A),

L_{90} : The level that were exceeded during 90% of the measuring time in dB(A).

Noise Pollution Level (LNP) expressed in dB is calculated by using the formula [$LNP = L_{eq} + a (L_{10} - L_{90})$, where, $a = 1.0$ (constant in the equation)]. Noise Climate (NC) is the range over which the sound levels are fluctuating in an interval of time and is assessed using the formula ($NC = L_{10} - L_{90}$). The TNI is another parameter, which indicates the degree of variation in a traffic flow. This is also expressed in dB (A) and can be computed using the relation [$TNI = 4 (L_{10} - L_{90}) + L_{90} - 30$ dB (A)]. The analysis of the measured noise levels generally depicts that there are existence of variations of noise with variables as the time of day, and road way types etc. In order to determine the existence and statistical significance of these variations and trends, a cross classification analysis along with F-test were assessed on the data.

A total of 201 human subjects was interviewed using a questionnaire from January to February, 2011 for their perception about the noise and its significance on health of community.

Results and Discussion

The noise data collected from different monitoring sites displayed wide ranges of noise level varying in four different times (7-10a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m.). The noise levels of 13 road sections ranged from 67.4 to 121.3 dB, 66.7 to 122.6 dB, 70.1 to 128.3 dB, 70 to 116.8 dB, 70.8 to 120.5 dB, 70.1 to 116.2 dB, 70.5 to 114.7 dB, 60.1 to 110.5 dB, 70.6 to 128.5 dB, 65.4 to 126.8 dB, 69.8 to 111.8 dB, 69.2 to 121.3 dB and 70.3 to 119.8 dB, respectively (Table 1). L_{10} values of all 13 monitored sites ranged from 97.4 to 102.3 dB; 94.1 to 100.3 dB; 97.4 to 105.5 dB; 99.4 to 108.9 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m. respectively (Table 1). Similarly, L_{50} and L_{90} values of all 13 monitored sites varied from 81.4 to 87.8 dB and 69.5 to 75.8 dB; 79.8 to 86.4 dB and 65.2 to 75.9 dB; 84.6 to 90.3 dB and 73.8 to 77.6 dB and 86.3 to 93.2 dB and 72.1 to 81.6 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m., respectively (Table 1). Accordingly, the calculated Leq (equivalent noise levels) values ranged from 93.4 to 100.5 dB; 91.5 to 100.6 dB; 95.1 to 107.3 dB and 97.3 to 106.3 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m. respectively (Table 1). LNP values of all 13 monitored sites ranged from 115.7 to 127.7; 114.2 to 129.8; 118.2 to 138.2 and 120.7 to 135 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m. respectively (Table 2). TNI values ranged from 134.3 to 154.7; 130.7 to 157.9; 136.7 to 168.2 and 137.2 to 165 dB during 7-10 a.m., 11a.m.-2 p.m., 3-6 p.m. and 7-10 p.m. respectively. Even the minimum LNP and TNI values were much more than 100 dB. These high values of LNP and TNI clearly demonstrated that the extent of noise pollution in the crowded squares was alarming. It was also observed that at some studied squares, located along the national highways (Charampa square and Bypass square), the characteristics of noise caused by fast moving traffic, are different from those caused by congested or slow moving traffic along the other investigated squares of the heart of the city. Noise from congested traffic was found to contain occasional peaks and varied more in levels. A systematic comparison between TNI and Leq noise levels for all selected locations revealed that the TNI values were much more than respective Leq levels. For example, Leq values of all the squares during 7-10 a.m. were 97.9, 95.9, 99.9, 99.2, 100.5, 93.4, 99.0, 96.2, 94.0, 95.7, 99.6, 95.5 and 95.8 dB respectively (Table 1); whereas TNI values were 148.4, 143, 148.8, 151.8, 150.3, 134.3, 142.9, 154.7, 136.6, 137.7, 148, 149.2 and 151. dB respectively (Table 2). This simply demonstrated that although the noise levels during any period of the day were generally constant but the presence of single – event noise was sufficient to affect the values of different noise percentile levels and consequently the TNI. This was due to overpopulated road ways with bad conditions, broken roads, minimal traffic management and hooting behavior of drivers (Agarwal and Swami, 2009a). Similarly, NC values ranged from 22.3 to 28.8; 21.2 to 29.2; 23.1 to 30.9 and 22.6 to 30 dB during

Table - 1: Values of Noise level (dB) at different squares of Bhadrak city at different time intervals

Name of the square	7 a.m. - 10 a.m.					11a.m. - 2 p.m.					3 p.m. - 6 p.m.					7 p.m. - 10 p.m.											
	Min	Max	Mean \pm SD	L ₅₀	Leq	Min	Max	Mean \pm SD	L ₅₀	Leq	Min	Max	Mean \pm SD	L ₅₀	Leq	Min	Max	Mean \pm SD	L ₅₀	Leq							
Apariti Bindha square	67.4	117.3	84.8 \pm 9.2	85.6	73.2	97.9	69.1	118.9	84.1 \pm 8.2	98.5	84.7	72.1	97.1	71.5	116.8	85.3 \pm 7.5	101.4	84.6	74.6	97.4	71.8	121.3	90 \pm 8.2	102.3	89.6	77.7	100.4
Bank square	68.2	116.4	84.7 \pm 9.5	84.6	72.2	95.9	66.7	113.4	84.2 \pm 6.8	96.4	85.2	72.2	95.6	67.4	120.5	88.1 \pm 9.6	100.8	87.6	77.6	97.2	71.1	122.6	88.4 \pm 9.6	101.3	87.6	77.9	97.3
Charampa square	71.4	109.8	86.3 \pm 9.5	87.4	72.8	99.9	70.1	111.7	86.1 \pm 7.6	97.1	86.4	75.9	94.4	72.1	118.6	89.7 \pm 8.2	105.5	90.3	74.6	107.3	77.8	128.3	92.8 \pm 8.1	108.9	91.6	80.2	106.3
Bus stand	72.1	112.5	87.5 \pm 9.4	86.7	75.8	99.2	70	110.7	84.8 \pm 7.6	100.3	85.4	71.1	100.6	72.6	116.8	88.1 \pm 9.3	98.7	89.9	73.8	100.9	74.6	116.3	91.7 \pm 9.1	103	92.3	78.5	103.0
Kacheri square	70.8	112.6	85.1 \pm 7.6	87.3	71.5	100.5	71.7	110.5	83.3 \pm 9.6	97.7	81.3	72.9	92.2	72.8	116.7	86.9 \pm 8.4	100.1	87.6	76.8	97.2	74.2	120.5	90.9 \pm 8.8	102.5	90.4	75.6	103.3
Townhall square	71.8	107.1	85.0 \pm 7.8	84.6	75.1	93.4	70.3	106.8	82.5 \pm 8.1	94.3	82.3	71.6	91.5	70.1	109.8	86.9 \pm 8.8	99.6	86.5	75.6	96.7	70.4	116.2	87.7 \pm 8.1	102.1	87.8	72.1	103.8
Rajhat square	70.5	108.7	86 \pm 8.1	87.8	72.5	99.0	72.9	106.2	84 \pm 8.1	96.4	83.2	74.1	92.0	71.5	112.4	86.1 \pm 8.9	99.5	86.6	73.8	98.3	75.6	114.7	89.5 \pm 8.3	101.7	89.1	78.6	98.6
Aradi square	62.1	108.2	82.3 \pm 7.4	81.4	69.5	96.2	60.1	105.7	81.3 \pm 7.2	94.1	82.3	65.2	97.2	70.7	108.9	86 \pm 8.1	98.4	86.3	74.3	96.6	70	110.5	89.1 \pm 8.3	99.4	89.9	76.8	99.0
Thana square	70.6	109.4	85 \pm 8.4	84.6	74.6	94.0	70.7	109.1	83.2 \pm 9.7	97	84.2	72.1	95.2	71.7	119.4	87.7 \pm 9.1	103.1	86.2	74.6	100.7	80.7	128.5	91 \pm 9.3	105.2	90.2	81.6	100.1
Banath square	66.3	114.2	86.1 \pm 9.2	86.5	76.5	95.7	72.1	115.6	83.8 \pm 8.8	98.7	82.1	74.6	92.4	65.4	116.8	88.7 \pm 6.1	100.8	89.9	76.6	100.3	80.1	126.8	92.5 \pm 7.3	106.7	93.2	80.6	105.3
Bypass road square	70	105.6	85.8 \pm 9.2	87.3	72.8	99.6	69.8	106.2	81.7 \pm 8.1	97.3	79.8	71.6	91.5	71.1	108.3	86.1 \pm 7.7	97.4	85.6	74.3	95.1	70.1	111.8	87.3 \pm 7.6	99.5	88.2	72.6	101.1
Dahani-gadia/Chitrapulia square	70.4	121.3	83.6 \pm 5.8	82.5	71.2	95.5	69.2	114.3	82.0 \pm 9.0	97.3	80.5	71.6	92.2	70.8	117.6	86.2 \pm 9.5	99.8	85.6	75.7	95.9	72.6	119.9	89.7 \pm 8.1	105.3	89.9	78.2	103.0
College square	70.3	116.8	83.3 \pm 7.6	82.3	71.6	95.8	71.2	116.4	81.8 \pm 9.6	98.1	80.2	72.4	91.9	71.7	117.7	85.6 \pm 8.1	98.6	85.9	73.8	96.8	72.4	119.8	87.1 \pm 6.8	99.4	86.3	73.2	98.5

Min: Minimum noise level, Max: Maximum noise level, Leq: Equivalent noise level, L₁₀: The level that were exceeded during 10% of the measuring time in dB(A) i.e. 10 percentile exceeded sound level (average peak level), L₅₀: The level that were exceeded during 50% of the measuring time in dB(A) i.e. median value of sound level, L₉₀: The level that were exceeded during 90% of the measuring time in dB(A) i.e. 90 percentile exceeded sound level (average background level)

Table- 2: Values (dB) of noise descriptors (TNI, LNP, NC) at different squares of Bhadrak city at different time intervals

Monitoring sites (Squares/Road intersection points)	7 a.m. - 10 a.m.			11a.m. – 2 p.m.			3 p.m. – 6 p.m.			7 p.m.- 10 p.m.		
	TNI	LNP	NC	TNI	LNP	NC	TNI	LNP	NC	TNI	LNP	NC
Aparti Bindha square	148.4	124.2	26.3	147.7	123.5	26.4	151.8	124.2	26.8	146.1	125	24.6
Bank square	143	121.1	25.2	139	119.8	24.2	140.4	120.4	23.2	141.5	120.7	23.4
Charampa square	148.8	126.4	26.5	130.7	115.6	21.2	168.2	138.2	30.9	165	135	28.7
Bus stand	151.8	125.7	26.5	157.9	129.8	29.2	143.4	125.8	24.9	146.5	127.5	24.5
Kacheri square	150.3	127.7	27.2	142.1	117	24.8	140	120.5	23.3	153.2	130.2	26.9
Townhall square	134.3	115.7	22.3	132.4	114.2	22.7	141.6	120.7	24	162.1	133.8	30
Rajghat square	142.9	124.1	25.1	132.1	114.3	22.3	146.6	124	25.7	141	121.7	23.1
Aradi square	154.7	125	28.8	150.8	126.1	28.9	140.7	120.7	24.1	137.2	121.6	22.6
Thana square	136.6	117	23	141.7	120.1	24.9	158.6	129.2	28.5	146	123.7	23.6
Banth square	137.7	118.5	22.8	141	116.5	24.1	143.4	124.5	24.2	155	131.4	26.1
Bypass road square	148	125.9	26.3	144.4	117.2	25.7	136.7	118.2	23.1	150.2	128	26.9
Dahanigadia/Chhapulia square	149.2	122.5	27	144.4	117.9	25.7	142.1	120	24.1	156.6	130.1	27.1
College square	151.6	123.3	27.5	145.2	117.6	25.7	143	121.6	24.8	148	124.7	26.2

TNI: Traffic Noise Index; LNP: Noise Pollution Level; NC: Noise Climate

7-10 a.m., 11 a.m.-2 p.m., 3-6 p.m. and 7-10 p.m., respectively (Table 2). All these values clearly showed high noise levels in Bhadrak city mostly throughout the day in general and during the evening (7 to 10 p.m.) in particular.

Analysis of variance was computed from all the thirteen investigated squares at the peak hour i.e. 7-10 p.m. (Table 3). The observed value of F (0.47) was less than the tabulated values and was not significant at both 5 and 1% levels of significance. Thus, it explicitly demonstrated that the noise levels of different squares do not differ significantly at their peak hours.

A comparative data on the number of different types of vehicles passes through the studied traffic squares in a day is presented in the Table 4. Maximum number of total vehicles passing in a day (from 7a.m. to 10p.m.) was observed at bus stand (7924) followed by Charampa square (7626) and Banth square (7356), whereas minimum number of total vehicles passing in unit time was observed at Townhall square (5969), Rajghat square (6096) and Kacheri square (6149). The peak traffic was observed during two specified times such as 7-10a.m. and 7-10p.m. at all the monitoring squares of the city. High frequency sound emitted- from electric horn and air horn of buses, trucks, cars, motorcycles, auto-rickshaws, engine of vehicles, crowding of general public create tremendous noise. The present study explicitly demonstrated that in most of cases the average assessed noise levels were more than the permissible limit i.e. 70 dB for road traffic noise

(W.H.O., 1999; Krishna Murthy *et al.*, 2007; Kudesia and Tiwari, 2007), 55 dB for residential area and 65 dB for commercial area (CPCB, 2000) during day time. Shockingly, the present noise assessment depicted that even the minimum values of Leq (91.5dB), LNP (114.2 dB), TNI (130.7 dB) were more than the permissible limit.

Excessive noise can lead to mental and physical health problems such as headache, bad temper, hearing problem, loss of concentration, aural communication disturbances etc. (Belojevic *et al.*, 2008; Lam *et al.*, 2009). Non-auditory physical health effects in general and annoyance from noise exposure in particular include changes in blood pressure, heart rate, and levels of stress hormones (Babisch, 2000, 2005; Bodin *et al.*, 2009). 76% of interviewed individuals opined that they were personally affected by noise pollution more than any other pollution. 61 % stated that they get highly annoyed by the vehicular noise. Majority of the respondents (79%) were irritated with the air-horn noise from motor cycle and auto-rickshaw. On the basis of analysis of questionnaire, it was found that loss of sleep (40%), insomnia (17%), mental stress (20%), headache (54%), hypertension (37%), temporary deafness (7%) were the main symptoms observed of individuals in Bhadrak city due to noise pollution. 65% of students in Bhadrak city observed disruption of study during noise hour.

Ban on hydraulic horn and very old vehicles and improved traffic control can abate traffic noise pollution (Pandya, 2001; Tripathi

Table- 3: Analysis of variance for different squares/ road intersection points during peak hour (7p.m.-10p.m.) at Bhadrak city

Sources of variation	Sum of squares (SS)	Degree of freedom (DF)	Mean squares	F values	
				Observed	Tabulated
Between squares	574.03	12	47.8	0.47	$F_{0.5} = 1.75$ $F_{0.1} = 2.18$
Within squares (error)	50242	494	101.7		
Total	50816.03			

Table- 4: Total number of vehicles passing the road in unit time at different times of a day at Bhadrak city

Monitoring sites	Number of vehicles that passed in a day												Total number of vehicles
	7 a.m. - 10 a.m.			11a.m.– 2 a.m.			3 p.m. – 6 p.m.			7 p.m.- 10 p.m.			
	2 & 3 W	LMV	HMV	2 & 3 W	LMV	HMV	2 & 3 W	LMV	HMV	2 & 3 W	LMV	HMV	
Aparti Bindha square	1172	223	33	1154	236	38	1368	241	39	1453	255	44	6256
Bank square	1358	257	22	1177	201	24	1289	214	21	1357	222	28	6170
Charampa square	1423	319	159	1384	345	163	1241	373	182	1441	387	209	7626
Bus stand	1381	302	201	1365	321	212	1475	332	237	1511	341	246	7924
Kacheri square	1214	251	37	1198	247	34	1251	273	37	1276	285	46	6149
Town-hall square	1244	235	24	1157	224	28	1205	238	32	1287	257	38	5969
Rajghat square	1235	239	25	1201	223	25	1272	258	28	1291	266	33	6096
Aradi square	1291	227	25	1234	236	27	1267	246	31	1288	275	46	6193
Thana square	1267	264	24	1176	272	29	1297	287	43	1302	285	45	6291
Banth square	1393	296	157	1276	279	166	1381	310	173	1407	334	184	7356
Bypass road square	1266	261	103	1282	237	108	1296	241	111	1324	284	117	6630
Dahanigadia /Chhapulia square	1293	253	105	1279	242	118	1298	264	127	1334	277	136	6726
College square	1276	207	98	1231	220	104	1286	239	109	1331	252	117	6470

2 & 3 W: Two and three wheelers; **LMV:** Light motor vehicles; **HMV:** Heavy motor vehicles

et al., 2006; Banerjee and Chakraborty, 2006). Thus, Integrated road traffic noise strategy (IRTNS) must be developed at government level to minimise noise pollution. Central Pollution Control Board (CPCB), India should lay down legal standards for noise levels from roads and Ministry of Environment and Forests should launch programmes to reduce noise from the motor vehicle.

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