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Assessment of Traffic Noise Pollution in Burla Town, India; An Inclusive Annoyance Study

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Abstract: Noise pollution is one of the major public health problems in urban areas throughout the world. Noise is unwanted sound which produces undesirable problems in day to day life of human being (e.g., physiological and psychological problems). Rapid increase of the industrialization, urbanization, infrastructure, volume of motor vehicles, and increase in the road networks brought noise pollution to the highest level of disaster in a current situation. In urban areas, road traffic noise plays commanding role among all noise sources and affects the exposed inhabitants. The present work is done to evaluate and assess the traffic noise and its effects in Burla town.

Burla, Vidyanagari of Odisha, is an emerging town in India, as it hosts national level of teaching and research institutions like IIM Sambalpur, a medical college-cum-hospital (VIMSAR), a technical university (VSSUT) and Sambalpur University. In last two decade, the road traffic volume has been increased and is facing severe noise pollution to its inhabitants. Noise pollution assessment was made at different locations of the town. This study unveiled the dismal state of noise pollution in the town. Noise contour maps were drawn to visualize the noise level at the traffic and its surroundings. The numbers of hearing impaired patients in different hospitals of the locality are increasing. That shows grim picture of the situation. Regression equations were established taking noise levels with percentage of highly annoyed people during study indicates strong correlation.

Keywords: Equivalent continuous noise level; traffic noise; noise index; noise climate; noise standards; annoyance

1 Introduction

In the recent years, noise pollution is considered as major trepidation that affects the quality of human life in urban as well as rural areas across the globe. From dawn to dusk, peoples are exposed to noise in various forms as traffic noise, industrial noise, railway noise and many ways in community areas. Because of rapid increase of industrialization, urbanization, transportation systems, population growth and associated with the growing number of automobiles, noise pollution has reached to a disturbing level over the years. Use of horns, traffic congestion and rapid increase of traffic flow are the main causes of

traffic noise enhancement in the urban areas. Menace of noise can be minimized if it is detected at the planning stage else it is beyond the economics of optimization.

For the present case, Burla town has been chosen. It is called Vidya nagari of Odisha [1] as it hosts the Sambalpur University, the Veer Surendra Sai Institute of Medical Sciences and Research (VIMSAR) and the Veer Surendra Sai University of Technology (VSSUT) and the Indian Institute of Management (IIM) Sambalpur. All the four institutions are premier and unique in their respective field. Besides these, numerous schools and colleges have been grown. Also head quarter of Mahanadi Coalfield Limited (MCL), Odisha Hydro Power Corporation (OHPC) and Western Electricity Supply Company (WESCO) are in the same town. World's longest earthen dam namely Hirakud dam, is situated at 4 km from the town. Thus the population at the height of the year around is sizable (more than 50,000).

2 Literature Review

The effect of noise on humans can be measured in various ways. Common ways of measuring the effects on humans are physiological and psychological. The impacts of physiology are headache, blood pressure, dizziness, fatigue and etc [2, 3]. The impacts of psychological are sleep disturbance, annoyance, irritation, loss of concentration and many more [4-8]. It is observed that traffic noise is the cause of increase in blood pressure, heart disease and sleep disturbances in USA [9]. In another study, Jibran et al. [10] mentioned that exposure of traffic noise and air pollution is the reasons of many health problems. Sharkawy and Aboukhashaba [11] have done the traffic noise analysis in the residential area of Jeddah city and they have correlated to the individual's response with level of noise. In Guwahati city, the noise level at various areas exceeds the national standards and it is observed that the higher noise is due to traffic congestion, narrow roads and ill traffic management [12, 13]. Similarly, the traffic noise is in alarming condition at different parts of the Indian port city, Visakhapatnam [14]. In another upcoming industrial city of Kolhapur in India, the noise in different parts of city is above the prescribed limits [15]. In another study in Sanandaj city (Iran), Seyed et al. [16] found that the minibus, vans and truck-buses were mainly responsible for producing high traffic noise. Using the geographic information system (GIS), Monazzam et al. [17] measured the traffic noise level and compared with their national standard in Tehran.

In traffic noise analysis, there are various noise pollution indices to present the noisy environment. These are NEI, NC, Lnp and TNI. Noise exposure index (NEI) is the pathways to measures the noise induced hearing losses [18]. Higher noise climate (NC) indicates high fluctuation of sound level for a given time period, which causes more annoyance [19]. Noise Pollution levels (L_{np}) serve as better indicator of the pollution in the environment for physiological and psychological disturbances of the human system [20]. That may be the cause of irritability, anxiety, and mental fatigue, interfere with personal communication and increase of blood pressure and pulse rate. Traffic noise index (TNI) is another parameter, which indicates the degree of variation in a traffic flow and correlates highly with general dissatisfaction [21].

Despite being a growing town with national and international standards of institutions of eminence and a technical university, no work on noise analysis had been carried out in Burla. So, the present works emphasis on the evaluation of traffic noise level and annoyance study in Burla town.

3 Experimentation and Observations

In present study, the evaluation and assessment of traffic noise was conducted in Burla town. Geographic features of Burla Town are shown in Tab. 1. The observations are taken with the help of sound level meter-cum-hand held analyzer (B & K make). Calibration is done before taking readings. Noise levels were measured on A-weighing scale.

The noise levels are measured in the month of January-April 2019 at nine different locations in the town. These locations are chosen on the basis of the categories of specific zones like silence zone, commercial zone, residential and recreational zone etc. There are two entrances to the town from national highway (NH-6) side,

Table 1: Geographic features of Burla town

S. No.	Features	Recorded Value
01	Population	46,698 (2011 Census)
02	Geographic area	25.4 Square km
03	Latitude/ Longitude	21.5°N/83.87°E
04	Above mean sea level	173 meters

one is PC Bridge chak and another is over bridge chak near Sambalpur University. The main road passes through the important locations like, PC Bridge (entrance to the town), VSSUT (a technical university), Kirba chak, Professors Colony chak, PG chak, VIMSAR (a medical college and hospital), Petrol pump (market place), Planetorium, Sambalpur University. Most of the vehicles pass through these locations. The specific locations are shown in Fig. 1.

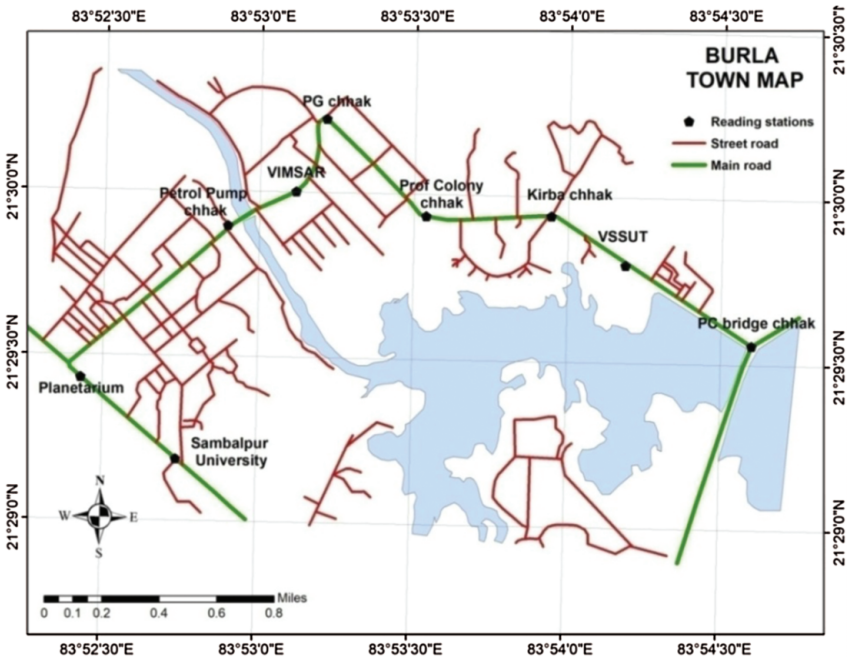

Figure 1: Map of Burla town showing the different locations

At each location, observations were taken on hourly basis. For a day, readings start from 6 am till 6 am of the next day. The instrument was kept at on a stand which is 1.2 meters above the ground. The distance in between kerb of road and instrument is 5 metres. The observations were taken in the day when there is no rainfall. For each location in the town, noise measurements were carried out for a week and twenty four hours in a day with starting time of measurement in morning at 6.00 am. Repetitions at same locations were carried out after two months for the cross verification. The noise measurement was done on working days only. The whole day is divided into three different timing; day time (6 am–6 pm), evening (6 pm–10 pm) and night time (10 pm–6 am). The data collected from each location and was processed for statistical analysis. The classifications of locations are mentioned in Tab. 2. The Central Pollution Control Board (CPCB, India)

Table 2: Locations and the respective zones

S. No.	Locations and corresponding zone	Features/zones	CPCB Standards Leq (dB(A))	
			Working time (6 am-10 pm)	Night time (10 pm-06 am)
01	Educational zone (VSSUT, VIMSAR, Sambalpur University)	Silent	50	40
02	Commercial zone (PC Bridge Chak, Petrol pump Chak)	Commercial	65	55
03	Planetarium	Recreational	55	45
04	Residential Zone (Professor Colony Chak, PG Chak)	Residential	55	45
05	Education-cum-Commercial (Kirba Chak)	Commercial	65	55

recommended noise level limit for different zones during working hours and in night hours are shown in same table.

Equivalent continuous noise level (Leq) and percentile values as $L_{10,}$ $L_{50,}$ L_{90} were assessed from the experimental data. These are used for evaluation by using equations of noise climate (NC), noise pollution level (Lnp), traffic noise index (TNI) and noise exposure index (NEI) by using following equations.

$$\text{Noise climate, (NC)} = L_{10} - L_{90} \tag{1}$$

$$\text{Noise pollution level } (L_{NP}) = L_{eq} + \text{NC} \tag{2}$$

$$\text{TNI} = 4\ (L_{10} - L_{90}) + L_{90} - 30\text{dB(A)} \tag{3}$$

$$\text{Noise exposure index (NEI)} = \frac{t_1}{T_1} + \frac{t_2}{T_2} \pm - - - + \frac{t_n}{T_n} \tag{4}$$

where, $t_{1,}$ $t_{2\ ....}$ t_{n} are actual exposures and $T_{1,}$ $T_{2,}$….T_{n} are permissible exposure as guide line given by the country or as per local laws. L_{10} is the level of sound exceeding for 10% of total time of measurement, L_{50} is the level of sound exceeding for 50% of total time of measurement; L_{90} is the level of sound exceeding for 90% of total time of measurement. Leq is the constant noise level that would result in the same total sound energy being produced over a given period.

Present status of annoyance due to noise was studied by the method of questionnaire and personal interviews of people (affected residents and people of business establishments). A socio-health survey on noise annoyance was carried out at all study locations. A total number of 396 people were interviewed and 376 people were participated in questionnaire survey. The questionnaires were of two parts. The first part relates to their personal information and second part relates to effect of noise on their physiological and psychological well beings.

4 Result and Discussion

The results and discussion of the present work mainly consists of the following;

i) Assessment of equivalent continuous noise level (Leq) at different locations.
ii) Analysis of noise indices like; NC, NEI, Lnp and TNI at different locations.

iii) Noise mapping of the town.
iv) In situ study on noise annoyance by population exposed.

4.1 Assessment of Equivalent Noise Level at Different Locations

The equivalent noise levels (for each hour) at all nine locations are presented in Tab. 3 (6 am-6 pm) and Tab. 4 (6 pm-6 am) separately. The timing *vs*. corresponding equivalent noise level (Leq) graphs for each zones are plotted. Those are shown in Figs. 2–7.

Table 3: Leq (in dB) at different location during day time

Locations	6-7 am	7-8 am	8-9 am	9-10 am	10-11 am	11-12 noon	12-1 pm	1-2 pm	2-3 pm	3-4 pm	4-5 pm	5-6 pm
PC Bridge Chak	68.2	70.1	78.1	78.4	76.8	74.1	74.2	73.1	72.2	71.8	69.4	72.3
VSSUT	64.8	69.8	73.4	70.8	70.1	69.7	72.7	75.7	72.8	70.4	71.5	76.3
Kirba Chak	66.2	71.5	73.6	74.5	74.1	74.1	69.4	71.6	71.7	68.8	69.6	70.8
Prof Colony Chak	67.6	69	71.3	72.8	71.3	73.7	71.2	70.8	71.2	72.2	71.4	71.2
PG Chak	68.1	69.2	76.9	73.1	72.4	74.1	74.1	71.2	70.7	70.1	70.3	71.2
VIMSAR	67.8	71.9	72.1	73.3	73.1	72.4	71.6	71.2	69.6	70.1	72.6	72.3
Petrol Pump Chak	70.2	74.3	77.3	76.4	78.2	78.2	77.8	77.1	77.3	75.2	77.6	78.1
Planetarium	66.1	69.1	68.8	69.1	69.5	69.2	69.2	69.3	69.5	69.6	69.2	67.8
Sambalpur University	62.1	64.5	66	68.5	69.2	67	68	67	68	71.4	68	70

Table 4: Leq (in dB) at different locations during evening-night time

Locations	6-7 pm	7-8 pm	8-9 pm	9-10 pm	10-11 pm	11-12 mid	12-1 am	1-2 am	2-3 am	3-4 am	4-5 am	5-6 am
PC bridge Chak	75.7	74.5	74.1	73.9	72.8	71.6	69.8	69.2	68.4	68	68.1	68.2
VSSUT	72.1	70.1	67.1	65.1	62.3	58.6	55.5	43.1	36	38.4	45.8	55.4
KirbaChak	71.6	70.1	68.2	66.3	64.7	60.1	58.4	44.1	36.1	40.1	46.2	58.4
Prof Colony Chak	71.8	72.7	68.2	65.2	62.7	59.8	58.2	45.2	35.1	40.9	50.4	56.7
PG Chak	70.6	71.6	70.8	67.1	63.4	59.8	58.4	48.2	37.7	41.8	52.1	59.2
VIMSAR	71.2	69.6	68.2	67.1	65.2	64.4	63.7	50.1	36.2	42.9	51.4	59.7
PetrolPump Chak	78.5	78.6	77.2	75.2	68.8	66.9	62.4	51.6	38.6	45.4	54.6	58.4
Planetarium	68.9	68.2	65.9	64.5	62.2	59.4	59.8	44.2	34.9	38.9	51.2	56.8
Sambalpur University	67	66.8	65	63	61.3	58.2	40.9	43.9	34.9	38.5	51.3	58.2

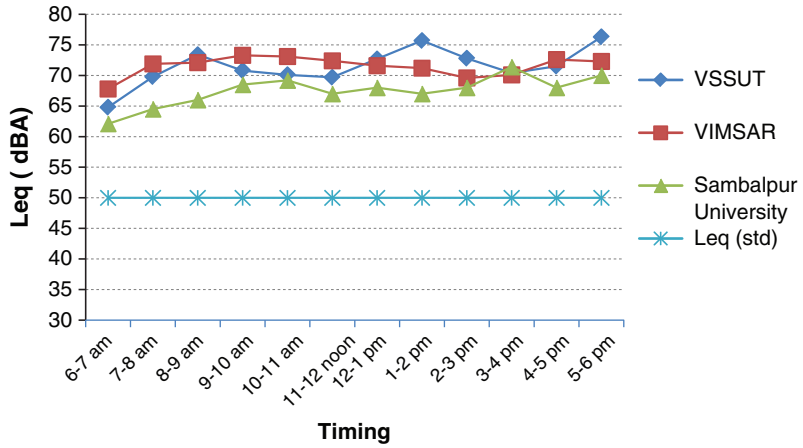

Figure 2: Leq at different locations (silence zone) during day time

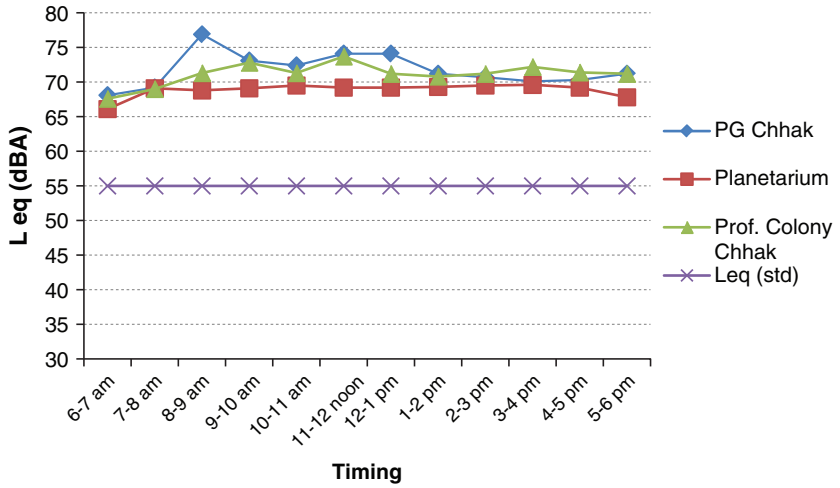

Figure 3: Leq at different locations (residential and recreational zone) during day time

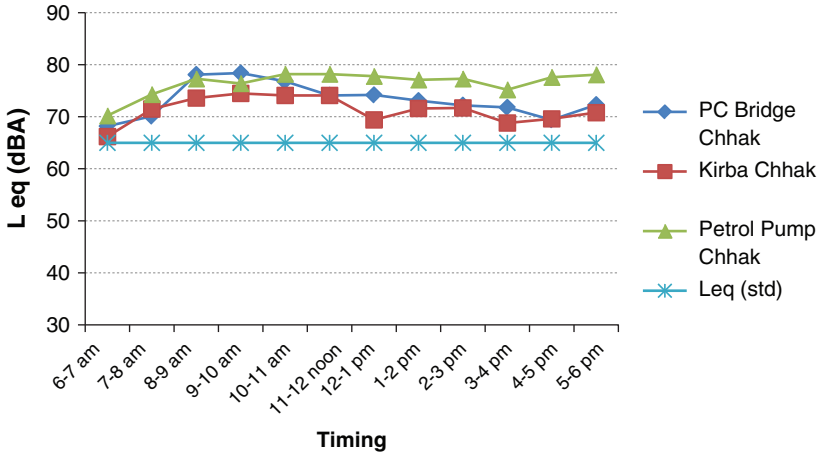

Figure 4: Leq at different locations (commercial zone) during day time

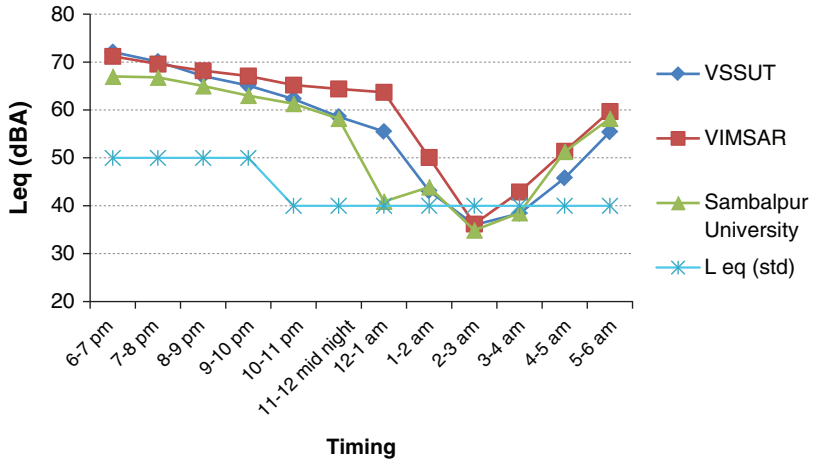

Figure 5: Leq at different location (silence zone) during evening-night time

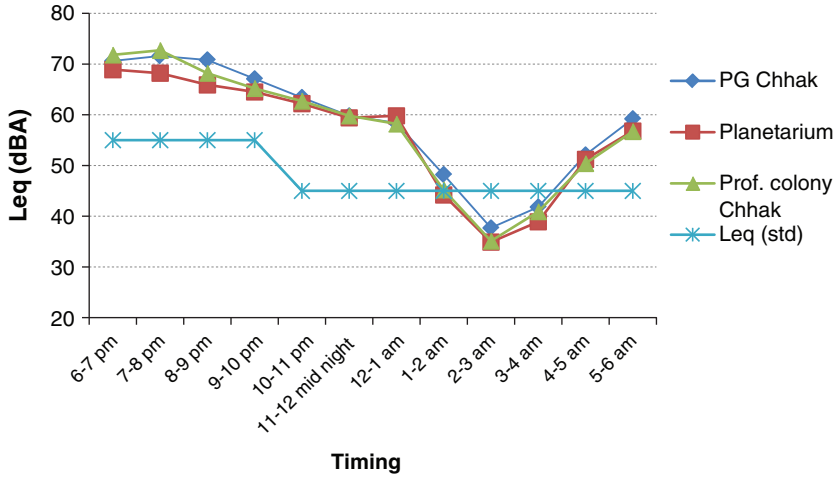

Figure 6: Leq at different locations (residential and recreational zone) during evening-night time

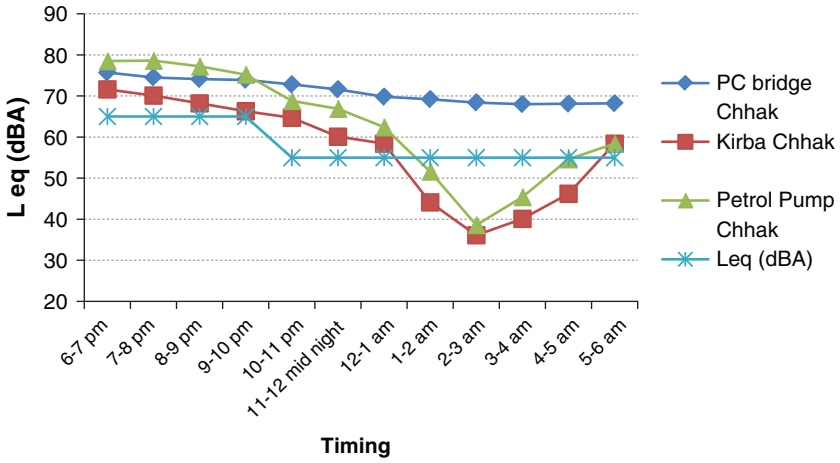

Figure 7: Leq at different location (commercial zone) during evening-night time

Figure 2 illustrates the day time noise levels at all locations of silence zone. At VSSUT, the highest (L_{eq} = 76.3 dB) during 5-6 pm, while minimum (L_{eq} = 64.8 dB) during 6-7 am. At VIMSAR, a medical college and a referral hospital has highest (L_{eq} = 73.3 dB) during 9-10 am and lowest (L_{eq} = 67.8 dB) during 6-7 am. At Sambalpur university, the highest (L_{eq} = 71.4 dB) recorded was during 3-4 pm and lowest (L_{eq} = 62.1 dB) during 6-7 am.

Figure 3 illustrates that at PG Chak, the highest (L_{eq} = 76.9 dB) during 8-9 am and lowest being (L_{eq} = 68.9 dB) during 6-7 am. Being only recreational zone in town, the Planetarium, the highest (L_{eq} = 72.3 dB) at 4-5 pm and lowest (L_{eq} = 68.1 dB) during 6-7 am. In Prof Colony, the highest (L_{eq} = 72.8 dB) during 9-10 am and lowest (L_{eq} = 65.2 dB) during 9-10 pm.

In the Fig. 4, it is illustrated that the day time noise levels at commercial zone. The highest (L_{eq} = 78.4 dB) during 9-10 am and the lowest being (68.2 dB) during 6-7 am. Kirba Chak is situated in between VSSUT and Prof Colony and is a commercial zone with highest (L_{eq} = 74.5 dB) during 9-10 am and lowest (L_{eq} = 66.2 dB) during 6-7 am. Petrol pump is the main commercial place, nearby bus stand and having shopping complexes. The highest (L_{eq} = 78.6 dB) during 7-8 pm and lowest (L_{eq} = 70.2 dB) during 6-7 am. At all locations of the town, the observed L_{eq} was well above the prescribed value of CPCB, India.

Figure 5 shows the evening and night time noise level at silence zone of town. At VSSUT the highest during evening-night time (L_{eq} = 72.1 dB) during 6-7 pm and minimum (L_{eq} = 36 dB) during 2-3 am. At VIMSAR the highest (L_{eq} = 71.2 dB) and lowest (L_{eq} = 36.2 dB) during 2-3 am. At Sambalpur University, the highest (L_{eq} = 67 dB) during 6-7 pm and lowest (L_{eq} = 34.9 dB) during 2-3 am.

In the Fig. 6, it shows that the evening-night time noise level of different residential and recreational zones of the town. At PG Chak, the highest (L_{eq} = 70.8 dBA) during 8-9 pm and minimum (L_{eq} = 37.7 dBA) during 2-3 am. At planetarium the highest (L_{eq} = 68.9 dBA) during 6-7 pm and minimum (L_{eq} = 34.9 dBA) during 2-3 am. At Prof Colony, the highest (L_{eq} = 72.7 dBA) during 7-8 pm and minimum (L_{eq} = 35.1 dBA) during 2-3 am.

Figure 7 illustrates the noise level in evening-night time at different commercial zones of the town. At PC Bridge the highest (L_{eq} = 75.7 dBA) during 6-7 pm and lowest (L_{eq} = 68 dBA) during 3-4 am. At Kirba Chak, the highest (L_{eq} = 71.6 dBA) during 6-7 pm and minimum (L_{eq} = 36.1 dBA) during 2-3 am. At Petrol Pump, the highest (L_{eq} = 78.6 dBA) during 7-8 pm and minimum (L_{eq} = 38.6 dBA) during 2-3 am.

4.2 Analysis of NC, NEI and Lnp at Different Locations

The L_{10}, L_{50} and L_{90} values, obtained from the observations were used to calculate the noise pollution indices like; NC, NEI, TNI and Lnp. These are presented in Tabs. 5 and 6.

It is observed that, during day time, in all cases, the value of NEI exceeds 1, which is not desirable and some cases quite objectionable. Also at all locations, L_{np} is high, which are the causes of physiological and psychological disturbances of the human lives.

During evening-night time analysis of noise indices at educational zone (VSSUT, VIMSAR, Sambalpur University) it was observed, the value of NEI approaches less than one between 2-4 am at VSSUT, 2-3 am at VIMSAR and 2-4 am at Sambalpur University. It is good sign for the habitants; they can sleep well during that period. In commercial zone (PC Bridge Chak, Kirba Chak and Petrol Pump Chak), it was observed, the value of NEI approaches less than 1 between 12-4 am at Kirba Chak and less than 1 between 1-5 am at Petrol Pump Chak. At residential zone (Prof Colony Chak, PG Chak), it was observed, and the value of NEI approaches less than 1 between 2-4 am.

4.3 Noise Mapping of the Town

Equivalent noise levels at different locations during working hours and night hours were calculated by using the formula,

Table 5: Noise pollution indices during day time

Locations and Noise Descriptors		6-7 am	7-8 am	8-9 am	9-10 am	10-11 am	11-12 noon	12-1 pm	1-2 pm	2-3 pm	3-4 pm	4-5 pm	5-6 pm
PC Bridge Chak	NC	11.5	11.2	11.8	8.7	10.7	12.6	13	14	13.1	12.9	12.7	12.9
	NEI	1.05	1.08	1.2	1.2	1.18	1.14	1.14	1.13	1.11	1.11	1.07	1.11
	L_{np}	79.7	81.3	88.9	87.1	87.5	86.7	87.2	87.1	85.3	84.7	82.1	85.2
	TNI	79.1	77.1	86.3	75.2	81.9	83.7	85.1	85.9	83.9	83	79.9	83.3
VSSUT	NC	14.9	12.6	13.1	13	14	13.6	12.1	11.2	12.8	11	12.7	10.5
	NEI	1.29	1.39	1.46	1.41	1.40	1.39	1.45	1.51	1.45	1.40	1.43	1.526
	L_{np}	79.7	82.4	86.5	83.8	84.1	83.3	84.8	86.9	84	81.4	84.2	86.8
	TNI	87.8	80.8	84.4	81.1	86.2	84	80.4	81	77.6	74.1	82.2	80.4
Kirba Chak	NC	12	13.2	14.6	15.1	12	13.3	13.5	12.9	13	15.9	13.8	13
	NEI	1.01	1.1	1.13	1.15	1.14	1.1	1.07	1.1	1.1	1.05	1.07	1.09
	L_{np}	78.2	84.7	88.2	89.2	86.1	84.7	82.9	84.5	84.7	84.7	83.4	83.8
	TNI	78.1	83.7	88.7	92.2	80.9	84.1	83.7	82.8	82.9	92.5	85	80.9
Prof Colony Chak	NC	11.5	14	12.8	12.7	14	15.4	14.5	12.8	13.1	12.7	14	14.9
	NEI	1.35	1.38	1.42	1.45	1.42	1.47	1.42	1.41	1.42	1.44	1.42	1.42
	L_{np}	79.1	83.0	84.1	85.5	85.3	89.1	85.7	83.6	84.3	84.9	85.4	86.1
	TNI	77.6	85.1	82.3	82.2	85.9	90.8	87.7	80.3	82.7	82.4	85.9	88.8
PG Chak	NC	16	14.5	8.9	15	12.2	12.7	12.8	12.8	12.7	13.7	15	13.2
	NEI	1.23	1.25	1.40	1.33	1.32	1.35	1.35	1.29	1.29	1.27	1.28	1.29
	L_{np}	84.1	83.7	85.8	88.1	84.6	86.8	86.9	84	83.4	83.8	85.3	84.4
	TNI	91.8	86.6	76.5	89.8	80.7	83.7	84.3	82.3	79.9	83.2	88.1	83.7
VIMSAR	NC	16.8	15.3	12.3	14.3	13.9	12.3	15.4	13	14.4	13.7	12.3	13.5
	NEI	1.35	1.43	1.44	1.46	1.46	1.44	1.43	1.42	1.39	1.40	1.45	1.44
	L_{np}	84.6	87.2	84.4	87.6	87.0	84.7	87.0	84.2	84.0	83.8	84.6	85.8
	TNI	93.6	91.2	80.8	87.4	85.6	81	91.4	84.6	86.4	83.2	81	85.1
Petrol Pump Chak	NC	13.8	14	10.6	10.3	11	12.1	10.9	10.9	12	11.6	11.9	12.5
	NEI	1.08	1.14	1.19	1.18	1.2	1.2	1.19	1.19	1.19	1.16	1.19	1.21
	L_{np}	84.0	88.3	87.9	86.7	89.2	90.3	88.8	88.0	89.3	86.8	89.5	90.6
	TNI	83.3	87.2	81.2	79.1	83.3	87.3	82.7	81.9	85.3	82	85.5	88.7
Planetarium	NC	15.8	16	16	16	16.8	15.5	15.8	11.8	13.9	15.9	16.7	12.8
	NEI	1.32	1.38	1.37	1.38	1.39	1.38	1.38	1.38	1.39	1.39	1.38	1.35
	L_{np}	81.9	85.1	94.8	85.1	86.3	84.7	85	81.1	83.4	85.5	85.9	80.6
	TNI	85.5	88.2	87.8	88.8	91.8	88.1	89.5	74.3	82.5	89.7	92.4	78.5
Sambalpur University	NC	14.2	14.5	14	18.3	17.9	15	16.7	16.6	15.7	16.2	15.9	16
	NEI	1.24	1.29	1.32	1.37	1.38	1.34	1.36	1.34	1.36	1.42	1.36	1.4
	L_{np}	76.3	79.0	82.0	86.6	87.1	84.0	84.7	82.9	84.7	87.6	84.9	88.0
	TNI	75.7	79.2	80.1	95.1	94.9	84.1	89.8	88.7	87.2	90.3	86.8	90.1

Table 6: Noise pollution indices during evening-night time

Locations and Noise Descriptors		6-7 pm	7-8 pm	8-9 pm	9-10 pm	10-11 pm	11-12 midnight	12-1 am	1-2 am	2-3 am	3-4 am	4-5 am	5-6 am
PC Bridge Chak	NC	13.3	13.5	12.2	14	16	15	17	18	20.2	20.1	16.4	15.4
	NEI	1.16	1.14	1.14	1.13	1.32	1.31	1.21	1.26	1.24	1.23	1.24	1.24
	L_{np}	89.0	87.9	86.3	87.9	88.8	86.6	86.8	87.2	88.2	88.1	84.1	83.6
	TNI	86.3	86.8	82.4	86.1	93.1	91.4	95	103	113	113	98.7	94.7
VSSUT	NC	13.8	12.7	10.4	12.3	13.3	14	15.5	12.1	8.3	10.6	12.9	14.5
	NEI	1.44	1.49	1.48	1.47	1.55	1.46	1.38	1.07	0.9	0.96	1.14	1.38
	L_{np}	84.9	83	77.5	77.4	75.6	72.6	71	55.2	44.4	49	58.7	69.9
	TNI	85.7	78.4	74.5	80.8	89.3	69.5	61.9	56.1	55.3	50.3	65.1	65.2
Kirba Chak	NC	11.6	12.7	15.1	13	14.2	15.2	17.2	14	9.2	12	14.1	15.6
	NEI	1.01	1.08	1.05	1.02	1.17	1.09	1.06	0.8	0.65	0.72	0.84	1.06
	L_{np}	83.2	82.8	83.3	77.7	74.3	75.3	75.3	58.1	45.3	52.1	60.3	74
	TNI	80.8	76.7	92.2	82.1	80.9	79	84.9	69.1	41.4	55.3	70.5	88.6
Prof Colony Chak	NC	12.8	13	15.8	12.5	14.1	15.6	17	14.3	10.1	12.8	14.1	16.2
	NEI	1.43	1.45	1.37	1.3	1.39	1.32	1.29	1.0	0.78	0.9	1.12	1.26
	L_{np}	84.6	85.7	84.0	77.7	76.8	75.4	75.2	59.5	45.2	53.7	64.5	72.9
	TNI	87.6	82.1	91.3	79.6	73.5	79.7	82	71.3	43.5	59.3	74.5	88.9
PG Chak	NC	14.8	15.9	13.9	14.1	12	9.3	4.8	5.0	5.4	9.6	10.8	12.1
	NEI	1.28	1.30	1.28	1.22	1.40	1.33	1.29	1.07	0.83	0.92	1.57	1.32
	L_{np}	85.4	85.5	84.7	81.2	77.2	69.1	64.2	53.2	43.1	51.4	62.9	71.3
	TNI	88.3	92.8	85.8	90.6	67.1	55.3	32.2	36.1	26.7	47.5	63.3	75.6
VIMSAR	NC	12.7	14.5	15.8	15.5	16.4	18.1	21.1	14.7	7.3	10.8	12.6	13.9
	NEI	1.42	1.39	1.36	1.34	1.63	1.61	1.59	1.25	0.9	1.07	1.28	1.49
	L_{np}	83.9	84.1	84	82.6	81.6	82.5	84.8	64.2	43.5	53.7	64	73.6
	TNI	82	86.6	91.1	89.6	85.7	92.6	98.2	76.9	34.1	53.3	69.6	81.7
Petrol Pump Chak	NC	13.1	13.1	11.9	8	12	14	20.4	12	4.9	10	12	13.2
	NEI	1.2	1.2	1.2	1.03	1.18	1.03	1.13	0.91	0.70	0.82	0.99	1.06
	L_{np}	91.6	91.7	89.1	83.2	80.8	80.9	82.8	63.6	41.1	56.4	66.6	71.6
	TNI	91.4	91.6	84.8	67.1	103	101	111	67.1	26.4	53.1	70.1	79
Planetarium	NC	13.1	12.7	12	12.5	11.6	11.2	10.3	8.3	5.7	10.4	12.1	14.2
	NEI	1.25	1.24	1.19	1.17	1.38	1.32	1.32	0.98	0.84	0.86	1.14	1.26
	L_{np}	82.0	80.9	77.9	77.0	73.8	70.6	70.1	52.5	43.2	49.3	63.3	71
	TNI	81.7	78.9	73.3	72	89.3	87.5	98.2	29.1	25.1	47.9	68.5	80.9
Sambalpur University	NC	12	15.8	14	15.2	10.6	9.2	5.8	5.6	6.1	9.3	12.1	14.3
	NEI	1.34	1.33	1.3	1.26	1.53	1.45	1.02	1.09	0.87	0.96	1.28	1.45
	L_{np}	79	82.6	79	78.2	71.9	67.4	44.7	49.5	41	47.8	63.4	72.5
	TNI	86.9	86.3	79.1	80.5	85.1	76.8	24	34.5	26.7	43.3	68.6	82.4

$$L_{eq} = 10Log_{10}\left(\frac{1}{T}\sum 10^{(0.1)L_i T_I}\right) \quad (5)$$

where, T is 16, 8 and 24 for working hour, night hour and whole day respectively. The working hour includes day time and evening time, i.e., from 6 am to 10 pm. L_i is equivalent noise level of time of recording and T_i is time of recording. The equivalent noise level for working hours, night hours and day & night hours of whole day (Ldn) are mentioned in Tab. 7.

Table 7: Equivalent noise level (during working hours, night hours and whole day-night)

Name of the Locations	L_{eq} (Working hours) (6 am-10 pm)	L_{eq} (Night hours) (10 pm-6 am)	L_{dn} (day-night) (6 am-6 am)
PC Bridge	74.4	69.8	72.9
VSSUT	71.3	55.2	70.1
Kirba	71	57.5	69.5
Prof Colony	70.7	56	69.5
PG Chak	71.6	57	70.3
VIMSAR	70.8	59.7	69.7
Petrol Pump	76.7	57	75.4
Planetarium	68.17	55.6	67.0
Sambalpur University	67.4	55.1	65.9

Taking the above data, noise contour maps were drawn (using simulation) to visualize the equivalent noise level at the traffic (and traffic surrounding areas) during working hours and night hours separately. These are shown in Figs. 8 and 9 respectively. The noise level at surrounding area shows the spreading of noise if there are no obstacles.

After mapping and analyzing, it is observed that the noise level at Petrol Pump Chak and PC Bridge Chak (during working hours) is more compared to other areas of the town. At petrol pump, noise level is high because of its proximity to Bus stand and commercial market. At PC bridge chak, noise level is high because of heavy traffic in National Highway (NH-6). At the other locations, the noise level is less than these two locations due to lesser traffic.

Similarly during night hours, the noise level at PC Bridge chak is more among all places due to heavy traffic in National Highway. Also, its traffic volume is almost constant in night hours. The noise level is low at VSSUT, Prof Colony Chak, Planetarium and Sambalpur University respectively. Noise level is little higher at VIMSAR is due to its vulnerability to emergency ambulances and other vehicles.

4.4 In situ Study on Noise Annoyance by Population Exposed

Present status of annoyance due to traffic noise was analyzed. This survey shows that about 34% of people suffer from irritation, 26.2 % of people suffer from sleeplessness and 22% of people having low work performance, those who have been exposed to traffic noise more than 6 hours/day. Regression equations were established linking noise indices with highly annoyed population with higher correlation values. Tab. 8 shows the social wellbeing of the participants of all nine locations. The floating

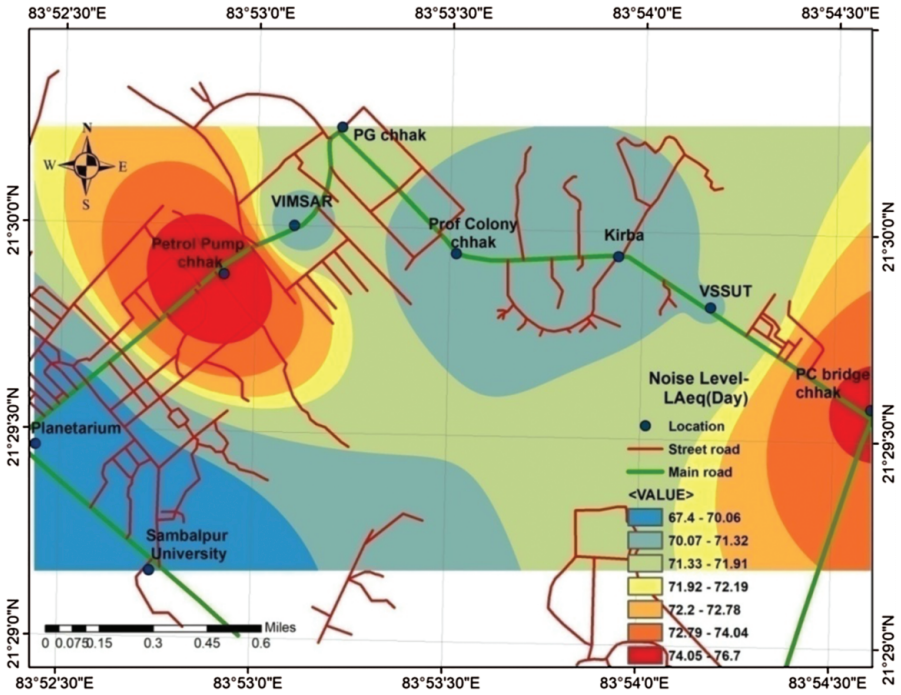

Figure 8: Noise mapping of the town (during working hours)

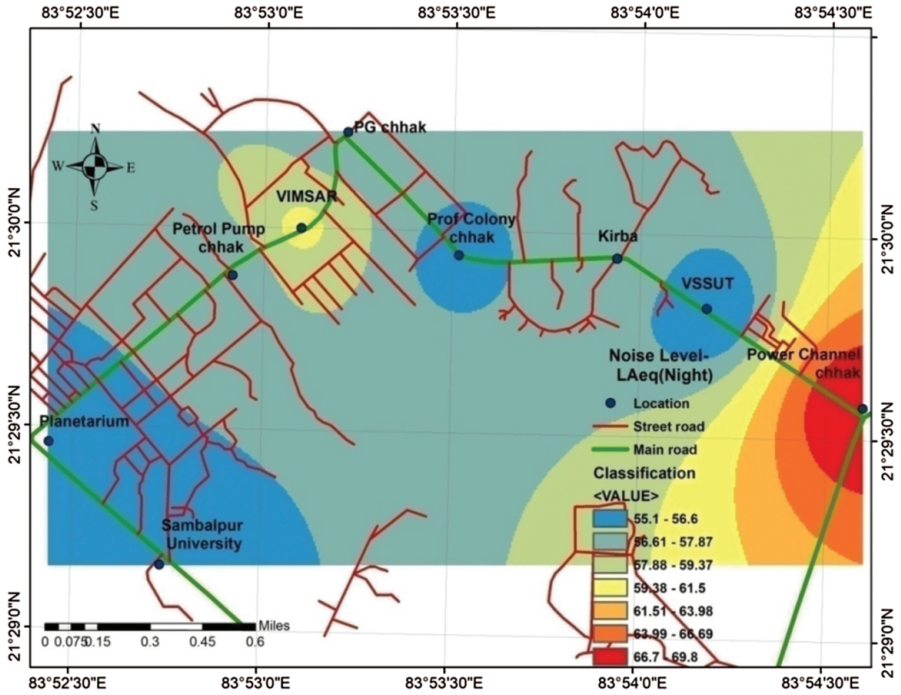

Figure 9: Noise mapping of the town (during night hours)

Table 8: Social survey of participants at different locations

Aspects of Participants		Participants at different Locations								
		1 PCB	2 VSS	3 Kirba	4 P.Col	5 PGC	6 VIMS	7 PP	8 Planet	9 SU
Gender	Male	75	75	69	55	69	52	70	60	66
	Female	18	20	22	16	25	14	23	24	19
Profession	Service	20	45	6	10	4	12	11	15	45
	Businessmen	40	20	50	31	51	28	65	40	20
	Students	12	16	20	10	19	6	7	10	10
	Others	21	14	15	20	20	20	10	19	10
Period of stay	3-5 years	15	10	10	11	10	11	17	13	12
	5-10 years	32	30	35	20	39	15	20	39	25
	≥10 years	46	55	46	40	45	40	56	32	48
L_{dn} (in dB)		72.9	70.1	69.5	69.5	70.3	69.7	75.4	67.0	65.9
Max. Lnp (in dB)		89	86.9	89.6	86.6	88.9	87.6	90.3	86.3	88
% of highly annoyed people		36.8	28.4	33	31	34	30.3	41	29.7	29.2

populations were excluded from purview of our study. Residents of more than three years in the town were taken into consideration. The reasons other than traffic noise related were excluded from study. The data well speaks for the population of the town.

Statistical analysis was carried out with percentage of highly annoyed persons to noise pollution level at all locations, which is shown in Fig. 10. Similarly, Fig. 11 shows the percentage of highly annoyed persons *vs*. equivalent noise level (day- night).

Figure 10 shows that when Lnp increases, the percentage of annoyed person increases. Similarly, Fig. 11 shows when Ldn increases, the percentage of annoyed person increases. The coefficients of correlation (R)

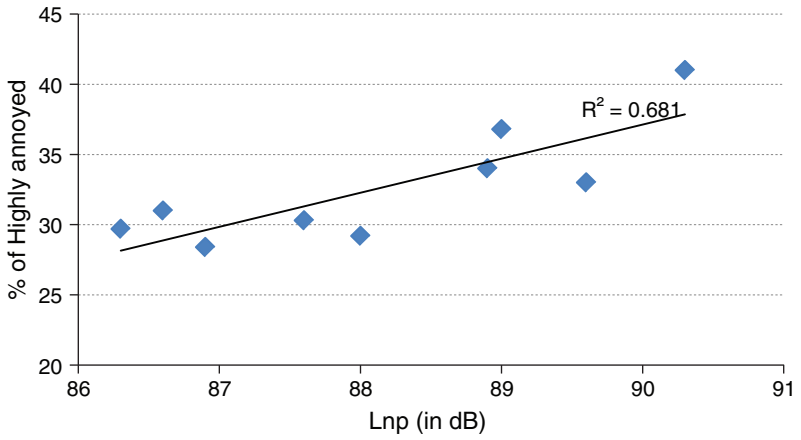

Figure 10: Maximum Lnp *vs*. percentage of highly annoyed people at different locations

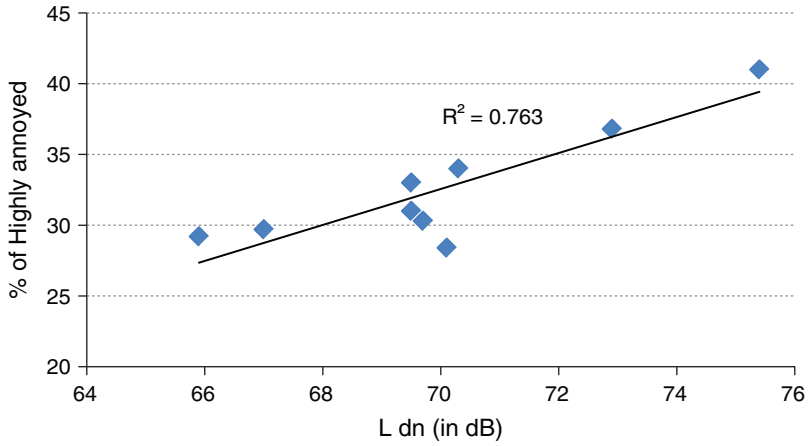

Figure 11: L_{dn} *vs*. percentage of highly annoyed people at different locations

for both cases are 0.82 and 0.87 respectively. This is an indicator of auditory health of persons of the same area is affected in environmental domain. Also, these statistical results show that at 5% confidence level, the t-statistical values (i.e., 4.30 and 5.82 respectively) are higher than the t-critical (i.e., 2.575). This implies that the correlations are very significant.

It is also found that the number of hearing impaired patient has been increased to 30,000 in the year 2018, whereas it was 16,000 in the year 2009 (as per data collected from local hospitals and VIMSAR). Expert doctors in the concern hospitals give views that the number of hearing impaired patients due to exposure of high noise is increasing. Excessive noise exposure can lead to a loss of hearing sensitivity, termed a threshold shift.

Researchers in any sphere has a duty to find a path to sustainability. The authors wish to be at service for certain suggestions to local government on mitigation of this threat. These are:

a) Road side plantation of trees,especially more numbers in residential colonies.
b) Vehicles having high noise level should be restricted or diverted.
c) Improvement and proper maintenance of road conditions which will smoothen the flow of traffic.
d) Battery auto-rickshaws should be encouraged to replace diesel auot-rickshaw. As diesel auto-ricshaw generate noise level of 100 dB, where battery auto-rishaw is of 80 dB.
e) Unorganised commercial activities should be discouraged in adjacent to residential colonies.
f) Periodic noise monitoring on the roads.
g) Awareness programmes should be conducted by local administration.
h) At few locations (like education/ silence zone) should be restrict as no horn zone.

5 Summary

The urban traffic noise is an alarming issue not only in India but also in all countries of the world. The approach to deal with this menace is definitely varying from one country to another. The present study revealed that the traffic noise level reached an alarming level in Burla town. The noise level at most of the traffic places are exceedings the national standard. During day time, at all locations, the value of NEI is more than one, which is not desirable and some cases quite objectionable. Higher Lnp indicates high fluctuation of sound level for a given time period, which causes of annoyance. As the Lnp increases, the percentages of annoyed people increases. The numbers and percentages of annoyed people's increase as

the equivalent noise level for day-night (Ldn) increase. High traffic noise not only gives the annoyance, it also decreases the work performanes of the affected people.

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