Advances in Environmental Technology 2 (2022) 145-157

Iranian Reasearch Organization for Science and Technology (IROST)

Advances in Environmental Technology

Journal home page: https://aet.irost.ir/

Vehicular noise pollution and its environmental impact in Berhampur, India

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ARTICLE INFO

Document Type:
Research Paper

Article history:
Received 13 February 2022
Received in revised form
10 July2022
Accepted 12 July 2022

Keywords:
Traffic noise
Noise pollution level
Noise exposure index
Annoyance
Wellness

ABSTRACT

Increased urbanization, industrialization, transportation, and infrastructural development in cities have resulted in an increase in noise level at an alarming rate. Traffic noise is one of the major sources of environmental noise pollution in urban areas. It reduces the wellbeing elements for the urban population. Exposure to excessive noise reduces the overall psychological and physiological wellbeing. The psychological physiological impacts are sleep disturbance, annoyance, irritation, headache, loss of concentration, sleeplessness, low work performance, hearing disability, impaired cognitive ability, hypertension, and much more. In this experimental study, the assessments and analysis of traffic noise in Berhampur, India, have been done. Its impact on socio-health has been studied. The key locations covering the entire city were chosen for traffic noise assessment. Also, the wellness and health of the affected people have been studied and statistical validation has been made. The study reveals that traffic noise levels and its effects are at an alarming state in the city.

1. Introduction

Noise is unwanted and undesirable sound discharged by various means into the atmosphere. When the noise level exceeds a certain limit, it has an adverse impact on the ecology and is treated as noise pollution. Although there are various sources of noise, traffic noise has a bigger share of noise pollution in urban areas. The higher population density, good transport facilities, and increasing numbers of vehicles in urban areas enhance the noise level. That causes the noise pollution and affects the normal life of the inhabitants. Noise pollution affects urban people on a daily basis. The most common health problem it causes is Noise Induced Hearing Loss (NIHL). Exposure to loud noise can also cause high blood pressure, heart disease, sleep disturbances, and stress. These health problems can affect all age groups, especially children. Animals use sound for a variety of reasons, including navigating, finding food, attracting mates, and avoiding predators. Noise pollution makes it difficult for them to accomplish these tasks, which affects their ability to survive in urban areas. Berhampur is the biggest city in the southern part of Odisha state, India. It is southern Odisha's administrative, business, and educational center. Berhampur city is well connected to

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DOI:10.22104/AET.2022.5425.1466

Odisha's other cities and the neighboring state. The national highways (NH 16, NH 59, NH 516) and other state highways pass through it to connect almost all other cities and towns of the state. The effective literacy rate of the city is more than 90 %. The city is free from industrial pollution, as no process industries are inside or nearby. It is included in the smart city mission of India. The smart city mission expects a population of 0.6 million. Due to peoples' migration from rural to urban areas for a better livelihood and educational purposes for their children, there is a growing demand to accommodate more and more people. Due to its increasing population, the traffic volume has increased proportionately.

Increases in urbanization, industrialization, transportation, and infrastructural development in cities have resulted in an increase in noise levels tan alarming rate. In cities, traffic noise represents a significant share of environmental noise. It has an unsought physiological and psychological impact on exposed people [1-4].The adverse effects of traffic noise on humans include annoyances, insomnia, low performance, impaired cognitive ability, hearing disability, etc. [5-9]. Also, the detrimental effects of hypertension and cardiovascular disease occur in some cases due to traffic noise [10-12]. The statistics [13] show that 100 million people in the United States are being disturbed by noise. In the United Kingdom, 3/4 of the residents living in big cities (i.e., London and Liverpool) are seriously impacted by noise; in Stockholm, Sweden, where it is usually considered a quiet city, 70% of people are disturbed by noise. Among them, a major part of noise originates from urban traffic. Chowdhury et al. [14] found that the noise level remains far above the acceptable limit all of the time in Dhaka (Bangladesh), with the highest population density. Also, they mentioned that exposure to high noise might cause severe stress on the auditory and nervous systems of city residents. A USA health review found that traffic noise is one of the reasons for the increase in blood pressure and sleep disturbances [15].Park T et al. [16]reported that traffic noise was the reason for adverse health effects (like annoyance and sleep disturbance) on the people in Gwangju (Korea).In another study in Brazil, it was observed that20% of the people suffered from headaches and sleeplessness due to traffic noise [17]. In the Netherlands, it has been observed that annoyance is highly correlated with the traffic noise level and noise indices like equivalent noise level for the whole day [18]. In Jeddah (Saudi Arab), Sharkawy, and Aboukhashaba[19], there is a strong correlation between resident wellness and the traffic noise level. In a health survey in Jaipur (India), it was observed that about 52% of the people suffered irritation, 46% felt hypertension, and 48.6% experienced sleep loss due to noise pollution [20].In another study in Calcutta (India), it was observed that 30% of the people were highly annoyed due to traffic noise [21]. In New Delhi (India),it was reported [22] that the tremendous increase in population, unchecked growth in vehicular traffic, and rapidly changing lifestyle were the major reasons for noise pollution. The major health implications are annoyance, sleep disturbance, and other harmful effects. Karthik and Partheeban[23] reported that the value of equivalent noise level (Leq) ranges from 60 to 87 dBA in Chennai (India), which was far above the prescribed limit. Kalawapudi et al. [24] reported that Mumbai (India) is greatly affected by noise pollution, and it is an emerging environmental threat to its inhabitants. Although Berhampur is a growing city and is on the smart city mission list, the effects of traffic noise on its inhabitants have not been investigated yet. In this present work, the assessment and analysis of traffic noise and its effect on its residents have been studied.

2. Materials and methods

2.1. Study locations

Eleven important locations in Berhampur were considered for assessing the noise level. These locations were chosen per specific categories:(i) the residential areas of Lanjipalli, Tulsi Nagar, and Kamapali,(ii) the silence areas of MAV School, MKCG Hospital, and K K College, and (iii) Annapurna Market, Tata Benz, Gate Bazar, Court peta, and New Bus Stand are as commercial area. All the locations are shown in Figure 1. The classifications of locations and recommended noise level by national standards India) [25] are shown in Table 1.

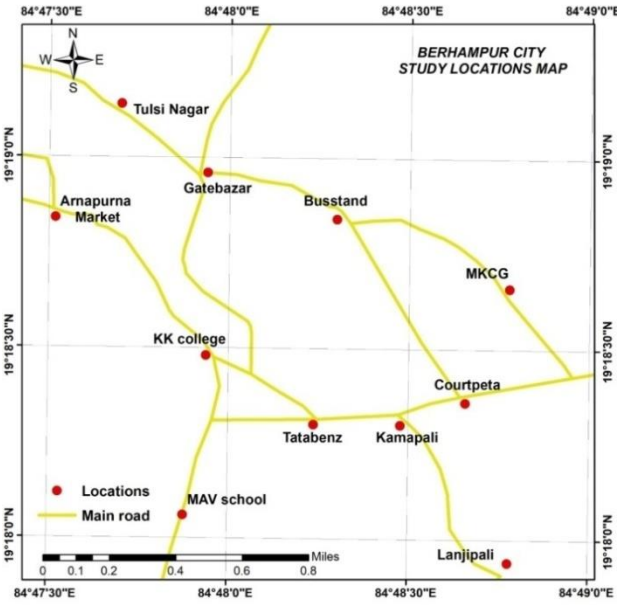

Fig. 1. Road network and important traffic locations of Berhampur city.

2.2. Instrumentation and methodology

The sound level meter (SLM) -cum- analyzer (B and K make) was used for taking the observations. The dynamic range of SLMis up to 140 dB and with a 16-bit recording system. The calibration was done before taking the readings. Noise levels (L_{10}, L_{50}, L_{90}, Leq) were measured on an A-weighing scale. Observations were taken at a 2.5 meter distance from the road curb and 1.2 meter height from the level of the road. The measurements of traffic noise levels were made at eleven different locations. The observations were taken from January-March 2019. The hourly readings were taken on working days. A complete day was divided into three different times; daytime(6 am-6 pm), evening (6 pm-10 pm), and nighttime(10 pm- 6 am). Along with the noise level measurement, the residents' wellness was also studied. The annoyance, low work performance, and sleeplessness were considered as wellness factors. The opinions/data collected from the participants were further processed for statistical analysis and validation. The values of L_{10}, L_{50}, and L_{90} were assessed from the experiment. These were used for evaluating noise climate (NC), noise exposure index (NEI), and noise pollution level (Lnp). The following equations were used to evaluate the above indices.

$$\text{Noise pollution level } (L_{NP}) = L_{eq} + NC \quad (1)$$

$$\text{Noise climate, } (NC) = L_{10} - L_{90} \quad (2)$$

$$\text{Noise exposure index (NEI)} = \frac{l_1}{L_1} \quad (3)$$

where $l_1$is the actual sound level and L_1 is the permissible sound level as per the guideline of the given country, andLeq (or equivalent continuous noise level) is the logarithmic average of the discrete-instantaneous noise level for a given time period. The equivalent noise level (Leq) for the daytime (or day hours), evening (or evening hours), and nighttime (night hours) are calculated by using the following formula [26]:

$$L_{eq} = 10\text{Log}_{10}\left(\frac{1}{T}\sum 10^{(0.1)L_i T_I}\right) \quad (4)$$

where L is the equivalent noise in the hour T_i and T is the time in hours of the computation period;L_{10}, L_{50}, and L_{90} are the noise levels exceeding 10 %, 50 %, and 90 % of the total time of measurement, respectively; and Leq is the equivalent continuous noise level. A socio-health analysis was carried out in the city. The status of wellness due to traffic noise was assessed and studied through a questionnaire and personal interviews. People of different gender, professions, age groups, and income groups participated in the survey. A total 2040 people participated; out of this group, 1320 were assessed through interviews, and 720withquestionnaires.

Table 1. Locations and the respective zones.

SN	Locations and corresponding zone	Features /areas	National Standards (Leq)	
			Working time (6 am-10 pm)	Nighttime (10 pm-06 am)
1	K K College, MAV School, MKCG Hospital-cum-college	Silent	50 dB	40 dB
2	Lanjipalli, Tulsi Nagar, Kamapalli	Residential	55 dB	45 dB
3	Annapurna Market, Gate Bazar, Courtpeta, Tata Benz, NBus Stand	Commercial	65 dB	55 dB

3. Results and discussion

The results and discussion of the present study consist of the following parts:

i. Assessment of hourly Leq.
ii. Evaluation of noise pollution indices.
iii. Evaluation of equivalent noise level of the city for different timings.
iv. Socio-health analysis.

3.1. Assessment of hourly Leq

The hourly Leq at different locations are presented in Table 2 (6 am- 6 pm) and Table 3 (6 pm- 6 am). The time vs. corresponding Leq plots for each location are drawn and mentioned in Figures 2 to 7.

Table 2. Hourly Leq at different locations during day hour.

Locations	Leq (in dB)											
	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
Tulsi Nagar	63.2	69.7	70.5	73.5	74.8	74.1	73.7	73.4	72.6	70.1	72.8	72.7
Kamapalli	69.1	72.5	74.9	76.1	75.9	75.1	74.9	74.6	74.1	73.9	74.4	76.6
Lanjipalli	68.2	70.3	72.0	72.3	73.1	72.2	71.1	70.2	69.8	69.4	72.1	72.2
MKCG Hospital	63.1	70.2	72.5	72.6	73.1	72.1	72.2	72.7	70.1	70.1	72.8	71.5
K K College	67.1	71.2	72.6	74.3	75.2	75.1	74.1	74.5	72.9	72.6	74.7	75.5
MAV School	65.2	71.5	72.5	72.7	72.6	71.2	72	72.7	70.2	70.3	72.7	72.5
A market	64.1	69.4	70.1	76.1	77.7	75.5	73.7	72.6	72.3	73.2	74.6	75
G Bazar	68.9	75.1	75.8	77.1	77.9	77.1	76.2	75.5	73.3	73.6	76.5	77.1
T Benz	67.8	71.2	72.8	75.3	76.1	74.1	73.8	73.3	72.1	72.4	74.2	74.5
Courtpeta	70.5	74.3	75.3	77.5	77.9	76.5	75.1	75.5	74.1	73.2	74.6	76.1
N Bus Stand	71.1	74.1	75.8	76.5	78.3	76.7	75.3	75.6	72.3	74.4	76.3	74.5

Table 3. Hourly Leq at different locations during evening-night hour.

Locations	Leq (in dB)											
	6-7 pm	7-8 pm	8-9 pm	9-10 pm	10-11 pm	11-12 midn	12-1 am	1-2 am	2-3 am	3-4 am	4-5 am	5-6 am
TulsiNagar	73.1	72.1	72	66.3	63.6	58	46	44	42.8	40.2	47.5	54
Kamapalli	74.5	73.8	73.6	71.3	68	66	63	49	44.2	44.8	49.7	54.1
Lanjipalli	71.5	71.6	70	68.3	64.7	59	58.7	45.7	42	43	44	55.9
MKCGHospital	70.7	72.2	71	69.7	66	64.4	61.3	48.3	39.8	39.9	44.5	59.8
K K College	70.2	72.3	73.5	72	63	58.6	56.1	44.3	38	39	45	55
MAVSchool	70	70.1	69.9	69.2	62	59	53	44	38	39	42	52
Amarket	75.5	76	74.8	73	70	62	55.1	48	44.9	44.5	48	54.2
GBazar	76.6	75.8	74.9	73.3	70.1	64	61	49	48	49	52	58
T Benz	74.8	75.5	73.8	71.4	68.7	64.2	61	48.5	45.2	48.2	49.4	55.5
Courtpeta	74.1	77.3	76	71.3	67.5	63.5	61.2	50.6	48.2	49.8	52.2	58
N Bus Stand	73.9	74	72.4	70	66	62	51	48	47	46	55	60

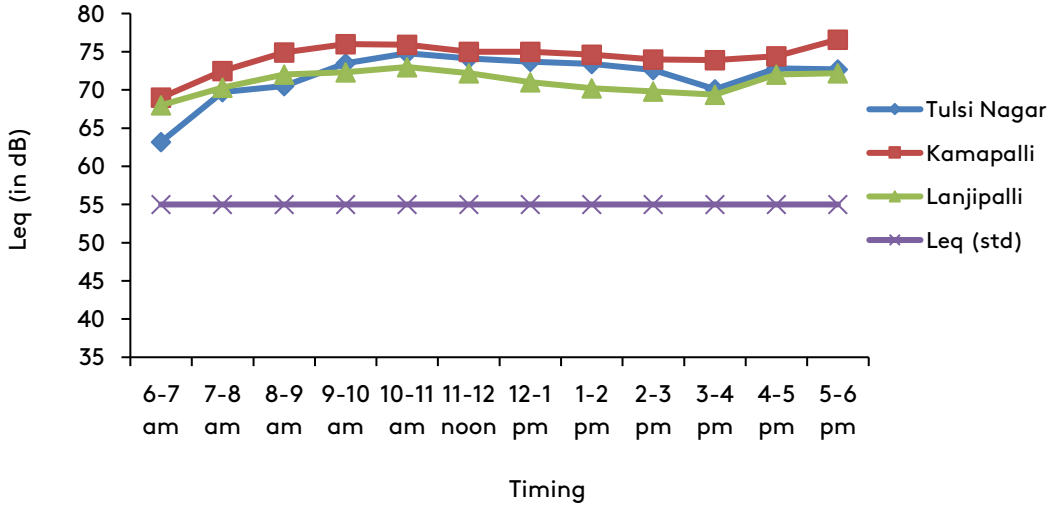

Fig. 2. Hourly Leq at the locations (of residential zone) during the day-time.

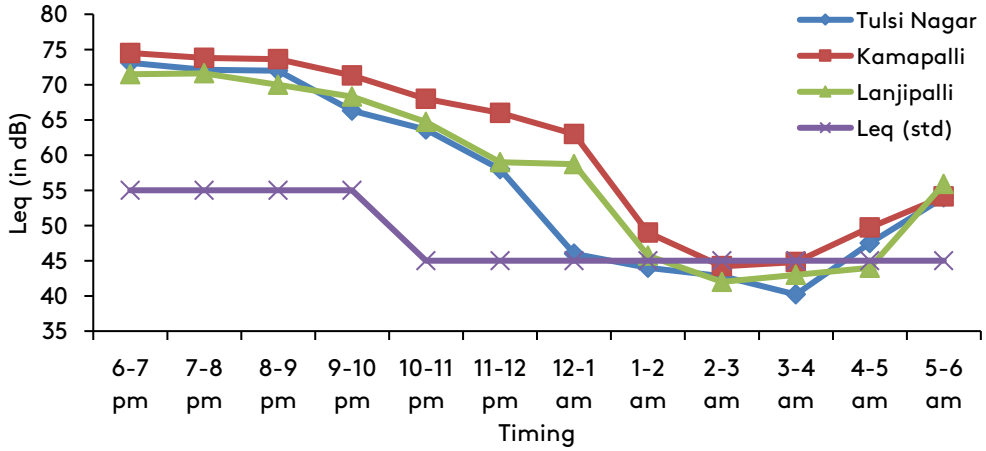

Fig.3. Hourly Leq at locations (of residential zone) during evening-nighttime.

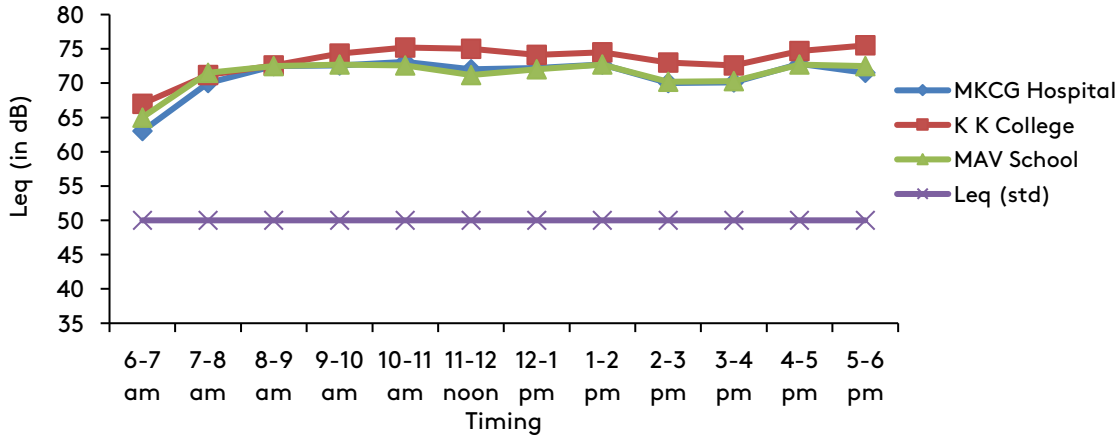

Fig.4. Hourly Leq at locations (of silent zone) during the daytime.

Figures 2 and 3 show that during the daytime, the noise levels at each location exceeds the prescribed level. It is observed that people residing near the road in these areas are irritated and distracted because of traffic noise. During the nighttime, the noise level is below the prescribed level for some hours, which is a good sign for the local residents.

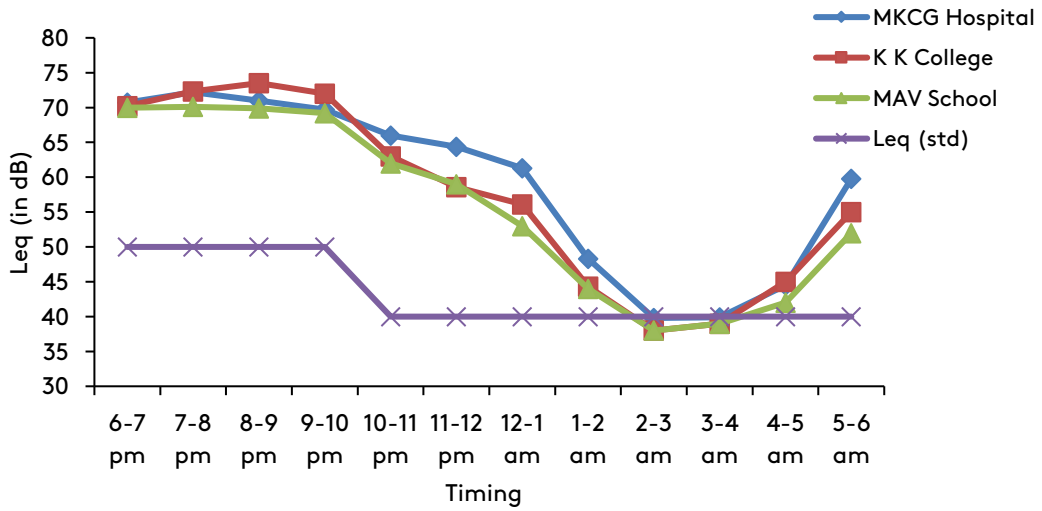

Fig.5. Hourly Leq at locations (of silence zone) during evening-nighttime.

Figures 4 and 5 show that during the daytime, the noise level at each location exceeds the prescribed level. The noise level is below the prescribed limit for a few hours during the night time. At MKCG medical-cum-hospital, the noise level is more than the prescribed level most of the time. That shows a nun healthy indication for the patients and inhabitants.

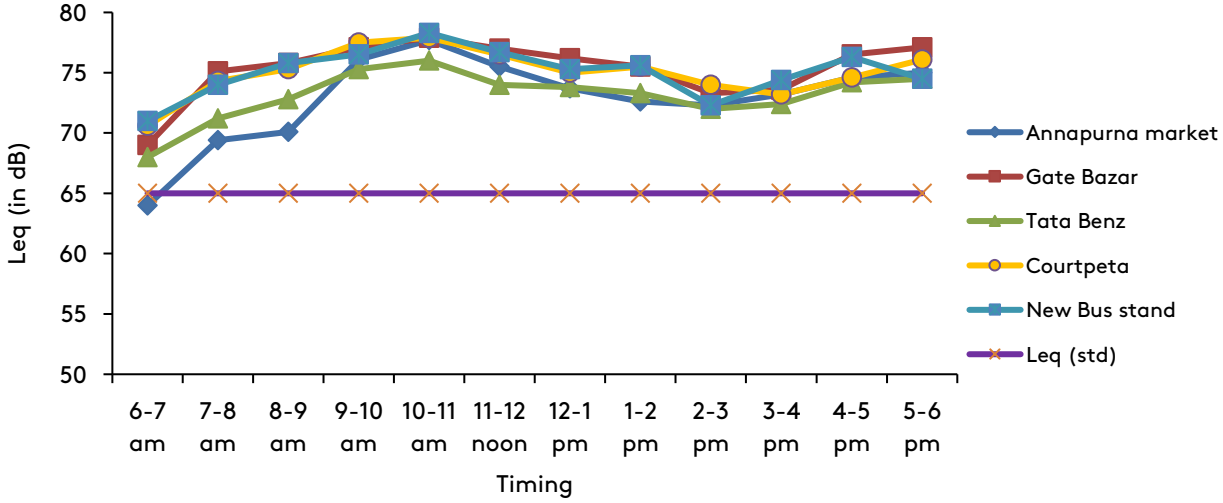

Fig.6. Hourly Leqat locations (of commercial zone) during the daytime.

Figures 6 and 7 show that during the day hours, the noise level at each location exceeds the prescribed level. The New Bus Stand, Courtpeta, and Gate Bazaar are high noisy places. At all these locations, the noise level is below the prescribed level for a few hours during the nighttime. At all the sampling location, the noise levels are above the national standard during the day time. The highest noise level is 78.3 dBat the New Bus Stand between 10-11 am. Similarly, the maximum noise level at Courtpeta and Gate Bazar is 77.9 dB during the same time. During the night hours, the MAV School and KK College area are quiet places. The minimum noise level is 38 dB from 2-3 am.

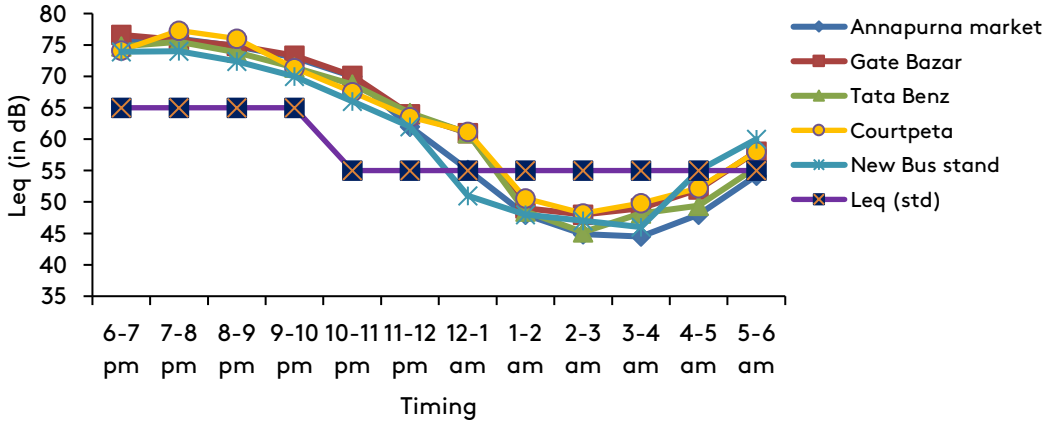

Fig. 7. Hourly Leq at locations (of commercial zone) during evening-nighttime.

3.2. Evaluation of noise pollution indices

The L_{10}, L_{50}, and L_{90}values were obtained from the observations. These were used to evaluate the noise pollution indices like the hourly NEI and Lnp at different locations. These are shown in Tables 4 and 5.

Table 4. Hourly NEI and Lnp during day hours.

Locations and noise indices		6-7 am	7-8 am	8-9 am	9-10 am	10-11 am	11-12 am	12-1 pm	1-2 pm	2-3 pm	3-4 pm	4-5 pm	5-6 pm
Tulsi Nagar	NEI	1.14	1.26	1.28	1.33	1.36	1.34	1.34	1.34	1.32	1.27	1.32	1.32
	L_{np}	87	84.8	85.5	87	87.3	87.5	88.2	88.2	86.3	81.3	83.4	86.5
Anna P Market	NEI	0.98	1.07	1.08	1.17	1.19	1.16	1.13	1.12	1.11	1.13	1.15	1.15
	Lnp	81.5	83.4	84.1	86.7	89.5	86.9	88.2	84	85.3	87.1	89.2	86.8
Gate Bazar	NEI	1.06	1.16	1.16	1.19	1.20	1.18	1.17	1.16	1.13	1.13	1.17	1.19
	Lnp	82.1	89.5	89.8	87.9	90.6	88.2	86.8	86.9	86.5	88.2	86.7	89.2
Tata benz	NEI	1.05	1.10	1.12	1.16	1.17	1.14	1.14	1.13	1.11	1.11	1.14	1.15
	Lnp	79.8	84.2	84	86.8	87.2	86.7	89.1	90.2	85.6	87.3	86.1	89.2
MKCG Hosp	NEI	1.26	1.4	1.45	1.45	1.46	1.44	1.44	1.45	1.4	1.4	1.46	1.43
	Lnp	88.1	85.3	85.4	86.2	87.6	85.8	86.7	87.4	86.7	88.2	88.4	86.1
Kama palli	NEI	1.25	1.31	1.36	1.38	1.38	1.36	1.36	1.35	1.34	1.34	1.35	1.39
	Lnp	83.8	82.8	86.2	90.2	88.6	89.2	89.6	89.2	88.3	89.2	89.2	87.3
Lanji palli	NEI	1.23	1.28	1.31	1.31	1.33	1.31	1.29	1.28	1.30	1.26	1.31	1.31
	Lnp	88.9	85.6	79.4	83.6	87.3	87.9	84.6	81.3	87.2	83.8	84.6	85.8
Court peta	NEI	1.09	1.14	1.16	1.19	1.20	1.18	1.15	1.16	1.14	1.13	1.15	1.17
	Lnp	75.3	87.9	89.0	77.9	79.8	76.4	87.8	85.7	87.2	86.7	89.2	78.2
K K College	NEI	1.34	1.42	1.45	1.47	1.50	1.5	1.48	1.49	1.46	1.45	1.49	1.51
	Lnp	83.7	84.2	84.6	88.5	86.9	87.3	87.4	88.3	85.2	83.1	86.4	89.4
New Bus stand	NEI	1.09	1.14	1.16	1.18	1.20	1.18	1.16	1.16	1.11	1.14	1.18	1.15
	Lnp	82.4	90.8	76.4	76.8	78.2	78.6	77.8	79.5	84.3	86.1	77.3	76.2
MAV School	NEI	1.3	1.43	1.45	1.45	1.45	1.42	1.44	1.45	1.40	1.40	1.45	1.45
	Lnp	82.4	86.7	86.2	87.2	83.8	83.8	86.8	88.5	82.4	81.6	84	86.3

Table 5. HourlyL_{np} and NEI during evening and night hours.

Locations and noise indices		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
Tulsi Nagar	NEI	1.33	1.31	1.31	1.21	1.41	1.29	1.0	0.97	0.95	0.89	1.05	1.2
	L_{np}	88.1	81.9	83.2	86.8	79.2	64.2	59.5	53.7	54.7	53.7	74	76.8
Anna P Market	NEI	1.16	1.17	1.15	1.12	1.27	1.12	1.0	0.87	0.81	0.81	0.87	0.98
	Lnp	91.6	89.2	87.4	81.2	76.4	72.1	60.5	54.3	50.7	53.7	64.8	75.8
Gate Bazar	NEI	1.18	1.16	1.15	1.13	1.27	1.16	1.1	0.89	0.87	0.89	0.94	1.05
	Lnp	80.8	89	83.6	82.7	78.3	71.4	67.2	54.6	52.8	54.3	58.9	68.4
Tata benz	NEI	1.15	1.16	1.14	1.1	1.25	1.17	1.1	0.88	0.82	0.87	0.9	1.0
	Lnp	85.7	88.8	89.6	82.3	78.4	73.2	68.2	56.7	51.8	52.7	58.7	65.3
MKCG Hosp	NEI	1.41	1.44	1.42	1.39	1.65	1.61	1.53	1.21	0.99	0.99	1.11	1.49
	Lnp	85.3	83.9	81.7	77.6	74.8	72.4	69.8	55.9	45.2	44.6	52.4	68.7
Kama palli	NEI	1.35	1.34	1.34	1.30	1.51	1.47	1.4	1.09	0.93	0.99	1.1	1.2
	Lnp	89.3	87.4	87.1	84.6	79.5	76	71	55	48.2	47.7	54.3	64.1
Lanji palli	NEI	1.3	1.31	1.27	1.24	1.43	1.31	1.3	1.01	0.93	0.95	0.97	1.24
	Lnp	86.4	85.8	84	81	75.3	68.3	65.2	50.3	46.4	47.8	49.5	65.8
Court peta	NEI	1.14	1.19	1.17	1.01	1.23	1.15	1.11	0.92	0.87	0.91	0.95	1.05
	Lnp	88.4	86.3	85.2	80	74.5	67.4	65.7	53.8	51.3	53.4	58.8	64.3
K K College	NEI	1.4	1.45	1.47	1.44	1.57	1.46	1.4	1.11	0.95	0.97	1.12	1.37
	Lnp	85.3	87.2	87.2	85	75.7	76.3	63.4	50.2	43.3	42.4	50.3	63.7
New Bus stand	NEI	1.14	1.14	1.11	1.08	1.2	1.12	0.93	0.87	0.85	0.83	1.0	1.09
	Lnp	87.2	87.2	85.2	82.3	76.3	70.2	58.2	53.2	51	49	63.6	69.2
MAV School	NEI	1.4	1.4	1.39	1.24	1.55	1.47	1.32	1.1	0.95	0.97	1.05	1.3
	Lnp	82.2	81.5	79	78.5	70	65.2	60.3	48	42.8	43.8	50.7	63.8

It is observed from Tables4 and 5 that during the day time hours, in all cases, the NEI exceeds 1, which is undesirable and quite unpleasant. These are the causes of physiological and psychological disturbances affecting human lives. Also, Lnp is high at all locations, which is the cause of irritation, nuisance, and displeasure. Even though the hourly noise levels at Courtpeta and Gate Bazaar were higher than at the MAV School and KK College, the NEI values were more at the MAV School and KK College. It happens because the MAV School and KK College belong to the silence area, and the prescribed noise level is less for such areas. The NEI value is the highest at KK College (1.5) during 10-11 am. The NEI value is minimum (0.81) at the Annapurna market during 2-4 am.

3.3. Evaluation of equivalent noise level of the city for different timings

Considering the hourly Leq, the equivalent noise levels at all locations during the daytime, evening, and nighttime were evaluated by using Equation 4. The equivalent noise levels (Leq) for daytime, evening, night time, and for a complete day (Ldn) were evaluated and are presented in Table 6. Here, for daytime, evening, and nighttime, T is taken as 12, 4, and 8, respectively. The Leq for the complete day (6 am-6 am) is considered as Ldn, and where T is 24. It is observed that Courtpeta is the noisiest place in the city during the day and evening hours. Gate Bazar is the second most noisy area in the city. These are the places where different roads meet from different places inside and outside of the city. These two places are the busiest and most

heavy vehicles pass through them. The analysis of the values of traffic noise indices (Leq, Lnp, and Ldn) at different locations in the city was performed. It could be concluded from the above results that most of the sampling locations were severely affected due to traffic noise. The respective noise levels are higher than the national standards. These findings are similar to traffic noise levels in other Indian cities like Kohlapur[1], Jaipur [20], Calcutta [21], Delhi [22], Chennai [23], and Mumbai [24], as well as foreign cities like Gwangju [16] and Jeddah [19]. The observation of different locations (of different areas) illustrates that the maximum noise level was observed in the commercial areas of Gate Bazaar and Courtpeta. The 'MAV School', a silence area, had the minimum noise level among all the sampling locations. The noise level at Lanjipali was minimum among the residential areas. Although 'Kamapali' belongs to the residential area, it also acts as a commercial area. Here, the noise level was high due to heavy traffic.

Table 6. Equivalent noise levelat different location for day hour, evening hour, and night hour.

Locations	Leq (day hour) 6am-6pm	Leq (evening hour) 6pm-10pm	Leq (nighthour) 10pm-6am.	Ldn(day-night) 6am-6am
Tulsi Nagar	72.5	71.5	57	71.4
Kamapalli	74.7	73.5	62	74.2
Lanjipalli	71.3	70.5	57.9	71.1
MKCG Hospital	71.7	71	60.9	71.9
KK College	73.8	72.7	56.4	72.6
MAV School	71.8	69.8	55.4	71
A Market	73.9	75	61.9	73.7
G Bazar	75.8	75.3	62.7	75.3
T Benz	73.5	74.1	61.7	73.6
Courtpeta	75.4	75.2	61.1	75
N Bus Stand	75.4	72.8	59.5	74.5

3.4. Socio-healthanalysis

A socio-health analysis on the effect of traffic noise was carried out. People of different ages, marital statuses, gender groups, income groups, professions, and education participated in the survey. The opinions of the people exposed for more than four hours/day to traffic noise and those residing 50 meters from the roads were taken into account for the analysis.

The following are two types of wellness studies of the exposed population conducted in the city.

(i) Attitude of the exposed people towards the traffic noise with respect to gender, marital status, age, etc.

(ii) Physiological and psychological wellbeing (i.e., annoyance, sleeplessness, and low work performance) of persons exposed to heavy traffic noise.

3.4.1. Attitude of the people towards traffic noise with respect to gender, marital status, age, etc.

The effect of traffic noise on peoples' health was studied and analyzed. The results are presented in Table 7. A statistical analysis of the health survey has been carried out. The larger part of the people (almost 52%) were highly disturbed (/annoyed) due to traffic noise. Similarly, 26 % reported having sleeplessness, 38% felt irritated; and28 % had low work performances because of exposure to traffic noise. The effect of traffic noise was found to be significantly affected by age, marital status, gender, and income. For example, 57 % of females were highly disturbed, whereas the percentage of maleswas48 %. Similarly, 60% of married persons were highly disturbed as compared to 44 % of those unmarried. Age was also a factor in the perceptiveness of disturbance. The study population was divided into four age groups:

children below 18 years, young 18-35 years, middle age 35-55 years, and elders above 55 years. The elder aged group was more sensitive to traffic noise compared to the young and middle age group. The percentages of annoyed people were57.2 %, 39.1 %, 51.8 %, and 63.6% for the children, young, middle age, and elder aged, respectively. A statistical analysis of the study population based on their income was also studied. The study population was divided into three groups according to their monthly income. These included the low-income group (monthly earnings of less than 15,000 rupees), middle income group (monthly earnings between 15,000-75,000 rupees), and high-income group (monthly earnings of more than 75,000 rupees). The analysis revealed that the high-income group was more affected (56 %) than the lower income ones (50%). But the difference was slight.

Table 7. Demographic-Socio-Health survey and statistical characteristics.

Aspects of Participants		Annoyed	Not annoyed	Can't say	Total	Calculated χ^2	Critical χ^2 (i,e.$\chi^2_{(0.05)}$)
Gender	Male	597	615	17	1229	15.28	5.99
	Female	463	333	15	811		
Marital status	Married	592	373	15	980	54.4	5.99
	Unmarried	468	575	17	1060		
Age group	Children	178	121	12	311	80.12	21.0
	Young	219	331	9	559		
	Middle-age	358	326	7	691		
	Elder-age	305	170	4	479		
Income group	Low	514	496	13	1023	9.0	9.5
	Medium	368	323	10	701		
	High	178	129	9	316		

The Chi-square (χ^2) test was used to verify the statistical significance of the demographic effect [27]. The calculated values of χ^2 and those ofχ^2-critical (i.e., at 95% confidence level) are also included in Table 7. The Chi-square analysis indicates that the difference in annoyance by gender is significant as the calculated χ^2 (15.28) is more than the χ^2-critical (5.99). In the present case, the percentage of females annoyed is more than the males. Considering the marital status, the calculated χ^2 (54.44) is more than theχ^2-critical (5.99), which shows that marital status is one of the significant factors for annoyance because of traffic noise. Similarly, the age group is also a significant factor for the sensitivity toward the traffic noise as the calculated χ^2 (80.12) is more than the χ^2-critical (21.0). The analysis of the income group shows that the calculated χ^2 (9.0) is little less than the χ^2-critical (9.5), which indicates that the income group is hardly affected by traffic noise.

3.4.2. Physiological and psychological wellbeing of people exposed to traffic noise

The health survey on traffic noise and its effect was carried out at all study locations. The wellness study was conducted on three aspects of the psychological and physiological well-being elements (annoyance, low work performance, and sleeplessness) of people exposed to heavy traffic noise in the city. The opinions of the participants are shown in Table 8. A statistical study was carried out with noise level to wellness of the inhabitants of the city. Figure 8 shows the Ldn vs. percentage of annoyed people at different locations. It indicates that with the increase of Ldn, the percentage (and the numbers) of annoyed persons increases. Figure 9 shows the Ldn vs. percentage of people suffering low work performance. It specifies that when Ldn increases, the percentage (and the numbers) of people having low work performance increases. Figure 10 shows the Ldn vs. percentage of people suffering sleeplessness. It also indicates that the percentage (and the numbers) of person suffering sleeplessness increases with the increase of Ldn. During the survey, it is observed that those

people (irrespective of profession) who spend more time in traffic are suffering a loss of sleep. The loss of sleep means the inadequate quantity or quality of sleep. The coefficients of correlation (R) for all cases are 0.83, 0.81, and 0.78, respectively. This is an indicator of the auditory health of the people in Berhampur. Also, these statistical results (of t-test) show that at a 5 % confidence level, the t-statistical values (4.3, 4.2, and 3.8, respectively) are more than the t-critical (1.833). This indicates that the relations are significant [28].

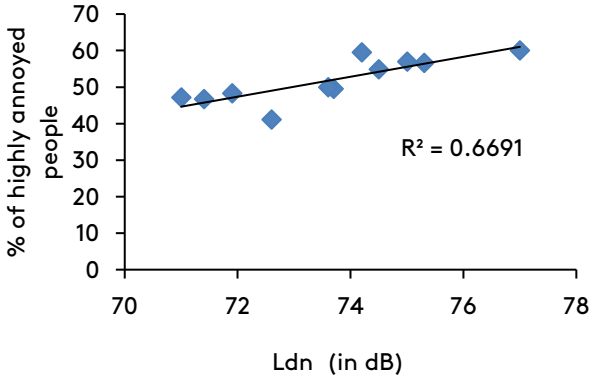

Fig.8. Ldn vs. % of annoyed persons at different locations in the city.

Doctors and environmentalists give view noise pollution as a serious matter of concern. Exposure to high traffic noise for long period can lead to a loss of hearing sensitivity and other physiological problems of residents. Noise-induced hearing loss (NIHL) is most likely the dominant cause of acquired hearing loss. Exposure to excessive noise can lead to a loss of hearing sensitivity, termed a threshold shift.

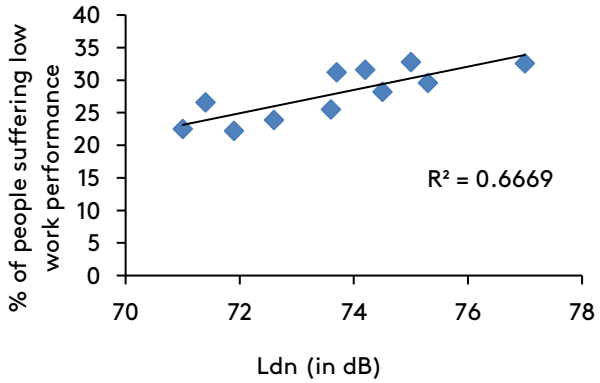

Fig.9. Ldn vs. % of people suffering low working performances at different locations.

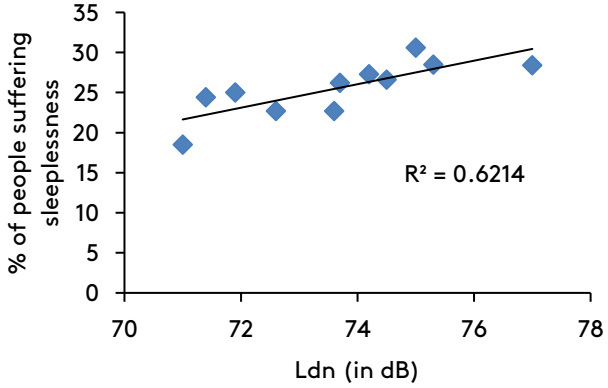

Fig. 10. Ldn vs. % of people suffering sleeplessness at different locations.

Table 8. Wellness of the people at different locations.

	Participants at different locations											t-calculated	t-critical
	1 TN	2 KP	3 LP	4 MK	5 KK	6 MAV	7 AM	8 GB	9 TB	10 CP	11 NB		
Total No. of persons	184	183	190	184	180	178	202	189	180	186	184		
Ldn (in dB)	71.4	74.2	77	71.9	72.6	71	73.7	75.3	73.6	75	74.5		
% of people highly annoyed	46.7	59.5	60	48.3	41.1	47.2	49.5	56.6	50	57	54.9	4.3	1.83
% of people having low work performance	26.6	31.6	32.6	22.2	23.9	22.5	31.2	29.6	25.5	32.8	28.2	4.2	1.83
% of people having sleeplessness	24.4	27.3	28.4	25	22.7	18.5	26.2	28.5	22.7	30.6	26.6	3.8	1.83

4. Conclusions

The current analysis on vehicular noise pollution in Berhampur has been done. The SLM- cum-analyzers were used to access the noise parameters at different locations in the city. The results show that traffic noise level is at an alarming state. The present experimental study ofthe city illustrates the following conclusions.

i. At all traffic locationsin the city,the noise levelsexceed the prescribed national level during the day-time and evening.It is below the prescribed limit during the nightime, only for a few hours.
ii. During the daytime, the NEI is more than one in all locations. That is highly undesirable and, in several cases, quite intolerable.
iii. The impactof traffic noise was found to be considerablyaffectedby gender, marital status,and age.
iv. The percentages (and the numbers) of annoyed people increase as the Ldn (equivalent continuous noise level for day-night) increases.
v. The high traffic noise not only causesannoyance, it also affects the day to day life of people. The work performaneand sleepof the exposed people are affecteddue to traffic noise. The percentage of people suffering sleeplessness and low work performance increases with an increase of Ldn.
vi. The coefficient of correlation (r) of the above situationsishigh. Theyare more than 0.78, indicating that the relations are significant.

Researchers in any sphere havea duty to find a path to sustainability. The authors wish to provide the followingsuggestions to local governmentson mitigation of this threat.

a) Road side plantingof trees,especially more in residential colonies.
b) Battery auto-rickshaws should be encouraged to replace diesel auto-rickshaws. The diesel auto-rickshaws generate a noise level of 100 dB, where the battery auto-rishaw is 80 dB or less.
c) There should be periodic noise monitoring on the roads.
d) Awareness programmes should be conducted by the local administration.

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