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Assessment, analysis and appraisal of road traffic noise pollution in Rourkela city, India

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Abstract

The problem of road traffic noise pollution has become a concern for both the public and the policy makers. Noise level was assessed in 12 different squares of Rourkela city during different specified times (7-10 a.m., 11 a.m.-2 p.m., 3-6 p.m., 7-10 p.m., 10 p.m.-12 midnight and 4-6 a.m.). Noise descriptors such as L_{eq}, traffic noise index, noise pollution level, noise climate, L_{day}, $L_{evening}$, L_{night} and L_{den} were assessed to reveal the extent of noise pollution due to heavy traffic in this city. The equivalent noise levels of all the 12 squares were found to be much beyond the permissible limit (70dB during day time and 55dB during night time). Appallingly, even the minimum L_{eq} and NPL values were more than 82 dB and 96 dB during day time and 69 dB and 91 dB during night time respectively. L_{den} values of investigated squares ranged from 83.4 to 86.1 dB and were even more than the day time permissible limit of traffic noise. The prediction model was used in the present study to predict noise pollution level instead of L_{eq}. Comparison of predicted with that of the actual measured data demonstrated that the model used for the prediction has the ability to calibrate the multi-component traffic noise and yield reliable results close to that by direct measurement. Lastly, it is inferred that the dimension of the traffic generated noise pollution in Rourkela is critical.

Key words

Noise prediction model, Noise pollution level, Noise climate, Traffic noise

Introduction

Traffic noise is considered as one of the most intrusive type of noise pollution and has become an issue of immediate concern for public administrations and authorities. The sources of traffic noise are primarily vehicle engines, exhaust systems, tyre-pavement interaction and aerodynamic friction (Cirianni and Leonardi, 2012; Steele, 2001). Due to rapid growth of the urbanization, the road traffic noise causes annoyance, damage hearing and pose a wide range of negative effects on the health in urban areas (Yoshida *et al*., 1997; Agarwal and Swami, 2009; Ouis, 2001). In Odisha, some studies on the traffic noise monitoring have been carried out at different cities like Jharsuguda (Patel *et al.*, 2006), Balasore (Goswami, 2009; Goswami *et al.*, 2011), Bhadrak (Goswami, 2011; Swain *et al.*, 2012b). An attempt has been made in this study to record the road traffic noise levels at 12 different squares in and around the Rourkela city. Due to rapid industrial growth of this city, the transportation sector is growing rapidly and the number of vehicles on roads is increasing at a faster rate from 14,226 registered in 2007 to 18,269 in 2011. Rourkela Steel Plant, a unit of Steel Authority of India Limited (SAIL) is one of the largest steel manufacturing facilities in India. Besides, there are many units in Rourkela producing sponge iron, cement, refractories and a number of small scale industries catering to the need of Rourkela Steel Plant and other large industrial units. As Rourkela has a huge steel manufacturing base, the population of the city is also increasing from 3,22,510 in 1981 to 7,06,196 in 2011. So, large numbers of rural

immigrants have settled in the city for their livelihood.

Noise descriptors such as L_{10}, L_{50}, L_{90}, L_{eq}, traffic noise index (TNI), noise pollution level (NPL), noise climate (NC), L_{day}, $L_{evening}$, L_{night}, L_{den} were assessed to reveal the extent of noise pollution in this city. The detected noise levels of this city in day time were compared with tolerance limit on roads (traffic noise) during day-time i.e. 70 dB (A) (WHO, 1999). The road traffic noise of night time of this city was compared with the interim target (IT) of 55 dB ($L_{night,outside}$) prescribed by WHO (WHO, 1999). Traffic noise prediction model is essential, as it supports in designing the roads and highways and in the assessment of existing or envisaged changes in traffic noise conditions (Steele, 2001). Thus, the Lyons's (1973) Traffic Noise Model was used in the present study to predict the NPL. These predicted values were compared with the calculated NPL values deduced from actual measured data.

Materials and Methods

Rourkela is located in the northwestern tip of the Odisha, India at the heart of a rich mineral belt. The city is located at 22° 12' N latitude and 84° 54' E longitude in the district of Sundergarh. The noise levels were measured following standard procedure using calibrated sound level (dB) meter from May to August, 2011 at twelve important and crowded squares of Rourkela. The instrument was placed at a height of about 1.2 m above the ground. Precautions were also taken to ensure that no reflections took place near the instrument. Baseline measurements were monitored at one minute interval during six specified times (7-10 a.m., 11 a.m.-2 p.m., 3-6 p.m., 7-10 p.m., 10 p.m.-12 midnight and 4-6 a.m.). The noise monitoring was done in a good climatic condition, where there was no sign for cloud.

Assessment of noise descriptors: Noise descriptors such as L_{10}, L_{50}, L_{90} were assessed to calculate the value of L_{eq} by using the formula given by Robinson (1971).

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

Noise pollution level (NPL) = $L_{eq} + a(L_{10}-L_{90})$, where, a = 1.0 (constant in the equation)

Noise climate (NC) = $L_{10}-L_{90}$

Traffic noise index (TNI) = $4(L_{10}-L_{90}) + L_{90} - 30$ dB (A)

were also worked out. All these noise descriptors are expressed in dB (A).

Assessment of L_{den}: L_{den} is a composite of long term L_{eq} values for day, evening and night and was calculated by the following formula.

$$L_{den} = 10.^{10}\log\frac{12.10^{\frac{L_{day}}{10}} + 4.10^{\frac{L_{evening}+5}{10}} + 8.10^{\frac{L_{night}+10}{10}}}{24}$$

L_{den} defines its time periods— day: from 6 a.m. to 7 p.m.; evening: from 7 p.m. to 10 p.m.; night: from 10 p.m. to 6 a.m.

Noise pollution level prediction: The highway noise prediction model used in this study was based on the key noise, produced by traffic and then attenuated by distance before it reached the listener. The noise level was well predicted using Lyons empirical model (Lyons, 1973). Because of the unavailability of speed measuring instrument 'radar gun', an approximate feel of it, i.e., average vehicle speed as a parameter had taken in the present work. Vehicle speed was taken as an average speed of all vehicle categories.

Statistical analysis: Statistical analysis (F test) was made on the data of noise monitoring.

Questionnaire survey: A public health survey was undertaken to know adverse effects of noise on human health. The questionnaire was the collection of health-related data.

Results and Discussion

The average noise levels in 12 different squares are shown in Table 1. The noise levels ranged from 68.5 to 120.3 dB at day time and 45.5 to 102.8 dB at night time. L_{eq} values of all 12 monitored squares during 7-10 a.m., 11 a.m.-2 p.m., 3-6 p.m., 7-10 p.m., 10 p.m.-12 midnight and 4-6 a.m. are also presented in the Table 1, while NPL, TNI and NC values are depicted in the Table 2. The minimum L_{eq} values were more than 82 dB during day time and 69 dB during night time, while minimum NPL values were more than 96 dB during day time and 91 dB during night time. Even the minimum TNI value was 103 dB. These distressing values of L_{eq}, NPL and TNI exceeded the permissible limit of traffic noise prescribed by WHO (1999) i.e., 70 dB for day time and 55 dB for night time. All these values of noise descriptors clearly showed high noise levels in Rourkela city mostly throughout the day in general and during the evening (peak hour: 7-10 p.m.) in particular. Analysis of variance (F test) revealed that the noise levels of different squares did not differ significantly ($F_{0.5}$=1.75 and $F_{0.1}$=2.18) at the peak hour (7-10 p.m.).

L_{den} values for 12 investigated squares ranged from 83.4 to 86.5 dB. These values are even more than the day time permissible limit (70 dB) of traffic noise. Thus, the data clearly revealed that there was noise pollution throughout the day, evening and night in and around Rourkela city. It is observed that the values of assessed predicted noise pollution levels are close to respective actual noise pollution

Table 1 : Noise level (dB) variations at different squares of Rourkela city at different time intervals

Name of the square	7 a.m. - 10 a.m.		11 a.m. – 2 p.m.		3 p.m. – 6 p.m.		7 p.m.- 10 p.m.		10 p.m. – 12 Night		4 a.m.- 6 a.m.	
	Mean ±SD	L_{eq}	Mean ±SD	L_{eq}	Mean ±SD	L_{eq}	Mean ±SD	L_{eq}	Mean ± SD	L_{eq}	Mean ±SD	L_{eq}
Ambagan square	82.6 ±7.3	83.4	81.4± 6.9	82.3	83.2 ±7.7	86.7	84.1± 7.7	87.8	61.1± 6.3	73.4	61.4 ±6.3	72.6
Sector-9 square	84.4 ±9.4	91.6	83.6 ±9.3	88.7	85.6 ±9.0	91.7	86.8± 9.2	93.2	59.5± 6.0	74.3	60.4 ±5.9	71.4
IG Park square	88.6 ±7.6	94.1	86.5± 8.9	92.7	89.2 ±7.7	94	90.8± 7.4	94	60.1± 5.9	71	59.6± 6.2	73.2
Traffic Gate square	84 ± 9.1	87.8	82.3± 9.1	86.7	86.8 ±9.2	95.9	87.3± 9.4	94.1	60.4 ±6.7	72.8	60.1 ±6.3	72.5
Bisra square	82.7 ±8.9	87.7	79.3± 9.8	86.1	83.2 ±9.1	87.3	85± 9.5	92.4	60.3± 6.3	72.6	60.7 ±5.7	70.4
Koel Nagar square	81.8 ±8.4	88.8	81 ±8.7	86.9	83.9 ±8.2	91.5	85.8± 7.7	88.5	59.6 ±6.6	74	60.8 ±6.3	71.8
Sector-2 square	81.6 ±7.9	87.6	82.3 ±8.7	86.8	83 ±8.1	87.6	84.9 ±8.0	90	60.6 ±5.1	69.6	58.7 ±5.9	73.5
Balia Gate square	82.8 ±7.8	87	82.4± 8.8	85.9	82.9 ±7.5	86.6	85.4± 8.3	90.2	61.7 ±5.6	72.8	61.7 ±6.2	72.5
Panposh square	83.7 ±7.6	89.2	81.9 ±9.0	87.7	82.9 ±7.9	89.2	85.1± 8.8	90.1	60.8 ±5.7	74.3	62.4 ±6.5	72.1
STI square	82.5 ±8.5	86.3	81.8± 8.5	86	84 ±7.5	87.6	87.1±7.2	92.4	60.4 ±6.2	69.8	62.2 ±6.6	70.9
Chhend square	82.8 ±8.4	85.9	82.2± 8.5	85.8	83.9 ±8.6	85.9	86.4± 8.9	93.9	60.2 ±7.3	72.5	61.7 ±5.9	71.5
Udit Nagar square	83.3 ±8.7	85.3	82.8± 8.8	85.7	84.8 ±8.5	89.1	85.6±8.0	90.7	61.6 ±6.4	70.4	63.5 ±6.3	71.1

Table 2 : Noise descriptors (TNI, NPL, NC) variations at different squares of Rourkela city at different time intervals

Monitoring sites	7 a.m. – 10 a.m.			11 a.m. – 2 p.m.			3 p.m. – 6 p.m.			7 p.m. – 10 p.m.			10 p.m. – 12 Night			4 a.m. – 6a.m.		
	TNI	NPL	NC	TNI	NPL	NC	TNI	NPL	NC	TNI	NPL	NC	TNI	NPL	NC	TNI	NPL	NC
Ambagan square	106.4	98.3	14.9	103	96.7	14.4	112.9	103.6	16.9	115.8	105.3	17.5	127.8	99.4	26	123.9	97.4	24.8
Sector-9 square	149.2	113.5	21.9	126.4	109.4	20.7	135	114.3	22.6	128.6	114	20.8	133.6	102	27.7	120	95.2	23.8
IG Park square	125.5	113.4	19.3	125	112.6	19.9	119	111.6	17.6	115.9	110.2	16.2	122.6	95.5	24.5	127.9	98.8	25.6
Traffic Gate square	125.5	108.4	20.6	122.9	106.8	20.1	127.6	116.9	21	129.4	115.1	21	125.7	98.5	25.7	129.3	98.9	26.4
Bisra square	139.7	108.2	20.5	127.8	108	21.9	126.5	107.9	20.6	133.7	114.9	22.5	127.4	98.5	25.9	120.1	94	23.6
Koel Nagar square	145.2	110.4	21.6	127.9	108.5	21.6	123.6	111.8	20.3	114	105.1	16.6	132.1	101.2	27.2	122.6	96.4	24.6
Sector-2 square	136.4	107.3	19.7	125.6	107.3	20.5	120.8	106.7	19.1	117.3	107.9	17.9	111.1	91.2	21.6	133.1	100.7	27.2
Balia Gate square	135.4	106.6	19.6	124.9	106.3	20.4	119.7	105.1	18.5	125	110	19.9	129.8	98.9	26.1	125.2	97.2	24.7
Panposh square	139.6	109.3	20.1	128.6	109	21.3	127.8	110	20.8	129	110.9	20.8	134.9	101.8	27.5	127.2	97.7	25.6
STI square	130.7	104.9	18.6	117.6	104.3	18.3	118.6	105.7	18.1	113.8	108.8	16.4	116	92.6	22.8	124.1	95.5	24.6
Chhend square	133.5	105.3	19.4	124.5	105.9	20.1	117.7	103.9	18	124.9	113.4	19.5	123.1	97.6	25.1	119.9	94.9	23.4
Udit Nagar square	129.7	103.9	18.6	124.2	105.7	20	120.9	108	18.9	119.9	109.1	18.4	115.2	92.6	22.2	117	93.9	22.8

Table 3 : Prediction of noise pollution level of different squares of Rourkela city

Monitoring sites	7a.m.-10 a.m.		11 a.m. – 2 p.m.		3 p.m. – 6 p.m.		7 p.m.- 10 p.m.	
	Predicted noise level	Actual NPL measured	Predicted noise level	Actual NPL measured	Predicted noise level	Actual NPL measured	Predicted noise level	Actual NPL measured
Ambagan square	102.8	98.3	104.3	96.7	106	103.6	107.3	105.3
Sector-9 square	106.3	113.5	103.9	109.4	105.3	114.3	107.1	114
IG Park square	105.9	113.4	104.9	112.6	105.7	111.6	106.9	110.2
Traffic Gate square	107.1	108.4	106.3	106.8	107	116.9	108.6	115.1
Bisra square	108.3	108.2	106.5	108	107.4	107.9	109.4	114.9
Koel Nagar square	108.6	110.4	106.8	108.5	107.8	111.8	108.9	105.1
Sector-2 square	107.3	107.3	106.4	107.3	107.8	106.7	107.8	107.9
Balia Gate square	107.7	106.6	107.1	106.3	107.7	105.1	107.4	110
Panposh square	106.3	109.3	105.1	109	106.1	110	106.9	110.9
STI square	106.2	104.9	104.9	104.3	106.1	105.7	107.4	108.8
Chhend square	105.8	105.3	105.3	105.9	106.2	103.9	106.7	113.4
Udit Nagar square	106.3	103.9	106.7	105.7	106.7	108	107.8	109.1

levels measured (Table 3). Such comparison depicted that the model used for the prediction in the present study has the ability to calibrate the multi-component traffic noise and yield reliable results close to that by direct measurement (Swain *et al.*, 2012a).

The noise perception survey was carried out by a questionnaire, which was conducted on 578 individuals in Rourkela. This survey clearly demonstrates that most of the people were aware of noise pollution (Patil *et al.,* 2011; Szeremeta and Zannin, 2009). 71% respondents were not satisfied about the noise level at Rourkela. 68% respondents ranked traffic noise in first place among the most frequently identified types of sound and considered unpleasant. The study also revealed that 45% of interviewees were highly annoyed by the noise produced from air horns of different vehicles. 18% of respondents told that they have had at least one experience of being temporarily "deafened" by loud noise. These symptoms may be due to some other factors. 39% of people shared their sleep disturbance due to traffic noise during night-time.

The results of this study clearly depicts that the calibrated model (Lyons, 1973) can be used for noise prediction in Indian conditions. It is obvious that in the next few decades, the noise level would also increase (Krishna Murthy *et al.,* 2007). Thus, installation of automotive synchronized traffic signals in all studied squares, introduction of one-way streets, construction of metro rail transport systems, fly-overs and expressways and massive plantation of trees with dense foliage (rich canopy) are the need of the hour in the city of Rourkela.

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