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Original Research

Critical analysis of day time trafc noise level at curbside open-air microenvironment of two types of road network of a big city

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ABSTRACT

Aim: The aim of the research work is to critically analyze day time traffic noise level (Leq) at curbside open-air microenvironment of two types of road network of Kolkata City, India. **Methods:** 280 sets of data on road width, traffic volume, Leq, peak (L_{10}) and background (L_{90}) noise level were collected from curbsides of 23 major roads. The data was sub set according to the following road network types i.e., one-way traffic in single or double lane (RN-1) and both-way traffic in single lane (RN-2). Noise Climate (NC) and Traffic Noise Index (TNI) were computed for both types of road network. **Results:** After sub setting of data the number of sets of data accounted for 234 and 46 for RN-1 and RN-2 type of road network. The ratio (RN-1/RN-2) of the averages road width and traffic volume of two types of road network was 2.28 and 1.89. The ratio of the average Leq, NC and TNI of two type of road network was 0.98, 0.89 and 0.94. The ratio of the average L_{10} and L_{90} of two types of road network was 0.99, 1.01. **Conclusion:** RN-1 type of road network was wider and also had higher traffic volume in comparison with RN-2 type of road network. On the contrary RN-1 type of road network was quieter and less annoying in comparison with RN-2 type of road network. Lower Leq of RN-1 type of road network in spite of higher traffic volume was attributed to lower L_{10}

KEY WORDS: Road network; Traffic noise level; Noise Climate; Traffic Noise Index; L_{10}; L_{90}

INTRODUCTION

Traffic noise contributes more than 55% of total environmental noise in urban area [1,2]. It is also accounted for over 1 million healthy years of life lost annually to ill health and may lead to a disease burden that is second only in magnitude to that from air pollution. Long-term exposure to traffic noise is found to be associated with cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus and annoyance in general population [3].

Excessive day time traffic noise level in curbside open-air microenvironment of cities is a universal problem [4,5]. Urban dwellers of Indian cities are also experiencing very high day time traffic noise level in last few decades due to substantial growth of new vehicles, low turnover of old vehicles, inadequate road network and urbanization [6-8]. The resultant traffic noise level at curbside open-air microenvironments of Indian cities are attributed to complex interactions between heterogeneous traffic and environmental conditions like, congestion, road conditions, frequent honking and lack of traffic sense [9,10].

Form the last decade Kolkata Traffic Police has introduced one-way traffic management practice on major roads of Kolkata city, India with the objectives to increase speed of vehicles, reduce accidents and control vehicular pollutions [11]. Due to introduction of the traffic management practice road network of the city may crudely be grouped according to direction of traffic flow i.e., one-way traffic in single or double lane (RN-1) and both-way traffic in single lane (RN-2). The aim of the research work is to critically analyze day time traffic noise level (Leq) at curbside open-air microenvironment of two types of road network of the city.

METHODS

Study Area

Kolkata is the capital of the state West-Bengal, India and is also one of the most populous cities of the country. The city is bounded to west and north-west by the river Hoogly. The city has a tropical savannah climate with a marked monsoon season. The city is divided into five major geographical regions namely, east, west, north, south and central Kolkata. There is hardly any demarcation of areas of distinct residential, industrial, commercial activities. The city area under the Kolkata Municipal Corporation covers an area of 187 km2 of which only 6% to 7% of land is used for road space. Vehicular density of the city is 5685 cars/ km2 and average traffic speeds is less than 20 km/h [12,13]. Major road networks of the area within four important traffic intersections of south Kolkata i.e., Park Street (22°33′ 17.23″N, 88°21′50.14″E), Park Circus (22°32′35.82″N, 88°21′58.14″E), Garia (22°27′57.08″N, 88°22′40.10″E) and Tollyguange Tram Depot (22°29′35.10″N, 88°20′43.04″E) was chosen for traffic volume and noise survey [Figure-1].

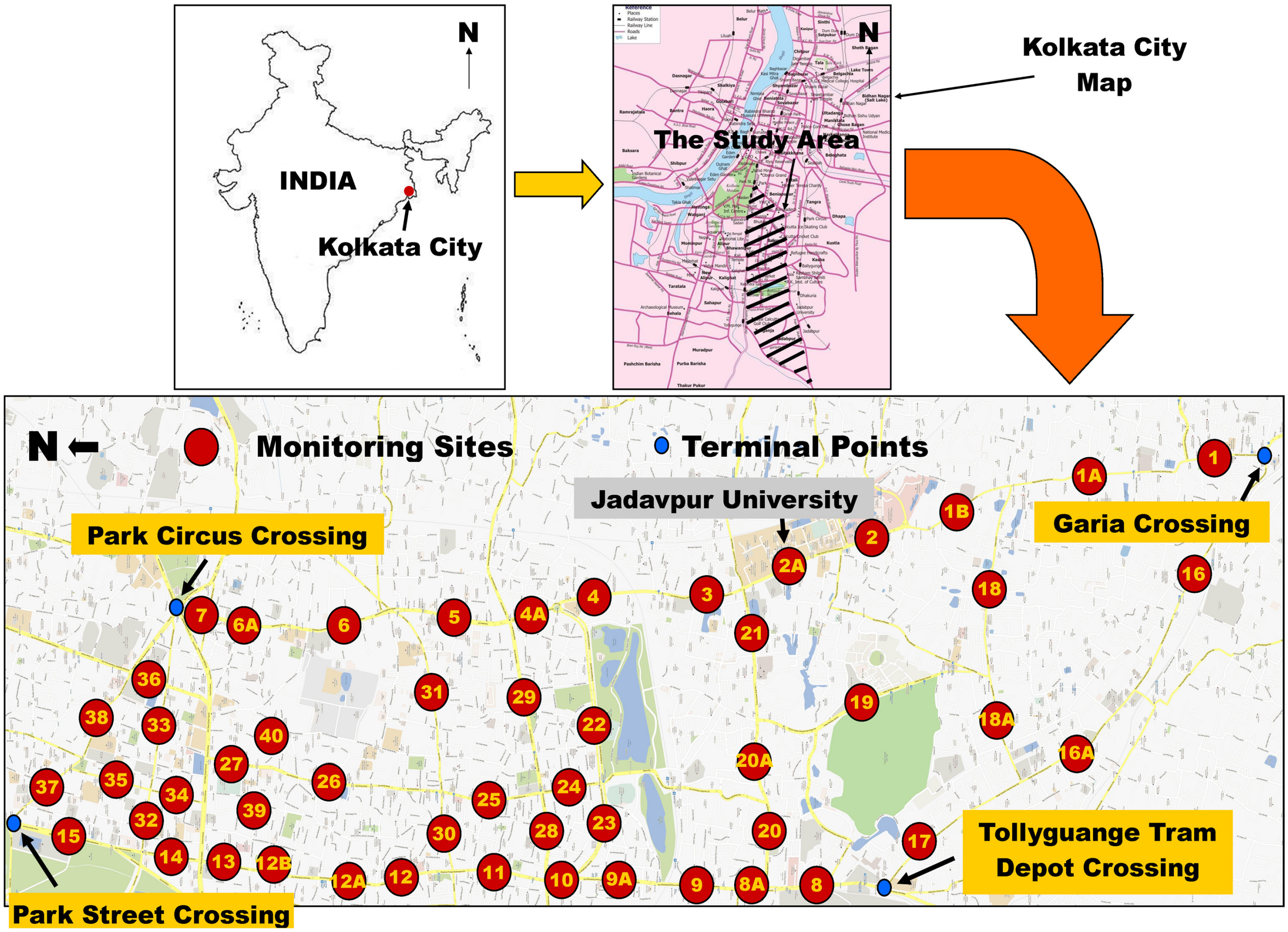

Figure 1. Diagrammatic representation of the study area for traffic volume and noise survey

Comprehensive Plan for Data Collection

Total 280 sets of data were generated on the following variables during two phases of monitoring programme. In the first phase, motorized traffic volume and L_{eq} were monitored for 4 h at curbside open-air microenvironment of 23 major roads of the study area. In this phase traffic volume and noise monitoring were performed once between 12:00 noon to 04:00 p.m. at 52 sites on different week days of March'2011 – May'2011. In the second phase, traffic volume and noise monitoring were performed at 38 sites located on 21 major roads of the study area. In this phase no monitoring was performed at the site number 39 and 40 as well as A and B sub-sites of the respective site number. At each monitoring site three consecutive 4 h monitoring of traffic volume and noise were performed on two different consecutive week days. On the first day the monitoring were performed between 04:00 p.m. – 08:00 p.m. and on the second day the monitoring were performed between 08:00 a.m. – 12:00 noon and 12:00 noon – 04:00 p.m. Three consecutive 4 h monitoring at each site were also repeated in summer of the year 2012 (March'2012 – May'2012) and 2013 (March'2013 – May'2013) and winter of the year 2011 – 2012 (November'2011 – February'2012) and 2012 – 2013 (November'2012 – February'2013). Road width of the monitoring sites was estimated once with a measuring tape. No monitoring was performed in monsoon and rainy day. Finally, collected raw data set was sub set according to RN-1 and RN-2 type of road network for further statistical analysis.

Monitoring of Traffic Noise

Traffic noise level of the microenvironment was determined in terms of 4 h A-weighted equivalent noise level (L_{eq}) with a Type – II (CESVA SC160, Barcelona, Spain) sound level meter (SLM). The SLM was operated under fast operation mode with 1 sec resolution. It was placed on a tripod, on road side walk, at a distance of 1 m from boundary wall and at a height of 1.5 m from ground level. It was also calibrated prior to each 4 h monitoring. Noise monitoring was strictly avoided near constructional activities. Peak (L_{10}) and background (L_{90}) noise levels were determined from the SLM software [14].

Monitoring of Traffic Volume

Motorized traffic volume was determined on analysis of 15 min video footage taken once in an hour during total 4 h noise monitoring with a digital camera (SONY DSC-W150, Suzumegairi, Japan). Traffic volume was determined on manual counting of vehicles passed through the cross section of the road observed through the digital camera. Then hourly traffic volume was determined with a multiplication factor of 4. Finally motorized traffic volume was represented as vehicles/4 h by simple addition of each 1 h data.

Computation of Noise Indices and Statistical Analysis

Noise indices like Noise Climate (NC) and Traffic Noise Index (TNI) were computed according to the following equations –

$$NC = L_{10} - L_{90} \quad (1)$$

$$TNI = (L_{90} + 4 \times NC - 30) \quad (2)$$

Noise indices were computed to determine the annoyance response to traffic noise level. Central tendency of the variables was determined through descriptive statistical parameters like, minimum, maximum, mean and standard deviation. Comparative analysis of road width, traffic volume, traffic noise level and annoyance response to traffic noise of two types of road network were determine through ratio (RN-1/RN-2) of the averages of same variable determined for RN-1 and RN-2 type of road network.

RESULTS

After sub setting of data the number of sets of data accounted for 234 and 46 for RN-1 and RN-2 type of road network. The minimum, maximum, average and standard deviation of road width, traffic volume, L_{eq}, NC, TNI, L_{10} and L_{90} of RN-1 and RN-2 type of road network are presented in Table 1 and Table 2.

Average traffic volume of RN-1 and RN-2 type of road network were 10435±3101 vehicles/4 h and 5533±1200 vehicles/4 h. On the contrary, average traffic noise level of RN-1 and RN-2 type of road network were accounted for 77.44±2.13 dB(A) and 78.66±1.60 dB(A). In spite of higher traffic volume average TNI of RN-1 type of road network (87.93±6.04 dB(A)) was also recorded lower than the RN-2 type of road network (93.16±4.60 dB(A)). RN-1/RN-2 of the averages of same variable of two types of road network is described in Figure 2.

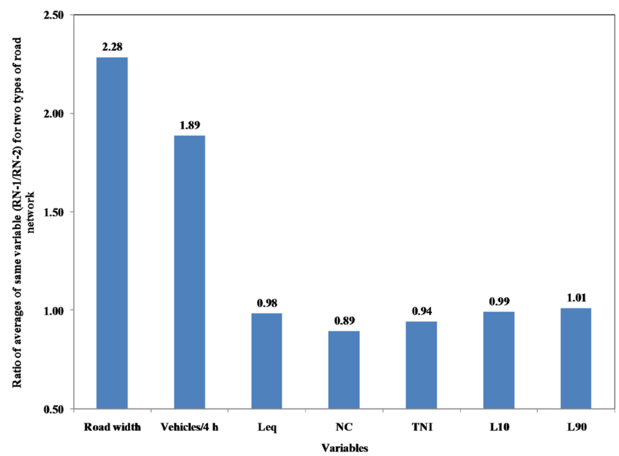

Figure 2. RN-1/RN-2 of the averages of same variable of two types of road network

Table 1. Descriptive statistics of the variables for RN-1 type of road network

Variables	Minimum	Maximum	Average	Standard deviation
Road width, m	10.00	31.00	20.30	5.22
Vehicles/4 h	3272	20688	10435	3101
L_{eq}, dB(A)	70.30	83.40	77.44	2.13
NC, dB(A)	8.80	18.80	12.75	1.72
TNI, dB(A)	75.30	107.40	87.93	6.04
L_{10}, dB(A)	72.80	85.00	79.70	2.07
L_{90}, dB(A)	61.20	72.00	66.95	2.32

Table 2. Descriptive statistics of the variables for RN-2 type of road network

Variables	Minimum	Maximum	Average	Standard deviation
Road width, m	7.00	12.00	8.89	1.65
Vehicles/4 h	3480	8820	5533	1200
L_{eq}, dB(A)	75.70	81.70	78.66	1.60
NC, dB(A)	11.10	17.60	14.26	1.49
TNI, dB(A)	83.10	102.10	93.16	4.60
L_{10}, dB(A)	76.60	83.50	80.39	1.67
L_{90}, dB(A)	60.60	69.80	66.13	2.37

DISCUSSION

Traffic noise level irrespective of road network types was higher than the prescribe standard of 65 dB(A) for day time and commercial area recommended by the Central Pollution Control Board of India [15]. Day time traffic noise level of more than 50 dB(A), the guideline recommended by World Health Organization for day time for outdoor living area were reported in cities like Sanandaj and New York [4,5]. Very high traffic noise level at the microenvironment in the context of different Indian towns and cities like Asansol, Kolhapur and Visakhapatnam has been reported by a number of researchers [6,7,16]. TNI irrespective of road network types was higher than 74 dB(A). Ma et al. reported that TNI greater than 74 dB(A) is sufficient to create annoyance among people [17]. TNI over 74 dB(A) have also been reported from the Indian towns and cities like Rourkela, Gwalior, Chidambaram and Baripada [8,18-20].

RN-1/RN-2 of the averages of road width and traffic volume of two types of road network was accounted >1. Therefore, it can be stated that RN-1 type of road network was wider and with higher traffic volume in comparison with RN-2 type of road network. On the contrary RN-1/RN-2 of the averages of L_{eq}, NC and TNI of two types of road network was accounted <1. Therefore, it can be stated that in spite of higher traffic volume RN-1 type of road network was quieter and less annoying in comparison with RN-2 type of road network. Chowdhury et al. and Vijay et al. also reported a negative correlation between traffic noise level and road width in the context of Indian cities like Kolkata and Nagpur [21,22]. The paradox of lower traffic noise level in spite of higher traffic volume in the context of RN-1 type of road network might be attributed to lower RN-1/RN-2 (<1) of the averages of L_{10}. Tirabassi and Can et al. reported that L_{eq} is stringently influenced by the noisiest events like, honking, sudden acceleration and deceleration of vehicles during the noise measurement period [23,24]. Vijay et al. reported that no honking may reduce traffic noise level by 2 to 5 dB(A) [10]. Therefore, lower peak noise level in RN-1 type of road network in comparison with RN-2 type of road network might be attributed to lower incidence of honking, sudden acceleration and deceleration of vehicles due to harmonized and one-way traffic flow through single and double lanes. A higher RN-1/RN-2 (>1) of averages of L_{90} of two types of road network was attributed to higher background noise level in wider roads. Background noise level generally generated from engine and road-tyre interactions of slowly moving vehicle and has lower influence on L_{eq}. Therefore, higher background noise level in wider roads might be linked with higher traffic volume [14].

CONCLUSION

RN-1 type of road network was wider and also had higher traffic volume in comparison with RN-2 type of road network. On the contrary RN-1 type of road network was less noisy and less annoying in comparison with RN-2 type of road network. Lower L_{eq} of RN-1 type of road network was attributed to lower L_{10}.

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