

Monitoring and Assessing the Environmental Noise along a Busy Traffic Corridor of Ahmedabad City, India

KETAN LAKHTARIA^{1,2*}, SANDIP TRIVEDI³ and ANURAG KANDYA⁴

¹Civil Engineering Department, Institute of Technology and Engineering, Indus University, Ahmedabad, India.

^{2,3}Department of Civil Engineering, Gujarat Power Engineering and Research Institute, Mehsana, India.

⁴Department of Civil Engineering, School of Technology, Pandit Deendayal Petroleum University, Gandhinagar, India.

Abstract

Noise pollution is a growing problem across the world and one which many people may not be aware of the impacts on their health. The environmental noise, and in particular the road traffic noise, remains a major environmental problem affecting the health and well-being of millions of people. With this background, a comprehensive 'noise pollution assessment study' was undertaken for a busy traffic corridor of Ahmedabad city of India. The traffic corridor which spans around 22.25 km passes through a mix of different areas like educational, commercials and residential. A two week long field survey was carried out on this corridor during 10-23 May, 2018 at 24 locations spread over the entire corridor. The assessment reveals that the average noise level always exceeded the prescribed guidelines of World Health Organization (WHO) for the daytime noise (75 dB (A) for Industrial area, 65 dB (A) for Commercial area, 55 dB (A) for Residential area and 50 dB (A) for Silence zones), which is quite alarming. For a major portion of the traffic corridor (79.6%), even the minimum noise level was above the permissible average noise level which is a matter of great concern. The highest noise level observed was 86.0 dB (A). Clubbing the ranks of the traffic corridor segments for the noise indicators like L_{Aeq} , L_{min} , L_{max} , L_{90} , L_{50} , L_{10} and L_{NP} revealed that locations like Akhbarnagar followed by Naranpura were in the nosiest. Looking to implications of the high noise levels on the human health and productivity, it is important to initiate suitable mitigation measures. The present comprehensive study brings forth the spatial and quantitative aspects of noise pollution across the busy corridor of the city which would be of great help to the civic administration in understanding the magnitude of the problem and subsequently initiate suitable mitigative measures.



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CONTACT Ketan Lakhtaria ✉ ketan.lakhtaria@gmail.com 📍 Civil Engineering Department, Institute of Technology and Engineering, Indus University, Ahmedabad, India.



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Introduction

Noise is one of the major urban pollutants affecting the majority of streets of modern cities^{1,2} and environmental noise pollution has been a growing worldwide problem over the past few years.³ Numerous studies have reported that the increase in the noise pollution is primarily because of the increase in the usage of the vehicles.^{4,5,6,7,8,9} Many studies have reported that there is evidence that exposure to traffic noise may be associated with wide range of psychological and physiological effects including annoyance, sleep disturbance, stress reaction, hypertension, cardiovascular event and diabetes.^{10,11,12,13,14,15} Accordingly to a published report by the World Health Organization (WHO), 'Noise Pollution is the second largest environmental threat to health after air pollution'.¹⁶ Looking to the impact of noise pollution on the human health and the increasing trend of the noise pollution, numerous studies have been planned around the world which focuses on various aspects of noise such as noise characteristics: sampling strategy,^{17,18} sources,^{19,20} etc. As it is important to estimate the population exposed to the varying noise levels, many studies have been attempted using models like Sound PLAN,^{21,22,23} CadnaA,^{24,25} LimA,²⁶ TRANEX,²⁷ MITHRA-SIG,²⁸ EMPARA.²⁹ Many researchers undertook field studies across the world like Tonkin, France,³⁰ Tehran city,³¹ Gwalior, India,³² Ahmedabad, India,³³ Visakhapatnam, India,³⁴ Rangareddy, India,³⁵ Hyderabad, India,³⁶ Kota, India,³⁷ China³⁸ for assessing the noise pollution and reported their findings using noise indicators like L_{Aeq} , L_{min} , L_{max} , L_{90} , L_{50} , L_{10} , Traffic Noise Index (TNI), NC (Noise Climate) and many others.

With the background the traffic noise problem is significantly increasing especially in rapidly urbanizing and industrializing cities and it largely overlooked by the environmental authorities, the present study is planned for Ahmedabad city of India which is one of the fastest urbanizing cities of the country and has witnessed an exponential rise in both the human population and number of vehicles. The main goal of the study is to bring forth the spatial and quantitative aspects of noise pollution across the busy corridor of the city. The findings of the present study would of great value to the city's civic authorities to understand the magnitude and dynamics of the problem and initiate suitable

measures which would reduce the health risk of the people.

Study Area

The present study is done over a busy traffic corridor of Ahmedabad city of India. Ahmedabad city is the 7th largest metropolis of India covering a geographical area of approx 464 km² having a road network of around 2600 km. The population which was around 5.58 million in the year 2011 has risen to around 8 million in the year 2020.³⁹ The growth of the number of vehicles was phenomenal in the last 2 decades and the city has around 49 lakh registered vehicles as on 31st March, 2020⁴⁰ and more than 70% are two-wheelers (Motor cycles).

The traffic corridor under investigation contains two routes which are (i) Route A – Ashram Road and (ii) Route R – 132 Ft Ring Road. It spans over 22.25 km and passes through different areas like educational, residential and commercial of the city. 24 sampling locations were identified over this corridor where the noise measurements were done. Fig 1 displays the respective traffic corridor along with the sampling locations while Table 1 contains the details of the sampling location.

Methodology

For the present study a comprehensive two weeks field survey was conducted during 10 - 23 May, 2018. The noise sampling was carried out on the 24 locations (as shown in Fig 1) during 0900 – 1300 hrs. Digital sound level meter (Instrument make: METRAVI, Model No: SL – 4015 having frequency range of 31.5 HZ to 8KHZ and IEC 61672- Class 2 standards) was used on slow mode. The device was mounted on a stand with a height of 1.5 m above the ground at a distance of 3.0 meter from the edge of the road and perpendicular to the road centreline. The sound pressure levels (SPL) were recorded in dB (A) at every second at each station. A database of the observed SPL was made subsequently noise indicators like mean A- weighted sound pressure level (L_{Aeq}), minimum noise level (L_{min}), maximum noise level (L_{max}), sound level exceeding for 90% of the sampling time (L_{90}) often related to the background noise level, sound level exceeding for 50% of the sampling time (L_{50}) which is statistically the mid-point of the noise readings, sound level exceeding for 10% of the sampling time (L_{10})

which is probably due to intermittent events, Noise Pollution Level (L_{NIP}) calculated as $L_{NIP} = L_{Aeq} + (L_{10} - L_{90})$, Traffic Noise Index (TNI) computed as $TNI = 4 \times (L_{10} - L_{90}) + (L_{90} - 30)$, Noise Climate (NC)

computed as $NC = L_{10} - L_{90}$ and Level roughness (σ_{oL}) computed as $\delta L_{(t)} = L_{Aeq1s(t+1)} - L_{Aeq1s(t)}$ for each location.

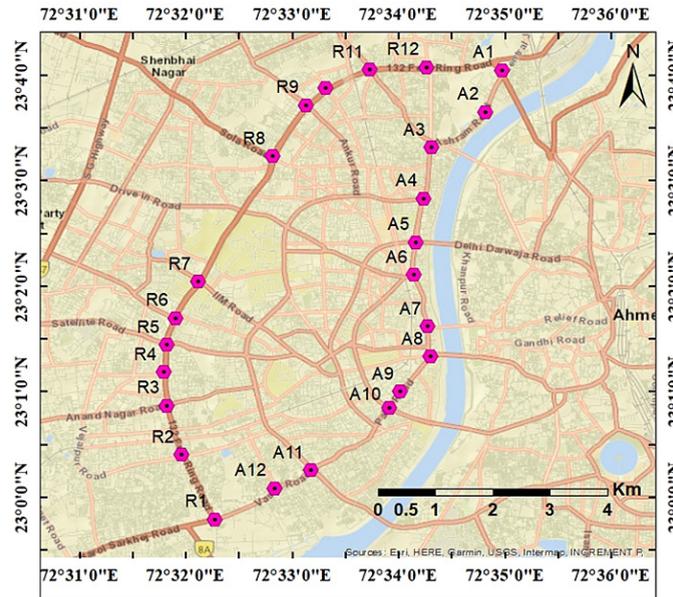


Fig. 1: Traffic corridor of Ahmedabad city along with the Noise pollution sampling locations

Table 1: Details of the Noise pollution sampling locations on the Traffic Corridor

Route A - Ashram Road		Route R - 132 feet Ring Road	
No.	Name of Station	No.	Name of Station
A1	RTO	R1	Vejalpur
A2	Sabaramati Ashram	R2	Jivraj Bridge
A3	Vadaj	R3	Parekh Hospital
A4	Usmanpura	R4	Punitnagar Rd
A5	Income-Tax	R5	Shivranjani
A6	Someshwar Temple	R6	Keshavbaug
A7	Nehru Bridge	R7	IIM
A8	Elliz Bridge	R8	Naranpura
A9	Bhikhu Chamber	R9	Ankur
A10	Paldi	R10	Pragatinagar
A11	120 Ft Ring Rd	R11	Akhabarnagar
A12	Vasna	R12	National Handloom

As there were 24 sampling locations, the entire traffic corridor was divided into 24 segments such that each sampling location is at the centre of the respective

segment and subsequently it was assumed that the sampling location would represent the corresponding traffic corridor segment.

Results and Discussions

Fig 2, 3 and 4 show the variation of the various noise indicators (parameters and indices) along the traffic corridor under study. Fig 2(a-c) shows the variation of L_{Aeq} , L_{min} and L_{max} ; Fig 3(a-c) shows the variation of L_{90} , L_{50} and $L_{=}$ while Fig 4(a-d) displays the variation of various noise indices like L_{NP} , TNI, NC, σ_{OL} along

the respective traffic corridor. Table 2 contains the range (min-max) of the various noise pollution parameters observed along the traffic corridor and Table 3 contains the details of the spatial extent (%) of the traffic corridor for the different ranges of the various noise pollution parameters.

Variation of L_{Aeq} along the Traffic Corridor

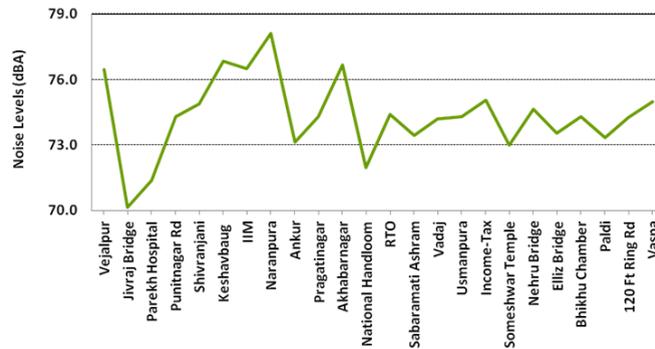


Fig. 2 (a): L_{Aeq} along the Traffic Corridor of Ahmedabad city

Variation of L_{min} along the Traffic Corridor

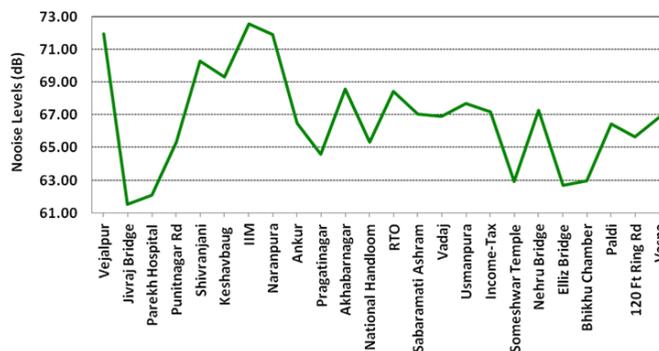


Fig. 2 (b): L_{min} along the Traffic Corridor of Ahmedabad city

Variation of L_{max} along the Traffic Corridor

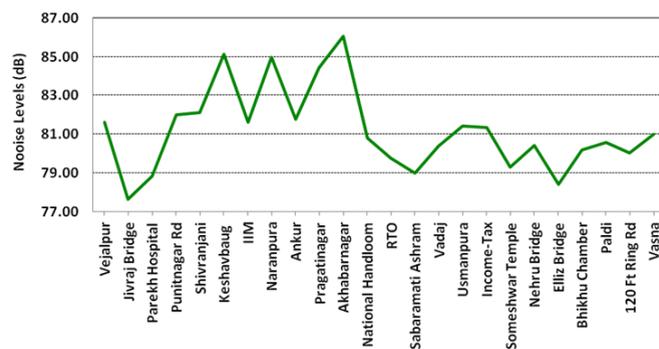


Fig. 2 (c): L_{max} along the Traffic Corridor of Ahmedabad city

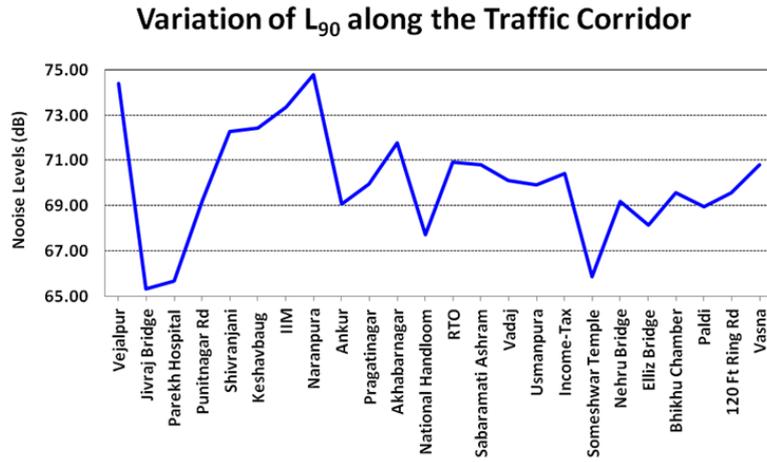


Fig. 3 (a): L_{90} along the Traffic Corridor of Ahmedabad city

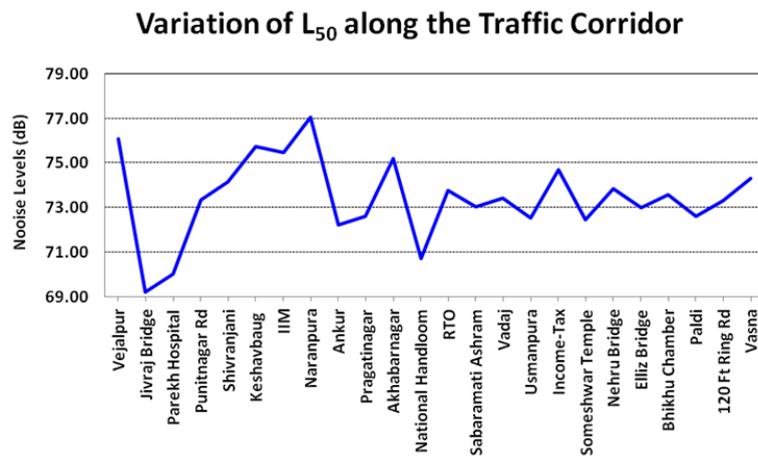


Fig. 3 (b): L_{50} along the Traffic Corridor of Ahmedabad city

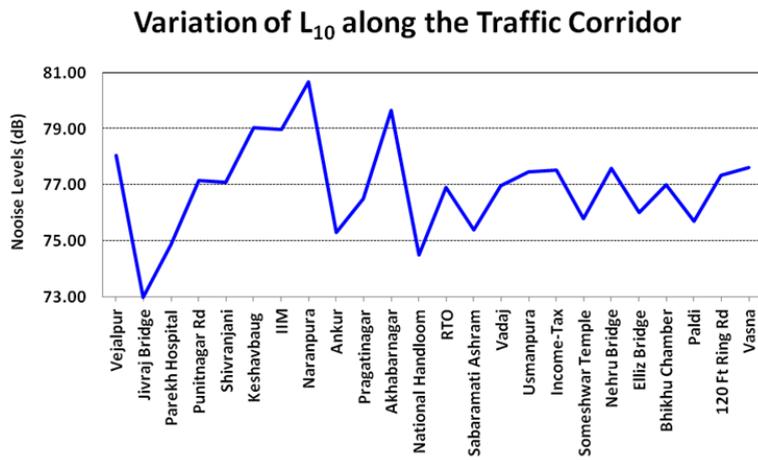


Fig. 3 (c): L_{10} along the Traffic Corridor of Ahmedabad city

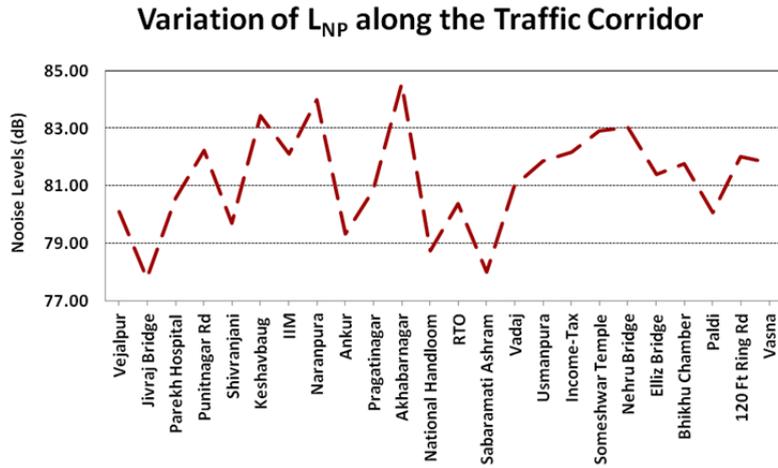


Fig. 4 (a): L_{NP} along the Traffic Corridor of Ahmedabad city

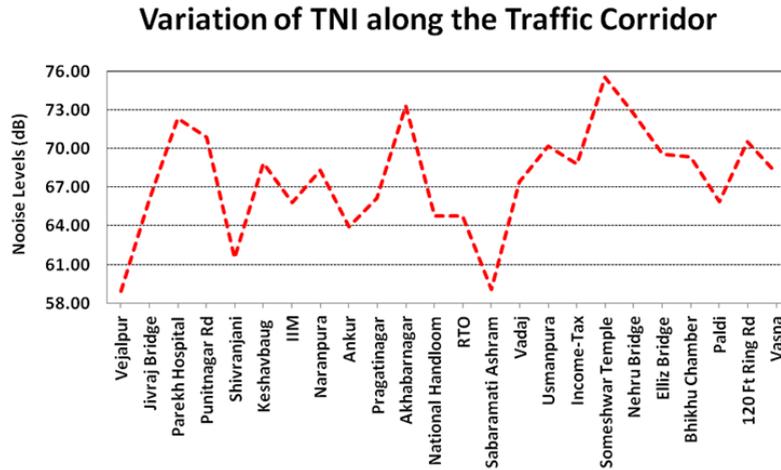


Fig. 4 (b): TNI along the Traffic Corridor of Ahmedabad city

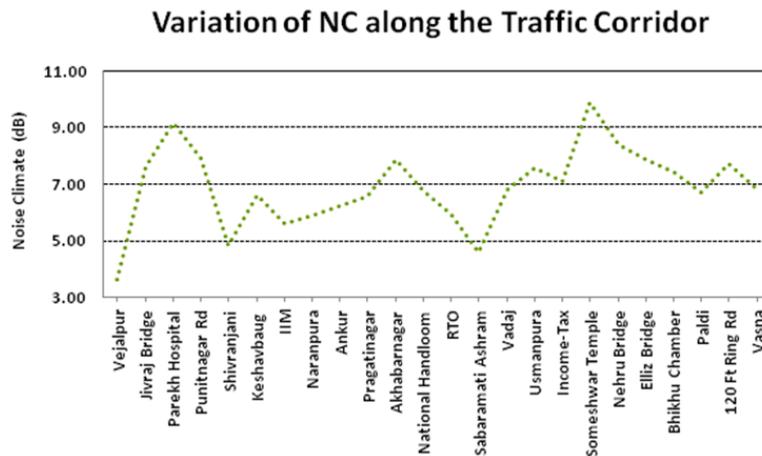


Fig. 4 (c): NC along the Traffic Corridor of Ahmedabad city

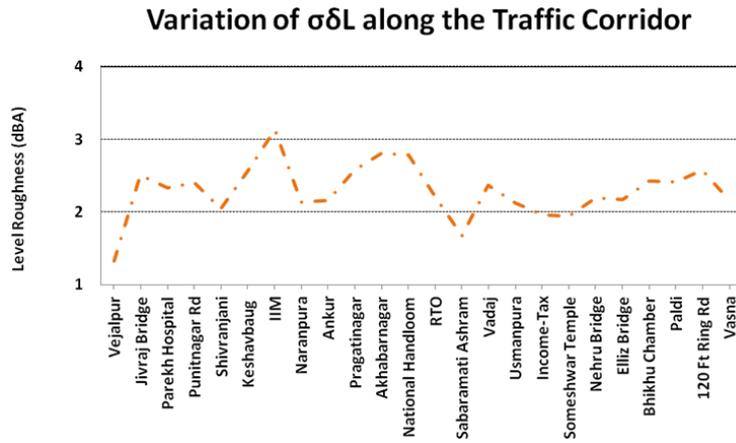


Fig. 4 (d): $\sigma_{\delta L}$ along the Traffic Corridor of Ahmedabad city

Table 2: Range of the various Noise Pollution Parameters across the Traffic Corridor

No.	Noise Pollution Parameter	Range of the Noise Pollution Parameter			
		Minimum		Maximum	
		dB (A)	Observed at sampling location	dB (A)	Observed at sampling location
1.	L_{Aeq}	70.2	Jivraj Bridge	78.1	Naranpura
2.	L_{min}	61.5	Jivraj Bridge	72.6	IIM
3.	L_{max}	77.6	Jivraj Bridge	86.0	Akhabarnagar
4.	L_{90}	65.3	Jivraj Bridge	74.8	Naranpura
5.	L_{50}	69.2	Jivraj Bridge	77.1	Naranpura
6.	L_{10}	73.0	Jivraj Bridge	80.7	Naranpura
7.	L_{NP}	77.8	Jivraj Bridge	84.6	Akhabarnagar
8.	TNI	59.0	Vejalpur	75.6	Someshwar Temple
9.	NC	3.6	Vejalpur	9.9	Someshwar Temple
10.	$\sigma_{\delta L}$	1.3	Vejalpur	3.1	IIM

Table 3: Spatial extent (%) of various Noise Pollution Parameters across the Traffic Corridor

No.	Noise Pollution Parameter (dB)	Range of the Noise Pollution Parameter (db)	Spatial Extent (%) of the traffic corridor
1.	L_{Aeq}	70 – 73	13.6
		73 – 76	58.9
		76 – 78	27.5
2.	L_{min}	61 – 65	20.4
		65 – 69	53.6
		69 – 73	26
3.	L_{max}	77 – 80	24.3
		80 – 83	58.1
		83 – 86	17.6

4.	L_{90}	65 – 68	17.1
		68 – 71	53
		71 – 75	29.9
5.	L_{50}	69 – 72	13.6
		72 – 75	58.9
		75 – 77	27.5
6.	L_{10}	73 – 76	29.8
		76 – 79	48.1
		79 – 81	22.1
7.	L_{NP}	77 – 80	20.3
		80 – 83	61.5
		83 – 85	18.2
8.	TNI	59 – 63	12.1
		63 – 67	33.4
		67 – 71	40.2
		71 – 76	14.3
9.	NC	3 – 5	12.1
		5 – 7	47.8
		7 – 10	40.1
10.	σ_{6L}	1 – 2	13.3
		2 – 3	86.7

 L_{Aeq}

From the Fig 3(a) and Table 2 & 3, it can be seen that the average noise pollution level (L_{Aeq}) of the entire corridor exceeds the prescribed guidelines (The Noise Pollution (Regulation and Control) Rules, 2000) which limits the daytime noise pollution level at 55 dB (A) for the residential areas and 65 dB (A) for the commercial areas. The L_{Aeq} ranges between 70.2 – 78.1 dB (A) and 58.9% of the corridor has the sound levels between 73 – 76 dB(A).

 L_{min}

From the Fig 3 (b) and Table 2 & 3, it can be seen that the minimum noise level (L_{min}) of the entire corridor ranged between 61.5 – 72.6 dB (A) and 53.6% of the corridor had the L_{min} between 65 - 69 dB (A).

 L_{max}

From the Fig 3 (c) and Table 2 & 3, it can be seen that the maximum noise level (L_{max}) of the entire corridor ranged between 77.6 - 86.0 dB (A) and 58.1% of the corridor had the L_{max} between 80-83 dB (A).

 L_{90}

From the Fig 4 (a) and Table 2 & 3, it can be seen that the background noise (L_{90}) of the entire corridor ranged between 65 – 75 dB (A) and 53.0% of the corridor had the L_{90} between 68 - 71 dB (A).

 L_{50}

From the Fig 4 (b) and Table 2 & 3, it can be seen that the average noise level (L_{50}) of the entire corridor ranged between 69.2 – 77.1 dB (A) and 58.9% of the corridor had the L_{50} between 72 - 75 dB (A).

 L_{10}

From the Fig 4 (c) and Table 2 & 3, it can be seen that the extreme noise (L_{10}) of the entire corridor ranged between 73.0 – 80.7 dB (A) and 48.1% of the corridor had the L_{10} between 76 - 79 dB (A).

 L_{NP}

From the Fig 5 (a) and Table 2 & 3, it can be seen that the Noise Pollution Level (L_{NP}) of the entire corridor ranged between 77.8 – 84.6 dB (A) and 61.5% of the corridor had the L_{NP} ranged between 80 – 83 dB (A).

TNI

From the Fig 5 (b) and Table 2 & 3, it can be seen that the Traffic Noise Index (TNI) of the entire corridor ranged between 59.0 – 75.6 dB (A) and 40.2% of the corridor had the TNI ranged between 67 - 71 dB (A).

NC

From the Fig 5 (c) and Table 2 & 3, it can be seen that the Noise Climate (NC) of the entire corridor

ranged between 3.6 – 9.9 dB (A) and 47.8% of the corridor had the NC ranged between 5 - 7 dB (A).

$\sigma_{\delta L}$

From the Fig 5(d) and Table 2 & 3, it can be seen that Level Roughness ($\sigma_{\delta L}$) of the entire corridor ranged between 1.3 – 3.1 and 86.7% of the corridor had the $\sigma_{\delta L}$ ranged between 2 – 3 dB(A).

- Ranking the various segments of the traffic corridor on the noise indicators like L_{Aeq} , L_{min} , L_{max} , L_{90} , L_{50} and L_{10} and further clubbing the performance reveals that segment represented by station R2 (Jivraj Bridge) had the relative lowest noise pollution while the segment represented by station R8 (Naranpura) had the relative highest noise pollution. The corridor segment represented by stations R5-R6-R7-R8 (Shivranjani - Keshavbaug - IIM - Naranpura) are in the bottom 6 stations of the corridor having relatively high noise pollution while stations R11 (Akhbarnagar) and R1 (Vejalpur) are the other 2 stations.
- Segment of the traffic corridor represented by stations A6 (Someshwar temple) and had the relatively highest Noise Climate value of 9.92 dB (A) while that represented by R1 (Vejalpur) had the relatively lowest value 3.64 dB (A).
- Segments of the traffic corridors represented by station R11 (Akhbarnagar) had the relatively highest Noise Pollution Level (L_{NP}) of 85.59 dB (A) followed by R8 (Naranpura) having 84.58 dB (A) while that represented by station A2 (Sabarmati Ashram) had the relatively lowest L_{NP} of 78.37 dB (A) followed by R2 (Jivraj Bridge) having it as 78.78 dB (A).
- From the present study, a brief idea can be drawn regarding the magnitude of the vehicular traffic led noise pollution problem in Ahmedabad city. Noting the fact that Ahmedabad city has 49 lakhs vehicles registered as on 31st March, 2020 (and is growing at the rate of 5-6% per annum), the per vehicle road length availability, which should have been ideally 2 m, is currently 0.54 m and is continuously dwindling due to stagnancy in the road network to 2600 km in the year 2017,⁴¹ there is an urgent need for undertaking the task of city level Noise Pollution Mapping and

subsequently initiating site specific noise pollution mitigation measures. The success of the mitigation measures would not only help to improve the health and productivity of the residents but would help the other urbanizing town and cities to take early preventive measures.

Conclusions

The salient conclusions of the 'noise pollution assessment' study performed over a busy traffic corridor of Ahmedabad city, one of the fastest developing cities of India, are as follows:

- The average noise level (L_{Aeq}) of the entire corridor always exceeded the prescribed guidelines (The Noise Pollution (Regulation and Control) Rules, 2000) which is indeed an alarming situation. The Noise Pollution (Regulation and Control) Rules, 2000 limits the daytime noise pollution level at 55 dB (A) for the residential areas and 65 dB (A) for the commercial areas.
- For the major portion of the traffic corridor (79.6%), even the minimum noise level (L_{min}) was above the permissible average noise level which increases the level of concern.
- The highest L_{max} observed was 86.0 dB (A).
- Segments of the traffic corridors represented by stations R11 (Akhbarnagar) and R8 (Naranpura) represent the noisiest locations.
- The traffic corridor segment represented by stations R5-R6-R7-R8 (Shivranjani - Keshavbaug - IIM - Naranpura) had the relatively high values for noise indicators like L_{Aeq} , L_{min} , L_{max} , L_{90} , L_{50} and L_{10}
- Looking to the implications the high noise levels have on the human health and in the background that the urban population would be increasing significantly, it is very important to focus on (i) improving the road infrastructure in terms of quality of roads and parking places (ii) regulating the traffic movement by synchronizing the traffic signals (iii) implementing the various aspects of Intelligent Transportation System (iv) popularizing the usage of public transportation vehicles (v) planning simple noise sinks like trees and plants (vi) strict implementation of rules pertaining to 'no parking' and 'no honking'.

- The findings of the present study would be of great help to civic administration of Ahmedabad city to understand the magnitude of the noise pollution problem which would help them to initiate mitigative strategies to abate the noise pollution problem of this busy traffic corridor of the city.

Future Scope of The Study

For the understanding the scenario of noise, efforts should be put for preparing a Noise Pollution Map of the city through field survey and through modelling. And later the effectiveness of the various mitigating strategies should be evaluated through the modelling approach. An interface of the noise pollution map with the population density map should also be attempted which would give a concrete idea regarding the number of people at different level of noise pollution led health risks. The synthesis of the above approaches would help to effectively plan the Noise Pollution Mitigative framework and the

execution of that would improve the quality of life of a common man.

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Conflicts of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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