Noise Measurement across Different Land-Use Patterns

Sreeraj Konadath, Akshay Mahadeva, Suma Chatni

Department of Audiology, All India Institute of Speech and Hearing, Mysore, Karnataka, India

Abstract

Introduction: In the current scenario, with noise exposure having serious effects on the well-being of an individual, it becomes necessary to monitor the noise levels in the environment and keep them under the permissible limits. The present research was aimed to measure and compare noise levels in different land-use patterns and also to identify a minimum duration required to obtain a stabilized LAeq values in environmental noise measurement. **Methods:** Noise measurements were carried out across residential, commercial, sensitive, and mixed land-use patterns during morning and afternoon time frames. The obtained results were represented using isopleth noise maps. **Results:** It was noted that noise levels exceeded the prescribed limits in all the four land-use categories. The greatest level of noise was noted in commercial areas followed by mixed, sensitive, and residential land-use types. Significant variations in LAeq values were noted only up to 10 min of noise measurement, and measured noise levels were stabilized beyond 10-min time mark in all the land-use categories. **Conclusion:** The higher noise levels recorded in the city would bring about adverse health effects on city dwellers in the long run, thus calling for strict law enforcement related to monitoring of noise levels and keeping them in check.

Keywords: Isopleth noise map, measurement duration, stabilized LAeq, time frames

Date of Submission : 03-07-2018 **Date of Revision :** 19-03-2019 **Date of Acceptance :** 22-04-2019 **Date of Web Publication :** 11-12-2019

Introduction

A typical human-built urban environment comprises the physical infrastructure, open fields, parks, and urban forests. Urbanization has been the constant shaping force of the human environment.[1] A built environment because of its inherent characteristics, built quality, and spatial planning has been attributed to bring about positive and negative health outcomes.[2,3] Progressive urbanization has been associated with negative health impact bringing about chronic outcome of diseases.[4] With advancement in urbanization, environmental noise has become a necessary part of urban soundscape with rail, road, and air traffic sources contributing as the major sources. Additional noise sources in an urban environment comprise domestic, commercial, and industrial noise sources.[5] Environmental noise has been linked to bring about certain negative impact on health and well-being of an individual which is majorly nonauditory in nature posing serious threat to the quality of life. Noise is considered as one of the major urban stressors in the current scenario, and studies in the literature have linked noise to several nonauditory effects including performance reductions,[6-8] abnormal endocrine responses,[9] sleep disturbances,[10] risk of cardiovascular problems,[11-13] and stress and anxiety.[14]

Certain regulatory bodies have been formulated to monitor the acceptable noise levels in the community. Environmental protection agency of the United States recommends maximum noise levels of 45 dB(A) and 55 dB(A) for intelligible communication to occur at indoor and outdoor, respectively.[15] However, in certain countries, the acceptable noise limits are given with respect to land-use patterns of the area.[16] The Indian Central Pollution Control Board constituted a Committee on Noise Pollution Control and provided guidelines for acceptable noise limits, and the same was later notified in the Environment Protection Act (EPA).[17] The acceptable noise limits vary depending on the time of the day and the land-use pattern of the area, where a greater allowance is given for day period and for industrial areas. The permissible

Address for correspondence: Dr. Sreeraj Konadath,
Department of Audiology, All India Institute of Speech and Hearing, Mysore, Karnataka, India.
E-mail: sreerajkonadath@aiishmysore.in

Access this article online

Quick Response Code:

Website: www.jisha.org

DOI: 10.4103/jisha.JISHA_26_18

How to cite this article: Konadath S, Mahadeva A, Chatni S. Noise measurement across different land-use patterns. J Indian Speech Language Hearing Assoc 2019;33:55-62.

noise limits generally increase with respect to the amount of activity occurring in the land under use. However, over the years, exceedance of noise levels has been noted in many urban settlements of developing countries.[18]

Since noise exposure has serious effects on the well-being of an individual, it becomes necessary to monitor the noise levels in the environment and keep them under the permissible limits. Research into these issues is required not only to protect the health and well-being of urban inhabitants but also plays a role in policy-making decisions and development planning that takes into consideration the potential health and environmental consequences of development.[19] To date, few studies have examined how noise varies as a function of urban development.[20,21] The aim was to examine how noise varies as a function of urban development.

Different measurement durations have been employed across studies to measure environmental noise levels. In one of the studies, they measured noise levels for duration of 8 h at every single recording point.[22] Few studies have employed a sampling frequency of 15-min measurements for every 2 h,[23] whereas others have employed continuous assessments (24 h).[24] A study was carried out to measure environmental noise using a measurement duration of 10 min with interval duration of 30 s,[25] whereas another study employed a measurement duration of 15 min to measure the noise levels in the city of Chennai during working and nonworking days.[26] As it could be seen, it is evident that different measurement durations have been employed in the literature for the purpose of noise measurement and it is not conclusive as to what is the minimum duration of measurement required to represent the environmental noise levels effectively.

The aim of the present research was to measure and compare noise levels in different land-use patterns of Mysore city during working hours. The current study also aims at establishing a norm for minimum duration for environmental noise measurement to obtain a stabilized equivalent continuous sound level (LAeq) values.

Methods

Description of study area

Mysore is located at 76°12' (East) longitude and 12°18' (North) latitude. It is the second single largest city in the state of Karnataka, with an average population about of 887,446 as per 2011 provisional census figures. The city has a wholesome climate, and the temperature varies from 12°C to 35°C. It has an average annual rainfall of about 798 mm. The city spreads across an area of 128.42 sq.km.[27] In the city of Mysore, majority of the lands have been devoted for residential purposes. This study area was confined to within the outer ring road and was classified into respective categories based on local land development authority's definition of land-use patterns.

Instrumentation and measurement points

Areas to be mapped were selected, and equidistant allocation of measurement points was done. This yielded a distance of approximately 500 m between two measurement points. Noise measurements were carried out at street level across different land-use patterns in the study area specifically, residential, commercial, sensitive, and mixed land-use patterns. On total, noise measurements were carried out at 216 selected points. Permissions were obtained from the concerned authorities to measure the ambient noise levels in various public places. Measurements were carried out during working days and under suitable weather conditions, in the following time frames: morning (07:00–12:00 h) and afternoon (12:00–17:00 h). The measurement during the above-mentioned time frame was carried out using a calibrated sound level meter (SLM) mounted on a tripod stand with the microphone placed at a height of 1.5 m from the floor of the measurement loci. A Brüel and Kjær type 2270 was employed which is a Class I SLM which performs sound intensity measurements as per IEC61043 standards with a frequency range of 4.2 Hz–22.4 kHz and measuring range of 16.6–140.6 dB(A). All the measurements were carried out using "A-" weighting network and in "fast" mode response. A windshield was used to cover the microphone during noise measurement, and appropriate corrections were employed. The following noise indices were computed: LAeq, LAFmax, and LAFmin (equivalent continuous sound level; maximum and minimum level with A-weighted frequency response and fast time constant). The LAeq, LAFmax, and LAFmin were measured over the period of the above-mentioned time frame. Measurement was done at a site for duration of 15 min and the same was repeated for three times within each time frame, which would later be averaged to obtain final LAeq, LAFmax, and LAFmin (average of measurement at a particular site for three times in each time frame). All together 1296 recordings were collected. Once the data were collected, it was analyzed to study the LAeq values at the end of the following time marks: 5, 10, 11, 12, 13, 14, and 15 min so as to study whether LAeq value is getting stabilized before the 15-min time mark.

Generation of isopleth noise maps

Isopleth map refers to a color-coded map wherein different colors indicate different noise levels present in various areas of the city under the study. Here, information on noise levels is superimposed as a layer, on the existing geographical map which could be used to visualize the level of noise in different parts of the city.

Coordinates (longitude and latitude) of all the measurement points were entered into the base map, which is the local planning area boundary of the Mysore city using ArcGIS was released by Esri and was unveiled at the Esri International User Conference (2000). Data on average noise levels (LAeq) in dB sound pressure level (SPL) at each of the measurement point were fed into the ArcGIS. This procedure was repeated for both time frames. Therefore, each measurement point on the map contained information regarding geographical coordinates and average noise levels. As noise measurements were carried out only at predetermined points, surface interpolation was employed to predict noise levels at nonmeasured locations. The surface area of the map was divided into many grid cells. Surface interpolation uses all or a defined set of samples to estimate the final output of each grid.[20] Kriging interpolation method was used to map the noise levels where noise levels at known points influenced the interpolated values depending on the distance from the output point.

The following formula was employed for Kriging interpolation:

$$\hat{N}(s_o) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

Where:

$Z(s_i)$ = the measured value at the i^{th} location

λ_i = an unknown weight for the measured value at the i^{th} location

s_0 = the prediction location

N = the number of measured values

The average level of noise obtained at each of the land-use types was compared to prescribed standards given by EPA.[17]

Results

Data obtained inset for all conditions were tabulated. Descriptive and inferential statics were carried out using the Statistical Package for the Social Sciences (SPSS), version 20 SPSS statistics, (IBM corporation, Armonk, Newyork). Prior to the inferential statistics, the data were subjected to check the assumptions of parametric statistics. The normality of distribution was tested using Shapiro–Wilk test. Results showed nonnormally distributed data for certain conditions ($P > 0.05$). Hence, nonparametric tests were used for further data analysis. Results of noise levels measured in all four categories and in two different time frames were subjected to descriptive statistics to obtain the mean and standard deviation. The same is tabulated in Table 1.

From the table, it could be noted that greater levels of noise were recorded in commercial area, followed by mixed and sensitive. Least amount of noise was recorded in residential areas. However, the level of noise did not vary greatly as a function of time frame during which noise was measured. Average levels of noise (LAeq) in four different land-use types at two measurement time frames are given in Figure 1.

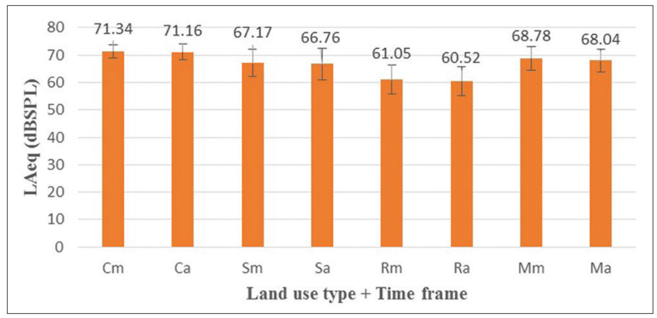

Figure 1: Average noise levels in the city of Mysore across different land-use types at two different time frames. Note: Cm: Commercial – Morning; Ca: Commercial – Afternoon; Sm: Sensitive – Morning; Sa: Sensitive – Afternoon; Rm: Residential – Morning; Ra: Residential – Afternoon; Mm: Mixed – Morning; Ma: Mixed – Afternoon

Table 1: Mean and standard deviation of LAeq, LAFmin, and LAFmax (maximum and minimum level with A-weighted frequency response and fast time constant) for different land-use patterns across two time frames

	LAeq (dB SPL)		LAFmin (dB SPL)		LAFmax (dB SPL)	
	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Commercial						
Mean	71.34	71.16	53.61	53.28	93.4	93.2
SD	2.50	2.92	4.88	5.01	3.24	4.50
n	54	54	54	54	54	54
Sensitive						
Mean	67.17	66.76	49.50	48.73	90.31	89.55
SD	5.08	5.71	5.18	5.47	4.41	5.93
n	32	32	32	32	32	32
Residential						
Mean	61.05	60.52	44.48	41.98	85.30	84.74
SD	5.33	5.26	16.20	4.43	6.07	6.18
n	92	92	92	92	92	92
Mixed						
Mean	68.78	68.04	50.35	49.88	92.27	90.43
SD	4.47	4.23	5.91	6.03	4.72	4.95
n	35	35	35	35	35	35

SD: Standard deviation; SPL: Sound pressure level

Studying the effect of land-use pattern and time frame of noise measurement on noise indices

To study the effect of land-use pattern, LAeq, LAFmin, and LAFmax values were compared across time frames between four categories using Kruskal–Wallis test with category being the grouping variable. The results revealed that all the noise indices compared varied significantly across four groups in both the time frames. Pairwise comparison was carried out following studying the effect of time frame of noise measurement on measured noise levels. Test statistics obtained were as follows:

- Morning: LAeq – $H(3) = 108.85$, $P < 0.01$; LAFmin – $H(3) = 93.42$, $P < 0.01$; and LAFmax – $H(3) = 75.37$, $P < 0.01$
- Afternoon: LAeq – $H(3) = 108.95$, $P < 0.01$; LAFmin – $H(3) = 103.16$, $P < 0.01$; and LAFmax – $H(3) = 66.01$, $P < 0.01$.

To study the effect of measurement time frame on noise levels, Mann–Whitney U-test was carried out comparing the values obtained across categories between two time frames. Measurement time frame was being the grouping variable. Results revealed that noise levels for any of the parameters assessed did not vary significantly in any of the land-use categories, as a function of time. Test statistics obtained were as follows:

- Commercial: LAeq – $U = 1436.50$, $z = -0.13$, $P > 0.05$, $r = -0.01$; LAFmin – $U = 1421.50$, $z = -0.22$, $P > 0.05$, $r = -0.02$; and LAFmax – $U = 1415.00$, $z = -0.26$, $P > 0.05$, $r = -0.02$
- Sensitive: LAeq– $U = 507.00$, $z = -0.67$, $P > 0.05$, $r = -0.08$; LAFmin– $U = 478.00$, $z = -0.46$, $P > 0.05$, $r = -0.05$; and LAFmax– $U = 474.50$, $z = -0.50$, $P > 0.05$, $r = -0.06$
- Mixed: LAeq – $U = 528.50$, $z = -0.98$, $P > 0.05$, $r = -0.11$; LAFmin – $U = 601.50$, $z = -0.13$, $P > 0.05$, $r = -0.01$; and LAFmax – $U = 512.50$, $z = -1.17$, $P > 0.05$, $r = -0.13$
- Residential: LAeq – $U = 3993.00$, $z = -0.66$, $P > 0.05$, $r = -0.04$; LAFmin – $U = 3730.00$, $z = -1.39$, $P > 0.05$, $r = -0.10$; and LAFmax – $U = 4011.00$, $z = -0.61$, $P > 0.05$, $r = -0.05$.

As the results of Kruskal–Wallis test showed a significant effect of land-use categories on the noise indices measured and there was no significant effect of time frame on measured noise levels, pairwise comparison was done using Mann–Whitney U-test, as to study among what groups did the significance was noted. Results revealed that all the categories were significantly different from one another, except for mixed land-use type when compared with sensitive category (LAeq – $U = 983.00$, $z = -1.32$, $P > 0.05$, $r = -0.16$; LAFmin – $U = 510.00$, $z = -0.62$, $P > 0.05$, $r = -0.07$; and LAFmax – U = 974.50, $z = -1.42$, $P > 0.05$, $r = -0.17$). Similar results were obtained for both the time frames. The test statistics are computed in Table 2.

Studying the effect of duration of noise measurement on average noise levels (LAeq)

The nonparametric Friedman's test was carried out for different land-use types, where LAeq at different time marks acted as the repeated measure in each group. Results revealed that on overall comparison, LAeq values varied significantly as a function of time marks only in residential land-use category (χ^2 (6) = 34.33, $P < 0.01$). However, there was no significant effect of different time markers on LAeq values for commercial (χ^2 (6) = 9.72, $P > 0.01$), mixed (χ^2 (6) = 13.66, $P > 0.01$), and sensitive (χ^2 (6) = 7.32, $P > 0.01$) land-use types. Since a significant effect of time marks on LAeq was noted in residential land-use category, pairwise comparison of LAeq at time markers was carried. Keeping LAeq at 15 min as the reference level, LAeq obtained at other time marks was compared to see whether any difference exists among LAeq values at different time marks. This would give an idea as to what is the time mark at which the LAeq values are getting stabilized. The results obtained on running the statistics are computed in Table 3 and represented in Figure 2.

Table 2: *Z* values obtained on pairwise comparison of land-use types at different time frames

Land-use category	LAeq (dB SPL), *Z*		LAFmin (dB SPL), *Z*		LAFmax (dB SPL), *Z*	
Comparison	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
1 Vs 2	−3.74*	−3.70*	−3.48*	−3.76*	−2.98*	−3.03*
1 Vs 3	−3.13*	−3.98*	−2.68*	−2.86*	−1.37*	−2.93*
1 Vs 4	−9.40*	−9.31*	−8.52*	−8.90*	−7.81*	−7.50*
2 Vs 3	−1.31	−0.94	−0.62	−0.64	−1.42	−0.76
2 Vs 4	−4.90*	−4.95*	−5.36*	−5.48*	−4.18*	−3.60*
3 Vs 4	−6.37*	−6.30*	−5.71*	−6.19*	−5.52*	−4.59*

*P<0.01; two-tailed. SPL: Sound pressure level

Table 3: Comparison of LAeq values at different time marks with 15-min time mark across land-use categories

	LAeq 15	LAeq 14	LAeq 13	LAeq 12	LAeq 11	LAeq 10	LAeq 5
Commercial (*n*=54)	71.25	71.23	71.24	71.20	71.16	71.18	70.96*
Sensitive (*n*=32)	66.96	66.94	66.92	66.77	66.66	66.92	66.82
Mixed (*n*=35)	68.41	68.45	68.46	68.40	68.39	68.36	68.97*
Residential (*n*=92)	60.78	60.73	60.71	60.67	60.69	60.53	60.12*

*P<0.01; two-tailed

From the above results, it could be noted that a significant difference in LAeq values was noted only on comparing noise levels at 15-min time mark with that of 5-min time mark for all the categories except for sensitive land-use type where the duration of noise measurement did not have any effect on noise levels. It could be concluded from the above findings that LAeq values are stabilized at 10 min of recording and did not vary significantly on comparing up to 15 min.

Discussion

Excessive noise levels in the surrounding environment have been one of the major complaints in most of the urban settlements in recent days. Disturbance arising from such noises has been noted in contributing to altered work and sleep patterns and affecting urban inhabitants in their daily life. With gradual increase in noise levels in the environment, a pressing need has been developed to monitor noise levels and thereby drawing the attention of environment researchers. The current research was carried out with an aim of measuring noise levels across different land-use patterns in the city of Mysore during morning and afternoon time frames and comparing it with the prescribed noise standards. The current study also intended in finding out the minimum duration of noise measurement required to obtain a stabilized LAeq values across different land-use categories.

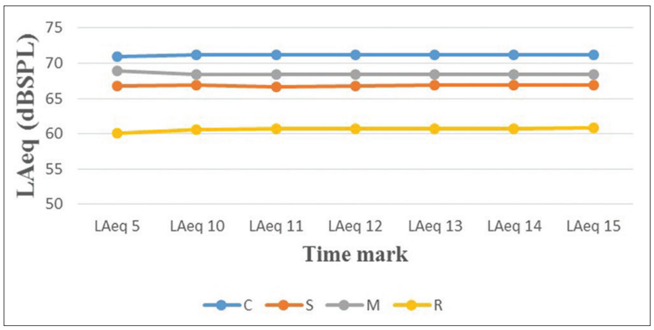

Figure 2: Comparison of LAeq values at different time marks across land-use categories

Relationship between land-use patterns and measured noise levels

Comparison of noise levels across different land-use types was carried out and was compared with the prescribed standards [Table 4].[17] Isopleth noise maps of average noise level for Mysore city during morning and afternoon time frames are shown in Figures 3 and 4. It was noted that noise levels varied significantly across land-use types during both the time frames. Highest levels of noise were recorded in commercial land-use type followed by mixed, sensitive, and residential areas.

It could be noted that the measured levels exceeded the prescribed noise limits across all the land-use categories. The

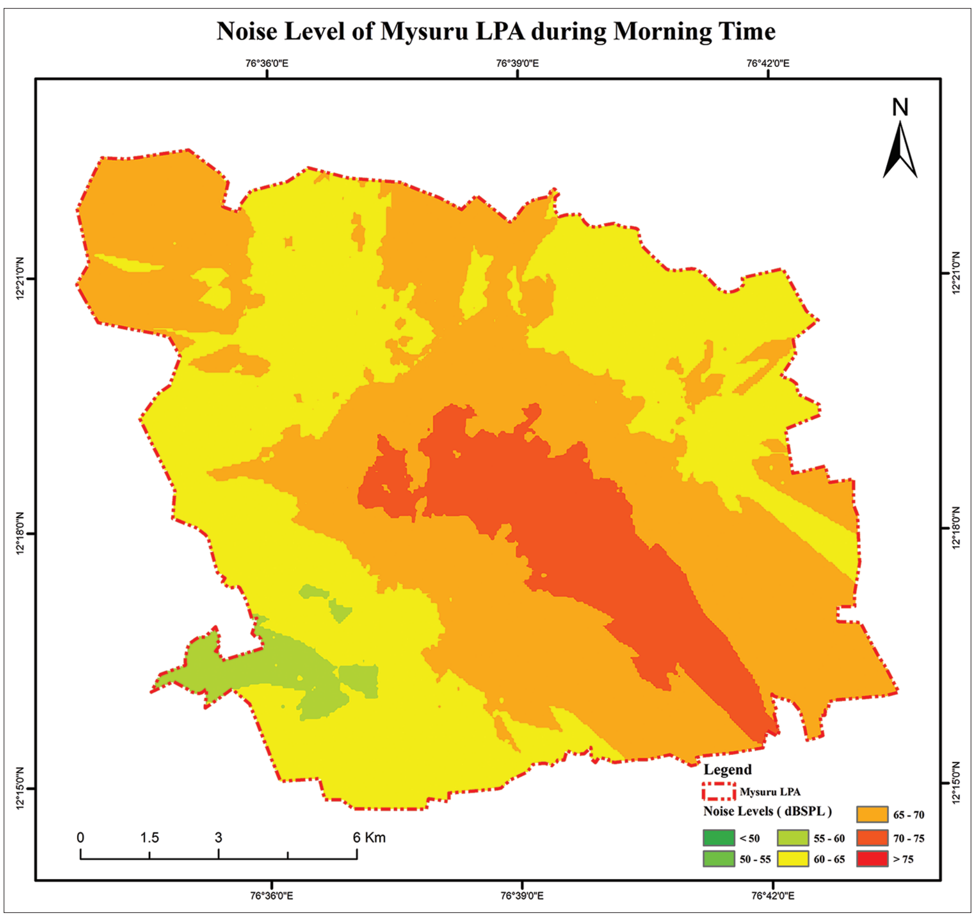

Figure 3: Isopleth noise map of average noise levels for Mysore city during morning time frame

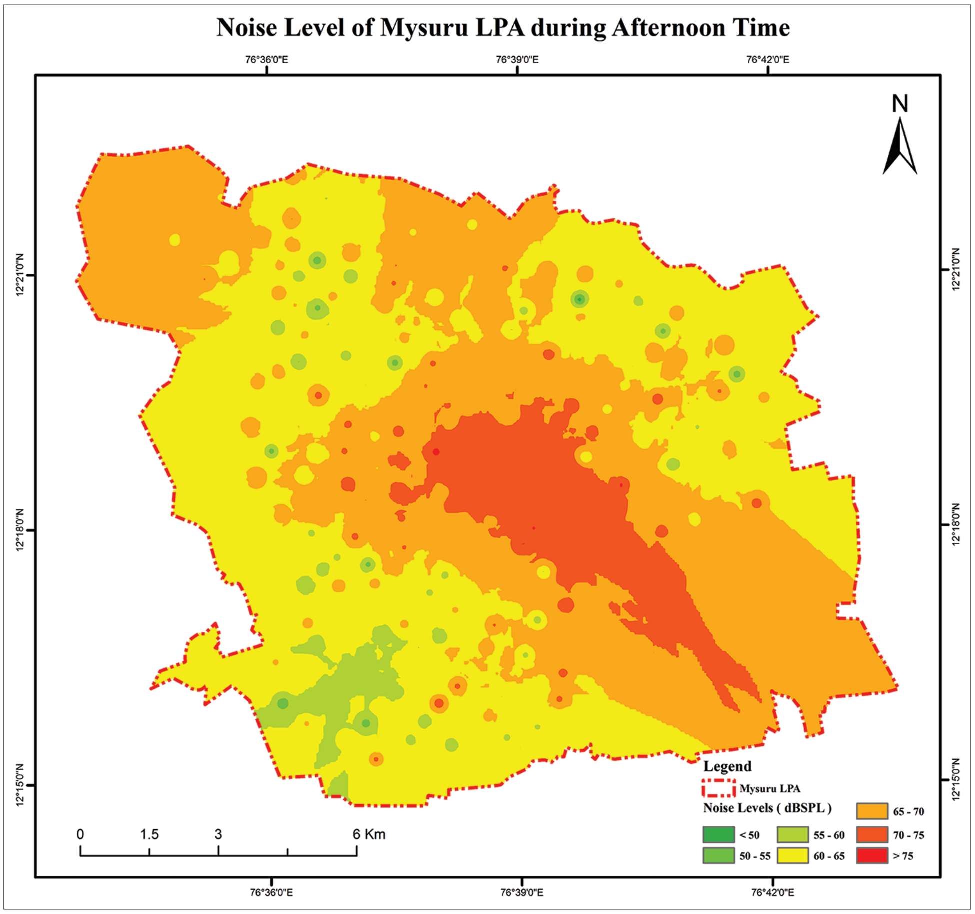

Figure 4: Isopleth noise map of average noise levels for Mysore city during afternoon time frame

Table 4: Comparison of measured and prescribed, LAeq values across different land-use categories

Land-use type	Daytime (dB SPL)	
	Prescribed levels	Measured levels
Mixed area	Norms not available	68.41
Commercial area	65	71.25
Residential area	55	60.78
Silent zone	50	66.96

SPL: Sound pressure level

average noise level measured in commercial area was 71.25 dB SPL ranging from 61.22 to 76.58 dB SPL. Although majority of the lands in the city have been denoted toward residential purposes, being an urban settlement, the city encompasses numerous commercial settings varying from isolated settings to clustered ones. The increased noise levels in the commercial setup could be attributed to narrow roads and tall commercial buildings bringing about a canyon effect. It was also noted that most of the commercial setups were established in the city center, where a greater vehicular density on road was observed. With noise levels being higher than the prescribed limits, people who have work setup over here are at greater risks for adverse effects of noise. Excessive noise levels in sensitive zones (areas within 50 m of an educational/hospital set-up) could be attributed to poor city development planning. The average noise levels measured in sensitive area was 66.96 dB SPL ranging from 53.30 to 75.56 dB SPL. Most of the sensitive zones have been placed among the commercial setup where higher levels of noise become inevitable. Lack of adequate 'no honking' signs and minimal awareness among common citizens has contributed to poor ambient noise levels.

Nearly 50% of land uses in the city planning have been attributed to residential purposes. Although the least levels of noise were recorded in residential land-use type, the levels recorded were greater than the prescribed noise limits. The average noise level measured in residential area was 60.78 dB SPL ranging from 46.91 to 73.07 dB SPL with vehicular noise being the major contributor. Two different kinds of residential setup were observed in the study area. One being, with ample space among the residential structures, well vegetated and with thick green belt, whereas, the other setup had tall and crowded residential infrastructures with minimal vegetation were noted in other categories. Higher levels within residential land use were noted in such crowded residential infrastructures, with their residences being more prone to adverse effect of environmental noise. An average noise level of 68.41 dB SPL was noted in the mixed land-use pattern. The noise levels ranged from 57.40 to 77.25 dB SPL. Although no prescribed noise standards have been given for mixed land-use type, the levels measured could be assumed to be greater than the desirable levels, as they exceed the limits for a completely commercial land-use type. The mixed land-use pattern basically comprised residential and commercial setups, thereby accounting for the wider range in measured noise levels.

Although not statistically significant, higher levels of noise were recorded during morning time frame compared to afternoon which could be attributed to morning rush seen due to people attending to their workplace.

Studying the effect of duration of noise measurement on average noise level (LAeq)

With various noise duration measurements employed in the literature, the current study aimed to understand as to what is the minimum duration of measurement required to obtain a stabilized LAeq values. On initial overall comparison, effect of duration was found to be significant only in residential land-use type. The general background activity observed in the study area was low due to minimum vehicular movement and commercial activities. With the background noise level generally being on the lower side, one sporadic high-intensity instance occurring at any moment (e.g., a truck passing by car/bike honking, dog barking, etc.) would bring about a greater change in the overall noise level being measured. However, such effects were not seen in other land-use types, where general background noise was not low enough for one sporadic high-intensity event to bring about a drastic change in overall noise levels measured.

From the statistics reported in the result section, it could be noted that although significant effect of duration was noted only in residential land-use type, on pairwise comparison, it could be seen that there existed a significant difference in LAeq values measured at the end of 5- and 15-min time mark among all the categories except for sensitive land-use type. However, no significant difference in LAeq values was noted on the following comparisons in any of the land-use categories: 15 versus 14, 15 versus 13, 15 versus 12, 15 versus 11, and 15 versus 10 min time mark. Based on the above findings, it could be said that significant variations in LAeq values were noted only up to 10 min of noise measurement and measured noise levels were stabilized beyond 10-min time mark.

Conclusion

The present research studies the levels of noise in the city of Mysore as a function of land-use types and time frame of measurement. It was noted that the levels of noise exceeded the prescribed limits in all the four land-use categories, indicating that land-use activities in these categories were carried out without taking noise limits into consideration. No significant difference in noise levels was noted between two time frames of noise measurement. The greatest level of noise was noted in commercial areas, followed by mixed, sensitive, and residential areas indicative of influence of land-use types on noise levels. Vehicular noise was identified as the major noise source, with increase in number of private vehicles contributing to it. Strict rules are needed to be employed on limits on noise generated by vehicles, as alterations of automobile silencers emitting greater noise have grown as a trend. Increase in green belts could be used as an effective strategy in noise controlling, which acts as a noise barrier in the path of transmission. The higher noise levels recorded in the city would bring about adverse health effects on city dwellers in the long run, thus calling for a strict law enforcement related to monitoring of noise levels and keeping them in check.

Financial support and sponsorship

This study was financially supported by the AIISH Research Fund ARF-27/2015-16.

Conflicts of interest

There are no conflicts of interest.

References

1. Northridge ME, Sclar ED, Biswas P. Sorting out the connections between the built environment and health: A conceptual framework for navigating pathways and planning healthy cities. J Urban Health 2003;80:556-68.
2. Galea S, Ahern J, Rudenstine S, Wallace Z, Vlahov D. Urban built environment and depression: A multilevel analysis. J Epidemiol Community Health 2005;59:822-7.
3. Kaczynski AT, Potwarka LR, Saelens BE. Association of park size, distance, and features with physical activity in neighborhood parks. Am J Public Health 2008;98:1451-6.
4. Dannenberg AL, Jackson RJ, Frumkin H, Schieber RA, Pratt M, Kochtitzky C, *et al.* The impact of community design and land-use choices on public health: A scientific research agenda. Am J Public Health 2003;93:1500-8.
5. Brown AL, Lam KC. Urban noise surveys. Appl Acoust 1987;20:23-39.
6. Loeb M. Noise and Human Efficiency. Ch. 9. Chichester, U.K: New York: Wiley; 1986. p. 181.
7. Salame P, Baddeley A. Disruption of short-term memory by unattended speech: Implications for the structure of working memory. J Verbal Learn Verbal Behav 1982;21:150-64.
8. Glass DC, Singer JE. Urban Stress: Experiments on Noise and Social Stressors. Ch. 1. New York: Academic Press; 1972. p. 20.
9. Cavatorta A, Falzoi M, Romanelli A, Cigala F, Riccò M, Bruschi G, *et al.* Adrenal response in the pathogenesis of arterial hypertension in workers exposed to high noise levels. J Hypertens Suppl 1987;5:S463-6.
10. Horne JA, Pankhurst FL, Reyner LA, Hume K, Diamond ID. A field study of sleep disturbance: Effects of aircraft noise and other factors on 5,742 nights of actimetrically monitored sleep in a large subject sample. Sleep 1994;17:146-59.
11. Zhao YM, Zhang SZ, Selvin S, Spear RC. A dose response relation for noise induced hypertension. Br J Ind Med 1991;48:179-84.
12. Herbold M, Hense HW, Keil U. Effects of road traffic noise on prevalence of hypertension in men: Results of the luebeck blood pressure study. Soz Praventivmed 1989;34:19-23.
13. Green MS, Schwartz K, Harari G, Najenson T. Industrial noise exposure and ambulatory blood pressure and heart rate. J Occup Med 1991;33:879-83.
14. Cohen S, Weinstein N. Nonauditory effects of noise on behaviour and health. J Soc Issues 1981;37:36-70.
15. United States. Office of Noise Abatement, Control. Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety for Sale by the Supt. of Docs., US Govt. Print. Off.; 1974.
16. Berglund B, Lindvall T, Schwela DH; World Health Organization. Guidelines for Community Noise 1999. World Health Organization; 2014. Available from: http://whqlibdoc.who.int/hq/1999/a68672.pdf.

[Last accessed on 2019 May 01].
17. EPA. Air Quality Criteria Document for Lead. Environmental Criteria and Assessment Office, US Environmental Protection Agency, Research Triangle Park, North Carolina; 1986.
18. Edwin C, Tuya Y. State of the Environment and Policy Retrospective: 1972-2002. UNEP; 2014.
19. King G, Roland-Mieszkowski M, Jason T, Rainham DG. Noise levels associated with urban land use. J Urban Health 2012;89:1017-30.
20. Jamir L, Nongkynrih B, Gupta SK. Community noise pollution in urban India: Need for public health action. Indian J Community Med 2014;39:8-12.
21. Garg N, Maji S. A retrospective view of noise pollution control policy in India: Status, Proposed revisions and control measures. Curr Sci 2013;111:29-38.
22. Iaaly-Sankari A, Jadayel O, El-Murr N, Center GI. Urban noise mapping: The case of the city of El-Mina, North Lebanon. In: Proceedings Middle East & North Africa Users Conference ESRI; 2010.
23. Piccolo A, Plutino D, Cannistraro G. Evaluation and analysis of the environmental noise of Messina, Italy. Appl Acoust 2005;66:447-65.
24. Gaja E, Gimenez A, Sancho S, Reig A. Sampling techniques for the estimation of the annual equivalent noise level under urban traffic conditions. Appl Acoust 2003;64:43-53.
25. Baloye DO, Palamuleni LG. A comparative land use-based analysis of noise pollution levels in selected urban centers of Nigeria. Int J Environ Res Public Health 2015;12:12225-46.
26. Kalaiselvi R, Ramachandraiah A. Environmental noise mapping study for heterogeneous traffic conditions. In: Proceedings of 20th International Congress on Acoustics, ICA; 2010. p. 23-7.
27. Shankar B, Vidhya D. Changing dynamics of land use in residential neighbourhood of Vani Vilasa Mohalla Mysore. Int J Modern Eng Res 2013;3:678-84.