Development of Noise Map using GIS for Lucknow Metropolis

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Abstract*: Noise pollution is a problem increasingly acknowledged by authorities and governments around the globe. Geographical Information Systems (GIS 10.1)can conveniently be adapted together to analyse and present noise information. Noise maps can be used to assess and monitor the influence of noise effects. Residents living in high rise buildings are also severely affected by traffic noise. The integration of GIS and noise maps makes it possible to increase the quality of noise effect studies by dealing with uncertainties, by applying standardized methods to study and quantify noise effects.The present work aimed at development of noise map for Lucknow metropolis. In this study, a total of 10 locations were selected for collection of data. Noise pollution can damage physiological and psychological health. The noise levels in terms of L_{10}, L_{90}, L_{AEQ},L_{NP} and TNIhave measured using Sound Level Meter (SPL). The noise levels were observed in the month of September 2017 to November 2017. In the morning time (7AM-9AM) residential zones L_{EQ} was found in the range of 77.89-80.70dB (A), in commercial zones L_{EQ} was in the range of 72.00-82.16dB (A), in industrial zones L_{EQ} was in the range of 68.26-71.62dB (A) and in the silence zones L_{EQ} was in the range of 75.00-78.26dB (A).In the afternoon(12PM-2PM) noise levels were observed for residential zones L_{EQ} was in the range of 64.70-83.72dB(A), for commercial zones L_{EQ} was in the range of 74.90-84.52dB(A), for industrial zones L_{EQ} was in the range of 72.32-75.28dB(A) and for silence zones L_{EQ} was in the range of 73.19-76.49dB(A). In the evening (6PM-8PM) noise levels for residential zones L_{EQ} were found in the range of 76.29-81.03dB (A), for commercial zones L_{EQ} was in the range of 75.16-85.45dB (A), for industrial zones L_{EQ} was in the range of 69.68-81.82 dB(A) and for silence zones was in the range of 68.74-71.78dB(A).Except in industrial zone in all other zones the noise levels are beyond limits.

***Index Terms*: – Noise Pollution, GIS, Traffic Noise Maps.**

I. INTRODUCTION

Noise levels can be researched in different ways: as traffic and transportation; industrial activities, marketing and entertainment facilities [Dursun]. In contrast to other pollutants, the control of environmental noise is interrupted by insufficient knowledge of its effects on humans and lack of defined criteria. Noise pollution is a significant environmental problem in many rapidly urbanizing areas; it is not recognized as serious in many cases, yet it steadily grows in developing and developed countries alike. Among the common negative consequences resulting from urbanization is environmental noise pollution. This is an obvious problem at a time when there is great difficulty in ensuring that urban areas of Lucknow become functional and aesthetically pleasing. Urbanization is the common primary reason commonly advanced for the present advanced deplorable state of many cities in the country [Santos].The World Health Organization [WHO] promotes actions against noise pollution. Environmental noise management is a part of environmental impact studies and of guidelines for urban development in various countries. Lucknow metropolis, with a population of over 28.2 Lakhs inhabitants, deserves its own noise map. Accordingly, this investigation seeks to develop a noise map of the city based on the noise parameters as L_{AEQ}, TNI (traffic noise index) and L_{NP}.

II. LITERATURE REVIEW ON NOISE MAPPING NITS

Noise maps describe spatial distributions of noise levels. They allow an efficient visualization of the noise distributions in areas where land uses are sensitive to noise. Noise mapping is an efficient assessment method in urban areas [Coelho]. A noise map provides a comprehensive look for the problem of multiple sources and receivers, and thus can improve urban planning. According to Santos, the use of noise mapping allows:

- Quantification of noise in the studied location
- Assessment of population exposure
- Composition of a database for urban planning with localisation of noisy activities and sensitive zones
- Modelling of different scenarios for the future
- Forecast of impact noise of the projected infrastructure and industrial activities.

The most advanced research in noise mapping has been performed in European countries. For example, Germany has conducted relevant research for more than 25 years. Based on the results of previous studies, traffic noise is frequently identified as the main noise source. The UK published the London noise map in 2004, which is the first noise map produced by a national government, as a reference for London citizens to avoid noise nuisances [Livingston]. De Kluijver and Stoter concluded that appropriate use of Geographic Information System (GIS) in mapping noise effects makes it possible to optimize the quality and efficiency of noise effect studies.

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The GIS is an important tool in spatial analysis and modelling. Sheng and Wa Tang applied a GIS-based traffic noise model system to investigate the influences of existing urban forms on vehicle transport and pedestrian exposure to traffic noise in the Macao Peninsula. Wazir prepared a noise map using ArcGIS 9.3.1 software for better visual information of the noise environment of Guwahati City and its diurnal variations. Interpolation is an effective technique used by various researchers for the purposes of noise mapping. The study highlighted the noise-polluted and vulnerable areas through diurnal noise mapping. It was observed that areas with high traffic congestion, narrow roads, heavy constructional activities and poor traffic management are more vulnerable to high noise levels. Some of the educational institutions, hospitals and nursing homes are within a high-noise environment. Some researchers have developed high temporal/spatial resolution systems for modelling air quality or noise.

III. MATERIALS AND METHODS

A. Study area

This study is based on the results of outdoor sound level measurements carried out in September to November 2017 at 10 different locations (2 residential locations, 4 commercial locations, 2 industrial locations, 2 silence locations) in Lucknow metropolis, the capital city of Uttar Pradesh State over the study area; i.e. 80.95°E longitude (Lucknow) and 28.70°N latitude.. Figure 1 is a general view of Lucknow metropolis showing the areas of noise measurements for this study.

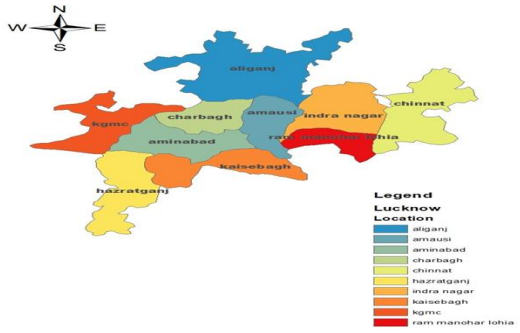

Figure-1 General view of Lucknow metropolis showing the locations of noise measurements

B. Experimental Procedure

Instrumentation for the field measurements consisted of a precision-grade sound level meter (Lutron-SL 4010). The instrument was calibrated by the internal sound level calibrator before making measurements at each site. All the instruments comply with the International Electrotechnical Commission (IEC) standards. Monitoring was carried out at a height of 1.5 m and 1 m away from the chest for 60 min. at interval of 15 seconds. L_{Ai} (A-weighted instantaneous sound pressure level) measurements were recorded at intervals of 15 seconds for a period of 60 min, giving 240 readings per sampling location. This procedure was carried out for morning (7AM–9AM), afternoon (12PM–2PM.), evening (6PM–8PM) measurements. From these readings, commonly used community noise evaluation quantities like the exceedence percentiles,L_{10}andL_{90}, the A-weighted equivalent sound pressure level L_{AEQ}, the noise pollution level L_{NP},and the traffic noise index TNI, were determined. These noise measures are defined as follows:

$$L_{AEQ}=10\log_{10}\left[\frac{1}{N}\sum_{i=1}^{n}(anti\ \log\frac{LAi}{10})ni\right] \quad (1)$$

$$L_{NP}= L_{EQ} + (L_{10} - L_{90}) \quad (2)$$

$$TNI= 4(L_{10} - L_{90}) + (L_{90}-30) \quad (3)$$

where L_{AI} is the ith A-weighted sound pressure level reading dB, n is the total number of readings, L_{Aeq} is the A-weighted equivalent sound pressure level, L_{10} is the noise level that exceeded 10% of the time, L_{90} is the noise level that exceeded 90% of the time (also referred to as background noise level), L_{NP} is the noise pollution level, and TNI is the traffic noise index.

IV. RESULTS AND DISCUSSION

A. Assessment of noise parameters:

The average noise parameters were determined at different locations.Table 1 shows the daily average values of noise parameters for the study area. At eight locations values of L_{EQ}, LNP, and TNI were exceeded from the permissible limits in the month of September 2017 for time span (7Am to 9AM), (12PM to 2PM) and (6PM-8PM) respectively. The different noise level parameter such as $L_{10,}$ L_{90}, $L_{NP,}$ $L_{EQ}$and TNIare shown for different locations from 7am to 9am in figure 2.The L_{10}values of noise level varies between 72.83 to 84.68dB, L_{90} values varied between 60.13 to 71.26dB, L_{NP} values varied between 78.28 to 104.18dB, $L_{EQ}$was in the range of 69.68 to 80.41dB and TNI values varied between 68.63 to 125.9dB and further same the different noise level parameter were showed at different locations for 12pm-2pm.The L_{10}values varies between 76.28 to 86.25dB, L_{90} values varies between 61.02 to 73.25dB, L_{NP} valued varies between 84.25 to102.77dB and L_{EQ} is in the range of 66.15 to 83.59dB and TNI values were varied between 80.6 to 117.30dB and also same the different noise level parameterswere showed at different locations in 6pm-8pm.The L_{10}values varies between 72 to 88.56dB, L_{90} valuesvaried between 59.00 to 83.00dB, L_{NP} values varied between 81.57 to 105.8dB, $L_{EQ}$was in the range of 68.74 to 84.15dB and TNI values varied between 81 to 119.40dB.

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Table1-Average noise parameters at study locations for the month of September 2017

Time	7AM-9AM					12PM-2PM					6PM-8PM				
Parameters / Locations	L_{10} dBA	L_{90} dBA	L_{Aeq} dBA	LNP dBA	TNI dBA	L_{10} dBA	L_{90} dBA	L_{Aeq} dBA	LNP dBA	TNI dBA	L_{10} dBA	L_{90} dBA	L_{Aeq} dBA	LNP dBA	TNI dBA
CHINNAT	76.82	65.68	69.72	80.86	80.24	80.00	68.00	72.32	84.32	86.00	83	71	78	91	89
RAM MANOHAR LOHIA	78.19	64.19	76.41	90.41	90.19	77.27	66.16	73.20	84.31	80.60	72.83	60	68.74	81.57	81.32
INDRA NAGAR	82.93	60.13	79.26	102.06	121.33	76.90	62.00	66.15	85.15	91.60	85	64.2	79.66	100.4	117.4
ALIGANJ	81.5	62.53	77.89	96.867	108.41	82.59	61.02	81.20	102.77	117.30	81.48	68.3	76.29	89.47	91.02
KGMC	79	64	75.75	90.75	94	78.00	66.00	73.90	85.90	84.00	72	59	68.81	81.81	81
AMAUSI	72.83	64.23	69.68	78.28	68.63	78.25	67.00	73.63	84.88	82.00	81.27	69.56	79.77	91.48	86.4
CHARBAGH	82.92	64.56	78.92	97.28	108	86.25	73.25	83.59	96.59	95.25	88.56	68.26	82.26	102.5	119.4
KAISERBAGH	79.26	71.26	75.55	83.55	73.26	81.26	69.26	79.82	91.82	87.26	84.26	62.53	84.14	105.8	119.4
HAZRATGANJ	79	66	72.22	85.22	88	82.00	64.00	74.90	92.90	106.00	81.9	66.1	75.16	90.97	99.3
AMINABAD	84.68	60.91	80.41	104.18	125.99	82.95	68.21	78.47	93.21	97.17	86.93	70.1	80.32	97.15	107.4

Table 2-Average noise parameters at study locations for the month of October 2017

Time	7AM-9AM					12PM-2PM					6PM-8PM				
Parameters / Locations	L_{10} dBA	L_{90} dBA	L_{Aeq} dBA	LNP dBA	TNI dBA	L_{10} dBA	L_{90} dBA	L_{Aeq} dBA	LNP dBA	TNI dBA	L_{10} dB A	L_{90} dB A	L_{Aeq} dBA	LNP dBA	TNI dBA
CHINNAT	77.92	67.72	70.72	82.92	78.52	81.78	70.92	73.62	84.48	84.36	81.78	70.92	79.62	92.65	94.87
RAM MANOHAR LOHIA	79.17	65	77.01	91.06	91.32	78.25	67	74.86	85.83	81.16	78.25	67	70.37	82.75	80.31
INDRA NAGAR	83.62	61.12	79.69	102.19	121.12	77.62	63.82	64.70	78.50	89.02	77.62	63.82	79.58	99.98	117.4
ALIGANJ	82.56	66.45	76.88	92.99	100.89	84.28	62.53	82.23	103.98	119.53	84.28	62.53	77.95	87.95	81.25
KGMC	79.58	65	77.48	91.94	92.96	78.18	67	74.84	85.74	80.88	78.18	67	70.54	83.33	81.95
AMAUSI	76.82	66.52	69.97	82.17	77.72	81.78	70.92	74.74	85.60	84.36	81.78	70.92	78.94	91.97	94.87
CHARBAGH	82.92	64.56	78.92	97.28	108	86.25	73.25	83.59	96.59	95.25	88.25	74.89	82.26	102.5	119.4
KAISERBAGH	79.26	71.26	76.35	84.35	73.26	81.26	69.26	79.82	91.82	87.26	81.5	70.86	84.14	105.8	119.4
HAZRATGANJ	80	67.52	74	86.77	87.04	83.45	66.79	75.82	92.47	103.43	83.45	66.79	75	93.06	106.1
AMINABAD	85.15	61.28	81.49	105.36	126.76	83.3	70.2	78.66	91.76	92.6	83.3	70.2	80.98	97.38	107.5

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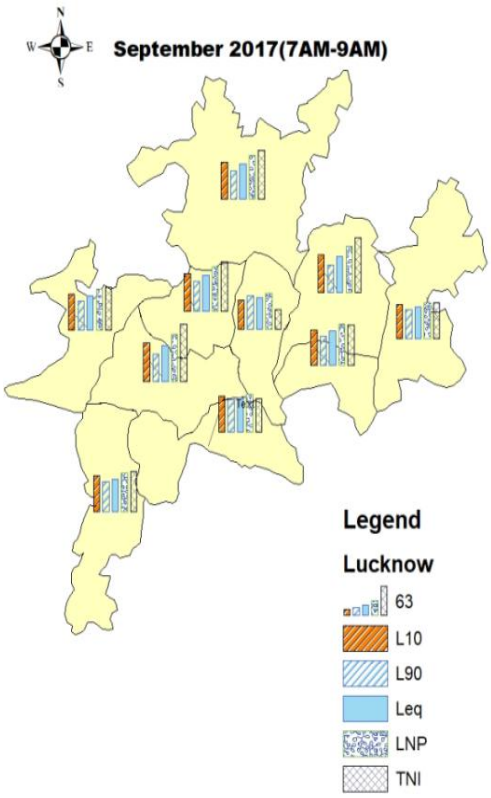
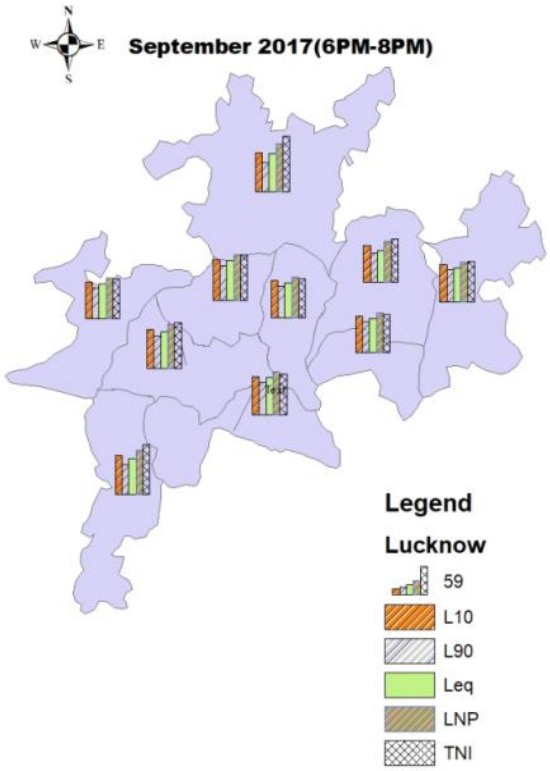




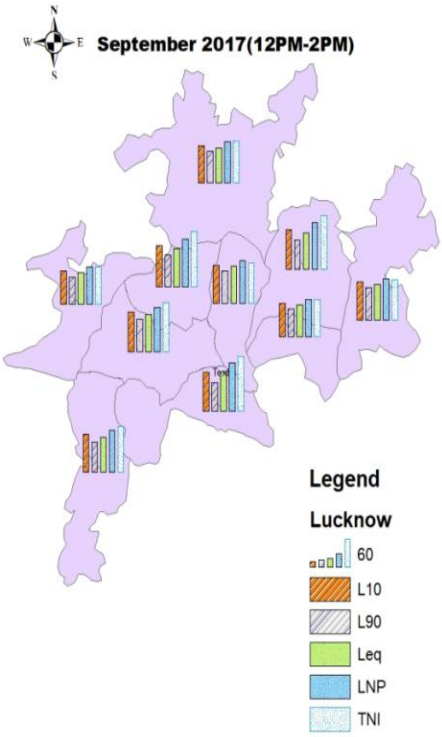


Figure2. Noise map for Lucknow metropolis for the month of September 2017

Table 2 shows the daily average values of noise parameters for the study area. At eight locations values of LEQ, LNP, and TNI were exceeded from the permissible limits in the month of October 2017 for time span (7Am to 9AM), (12PM to 2PM) and (6PM-8PM) respectively. The different noise level parameter such as L10, L90, LNP, LEQ and TNIare plotted for different locations from 7am to 9am in figure 3.The L10 values of noise level varies between 76.82 to 85.15dB, L90 values varied between 61.12 to 71.26dB, LNP values varied between 82.17 to 105.36dB, LEQ was in the range of 69.97 to 81.49dB and TNI values varied between 73.26 to 121.12dB and further same the different noise level parameter were showed at different locations for 12pm-2pm.The L10values varies between 77.62to 86.25dB, L90 values varies between 62.53 to 73.25dB, LNP valued varies between 78.50 to103.98dB and LEQis in the range of 64.70 to 83.5dB and TNI values varied between 80.88 to 119.53dB and also same the different noise level parameters were showed at different locations in 6pm-8pm.The L10 values varies between 77.62 to 88.25dB, L90 values varied between 62.53 to 74.89dB, LNP values varied between 70.37 to 105.8dB, LEQ was in the range of 70.37 to 84.14dB and TNI values varied between 82.75 to 119.40dB. Table 3 shows the daily average values of noise parameters for the study area. At eight locations values of L_{EQ}, LNP, and TNI were exceeded from the permissible limits in the month of November 2017 for time span (7Am to 9AM), (12PM to 2PM) and (6PM-8PM) respectively. The different noise level parameter such as $L_{10,}$ L_{90}, $L_{NP,}$ L_{EQ} and TNIwere shown for different locations from 7am to 9am in figure 4.

The L_{10} values of noise level varies between 77.67 to 86.17dB, L_{90} values varied between 61.82 to 71.93dB, L_{NP} values varied between 80.77 to 105.55dB, L_{EQ} was in the range of 70.89 to 82.16dB and TNI values varied between 76.73 to 126.34dB and further same the different noise level parameter for different locations for 12pm-2pm.The L_{10}indicates noise level between 78.52 to 86.25dB, L_{90} values varies between 62.92 to 73.25dB, L_{NP} valued varies between 80.13 to105.64dB and $L_{EQ}$is in the range of 65.73 to 84.52dB and TNI values were varied between 82.96 to 120.68dB and also same the different noise level parameters at different locations during 6pm-8pm.The L_{10}values varies between 74.12 to 89.26dB, L_{90} values varied between 62.00 to 73.67dB, L_{NP} values varied between 83.56 to 102.2dB, L_{EQ} was in the range of 71.44 to 85.44dB and TNI values varied between 80.14 to 122.4dB.

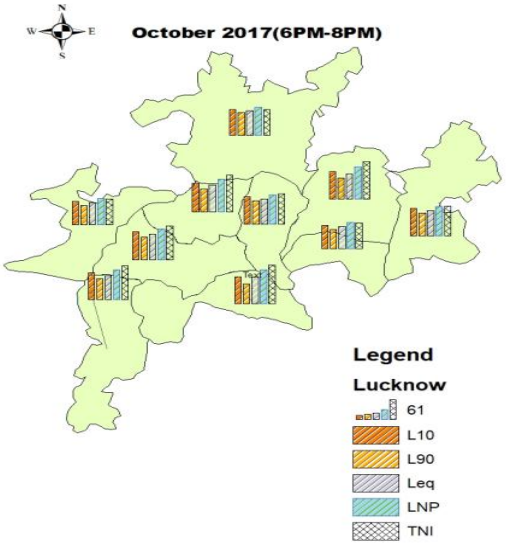
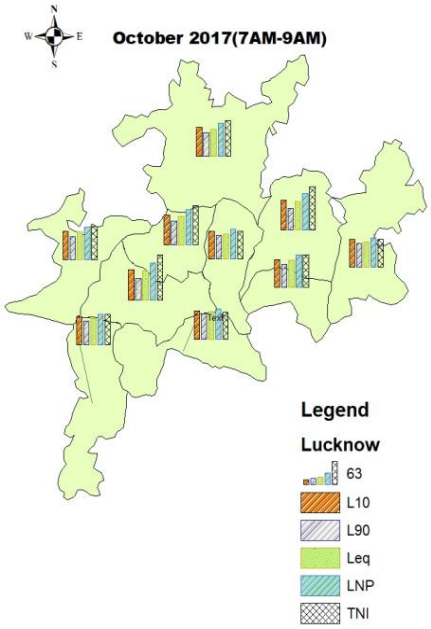
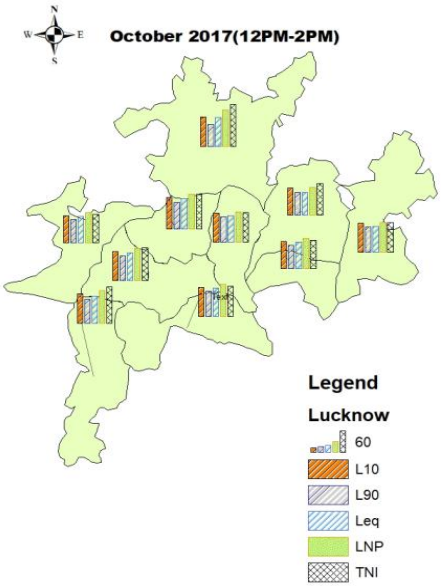
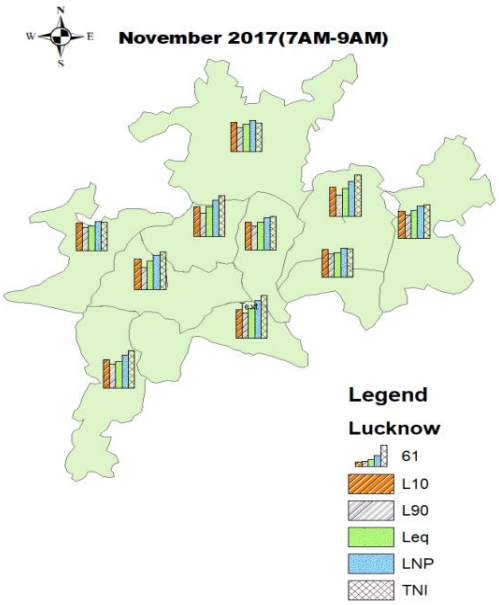
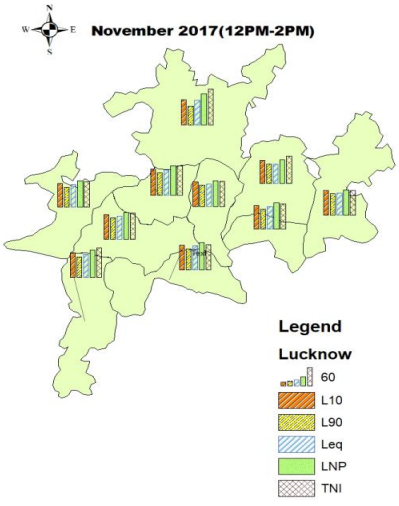


Figure3. Noise map for Lucknow metropolis for the month of October 2017









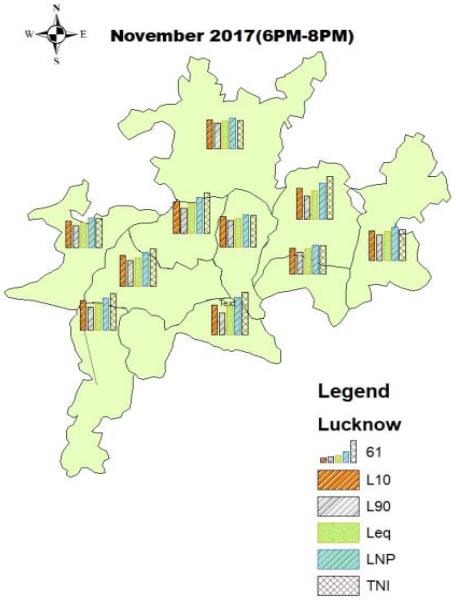


Figure 4. Noise map for Lucknow metropolis for the month of November 2017

Table 3-Average noise parameters at study locations for the month of November 2017

		L_{10} dBA	L_{90} dBA	L_{Aeq} dBA	LNP dBA	TNI dBA
7AM-9AM		77.69	66.79	71.62	85.3	80.39
		80.27	66	78.31	92.41	92.57
		84.12	61.82	80.70	103.0	121.02
		83.29	67.26	77.80	93.83	101.38
		80.17	66	78.26	92.26	92.17
		77.67	67.79	70.89	80.77	77.31
		83.56	65.23	79.65	97.98	108.55
		80.63	71.93	77.95	86.65	76.73
		81	67.52	75	89.07	92.52
		86.17	62.78	82.16	105.55	126.34
12PM-2PM		82.78	72.72	73.92	85.57	82.96
		79.48	67	76.48	88.68	86.08
		78.52	64.12	65.73	80.13	91.72
		84.86	62.92	83.70	105.64	120.68
		79.52	67	76.49	88.73	86.24
		82.78	72.29	75.28	85.77	84.25
		88.25	74.89	84.52	97.88	98.33
		81.95	70.86	80.16	91.25	85.22
		83.38	67.81	76.89	92.46	100.09
		83.68	71.79	78.80	90.69	89.35
6PM-8PM		84.92	73.62	81.82	96.44	88.82
		74.12	62	71.44	83.56	80.48
		87.56	66.36	81.03	102.2	121.1
		82.18	72.86	78.42	87.74	80.14
		74.91	62	71.77	84.68	83.64
		84.92	73.67	79.78	91.03	88.67
		89.26	70.61	83.18	101.8	115.2
		85.62	63.35	85.44	107.7	122.4
		84.27	67.28	76	93.07	105.2
		89.11	73	81.57	97.68	107.4

V. CONCLUSION AND RECOMMENDATION

In this study, a noise map of Lucknow metropolis has been developed based on the noise parameters: equivalent noise level (L_{Aeq}), background noise level (L_{90}), TNI, noise pollution level (LNP), L_{10}.The noise map shows that locations near busy roads/road junctions, commercial places and passengers loading parks have higher background noise level and peak noise level than locations near residential areas. This analysisshows that noise levels at 8 of 10locations exceeded the recommended limit prescribed by CPCB. Hence, the noise pollution in Lucknow metropolis poses a severe health risk to the residents. Even, discomfort and irritation from the pollution can drastically reduce productivity, both in public service and private sectors. The most valuable step to decrease noise pollution in a big city of Uttar Pradesh like Lucknow is the preparation of noise maps. The noise map itself, with the values of noise parameters, provides baseline data for town planners, engineers and others for planning and execution of their projects. Most of the cities in Uttar Pradesh have not produced noise pollution maps.Tree plantation is the suggestive measure to mitigate noise pollution level around residential and silence zones. It is suggested that noise maps should be developed for every big city in Uttar Pradesh to serve as a noise control measure.

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