JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Monitoring and Assessment of Environmental Noise Pollution in the areas of Chandigarh using SLM and ArcGIS

Kshipra Kapoor [1], Shakti Kumar[1] Yashpal Kumar[2]

[1]Research Scholar, Department of Civil Engineering, Punjab Engineering College (Deemed to be University), Chandigarh, 160012
[1]Professor, Department of Civil Engineering, Punjab Engineering College (Deemed to be University), Chandigarh, 160012
[2]Assistant Professor, Department of Civil Engineering, Guru Kashi University, Talwandi Sabo, Bathinda, Punjab, 151302

Abstract: The term "environmental noise" refers to any sound that is unwelcome or potentially hazardous that is produced outside and is often caused by things like traffic, industrial, construction, and recreational activities. Since the traffic noise pollution becomes a major contributor to the deteriorating environment conditions, this article is focused on the on the evaluation and management of environmental noise pollution in the Chandigarh. This study however also examines the advantages and disadvantages of a variety of approaches to noise pollution management that have been used by researchers working in the field of environmental noise pollution monitoring and control. Throughout order to get an accurate reading of the noise level in the Union Territory, 22 different measuring stations were chosen. During the course of five months, measurements were taken early in the morning (from 6:00 AM to 8:00 AM and again from 9:00 AM to 10:00 AM), in the afternoon (from 12:00 PM to 1:00 PM), in the evening (from 5:00 PM to 6:00 PM), and again from 8:00 PM to 10:00 PM on weekdays and on weekends. In addition, a comparison with the standard established by the CPCB was carried out as part of the research. For this purpose, the regions under investigation were split up into four distinct zones in accordance with the recommendations of the CPCC, Chandigarh. The noise level data that were obtained show that the overall quality of the acoustic environment in our research region was at medium level. This indicates that exposure to these levels for an extended length of time may have an effect on human health as well as quality of life. Mapping of the city's noise pollution was then done using ArcGIS.

Keywords: Environmental Noise Monitoring, CPCB Standard, Sound Level Meter Calibration,

1. Introduction

Environmental noise pollution has been a major issue across the globe. The increasing ambient noise levels are not only contributing to community annoyance, but also creating health hazards. Environmental noise has been steadily increasing from the past few decades with the rapid increase in the number of vehicles on the roads and with industrialization. It has thus become a global issue and a matter of great concern. The growing number of vehicles on limited road stretch, loudspeakers, noise from the mechanical plants, generators, firecrackers etc. contributes to the environment noise, but the vehicular traffic remains the prime source of noise in the urban areas. Noise in general has many adverse effects on human health and as well as on the various day to day activities, like it creates irritation among human beings and also disturbs their sleeping hours[1]. However continuous exposure to noise at higher levels may lead to some severe health issues such as arterial hypertension myocardial infarction and stroke[2] . Ouis (1999), described the impact of nocturnal road traffic on sleep and how it affects the physiological and psychological functions like daily performance of human and cardiovascular reactivity[3] . Not only the road traffic but also some other factors are there which contributes to noise pollution like construction projects, loud speakers etc. near the residential places [4]. In daytime one out of three individual is annoyed by traffic noise and one out of five individuals has disturbed sleep in night time due to excessively high noise levels [5]. Lex (2015) work illustrated the burden of disease from the elevated environment noise in Asian cities. Together with discussing the burden of diseases some new interventions to reduce the environmental noise had been debated [6] .The strategies aimed to control the rise in ambient noise levels demands the monitoring of noise levels as the first step. Across the world, there had been many studies conducted by different researchers for monitoring and control of environmental noise pollution using newer methods and strategies [7]– [10]. Primarily, noise monitoring units employ hand-held sound level analyzers or meters (fixed on suitable platforms) for measuring and assessing the environmental noise pollution in terms of equivalent sound levels, L_{den}, $L_{eq,24h}$, L_{day}, L_{night} etc.[11]– [14] However, newer technological advancements pertaining to Smartphone applications and Wireless sensing units had been reported recently. Smartphone applications have been made accurate by calibrating them with the highly precise sound level meter at national laboratories realizing the sound standards [15]– [18] .Recently many researchers have introduced a new method of monitoring noise that is by using wireless sensor networks as shown in fig. 1. Though this method has been used frequently in various other application also but not much work has done in the field of noise by this method. In this method sensor nodes are employed over a larger or smaller area of interest. These nodes are connected to a central server. This method proves to be one of the best for the long-time noise monitoring. Mobile crowd sensing is another alternative for monitoring noise in large areas. Generally, this consists of data collection, data communication, data storage and noise map application which are used on smartphones. This crowd sensing approach shall be more helpful in planning 'Smart Cities' and in efficient urban planning [19]. A SWOT analysis of various noise monitoring strategies is presented in Table 1 based on the review of previous studies conducted so far. However, in Indian perspectives, a diversified National Ambient Noise Monitoring Network (NANMN) had been established by Central Pollution Control Board (CPCB) of India employing the conventional technology of Noise Monitoring Terminals setup across seven major cities of India[20]– [24]. However, there are many studies in literature which discuss about the various dynamic noise modelling techniques and control [25]– [29]. This article, on the other hand, is focused on the environmental noise monitoring of Chandigarh city using sound level meters (SLMs) since the other methods of the noise monitoring are not economical for the study at smaller regions or for short term noise monitoring. Based on the noise data collected from the various parts of the city, it is evident that the noise levels are exceeding the noise limits prescribed by the CPCB at almost every location. As a result, the goal of this article is to measure the levels of noise at a number of notable places all across the city of Chandigarh and then compare those levels of noise to the CPCB Standards. In addition, noise mapping of the city is going to be done with the help of ARCGIS, and it will be based on environmental noise monitoring. So, 15 sites were thus selected for noise monitoring and then study was extended to 22 sites for noise mapping so that the Inverse Distance Weighting Technique (IDW) can work more effectively.

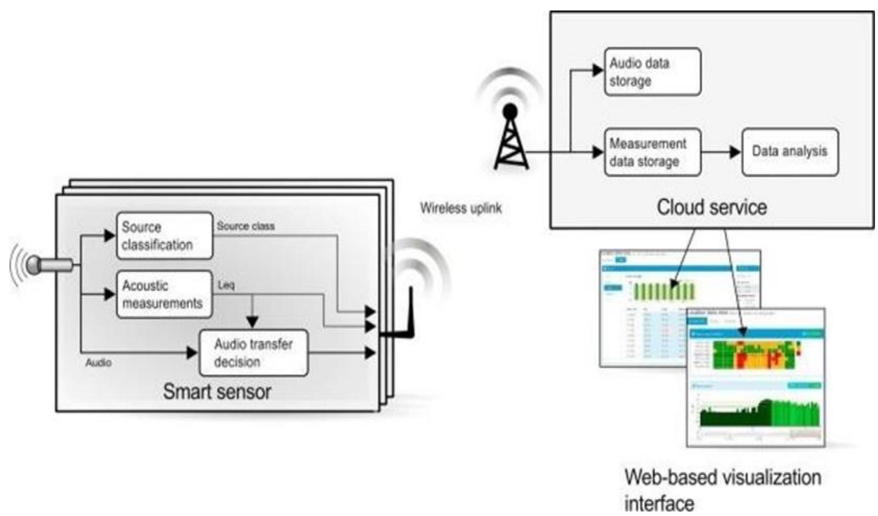

Figure 1 Block Diagram of noise monitoring using Wireless Sensor Networking (Taken from Maijala P et. al., 2018, [14]).

Table 1. SWOT analysis on traditional and advanced modes of environmental noise monitoring.

	Strengths	Weakness	Opportunities	Threats
Sound Level Meters or Analysers or Noise Monitoring Terminals (NMT's)	Easy to use and highly accurate and precise for measurement of ambient noise levels at a given site.	Need a skilled manpower for noise assessment using sound level meter and their calibration while taking field measurements.	Noise maps can be drawn and also finds opportunities for control. Can be used with central database system for dynamic noise mapping.	Sound level meter is difficult to use in controlled environments such as working at heights and Confined space; extreme weathers
Smartphone Noise Monitoring	A number of applications are available on play store; Easy to operate. Can handle a set of operations related to the characterization of sound environments.	For smartphone apps to gain acceptance in the occupational environment the apps must meet certain minimal criteria for functionality, accuracy, and relevancy to the users in general and the worker in particular.	Collecting real-time occupational and environmental noise data.; Mobile devices are uniquely suited to measuring sound in a manner that is not applicable to any other occupational or environmental hazard.	Limited accuracy of applications, dealing with bad or corrupted data, and mechanisms for storing and accessing such data.
Wireless sensing Network	Wireless sensor networks also allow monitoring pollution parameters in urban areas at an accuracy and scale that were previously unreachable; A network of cheap wireless sensor nodes deployed over the area of interest can be used for longer times.	Comparatively low speed of communication; Gets distracted by various elements like Blue-tooth. Still Costly (most importantly).	Since sensor nodes are typically equipped with several different sensors, they can label the collected noise data with additional information like, e.g., the temperature and humidity values	It is easy for hackers to hack it we couldn't Control propagation of waves; External signals can disturb the sensor data
Noise mapping using validated model or field measurements	Can be used for devising control action plans and understanding the noise scenario; Validated models can be used for noise mapping without excessive field measurements.	Strategic noise maps should be used where some degree of inaccuracy in results must be accepted; it is complex and relies on more input datasets	A wide variety of Calculation methods may be used in the development of a noise map; Interpolation algorithms are also required for noise mapping	A validated model is required in noise mapping; Expensive instruments are required for accurate mapping; In Indian perspectives, honking noise etc. is major issue for model validation

2. Materials and Methods:

In this study monitoring of noise had been done by sound level meter which is available at environmental engineering lab of the civil engineering department. Apart from it, Data was mapped using GIS software which is installed in computer labs of civil department i.e., ArcGIS 10.4.

2.1. Calibration of SLM:

Mextech SLM was used for the environmental noise monitoring and which is calibrated using beat frequency oscillator. The sound source was aligned opposite to the smartphone and the sound level meters. The voice was generated by a beat frequency oscillator, which generated voice at every frequency. The artificial voice generator is generating a sound pressure level in the frequency range from 31.5 Hz to 10 KHz. The generated sound levels range from 80-110 dB. While running the setup the deviation between the reading of Standard Sound level meter and the Mextech SLM is reported in figure 2. Finally, the error in sound level measurement of Mextech SLM and standard SLM is reported and relative response for is calculated.

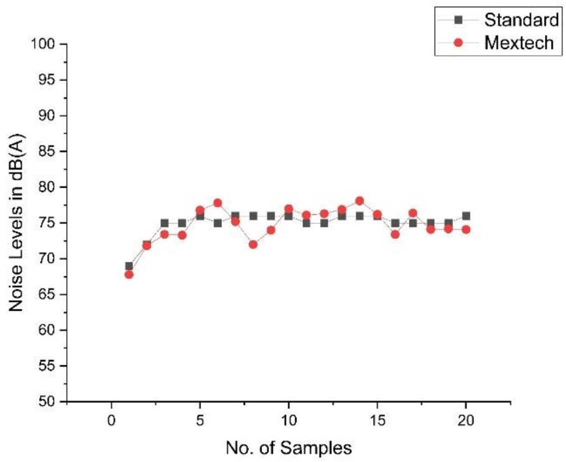

Figure 2 Standard Vs. Mextech Noise levels corresponding to 20 Samples

2.2. Site Selection:

Google earth was used for collecting respective Latitude and longitudes of concerned sites. The selected study is chosen on the basis of the following neighbourhood. A total of 22 sites was selected based upon the categories for the environmental noise monitoring i.e., commercial centers, major road junctions, passenger loading parks, high-density residential areas), Low noise areas (low-density residential areas).

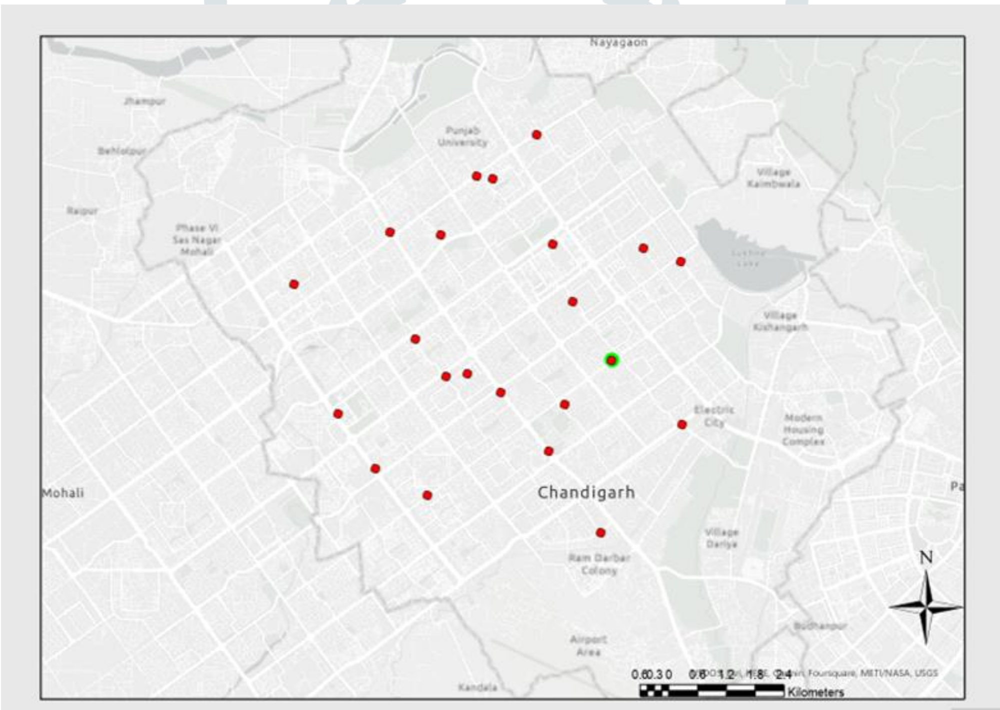

Figure 3 Noise Monitoring Locations in Chandigarh

2.3. Frequency Selection of Sound Level Meter

The noise energy produced by a light vehicle is concentrated in the frequency range of 500–2500 Hz, with the highest frequency occurring at around 1250 Hz. The range of frequencies that contain the most noise energy for a medium vehicle is between 315 and 2500 hertz, with the highest frequency coming in at about 1600 hertz. The range of frequencies that contain the most noise energy for an overloaded vehicle is between 315 and 2500 hertz, with the highest frequency coming in at about 500 hertz. Both the sound pressure level (SPL) and the frequency characteristics of a vehicle will be affected by the vehicle's speed. The noise spectrum has a pattern of concentration that becomes more pronounced with increasing speed. If we take the example of a light vehicle, we can see that the rate of noise energy production in the essential frequency range of 1000 Hz to 2500 Hz rises as the vehicle speeds up, whereas the level of irrelevant frequencies, such as low and medium-low frequencies, falls as the vehicle moves faster[30]. In addition to this, the fundamental frequencies increase as the speed of the vehicle increases, especially for a vehicle that is not very heavy. The noise frequencies that are emitted by overloaded vehicles are mostly medium-low frequency and medium-high frequency. This is in stark contrast to the noise frequencies that are emitted by light and medium vehicles, which are predominately medium-high frequency. So, these points were taken into due consideration while monitoring the noise at the mentioned locations in Chandigarh.

3. Data Acquisition and Analysis

A formal method of information collection is vital since it ensures that the information gathered is both described and precise as well as significant. Given that the recognized formal problem is related to noise pollution, so the formal procedure for noise monitoring was followed as per the instructions by CPCB, New Delhi [31]. The noise data thus collected were done using a calibrated Noise Level Meter of Mextech. Monitoring of Chandigarh's ambient noise has been conducted at initially at 15 different places around the city. After processing, the sound level data is compared to the Ambient Noise Level Standards that were issued under the Noise Pollution (Regulation and Control) Rules, 2000. The graphical depiction of this data, broken down by zone, is shown in Figures 4-7. These 15 stations are chosen as per the notice of the Chandigarh Pollution Control Committee which bifurcates the Chandigarh into various zones namely Silence, Commercial, Industrial and Residential zones. Hence the data was collected by adhering to the directions of all the major government authorities. However, the $L_{eq.}$ for the sites were measured and shown in figure 8.

Noise levels in the commercial areas of Chandigarh are however greater than the prescribed CPCB norms for respective sites. The levels of noise on an average are however greater at GMCH 32 at all times, the maximum noise level at GMCH were recorded to be 73 dBA in the morning, this might be due to the volume of travellers going to office passes through the nearby area in a greater number. PGI Chandigarh, were the second most critical zone with highest level recorded to be 72.6 dBA during the same time frame. The trends of the noise levels are however clearly plotted in the figure 4 to figure 7 with their corresponding zones. One most interesting fact that comes out from these trends is that the noise level in the industrial area was found to be in the limits of the CPCB at all levels. A comparison with the CPCB standard of the specified locations is given in figure 8 to make the things clearer.

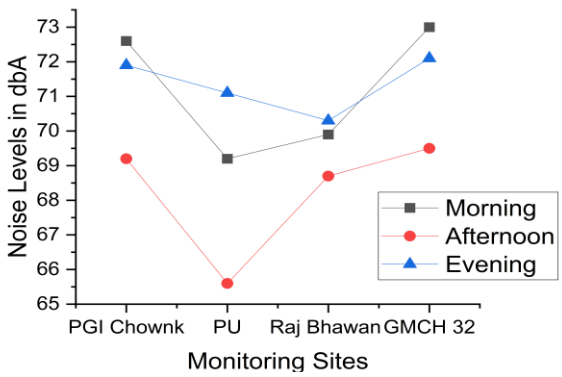

Figure 4. Trends of Silence Zone

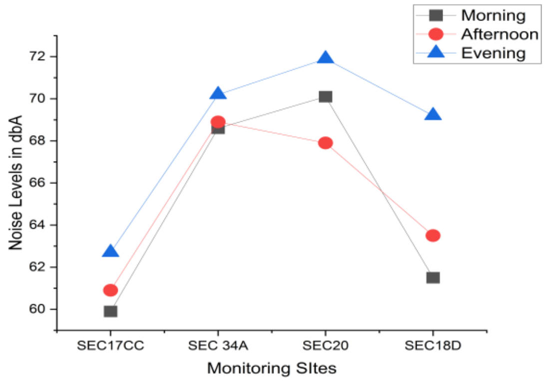

Figure 5. Trends of Commercial Zone

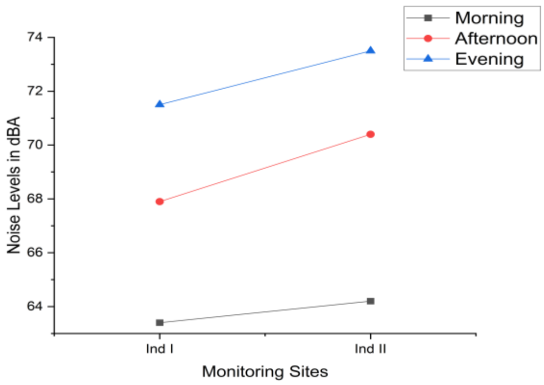

Figure 6. Trends of Industrial Zone

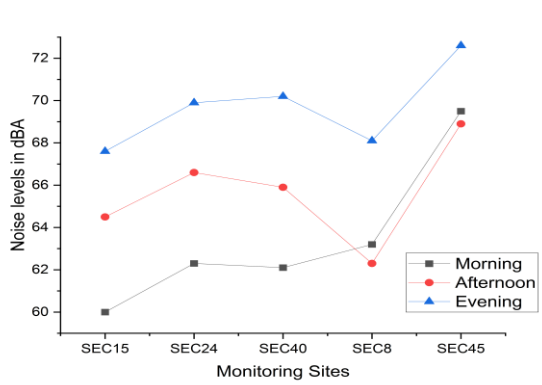

Figure 7. Trends of Residential Zone

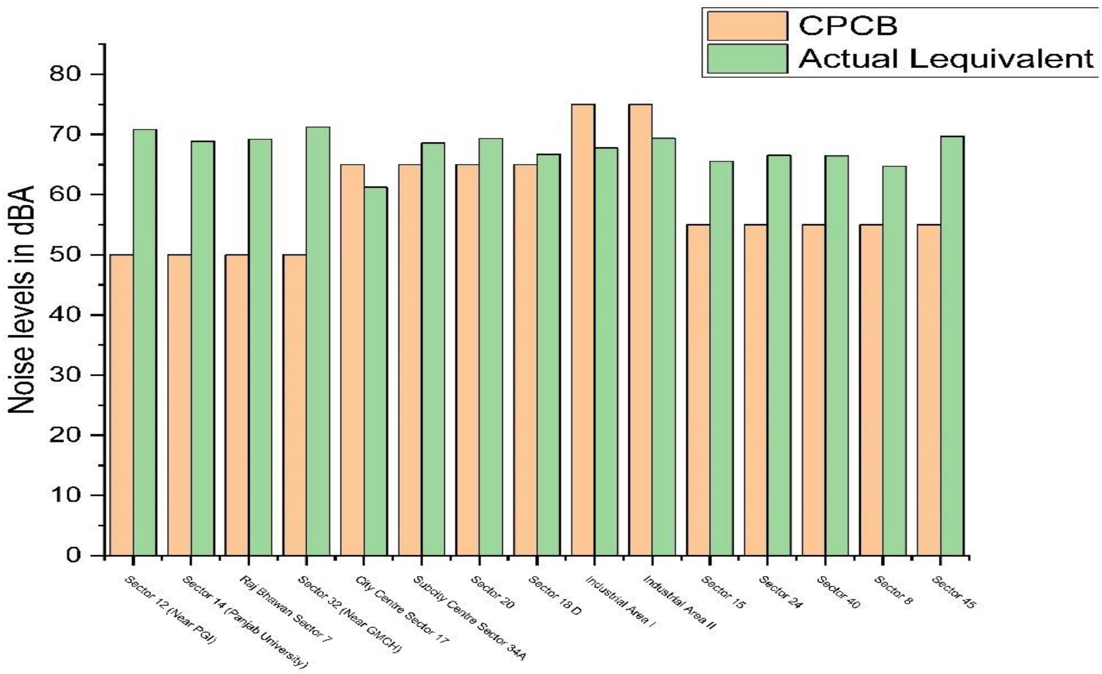

Figure 8 Comparison of Leq. to the CPCB data with respect to various sites

3.1. Geospatial Mapping

After the free field measurements are done, Noise values will be shown on a map using the student version of ArcGIS software. This map is constructed by aggregating all the noise measurements on a map. Real-Time monitoring of the Noise readings of all 15 sites, tells elevated Noise levels around Chandigarh. Results of this study show that the A-weighted sound Level varies with location and period of the day due to traffic characteristics especially traffic volume, vehicle horns, vehicle-mounted speakers, and unmuffled vehicles at road Junctions, motor parks, and commercial centers. According to The Central

Pollution Control Board (CPCB) and the State Pollution Control Boards (SPCBs) recommendation and standards, two sites i.e., industrial are I and II of the 15 sites considered are under normally acceptable Noise levels. To make the noise Map more accurate, many other data points are also taken to cover the Chandigarh area under study and to interpolate the data more accurately.

A strategic noise map is designed for the assessment of noise exposure in a given area, resulting from strategic noise sources such as roads, railways, airports, and industry. Just as an Ordnance Survey map may have contours indicating how ground level height changes across an area, a noise map can illustrate how environmental noise levels change across an area as shown in Figure 9. For the noise mapping of short-term noise measurements, we have used student version of ArcGIS software. Inverse Distance Weighting (IDW) technique is used for the interpolation of the data. The Noise map of Chandigarh and PGI Chandigarh shows how the noise value is pertaining around the area with different colours showing different noise bands.

Geo-Spatial Noise Mapping of Chandigarh

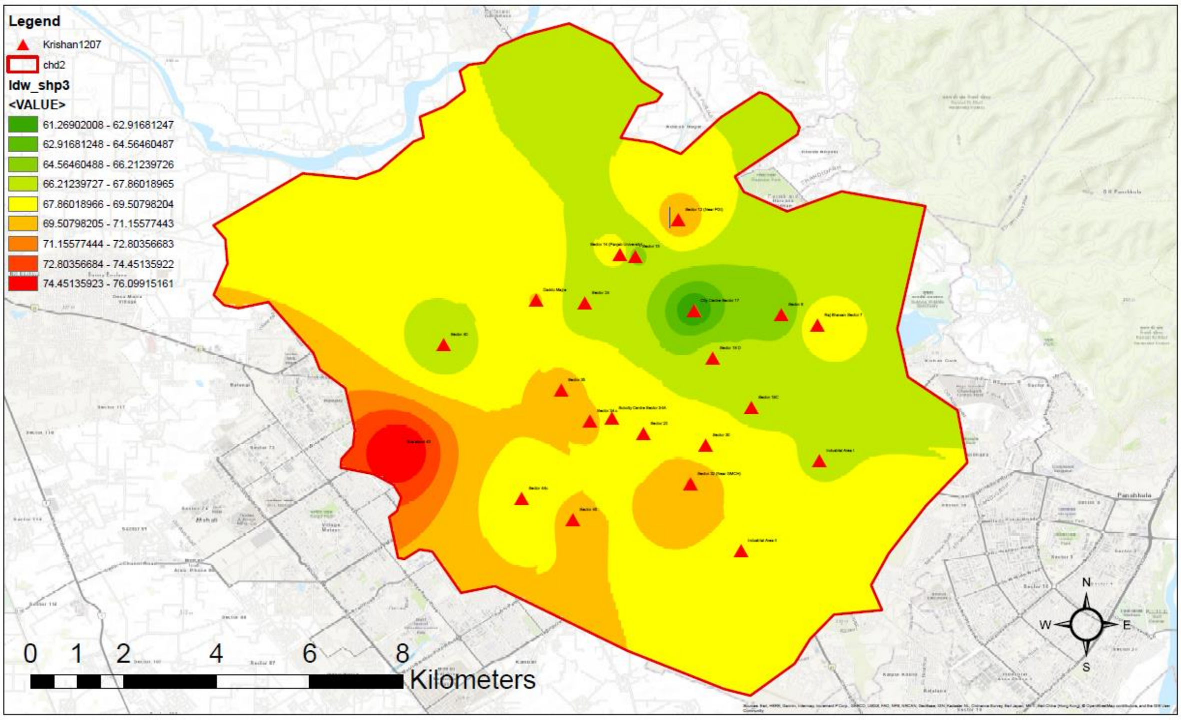

Figure 9 ArcGIS noise mapping of PGI Chandigarh

4.Results and Discussions

Figure 8 is a figure that presents the overall average of all noise descriptors. The location close to GMCH Sector 32 has the highest values of Leq both during the workday and on the weekend, with corresponding readings of 71.2 and 70.6. Similarly, the city center had the lowest readings during the weekdays at 61.3 dB(A), while Sector 8 had the lowest readings during the weekends at 61.7 dB(A). It comes as a surprise to learn that even the noise levels have exceeded the Indian norms in some regions, such as the quiet zone, the commercial zone, and the residential zones. On the other hand, the noise levels in the industrial sectors are under control. It was discovered that the sector 45 station has the highest possible Leq of 72.6 in the evenings throughout the week. Other stations have been discovered to have a maximum Leq throughout the morning (Sector 32 with 73 dB(A)), as well as the afternoon (Sector 32 and Industrial are II with 69.2 and 70.4 dBA). It has been noticed that the evenings are the times when the noise levels are at their highest in all of the locations. In the event of a weekend, the majority of the sample sites were found to have the highest Leq in the evening (Sector 12 with 70.1 dBA and Sector 45 with 70.3 dB(A), while just a handful had it in the afternoon (or the morning) (Sector 12 with 68.8 dB(A). Both the maximum and minimum values of the Leq are found to be at their highest in GMCH 32 (72 dB(A)) and City Centre 17 (58.1 dB(A), respectively). Figure 10 shows a comparative analysis of Leq. comparison of weekday and weekend.

The noise map for the equivalent noise level at the location was developed with the use of an algorithm called Inverse Distance Weighting (IDW). IDW is used in the process of interpolating a collection of point values that is already known. The unknown point values are determined by monitoring the data at other additional 7 more places, bringing the total number of locations up to 22. The weighted average of the known point values is used to determine the other unknowns that are dependent on the unknown point values. Figure 9 displays noise maps that were obtained after interpolation was performed. Figure 9 makes it abundantly evident that the noise levels in the neighbourhoods around Sector 45, Sector 43, and GMCH 32 are in the range of 70 to 75 dB(A), which is 20 to 25 dB(A) higher than the level that is mandated by the CPCB in New Delhi. As a result, appropriate noise reduction measures have to be implemented without delay.

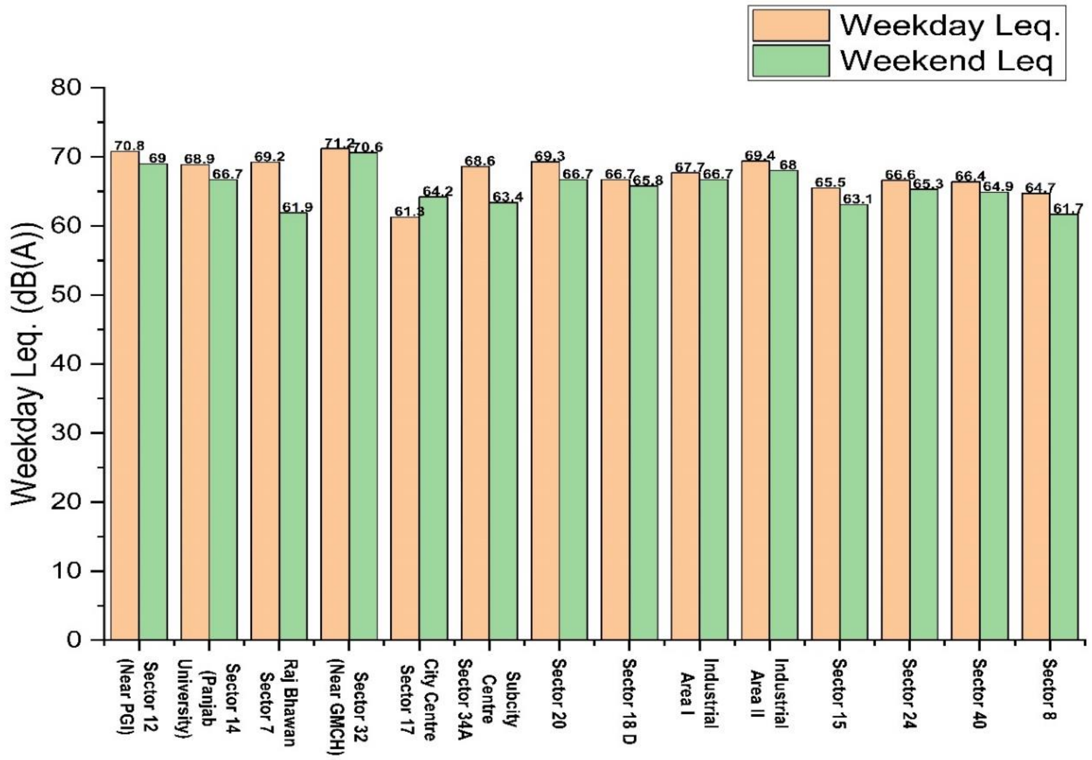

Figure 10 Leq. comparison at each site for Weekday and Weekend noise level

5. Conclusion:

The article presented the noise monitoring study of Chandigarh as well as for PGI Chandigarh. Short term noise monitoring was conducted initially at 15 sites in Chandigarh and then extended to 22 sites for the accuracy in noise map. On the basis of short-term measurements, noise map has been also developed for the 22 sites. The calibration of the instrument was conducted and Mextech (used in study) was found to be good agreement with error of 2%. The noise monitoring at 22 sites revealed that almost all the sectors of the Chandigarh have the noise levels above the CPCB standards except the Industrial area I and Industrial area II (Figure 8). The noise levels of PGI Chandigarh and Sector 32 were found to be 20 dBA and 18 dBA more than the prescribed levels. Vehicular traffic and traffic honking were found to be the key cause of the elevated noise levels both in the winter and in the summer season. Geo-Spatial mapping of 22 sites for the short-term measurements was developed using the student version of the ArcGIS software.

Acknowledgements: The authors are thankful to CPCC Chandigarh, as the classification of the sites were done according to their reference given on their website.

References

[1] D. Halperin, "Environmental noise and sleep disturbances: A threat to health?," Sleep Sci, vol. 7, no. 4, pp. 209–212, 2014, doi: 10.1016/J.SLSCI.2014.11.003.

[2] T. Münzel, T. Gori, W. Babisch, and M. Basner, "Cardiovascular effects of environmental noise exposure," Eur Heart J, vol. 35, no. 13, p. 829, Apr. 2014, doi: 10.1093/EURHEARTJ/EHU030.

[3] D. Ouis, "Noise and Health," Noise Health, vol. 1, no. 4, p. 11, 1999, Accessed: Jul. 24, 2022. [Online]. Available: https://www.noiseandhealth.org/article.asp?issn=1463-1741;year=1999;volume=1;issue=4;spage=11;epage=36;aulast=Ouis

[4] A. v. Vasilyev, "New Methods and Approaches to Acoustic Monitoring and Noise Mapping of Urban Territories and Experience of it Approbation in Conditions of Samara Region of Russia," Procedia Eng, vol. 176, pp. 669–674, Jan. 2017, doi: 10.1016/J.PROENG.2017.02.311.

[5] "Burden of disease from environmental noise: quantification of healthy life years lost in Europe." https://apps.who.int/iris/handle/10665/326424 (accessed Jul. 24, 2022).

[6] A. L. Brown, "Effects of Road Traffic Noise on Health: From Burden of Disease to Effectiveness of Interventions," Procedia Environ Sci, vol. 30, pp. 3–9, Jan. 2015, doi: 10.1016/J.PROENV.2015.10.001.

[7] E. Murphy and E. A. King, "Testing the accuracy of smartphones and sound level meter applications for measuring environmental noise," Applied Acoustics, vol. 106, pp. 16–22, May 2016, doi: 10.1016/J.APACOUST.2015.12.012.

[8] G. Guillaume et al., "Noise mapping based on participative measurements," Noise Mapping, vol. 3, no. 1, pp. 140–156, Jan. 2016, doi: 10.1515/NOISE-2016-0011.

[9] L. Filipponi, S. Santini, and A. Vitaletti, "Data collection in wireless sensor networks for noise pollution monitoring," Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 5067 LNCS, pp. 492–497, 2008, doi: 10.1007/978-3-540-69170-9_35/COVER.

[10] E. Murphy and E. A. King, "Smartphone-based noise mapping: Integrating sound level meter app data into the strategic noise mapping process," Sci Total Environ, vol. 562, pp. 852–859, Aug. 2016, doi: 10.1016/J.SCITOTENV.2016.04.076.

[11] M. Sahana, S. Dutta, and H. Sajjad, "Assessing land transformation and its relation with land surface temperature in Mumbai city, India using geospatial techniques," https://doi.org/10.1080/12265934.2018.1488604, vol. 23, no. 2, pp. 205–225, Apr. 2018, doi: 10.1080/12265934.2018.1488604.

[12] C. Thakre, V. Laxmi, R. Vijay, D. J. Killedar, and R. Kumar, "Traffic noise prediction model of an Indian road: an increased scenario of vehicles and honking," Environmental Science and Pollution Research, vol. 27, no. 30, pp. 38311–38320, Oct. 2020, doi: 10.1007/S11356-020-09923-6/FIGURES/5.

[13] B. Huang, Z. Pan, and G. Wang, "A methodology to control urban traffic noise under the constraint of environmental capacity: A case study of a double-decision optimization model," Transp Res D Transp Environ, vol. 41, pp. 257–270, Dec. 2015, doi: 10.1016/J.TRD.2015.09.026.

[14] A. K. Shukla, S. S. Jain, M. Parida, and J. B. Srivastava, "Performance of FHWA model for predicting traffic noise: A case study of Metropolitan city, Lucknow (India)," Transport, vol. 24, no. 3, pp. 234–240, Sep. 2009, doi: 10.3846/1648-4142.2009.24.234-240.

[15] Ilkka Kivelä and Ismo Hakala, "Area-based environmental noise measurements with a wireless sensor network," Proceedings of the EuroNoise, Maastricht, vol. 5, no. 31, 2015, Accessed: Jul. 24, 2022. [Online]. Available: https://scholar.google.com/citations?view_op=view_citation&hl=en&user=H9PE0WMAAAAJ&citation_for_view=H9PE0WMAAAAJ:IjCSPb-OGe4C

[16] N. Garg et al., "Study on the establishment of a diversified National Ambient Noise Monitoring Network in seven major cities of India," Curr Sci, vol. 113, no. 7, pp. 1367–1383, 2017, doi: 10.18520/CS/V113/I07/1367-1383.

[17] R. Kumar, A. Mukherjee, and V. P. Singh, "Traffic noise mapping of Indian roads through smartphone user community participation," Environ Monit Assess, vol. 189, no. 1, pp. 1–14, Jan. 2017, doi: 10.1007/S10661-016-5741-1/TABLES/4.

[18] P. Maijala, Z. Shuyang, T. Heittola, and T. Virtanen, "Environmental noise monitoring using source classification in sensors," Applied Acoustics, vol. 129, pp. 258–267, Jan. 2018, doi: 10.1016/J.APACOUST.2017.08.006.

[19] C. Peckens, C. Porter, and T. Rink, "Wireless Sensor Networks for Long-Term Monitoring of Urban Noise," Sensors 2018, Vol. 18, Page 3161, vol. 18, no. 9, p. 3161, Sep. 2018, doi: 10.3390/S18093161.

[20] A. L. Brown and G. T. McDonald, "From Environmental Impact Assessment to Environmental Design and Planning," https://doi.org/10.1080/14486563.1995.10648318, vol. 2, no. 2, pp. 65–77, Jan. 2013, doi: 10.1080/14486563.1995.10648318.

[21] V. Nourani, H. Gökçekuş, I. K. Umar, and H. Najafi, "An emotional artificial neural network for prediction of vehicular traffic noise," Science of The Total Environment, vol. 707, p. 136134, Mar. 2020, doi: 10.1016/J.SCITOTENV.2019.136134.

[22] C. Steele, "A critical review of some traffic noise prediction models," Applied Acoustics, vol. 62, no. 3, pp. 271–287, Mar. 2001, doi: 10.1016/S0003-682X(00)00030-X.

[23] R. Vijay, A. Sharma, T. Chakrabarti, and R. Gupta, "Assessment of honking impact on traffic noise in urban traffic environment of Nagpur, India," J Environ Health Sci Eng, vol. 13, no. 1, pp. 1–10, Feb. 2015, doi: 10.1186/S40201-015-0164-4/TABLES/3.

[24] S. Agarwal and B. L. Swami, "Comprehensive approach for the development of traffic noise prediction model for Jaipur city," Environmental Monitoring and Assessment 2010 172:1, vol. 172, no. 1, pp. 113–120, Feb. 2010, doi: 10.1007/S10661-010-1320-Z.

[25] K. Abdur-Rouf and K. Shaaban, "Development of prediction models of transportation noise for roundabouts and signalized intersections," Transp Res D Transp Environ, vol. 103, Feb. 2022, doi: 10.1016/j.trd.2022.103174.

[26] F. Ibili, A. O. Owolabi, W. Ackaah, and A. B. Massaquoi, "Statistical modelling for urban roads traffic noise levels," Sci Afr, vol. 15, Mar. 2022, doi: 10.1016/j.sciaf.2022.e01131.

[27] M. Mir, F. Nasirzadeh, S. H. Lee, D. Cabrera, and A. Mills, "Construction noise management: A systematic review and directions for future research," Applied Acoustics, vol. 197, Aug. 2022, doi: 10.1016/j.apacoust.2022.108936.

[28] J. H. Tang et al., "Dynamic modeling for noise mapping in urban areas," Environ Impact Assess Rev, vol. 97, Nov. 2022, doi: 10.1016/j.eiar.2022.106864.

[29] J. P. Faulkner and E. Murphy, "Road traffic noise modelling and population exposure estimation using CNOSSOS-EU: Insights from Ireland," Applied Acoustics, vol. 192, Apr. 2022, doi: 10.1016/j.apacoust.2022.108692.

[30] "Measurement and modelling of noise emission of road vehicles for use in prediction models (Technical Report) | ETDEWEB." https://www.osti.gov/etdeweb/biblio/20138118 (accessed Aug. 26, 2022).

[31] "Protocol for Ambient Noise Monitoring, CPCB New Delhi 2015. - Google Search." https://www.google.com/search?q=Protocol+for+Ambient+Noise+Monitoring%2C+CPCB+New+Delhi+2015.&rlz=1C1ONGR_enIN1006IN1006&oq=Protocol+for+Ambient+Noise+Monitoring%2C+CPCB+New+Delhi+2015.&aqs=chrome..69i57.173j0j7&sourceid=chrome&ie=UTF-8 (accessed May 27, 2022).

Appendix

Noise Monitoring Locations which were selected at the initial phase were exhaustively monitored for their respective noise levels for all over the day. $L_{eq.}$ which is the logarithmic mean of the noise levels were calculated using the Microsoft excel. Table given below gives a brief understanding about the noise monitoring conducted at various sites, however the data is already shown in Figure 7.

Site	Noise Levels (in dB(A)					
	6 AM-8 AM	9 AM-10AM	12PM-1PM	5PM-6PM	8 PM-10 PM	Leq. (Day)
Sector 12 (Near PGI)	68.6	72.6	69.2	71.9	70.4	70.81
Sector 14 (Panjab University)	66.6	69.2	65.6	71.1	69.6	68.87
Raj Bhawan Sector 7	65.4	69.9	68.7	70.3	70.2	69.23
Sector 32 (Near GMCH)	69.2	73	69.5	72.1	71.1	71.22
City Centre Sector 17	56.7	59.9	60.9	62.7	63.3	61.26
Subcity Centre Sector 34A	58.8	68.6	68.9	70.2	70	68.60
Sector 20	59.8	70.1	67.9	71.9	70.1	69.35
Sector 18 D	58.5	61.5	63.5	69.2	70.3	66.70
Industrial Area I	56.6	63.4	67.9	71.5	68.4	67.76
Industrial Area II	59.5	64.2	70.4	73.5	68	69.36
Sector 15	59.7	60	64.5	67.6	68.6	65.50
Sector 24	58.6	62.3	66.6	69.9	67.7	66.56
Sector 40	56.3	62.1	65.9	70.2	67.5	66.44
Sector 8	57.5	63.2	62.3	68.1	66.1	64.74
Sector 45	62.3	69.5	68.9	72.6	70	69.69