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Monitoring and mapping noise levels of university campus in central part of India

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ABSTRACT

Introduction: Each one of us is directly or indirectly exposed to noise pollution in our daily life. Noise has chronic effect on the human but many of us are not aware. In our modern research platform very few studies are available for monitoring and mitigating of noise pollution compared to other environmental pollution.

Materials and methods: This study has been designed to monitor, map the noise pollution in educational institute and find out the sources of noise followed by identification of hot spot. In this regards National Institute of Technology Raipur, Chhattisgarh, India was selected as study area. Noise levels measurements were carried out at 15 locations within the study area at time intervals of forenoon (9:30 – 10:30 AM), noon (12:30-1:30 PM) and afternoon (4:30-5:30 PM) for 5 days of the week (working days). Using GIS tool observed noise levels were interpolated by Inverse Distance Weighted (IDW) method and graphical plots were prepared for different time intervals.

Results: Noise Levels were found to be between 46 dBA to 72.08 dBA during our study. Sources contributing to higher levels of noise in the premises were traffic, honking of trains followed by students themselves. On comparing the finding with Central Pollution Control Board, New Delhi, India (CPCB) standards all the locations recorded higher noise levels than the prescribed limits.

Conclusion: Based on our finding, mitigating approaches like: plantation of trees, construction of noise barriers, proper parking area, restricting high speed of vehicles etc. were suggested for making a healthy learning environment.

Introduction

Unwanted sound generated in the environment causing discomfort to the ear is categorised as noise. From the Latin word “nausea” meaning sensation of discomfort or seasickness word “noise” has been derived. Noise comprises those occurring sound which are not acceptable in our environment. Noise is serious problem in many of the urban areas throughout the world however very less attention are paid regarding its monitoring and mitigating approaches [1-2]. Noise pollution is assessed by measuring the levels of noise in the environment from

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the different sources in the surroundings. When human beings are exposed to higher levels of noise for long duration it leads to psychological and physical illness [3-4]. Based on the magnitude and length of occurrence noise pollution effects are differentiated into four categories - (i) physical effects (hearing problem) (ii) psychological effect (anxiety, late night sleep, sleeplessness and bad temper) (iii) physiological effects (rise in blood pressure and heart beat abnormality) (iv) effects on efficiency [5]. To the modern world noise pollution causes series of health issues and mitigating of noise pollution can help in controlling these health effects: sleep disturbance, cardiovascular disease, learning impairment, loss of hearing, speech interference and many more [6-8].World Health Organization (WHO) also reported 7 categories of impact of noise on humans in 2011. The health effect described above falls under these categories. The higher level noise exposures are generally made by different sources which are classified as natural and manmade. Natural consists of noise from insects, birds, barking of dogs, thunderstorm, wind whereas for manmade traffic, industry, construction work, loudspeaker on festival eve, railway, firecrackers are the major contributor to the noise in our environment [9-12].

Noise pollution mapping is one of the modern techniques of showing noise levels of different locations on a single map [6, 9]. Noise map represents noise levels of geographical area at particular time and are useful in acoustic urban planning [13]. It helps in identifying the hotspot for noise pollution in an area. Noise mapping helps in evaluating noise pollution as well as it helps in mitigating noise pollution in an area [14]. In order to make noise map the digital information of area are required along with Geographic Information System (GIS) [5].

Hospitals, schools, universities, library, colleges have been categorised under silence zone [15]. In most of the cities across the world these areas are surrounded by the road and rail. The location in heart of the city also makes this area prone to higher levels of noise thus making such areas exposed to higher level of noise. Students learning capability and academic performances are affected when they are exposed to the higher level of noise in school or colleges [16]. In silence zone people exposed to higher levels of noise faces common problem of interference in communication [17]. While the lecture is going on students find difficult in hearing the voice of teachers and discussion in classrooms and other activities. Students can perform better in silence condition rather than noisy environment [18]. Students learning outcomes are directly affected by the learning environment. The background noise in the class can affect the learning's of students and hamper the class environment [19].

Many studies have been carried out for monitoring and mapping of noise pollution at different zones of the city but there is lack of study in context with educational zone. In order to provide a healthy learning environment in campus such studies are necessary. Noise pollution in the NITRR campus can be seen as it is situated in the heart of city surrounded by highway and busy railway line. Thus there is need for monitoring and mapping of noise pollution in the campus. Noise pollution monitoring has not been carried out for the campus neither noise map is available therefore this study has been set to find out the noise levels at different location of the campus with following objectives:

- To prepare noise map by measuring noise levels within NITRR campus.
- To identify the hot spot and main causes for noise pollution within campus.

• To suggest mitigating approaches for control of higher noise level in Campus.

Materials and methods

Study area

For carrying out this study National Institute of Technology, Raipur campus was selected. NITRR began as a campus of Government Engineering College in September, 1956 and is spread over an area of 100 acres at 21.2497° N, 81.6050° E coordinates. Campus front side is located on Great Eastern Road whereas its back side is situated on Mumbai- Howrah main rail line. This rail line is one of the busy lines in central India. The permanent site of NITRR consists of academic blocks, staff quarter, girl's hostel, boy's hostel, relaxation park, dispensary and playing area. Inside the campus the main sources contributing to noise are; vehicular traffic, honking of trains, generators, noise from students waiting for lectures and from students who finished their lecture. Study area is shown in Fig. 1. Methodology has been shown in Fig. 2.

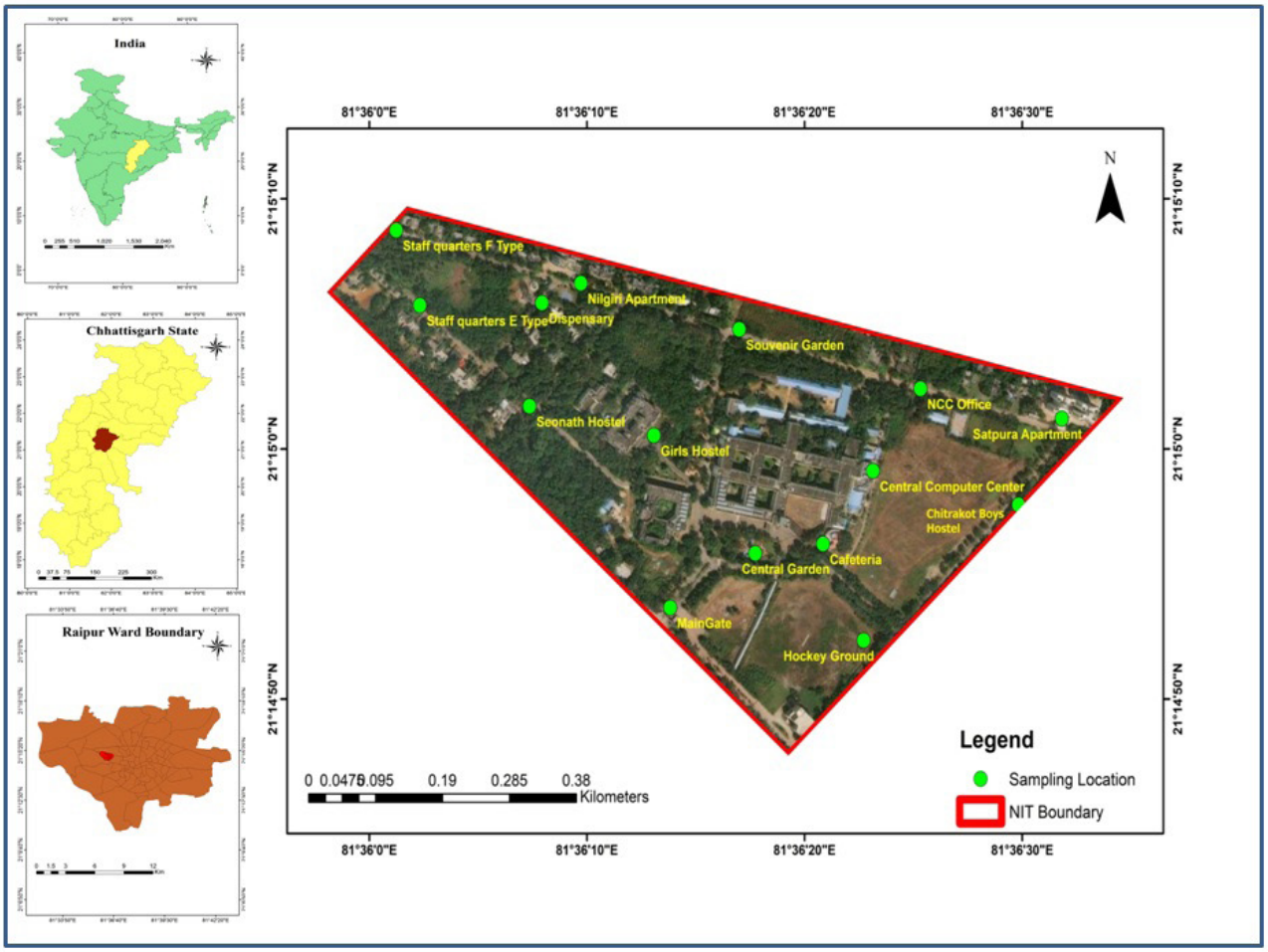

Fig. 1. Study area showing selected point for monitoring of noise within the campus

Sampling technique and data collection

Sampling stations were selected according to land uses in the campus for monitoring and mapping of noise pollution levels. The locations are shown in Table 1. Academic block (lecture hall, library, labs etc.), residential area (hostel and staff quarters), dispensary (health), recreational and commercial (gardens, playing area and cafeteria) were identified and selected for the study purpose respectively. Readings of noise levels were taken in forenoon 9:30 to 10:30 am, at noon from 12:30-1:30 pm and afternoon 4:30-5:30 pm (Monday to Friday) from 23rd May to 27th May 2022 in the academic year 2022-2023. Selection of this dates were made to cover all the working days in a week of the institute.

All the readings were taken by the help of field assistants across selected stations. Readings were taken by the using sound level meter (Extech-SL 400). Calibration of instruments was done before going to the sampling. Noise levels at 15 locations (Table 2) were taken using sound level meter. Microphone was placed 1.5 m above the ground surface and values displayed on the screen were recorded and mean values for each location were taken out. After collecting the data noise parameter LNP (Noise Pollution Level) was found out by using the equation given below (Eq. 1).

$LNP = L_{eq} \times 2.56\ \partial$ ..... (1)

Where LNP= Noise pollution level, L_{eq}= equivalent noise level, ∂ = standard deviation [20]

OR

$LNP = LA_{eq.} + (L10 - L90)$ .....(2)

OR

$LNP = LA_{eq.} + KS$ .....(3)

Where K= 2.56 and S= standard deviation of A weighted noise level [21]

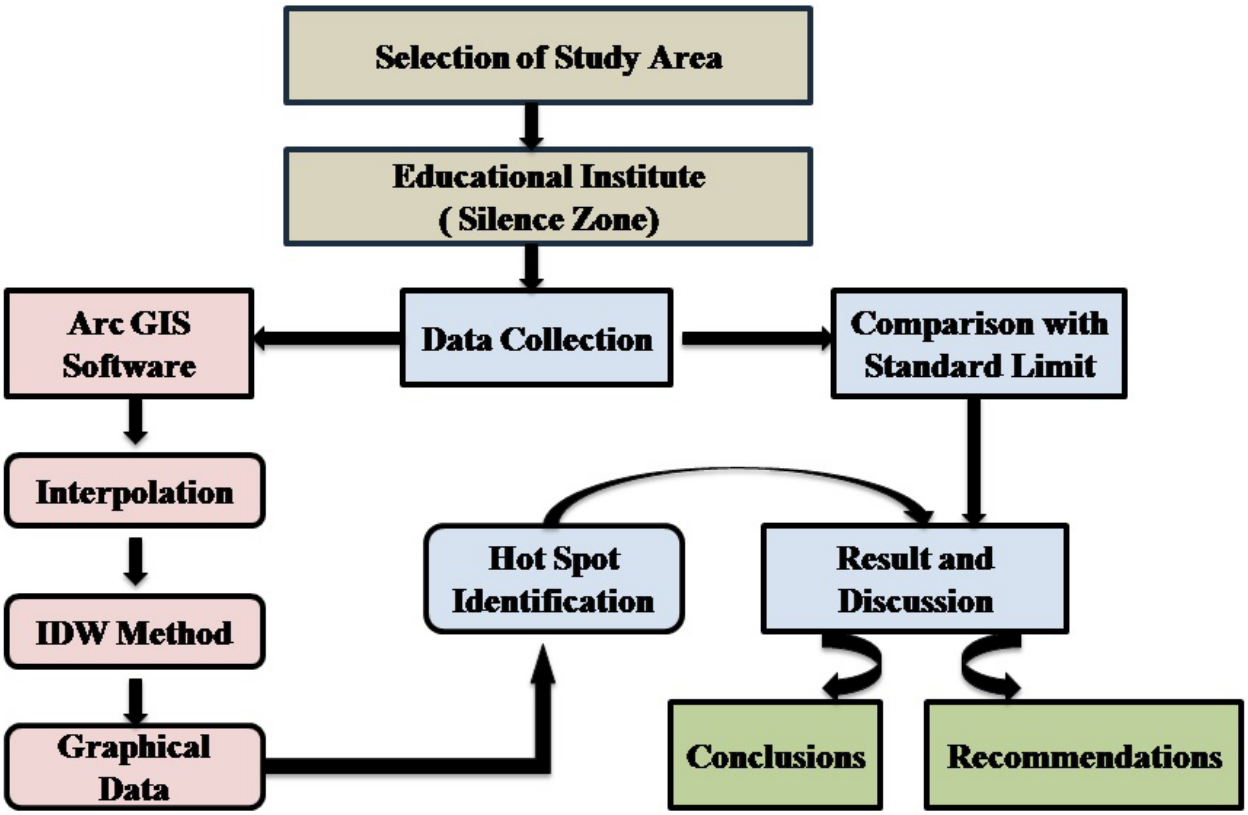

Fig. 2. Methodology of the study

Table 1. Selected points for noise monitoring

S. No.	Monitoring Station	Land Use	Station point
1	Dispensary	Health	S1
2	Staff quarters F Type		S2
3	Nilgiri Apartment		S3
4	Girls Hostel		S4
5	Seonath Hostel	Residential	S5
6	Staff quarters E Type		S6
7	Satpura Apartment		S7
8	Chitrakot Boys Hostel		S8
9	Central Computer Center	Academics	S9
10	Cafeteria		S10
11	Central Garden	Recreational and Playing	S11
12	Souvenir Garden		S12
13	Hockey Ground		S13
14	Main Gate	Commercial	S14
15	NCC Office		S15

Table 2. Central pollution control board, Delhi prescribed standards

Types of Area	Environmental Noise Standards (L_{eq}) in dBA	
	Day Time	Night Time
Industrial Area	75	70
Commercial Area	65	55
Residential Area	55	45
Silence Area	50	40

Source: C.P.C.B. New Delhi

Instrument, software, and techniques for data analysis

In order to carry out the mapping and monitoring of noise levels the instrument used along with software and techniques is combinations of the following;

- *Sound level meter:* In order to perform the noise pollution monitoring this instrument is used to find out the noise levels in the ambient environment. Calibration of SLM is done in dB(A) and dB(C). A weight is used while measuring the noise levels by SLM as it copies exactly the response of human ear to noise. The unit of measurement taken during the sampling are denoted as dB(A). After reading are taken stop button is pressed in order to save the readings in the inbuilt memory of instrument. Later on the readings are retrieved by connecting the instrument to the computer.

- *ArcGIS:* Utilization of this tool was done for data analysis and mapping. This software was used for performing the interpolation and generation of noise map. Study area map by plotting the coordinates reading of the study area was also prepared by using this software. For preparation of noise map IDW (Inverse Distance Weighted) technique was employed.

- *Microsoft excel:* To prepare the tables, computation of figures, chart plotting and converting data for exporting to ArcGIS workable conditions this software was used. Also retrieving of data from the SLM was done in this software.

- *GPS (Global Positioning System):* In order to get the coordinates reading of the study point this devise was used.

- *Microsoft Word:* For presenting the research work and formatting this software was used.

Results and discussion

Noise levels at 15 locations were observed and recorded in the selected study area. The results of the study are presented using numeric table and maps (graphical plots). The observations for the study period are presented in Table 3. For the forenoon, noon and afternoon during the study ranges of L_{eq} was found to be between 46 dBA to 72.08 dBA and for the L_{np} the ranges observed was between 50.13 dBA to 80.63 dBA respectively.Result in the table shows that for the silence zone S1, noise level is on elevated side compared to the CPCB standards (50dBA). Consequently in the residential zone S2 – S8 levels of noise is greater than 55dBA except for few locations in the noon when compared with the standards. The recorded noise levels for locations S9-S15 were also found to be on the higher side. Noise from railway is the major contributor of high levels of noise in the residential area of the campus. Thus from the obtained results of noise levels at all locations it is revealed that most of the locations are exposed to higher levels of noise within the campus.

Table 3. Leq(noise equivalent levels) and Lnp(noise pollution levels) for the study area

S. No.	Monitoring Station	Time	Average Leq(dBA)	Standard Deviation	Lnp
1	S1	Forenoon	53.41	0.87	55.63
		Noon	50.69	1.87	55.47
		Afternoon	51.78	1.28	55.06
2	S2	Forenoon	55.50	2.71	62.44
		Noon	50.53	0.70	52.32
		Afternoon	61.19	4.96	73.88
3	S3	Forenoon	57.21	1.87	61.99
		Noon	51.20	0.82	53.31
		Afternoon	57.78	1.67	62.05
4	S4	Forenoon	56.32	2.10	61.70
		Noon	50.27	2.14	55.75
		Afternoon	55.78	3.84	65.61
5	S5	Forenoon	53.69	1.38	57.23
		Noon	52.01	0.82	54.11
		Afternoon	53.76	0.98	56.27
6	S6	Forenoon	57.65	5.34	71.32
		Noon	62.15	7.22	80.63
		Afternoon	49.97	1.83	54.65
7	S7	Forenoon	51.55	0.94	53.96
		Noon	46.00	1.69	50.34
		Afternoon	48.71	0.55	50.13
8	S8	Forenoon	60.44	3.34	68.99
		Noon	59.54	4.14	70.15
		Afternoon	50.27	4.32	61.33
9	S9	Forenoon	53.66	1.37	57.17
		Noon	53.93	2.28	59.77
		Afternoon	56.11	3.43	64.89
10	S10	Forenoon	59.32	1.67	63.60
		Noon	60.33	0.89	62.61
		Afternoon	55.76	3.79	65.46
11	S11	Forenoon	63.87	1.55	67.84
		Noon	61.74	1.72	66.13
		Afternoon	61.69	2.21	67.35
12	S12	Forenoon	72.08	2.57	78.66
		Noon	55.43	5.06	68.39
		Afternoon	63.17	2.47	69.49
13	S13	Forenoon	56.70	1.19	59.75
		Noon	57.77	0.96	60.23
		Afternoon	54.87	1.96	59.90
14	S14	Forenoon	57.74	1.64	61.94
		Noon	50.73	0.90	53.04
		Afternoon	56.45	3.57	65.59
15	S15	Forenoon	54.45	2.90	61.87
		Noon	48.62	1.11	51.46
		Afternoon	56.23	1.34	59.65

Observed noise levels in the forenoon at the study area

Form the observations made at different locations noise maps was prepared for the forenoon noise levels as shown in Fig. 3. From the Table 3 ranges of noise levels in the forenoon is between 51.55 to 72.08 dBA.A highest noise level in the forenoon was 72.08 dBA at station S12. Also the L_{np} of 78.66 dBA at S12 was recorded as highest. As this station is situated nearer to the railway line and does not have any noise barrier. A lowest noise level of 51.55 dBA was recorded at station S7. The reason for low noise level is its location. Station S12 is situated at the end of the campus boundary in north east direction, very less vehicles moves in this area. From Fig. 3, it is found that stations S10, S11, S12, S13 and S14 recorded higher noise levels than other stations. The reason is because of its location from the main road of the city which is about 100 m. All vehicles enter to the campus from station S14 and thus lead to the generation of high noise levels. Work carried out by researchers reveals that in and around the educational institution noise levels should range between 40dBA to 50dBA [18]. On comparing our result we can say that at all the stations of our study area showed higher noise levels in the forenoon.

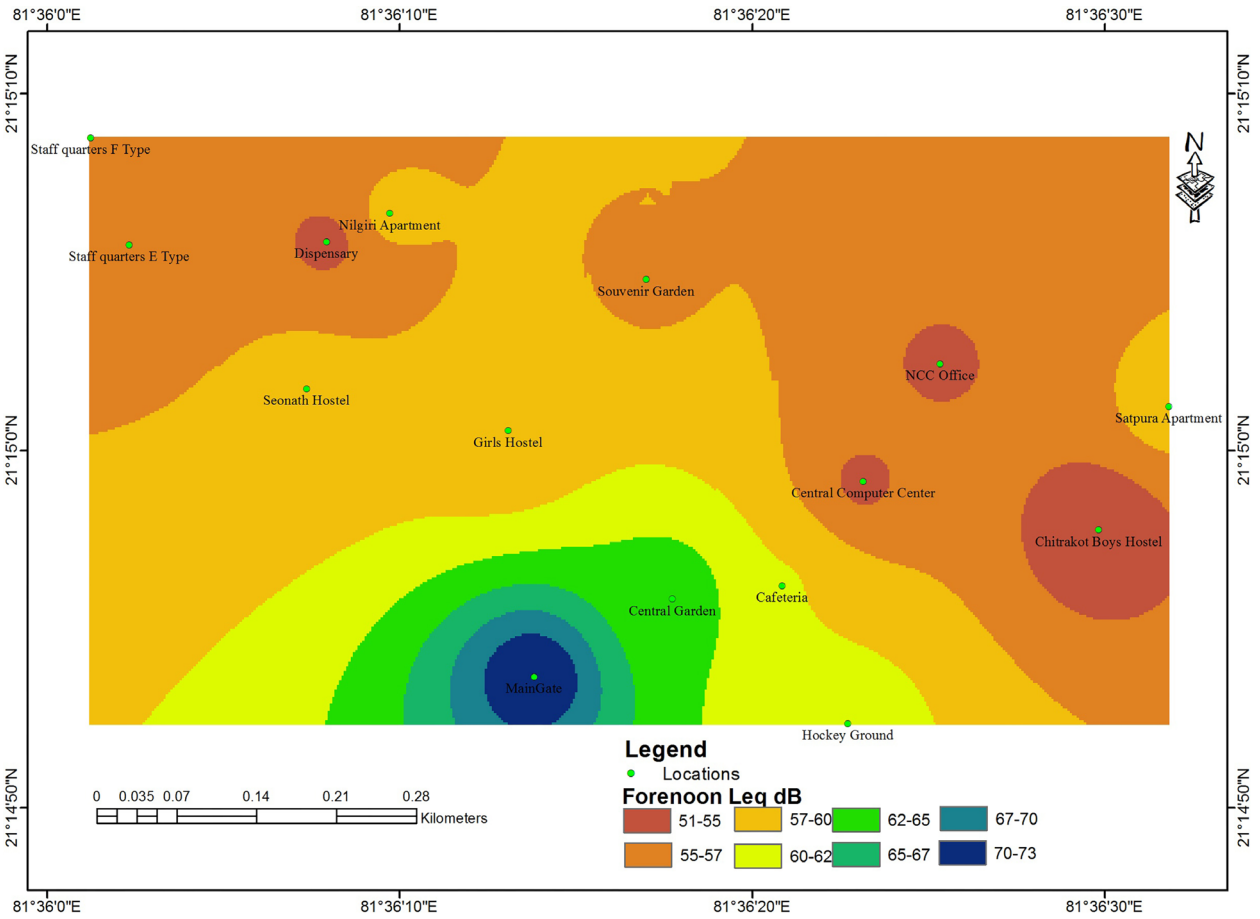

Fig. 3. Forenoon noise levels distribution in the study area

Observed noise levels in the noon at the study area

From the Table 3 ranges of Leq noise level for the noon is between 46 to 62.15 dBA while the L_{np} ranges between 50.34 to 80.63 dBA respectively. Highest level at station S10 and S11 were recorded i.e. above 60dBA. Most of the students take their lunch in cafeteria and garden in the noon time due to this reason the increase in levels of noise at both the locations were observed. Noise levels near to 50dBA were recorded for most of stations in the noon time which is lower than the forenoon noise levels. From Fig. 4 it is observed that stations S1 to S8 recorded lower noise levels compared to other stations. The reason for this is because the stations are surrounded by trees, thus the trees act as noise barrier for these locations as a result of which lower noise levels are observed. In a study, researchers concluded that major source for noise in the educational institute is vehicles (46%) and students (40%) [18].

Observed noise levels in the afternoon at the study area

From Table 3 the ranges of L_{eq} in the afternoon are found to be between 48.71 to 63.17 dBA. The maximum noise levels at station S12 is observed. The ranges of L_{np} are found to be between 50.13 to 73.88 dBA. At most of the stations noise levels are exceeding the CPCB standards shown in Table 2. From the Fig. 5, it is seen that noise levels in the afternoon are higher than the noon. The change in the levels is because of the movement of vehicles in the afternoon. After the ending of classes and working hour of the institute the vehicles start leaving the institute hence causing increase in noise levels in the premises.

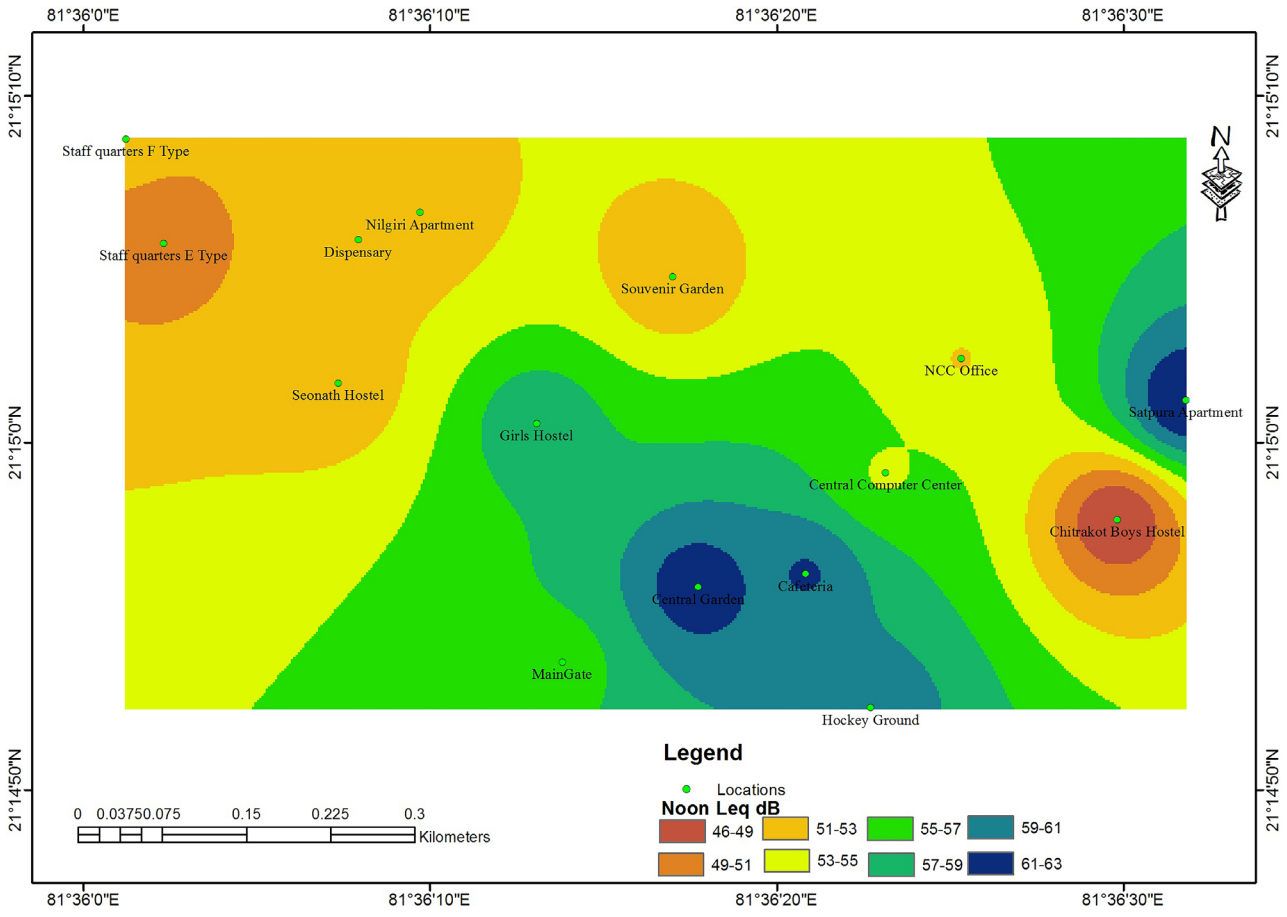

Fig. 4. Noon noise levels distribution in the study area

Hot spot identification, causes and sources of noise in the study area

Graphical plot prepared after the observations are compared and based on the three maps hot spot is identified. Among all the three maps common station S11 (central garden) and S14 (main gate) are showing high levels of noise in all the three intervals (forenoon, noon, afternoon) of observation. Hence from our finding it is concluded that both this station are hot spot for our study area. The main sources of noise in this are traffic and students itself. Our finding was corroborated by a study which was reported that, the educational institute lying beside the railway station and/or national highways have advantage but at the same time they contribute to higher noise levels in the premises of institute [15]. Our finding also aligns with a study in Nagaon, Assam India, where was concluded that main sources for higher noise levels in educational area was traffic as all the institutes were laying beside the busy road of the city [18]. Frequent honking of trains and noise from wheels of passing train also contribute to the high levels of noise in our study area.

Recommendations

Our finding shows that a higher noise level in the study area exists. Hence to reduce the noise to acceptable level following measures may be taken in the institute:

- Planting of more tress and vegetations near to the buildings and beside the service roads of the institute will help in absorbing the noise levels.
- Applying speed limit for the vehicles inside the campus and near to the main gate of institute will help in reducing high levels of noise.
- Making strict law on using of horns within the institute will mitigate noise pollution.
- Making public, teachers and students aware about harmfull effects of noise on health.
- Installing noise barriers near the railway and roadway will help in reducing noise pollution within the campus.
- Restricting outside vehicles movement within the premises and making parking area near to the entrance will help in reducing noise pollution.

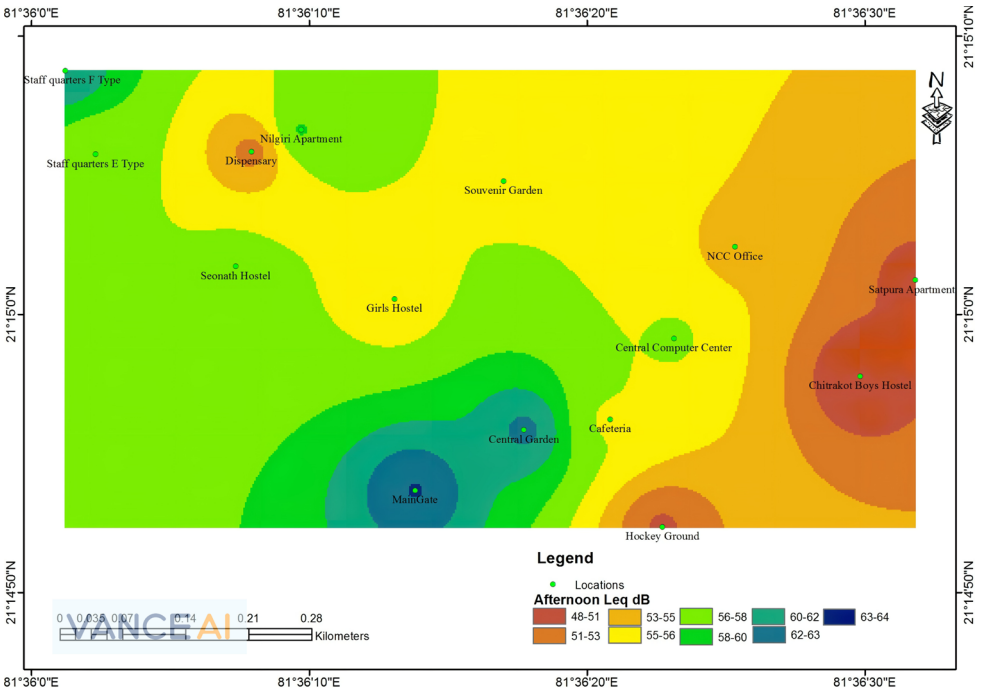

Fig. 5. Afternoon noise levels distribution in the study area

Conclusion

Based on the study it is concluded that noise generated by honking and movement of trains nearby, movement of vehicles inside the campus followed by students themselves are the major source of noise pollution. The range of noise levels for forenoon, noon and afternoon are found to be 51.55 to 72.08 dBA, 46 to 62.15 dBA and 48.71 to 63.17 dBA respectively. From the graphical plots it is concluded that noise levels in noon time is lower than forenoon and afternoon noise levels. Based on comparison of graphical plot stations S11 (central garden) and S14 (main gate) are identified as hot spot of the institute. On comparing the observed noise levels with the CPCB standards it is revealed that almost all stations have higher noise levels. The institute authorities must reassign the vehicle parking area so that the noise from honking and movement of vehicles does not interfere with the learning activities of the students. In order to make a healthy environment for students and staff suggested mitigating approaches must be incorporated. During the study it is found that, stations surrounded by trees recorded lower noise levels compared to other stations. Hence special events must be organized for plantation of trees and vegetation within the campus.

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Competing interests

The authors declare that there is not any conflict of interests regarding the publication of this manuscript.

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Ethical considerations

"Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/ or falsification, double publication and/ or submission, redundancy, etc) have been completely ob-served by the authors."

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