Journal of Environmental Informatics Letters 14(2) 91-99 (2025)

Journal of Environmental Informatics Letters

www.iseis.org/jeil

GIS-Based Mapping and Assessment of Noise Pollution during Diwali Festival in IIT(ISM) Campus, Dhanbad, India

R. Patel[1] *, P. K. Singh[1], A. Kumar[1], and S. K. Tiwari[2]

[1] *Department of Environmental Science and Engineering, Indian Institute of Technology, Indian School of Mines, Dhanbad 826004, India*

[2] *Vijaybhoomi School of Science and Technology, Vijaybhoomi University, Karjat 410201, India*

Received 05 September 2024; revised 13 Janurary 2025; accepted 02 May 2025; published online 22 December 2025

ABSTRACT. In the present study, ambient noise levels were monitored in IIT(ISM) Dhanbad campus on Pre-Diwali and Diwali day. The findings of noise level monitoring revealed that the noise level was increased during the Diwali celebration due to the burning of a large number of firecrackers and celebrations using a music system inside the campus. The study focuses on a small geographic area, but the problem of huge generation of noise pollution is not limited to the present study area but is common all over India. During the daytime, the value of the average equivalent noise level on Diwali day is 11.8% higher when compared to Pre-Diwali day. For the nighttime, the average equivalent noise value is 27.2% higher when compared to Pre-Diwali day. When compared to the noise standards prescribed by Central Pollution Control Board (CPCB) for educational institutes i.e., silence zone, it is observed that the noise level exceeds by 38.5 and 86.2% on Diwali day for daytime and nighttime, respectively. Moreover, for clear visualization of noise dispersion, noise maps are prepared for different monitoring hours using ArcGIS software.

*Keywords: n*oise pollution, GIS, noise mapping, IDW, CPCB

1. Introduction

Noise pollution, often known as environmental noise, refers to excessive or unacceptable amounts of sound in the environment induced generally by human activity. It can be generated from various sources, including the transportation sector, manufacturing activities, construction projects, recreational activities, and social gatherings. Among all sources of noise pollution, the transportation sector is a major contributor due to the growing number of vehicles on the roads (Ranjan et al., 2023; Patel et al., 2024). In addition to contributing to air pollution, the transporttation sector is a significant source of noise pollution (Sakshi et al., 2023). However, sources of noise pollution other than the transportation sector, including social gatherings, cannot be ignored. Noise from social gatherings, such as parties, concerts, festival celebrations, and public events, can significantly impact local communities and contribute to overall noise pollution levels. These non-transportation sources of noise can be particularly disruptive during nighttime hours, affecting sleep patterns and quality of life for nearby residents.

Noise is an undesirable and annoying sound that has the potential to not only divert our focus but also to inflict psychological stress and bodily harm to any individual who is exposed to it repeatedly (Lipowicz and Lopuszanska, 2005; Kadhim et al., 2019). World Health Organization (WHO) identified seven types of negative health impacts caused by noise pollution in humans. Which consists of hearing loss, interference in communication, sleep difficulties, cardiovascular disturbances, mental health disorders, decreased task performance, bad social conduct, and irritational behavior. One of the most common effects of noise is hearing loss, which can be temporary or permanent depending on the extent of exposure. Noise pollution often causes irritation to human beings, which leads to learning disabilities (Town and Debnath, 2012). Prolonged noise raises cholesterol levels, resulting in persistent narrowing of blood vessels, which makes heart attacks more likely (Klompmaker et al., 2019; Biel et al., 2020).

Environmental noise is considered the third most dangerous pollutant, after air and water pollution (WHO, 2001). In a country like India, social gatherings are mainly prevalent during festive seasons, contributing significantly to noise pollution. This issue is amplified by the diverse cultural and religious ceremonies that typically involve loud music and fireworks. Diwali is among the most widely celebrated festivals throughout India with great enthusiasm. It is also called a festival of light that is celebrated with enormous devotion, usually in October or November. Every section of the community in India celebrates this occasion by lighting firecrackers and lights as a sign of joy and prosperity. It is also known for the biggest shopping season, so it is the reason for huge gatherings in the marketplace and residential areas. This gathering, along with the burning of firecrackers, is mainly responsible for the increased

* Corresponding author. Tel.: +919473973141.
E-mail address: rohitpatelp7@gmail.com (R. Patel).

ISSN: 2663-6859 print/2663-6867 online
 doi:10.3808/jeil.202400169

level of noise pollution, which is very dangerous for the environment and residents exposed to it. The usage of loudspeakers and musical activities during religious festivals in India generates noise pollution. Criminals take advantage of this opportunity and commit crimes when there is significant noise (Sharma and Joshi, 2010). During festivals, noise from firecrackers is among the most critical environmental issues. Every year, during the Diwali celebration in India, a substantial number of firecrackers are used. Moreover, many other festive occasions, such as Durga Pooja and Dussehra, as well as wedding functions, produce and release a tremendous amount of noise, especially in residential areas, which, as a result, gives rise to noise pollution and air pollution.

A study conducted in Jaisalmer City revealed that ambient noise levels significantly spiked during the Diwali festival due to the heavy use of firecrackers, with average noise levels rising from 61.94 to 72 dBA in residential areas and from 64.68 to 73.74 dBA in commercial areas (Mahecha et al., 2012). Another investigation done in Haridwar City found that noise levels dramatically increased during the festival of Diwali compared to non-festive days, with average noise levels rising by 29.6% in residential areas and 18.1% in commercial areas (Shar-ma and Joshi, 2010). A study indicated that noise and air pollution levels surged considerably in Sambalpur City during the Diwali festival, exceeding CPCB regulations, with maximum noise levels reaching up to 80.3 dBA in certain areas (Sahu et al., 2020). Similarly, the noise levels increased significantly during the Diwali festival in Raipur City (Ahirwar and Bajpai, 2015) and Kolhapur City (Mangalekar et al., 2012).

Existing studies often focus on broader urban areas like cities or residential and commercial zones. Conversely, this research focuses on a specific and unique environment, which is an educational institute with distinct characteristics like a mix of academic, residential, and recreational areas. As an educational institution, the campus falls under a silence zone with lowest permissible noise limits compared to other zones as per CPCB norms, making it a critical area for assessing compliance with noise standards during festivals. While prior research has analysed noise pollution during festive seasons, but limited studies use spatiotemporal noise distribution using GIS in such confined and sensitive areas as educational institutions. Additionally, no previous research has been undertaken to quantify health impacts such as annoyance and sleep disturbances, the study establishes a direct connection between noise levels and health outcomes, offering a holistic perspective. Monitoring noise levels during a culturally important event, including Diwali, provides data that can be used to influence policy decisions aimed at enhancing enforcement of the current CPCB standards, particularly in silence zones.

In the present study, the primary aim is to monitor ambient noise levels at several sites throughout campus, analyze the variations among Pre-Diwali and Diwali noise levels, and use GIS-based noise mapping tools to visualize the spatial distribution of noise pollution. Also, the health impacts in terms of annoyance and sleep disturbances have been comprehensively analyzed. This study seeks to highlight the level of noise pollution during the festival and the variation from CPCB norms for educational institutes, hence emphasizing the broader concern of environmental noise during festive occasions in India.

2. Study Area

This study aimed to compare noise levels on Diwali and non-Diwali day along with the preparation of noise contour maps of the IIT (ISM) campus, Dhanbad, Jharkhand, India (Figure 1). Dhanbad is also known as the coal capital of India, IIT (ISM) campus is located at 23.8133° N 86.4419° E with a population of around 11,000 including students, faculty, and all other staff. Seventeen monitoring locations were selected, which are homogeneously distributed and cover the entire campus area.

3. Materials and Methods

The sound level meter used for the recording of noise levels at various sites was Bruel and Kjaer, mediator 2238, with IEC 1672 class 1 standards. It is generally a recording type and can hold numerous readings. It measures sound pressure level in dBA, on an A-weighted scale. The dBA corresponds to a time-weighted average of sound pressure level. Moreover, to get the exact location of each monitoring location over a map in the form of latitude and longitude, a GPS meter (model: etrex H. Garmin) was utilized. ArcGIS version 10.5 has been utilized for noise mapping which is a cutting-edge GIS software package. ArcView is a well-established desktop GIS system well-known for its reliability and ease of use. GIS provides a robust set of tools for storing and accessing, interpreting, and displaying spatial data from the real world for a particular set of services.

3.1. Data Collection and Noise Descriptors Calculation

In the present study, noise levels were monitored at 17 selected locations during the Diwali festival in November 2023. Noise monitoring was conducted in compliance with the guidelines outlined in IS: 9989-1981. The measurements were conducted only under favorable weather conditions, ensuring the absence of strong winds, as wind speed above 5 m/s can affect the measurement accuracy. A Bruel and Kjaer 2238 Class 1 sound level meter (SLM) was used to record A-weighted noise levels. The SLM was mounted on a tripod at a height of 1.2 to 1.5 m above the ground and at least 3.5 m away from any sound reflecting objects for consistency and precision. The noise monitoring was carried out a day before Diwali and on Diwali day. It is well known that the primary cause of the higher level of noise during the Diwali festival is firecrackers and music systems everywhere. In India, firecrackers and music systems have been effectively started in the evening, preferably after 5 PM, and continued till midnight. However, the noise level monitoring was performed from 4 PM to 2.25 AM to get the accurate noise level variation caused by early or delayed Diwali celebrations at the selected monitoring locations. Besides noise level data, the latitude and longitude were also noted for the exact location of the monitoring sites.

The CPCB guidelines well define the time range as the period between 6 AM to 10 PM will be considered as daytime and between 10 PM to 6 AM will be considered as nighttime as

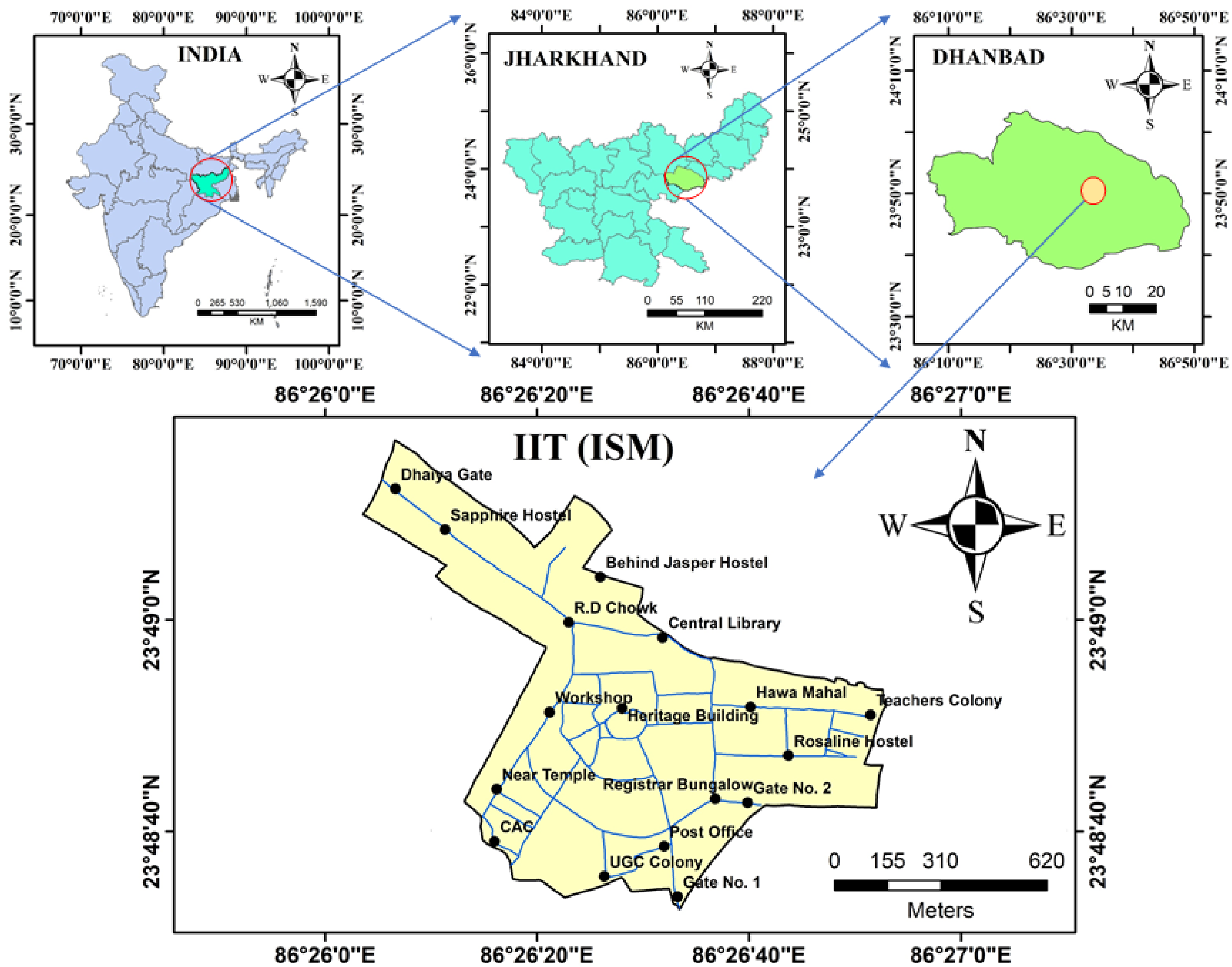

Figure 1. Location map of the study area.

mentioned in the Noise Pollution Regulation and Control Rules, 2000 (Ministry of Environment and Forest, 2000). As per the observation, L_{10}, L_{90}, and L_{eq} levels were measured. In addition to these, Lcpkmax was also recorded to highlight the impulsive noise caused by the burning of firecrackers. In general, L_{10} signifies the upper end of the noise level range, whereas L_{90} shows the background noise level in the absence of surrounding noise sources (Ranjan et al., 2023; Tiwari et al., 2024). Further, these parameters (L_{10} and L_{90}) are used for the calculation of noise climate (*NC*) and noise pollution levels (*LNP*), which are shown in Equations (1) and (2). *LNP* possesses variation in acoustic signal with fluctuating noise (Parbat and Nagarnaik, 2008):

$$NC = L_{10} - L_{90}\ (\text{dBA}) \tag{1}$$

$$LNP = L_{eq} + NC\ (\text{dBA}) \tag{2}$$

where, L_{10} = Noise level exceeding 10% of the time of the whole measurement duration, L_{90} = Noise level exceeding 90% of the time of the whole measurement duration.

The observed noise levels were compared with prescribed standards given by the Central Pollution Control Board (Ministry of Environment and Forest, 2000), shown in Table 1. For a better visual understanding of noise levels in the IIT (ISM) campus and its Spatiotemporal variations, noise maps were created using ArcGIS 10.5 software. The ambient noise contours were plotted using the interpolation approach in ArcGIS 10.5 software. Inverse Distance Weighted (IDW) is used in this interpolation approach to evaluate the acoustic characteristics of the geographic location. The noise level maps were created in ArcGIS for daytime and nighttime on Diwali and Pre-Diwali day to show the campus diurnal variation in noise levels. A spatial distribution map using IDW provides enhanced visual information on areas with higher noise levels and highlights areas more susceptible to noise pollution (Alam, 2011; Garg et al., 2021). The noise maps are created with bandwidths of 1 ~ 9 dBA. Each band has a varied color scheme that corresponds to different sound levels on the noise map. In the present study, the sound level scale varies from 43.2 to 80.3 dBA. The coordinate system projection for the Dhanbad region is UTM WGS 1984. Four different maps are created for workdays, i.e., for Pre-Diwali and Diwali daytime and nighttime.

Table 1. Standards of Noise Specified by Central Pollution Control Board, New Delhi (Ministry of Environment and Forest, 2000)

Code of Area	Category	Noise level as L_{eq} in dBA	
		Daytime (6AM ~ 10 PM)	Nighttime (10PM ~ 6AM)
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

Table 2. Noise Level Status During Pre-Diwali and Diwali Day (Daytime)

Location	Pre-Diwali day						Diwali day					
	L_{cpkmax}	L_{10}	L_{90}	NC	L_{eq}	LNP	L_{cpkmax}	L_{10}	L_{90}	NC	L_{eq}	LNP
Gate No. 1	96.0	87.6	60.6	27.0	68.9	95.9	96.8	83.4	57.6	25.8	71.9	97.7
Post Office	100.9	91.1	48.0	43.1	66.5	109.6	93.8	80.3	45.1	35.2	70.6	105.8
Gate No. 2	90.6	78.7	53.7	25.0	63.9	88.9	111.5	84.8	55.1	29.7	67.5	97.2
Registrar Bungalow	89.3	74.9	46.6	28.3	60.5	88.8	94.2	70.9	47.5	23.4	66.2	89.6
Rosaline Hostel	90.4	81.4	48.4	33.0	60.1	93.1	94.8	77.7	44.6	33.1	65.3	98.4
Teachers Colony	89.2	65.5	37.7	27.8	51.1	78.9	97.3	74.9	39.8	35.1	58.7	93.8
Hawa Mahal	84.5	69.5	39.8	29.7	52.7	82.4	100.6	74.8	51.7	23.1	59.4	82.5
Central Library	102.9	86.3	52.8	33.5	62.2	95.7	103.8	79.3	54.4	24.9	75.1	100.0
Behind Jasper Hostel	99.4	74.1	43.6	30.5	50.3	80.8	111.7	84.0	47.6	36.4	67.2	103.6
Dhaiya Gate	96.0	76.0	50.7	25.3	60.3	85.6	101.7	76.8	56.1	20.7	70.2	90.9
Sapphire Hostel	96.3	73.2	43.0	30.2	66.0	96.2	98.1	76.9	46.6	30.3	68.9	99.2
R.D Chowk	92.7	78.9	45.3	33.6	59.0	92.6	94.7	83.0	45.5	37.5	67.8	105.3
Workshop	88.6	72.2	43.9	28.3	55.2	83.5	107.9	80.8	47.6	33.2	65.3	98.5
Near Temple	99.5	74.0	45.5	28.5	54.0	82.5	116.9	94.0	50.8	43.2	72.4	115.6
CAC	97.9	74.0	43.7	30.3	58.1	88.4	116.6	91.5	47.9	43.6	71.6	115.2
UGC Colony	89.7	74.2	48.8	25.4	57.6	83.0	107.7	83.1	45.7	37.4	66.5	103.9
Heritage Building	91.4	72.9	43.8	29.1	49.3	78.4	98.7	78.4	50.1	28.3	56.2	84.5

4. Results

The results of noise monitoring for 17 different locations in the IIT (ISM) campus during Diwali and Pre-Diwali days (for both daytime and nighttime) are summarized in Tables 2 and 3. In the case of daytime, the average noise level on Diwali day is 14.5% higher, when compared with Pre-Diwali day. For the nighttime, the average noise value is 31.2% higher, when compared to Pre-Diwali day. When compared to the permissible noise standards, since educational institution comes under the category of the silent zone, all the monitoring sites exceeded the noise level during both Diwali and non-Diwali day except one monitoring site, i.e., a heritage building that was within the permissible limit given by CPCB during the daytime on Pre-Diwali day.

Furthermore, statistical data were analyzed using a box plot as shown in Figure 2. A box plot is a graphical representation of data distribution, summarizing key statistical measures and identifying variability. It comprises of three components namely Median, Interquartile Range, and Whiskers. The central line within the box represents the median, which is the middle value of the dataset, providing understanding of the central tendency of the data. The box itself spans the interquartile range (IQR), which extends from the 25th percentile (Q1) to the 75th percentile (Q3), capturing the middle 50% of the data and emphasizing the variability within this range. Whiskers extend from the edges of the box to the lowest and highest data points within 1.5 times the IQR from Q1 and Q3, demonstrating the range of non-extreme values. The box plots efficiently demonstrate the temporal variation in noise levels. They allow comparisons across different monitoring periods, providing visual indication of the substantial increase in noise pollution during the Diwali festival.

It was observed that on Pre-Diwali during the daytime, the minimum, maximum, and mean noise levels were 49.3, 68.9, and 58.3 dBA, respectively, with a standard deviation of ±5.9 dBA. On the other hand, on Diwali, during the day, the minimum, maximum, and mean noise levels were 56.2, 75.1, and 66.9 dBA, respectively, with a standard deviation of ±5.1 dBA. Furthermore, during nighttime on Pre-Diwali, minimum, maximum, and mean noise levels were 43.2, 64.2, and 54.5 dBA, respecttively, with a standard deviation of ±6.7 dBA. Subsequently, minimum, maximum, and mean noise levels increased to 58.6, 80.3, and 71.8 dBA, respectively, with a standard deviation of ±5.3 dBA on Diwali night.

4.1. Health Issues in Terms of Annoyance and Sleep Disturbances

Environmental noise pollution is a severe hazard that has the potential to threaten the well-being of those who live in thesurrounding areas. Prolonged exposure to noise levels might disrupt sleep and annoy people, causing psychological, emotional,

Table 3. Noise Level Status during Pre-Diwali and Diwali Day (Nighttime)

Location	Pre-Diwali night						Diwali night					
	L_{cpkmax}	L_{10}	L_{90}	NC	L_{eq}	LNP	L_{cpkmax}	L_{10}	L_{90}	NC	L_{eq}	LNP
Gate No. 1	93.4	77.5	51.5	26.0	62.5	88.5	113.7	88.4	59.3	29.1	70.8	99.9
Post Office	90.1	75.6	48.4	27.2	60.4	87.6	115.6	86.3	54.5	31.8	68.8	100.6
Gate No. 2	112.8	84.4	52.7	31.7	64.2	95.9	115.2	90.0	58.1	31.9	71.2	103.1
Registrar Bungalow	108.3	86.2	53.1	33.1	63.7	96.8	118.4	89.5	58.4	31.1	70.8	101.9
Rosaline Hostel	104.5	90.6	49.5	41.1	58.3	99.4	112.0	92.4	60.1	32.3	72.4	104.7
Teachers Colony	96.8	74.0	36.6	37.4	51.8	89.2	108.7	89.2	54.3	34.9	69.3	104.2
Hawa Mahal	88.0	65.7	35.8	29.9	45.1	75.0	104.0	88.9	55.8	33.1	67.4	100.5
Central Library	90.0	65.2	38.4	26.8	43.2	70.0	118.4	101.2	57.3	43.9	80.3	124.2
Behind Jasper Hostel	92.6	70.8	44.8	26.0	50.0	76.0	116.7	101.3	47.9	53.4	78.2	131.6
Dhaiya Gate	92.4	75.0	38.2	36.8	52.2	89.0	116.9	95.2	53.0	42.2	70.2	112.4
Sapphire Hostel	96.7	78.3	46.3	32.0	54.1	86.1	115.4	98.0	54.7	43.3	74.3	117.6
R.D Chowk	98.4	80.6	47.3	33.3	58.0	91.3	109.7	106	46.4	59.6	76.2	135.8
Workshop	90.2	79.5	40.3	39.2	57.4	96.6	113.4	90.4	49.6	40.8	68.9	109.7
Near Temple	102.4	81.4	43.5	37.9	61.1	99.0	115.4	98.2	50.4	47.8	70.5	118.3
CAC	93.6	73.0	39.5	33.5	51.1	84.6	116.7	100.8	55.7	45.1	78.3	123.4
UGC Colony	97.3	77.9	46.1	31.8	54.8	86.6	114.5	102.4	58.4	44.0	77.9	121.9
Heritage Building	81.4	70.5	38.7	31.8	44.6	76.4	97.4	74.2	49.0	25.2	58.6	83.8

Table 4. Percentage of People Highly Annoyed and Facing Sleep Disturbance

Parameters	Pre-Diwali	Diwali
DNL (dB)	66.4	81.6
HA (%)	22.4	53.0
HSD (%)	10.3	25.1

and physiological stress responses (Guski et al., 2017; Eze et al., 2018; Babisch, 2019; Kadhim et al., 2019). In the Indian context, a recent study conducted in Kanpur City compared the health risk associated with environmental noise pollution during pre-lockdown, lockdown, and unlock phase in terms of annoyance and sleep disturbances employing Equation 4 and 5 (Mishra et al., 2021). Similarly, in the present study based on exposure to environmental noise levels during the Diwali festival, the present study included two methods to assess the population at increased risk of being highly annoyed (%*HA*) and the proportion of individuals with a greater extent of sleep disturbance (%*HSD*). The percentage of the population who are highly annoyed as a result of exposure to excessive noise can be approximated as a function of day-night noise level (*DNL*) using Equation (3) (Miedema et al., 2002; Mishra et al., 2021). They assumed that at a noise intensity of 42 dB or lower, the level of annoyance is zero, and the Equation (3) is expressed as:

$$\%HA = 0.24\times\left(DNL-42\right)+0.0277\times\left(DNL-42\right)^2 \qquad (3)$$

The day-night noise level has been estimated using Equation (4):

$$DNL = \frac{10\log\left(15\times10^{\frac{L_d}{10}}+9\times\frac{10^{\left(L_n+10\right)}}{10}\right)}{24} \qquad (4)$$

where, L_d corresponds to the average daytime noise level, L_n corresponds to the average nighttime noise level.

Similarly, the percentage of people with high sleep disruptions (%*HSD*) due to environmental noise can be calculated using Equation (5) (Miedema and Oudshoorn, 2001; Mishra et al., 2021):

$$\%HSD = 20.8-1.05L_n+0.01486L_n^2 \qquad (5)$$

Table 4 shows the percentage of highly annoyed people and the percentage of people facing high sleep disturbances on the campus during Diwali and Pre-Diwali days. During the Pre-Diwali day, 22.4% of individuals were expected to be highly annoyed, with the percentage rising to 53% during Diwali day. Furthermore, the risk of sleep disruption was found to be 10.3% during the Pre-Diwali day, rising to 25.1% during Diwali day. Therefore, it can be concluded that % of annoyed people increased by 137.5% on Diwali when compared to Pre-Diwali, and the risk of sleep disruption increased by 143.7% during Diwali when compared to Pre-Diwali.

4.2. Noise Mapping

In noise pollution research, GIS serve as a complementary tool to Remote Sensing, enhancing spatial analysis capabilities and supporting informed decision-making processes (Sakshi et al., 2023). In the present study, as mentioned earlier, the Inverse Distance Weighted (IDW) technique, a popular interpolation method

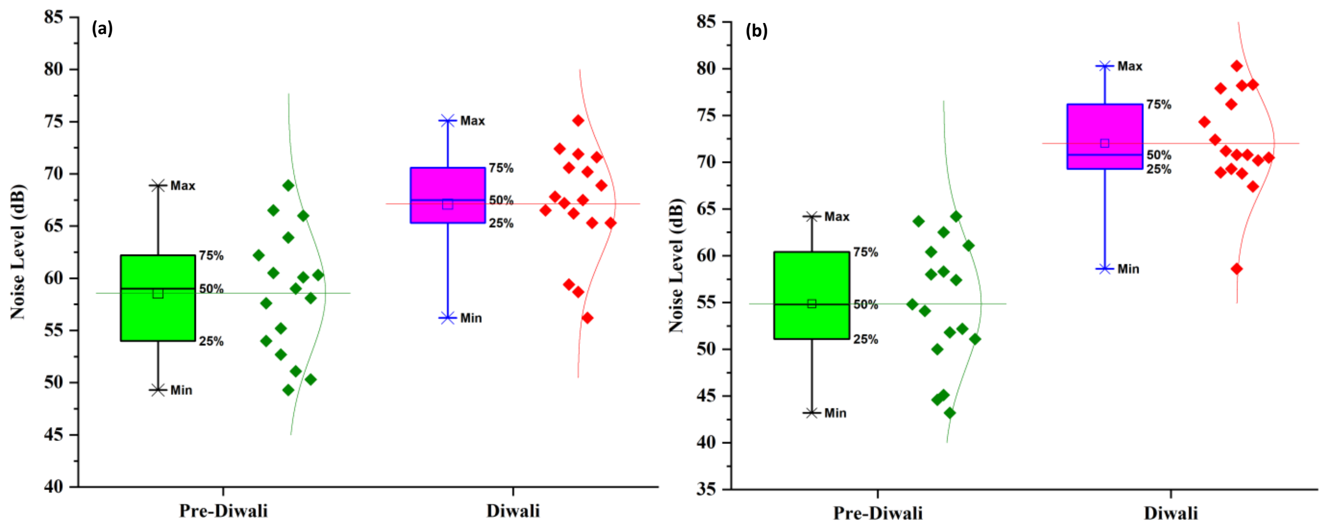

Figure 2. Box plot of L_{eq} for Pre-Diwali and Diwali (a) daytime and (b) nighttime.

in ArcGIS, was employed to create noise maps from discrete data points. The IDW technique for noise mapping involves several key steps. First, noise data is collected from multiple monitoring stations across the study area, creating a dataset of noise levels with geographic coordinates. Subsequently, nearby monitoring points are selected for each interpolation location based on a defined radius or the nearest points. These neighboring points are assigned weights inversely proportional to their distances, with closer points having a more significant influence. The noise level at each interpolation point is then calculated as a weighted average of the nearby measurements. Finally, the interpolated values are used to generate a continuous noise contour map, demonstrating areas of equal noise levels across the region. A limitation of the IDW technique is that it may not accurately capture complex noise propagation patterns influenced by factors such as terrain or building structures (Patel et al., 2024).

4.2.1. Noise Map for Pre-Diwali and Diwali (Daytime)

It has been observed that the maximum noise level during daytime is 68.9 dBA at Gate No. 1 of the institute because it lies adjacent to the national highway, and traffic noise is significant in this location. The quietest site is a heritage building with a noise level of 49.3 dBA because it is located at the institute's center, where interference from traffic is minimal. It is concluded that noise during the daytime on Pre-Diwali day exceeded the permissible limit given by CPCB except for one location, i.e., the Heritage building. Noise contour maps for the Pre-Diwali day show that the variation of noise level is from 49 to 69 dBA (Figure 3a). It can be clearly seen those monitoring locations that are close to the highway and where interference from the external environment other than the college campus, i.e., Gate no. 1, Gate no. 2, Registrar Bungalow, Dhaiya Gate, and Sapphire Hostel, have maximum values of noise levels.

On Diwali day, it was seen that the noisiest location was the Central Library, which had a noise level of 75.1 dBA because students had arranged a DJ and music system for the celebration. Again, the minimum noise level was reported at the Heritage Building, i.e., 56.2 dBA. At all the monitoring locations, noise level was beyond the permissible limit prescribed by CPCB. Noise contour maps of the campus for Diwali day show that variation in the value of noise is from 56 to 75 dBA (Figure 3b). Most of the campus areas during this time are exposed to the higher noise level of 59 to 65 dBA, indicated with yellowish to light orange color on the map.

4.2.2. Noise Map for Pre-Diwali and Diwali (Nighttime)

The maximum noise level of 64.2 dBA was encountered at Gate No. 2, which is exposed to traffic noise since a national highway passes adjacent to it. A minimum noise level of 43.2 dBA is observed at the central library. In these monitoring durations, all the locations exceed the noise level prescribed by CPCB. The noise map of campus for Pre-Diwali nighttime shows that noise level varies from 43 to 65 dBA (Figure 4a).

On Diwali, during nighttime, the maximum noise level of 80.3 dBA was observed at the library due to the celebration using a DJ and music system along with the burning of firecrackers. A minimum value of 58.6 dBA was measured at the heritage building, which confirms that the heritage building is the quietest among all the locations. Again, the noise level at all the sites exceeded the standard prescribed by CPCB. Noise contour maps of Diwali night show the variation of noise levels from 59 to 81 dBA (Figure 4b). The majority of the campus area during this time is yellowish to orange in color, showing very high level of noise pollution from 64 to 78 dBA.

5. Discussion

Diwali is one of India's most popular festivals, and it has been observed since ancient times. The ancient celebration style was environmentally friendly and symbolized Indian culture and values. In the early days, earthen lamps were only made on

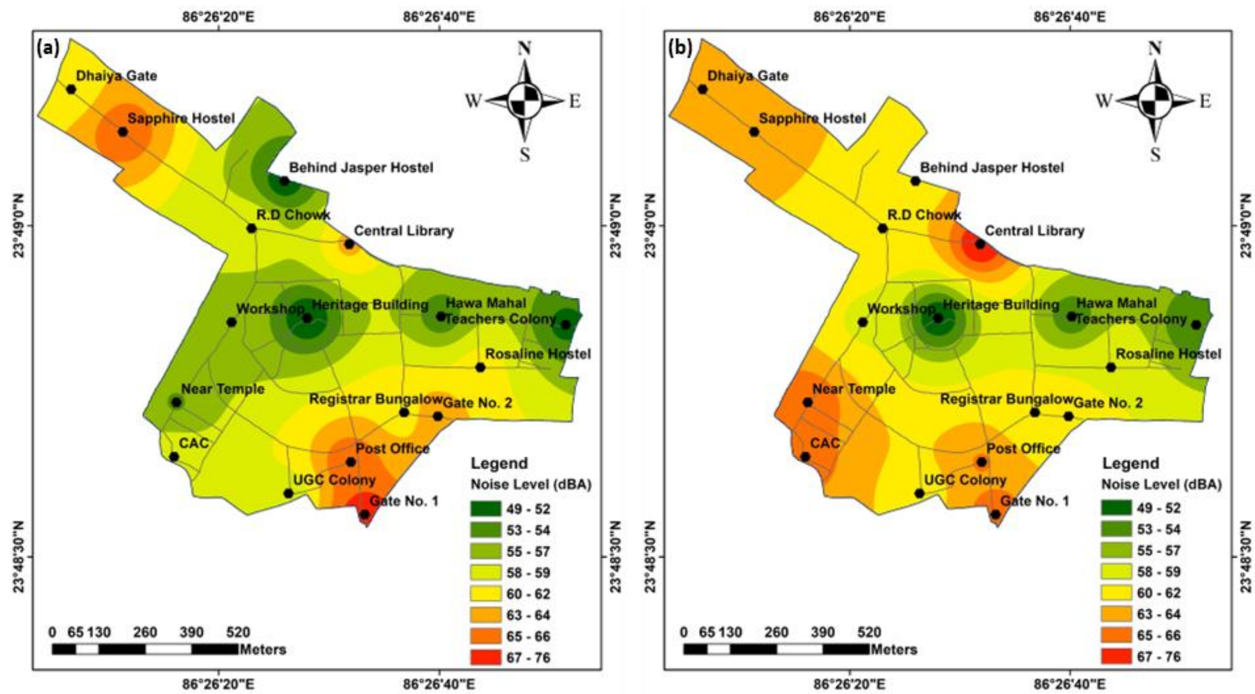

Figure 3. Noise map for daytime (a) Pre-Diwali and (b) Diwali.

Diwali, and no crackers burst, which caused neither noise pollution nor air pollution. But nowadays, the scenario has changed because of the modern and advanced way of celebrating Diwali. On such holidays, the excessive usage of firecrackers transforms the clear, fresh, and pleasant atmosphere into a smoky air with elevated noise levels. On celebration day, the average equivalent sound level in selected residential and commercial districts of Jaisalmer city increased from 61.94 to 72 dBA and 64.68 to 73.74 dBA (Mahecha et al., 2012). On a festive day in Kolhapur city, the Researcher observed average noise levels of 94.29 and 89.32 dBA in chosen commercial and residential zones, respectively (Hunashal and Patil, 2011). In another study, as compared to other days in Delhi, it has been reported that the concentration of pollutants in the air and noise intensity is significantly higher on Diwali days (Mandal et al., 2012). Diwali festival has a more significant impact on residential regions of Delhi than on commercial areas (Singh et al., 2010). Diwali celebrations have harmed not only Delhi but also other Indian cities. According to some previous studies, it has been observed that even on a normal day, the noise level is found to be more than the standard values. It has been found that maximum and minimum noise levels in Moradabad city were 109.70 and 72.86 dBA in the residential area and 108.3 and 53.1 dBA in the commercial area (Chauhan et al., 2010). It has been reported that environmental noise pollution is the leading cause of headaches, elevated blood pressure, and other stress in people working near Varanasi (Sahu et al., 2021).

In the present study, it has been reported that on Pre-Diwali day, the noise level ranges from 49.3 to 68.9 dBA and 43.2 to 64.2 dBA during day and nighttime, respectively. During the whole monitoring period, it was observed that all the monitoring stations exceeded the noise level from standard value except for the heritage building. It has a noise level of 49.3 dBA during the daytime on Pre-Diwali day, which is within the permissible limit, i.e., 50 dBA for a silence zone in the daytime according to CPCB. The Heritage Building had the lowest noise levels due to its central location, insulated from traffic and celebratory noise. On Diwali day, the maximum noise level of 80.3 dBA was observed at the central library. The arrangement of DJ night was made by students at the central library, which resulted in the gathering of a massive crowd with firecrackers burning; due to this, a peak value of noise level was reported at this particular location. It has also been found that a few monitoring sites, such as Gate No. 1, Gate No. 2, Behind Jasper Hostel, Dhaiya Gate, and CAC (Children Activity Centre), show greater noise levels during all the monitoring periods because of the reason that all these sites are located at the periphery of the campus. Therefore, the Influence of the Diwali celebration outside the campus was seen in these peripheral locations. Additionally, these peripheral locations experienced higher noise due to proximity to the national highway. The peripheral areas showed higher noise level from off-campus celebrations and external traffic interference, signifying that even regulated zones cannot completely avoid external influences. To protect the population from exposure, precautionary measures must be implemented. Salient preventive measures recommended that the public should adopt to control noise pollution during the festive season are as under:

- Crackers may be burned in open areas away from residential areas.
- Fireworks (crackers and illuminations) should be used minimally.
- Instead of using firelights, electric lighting should be encouraged.

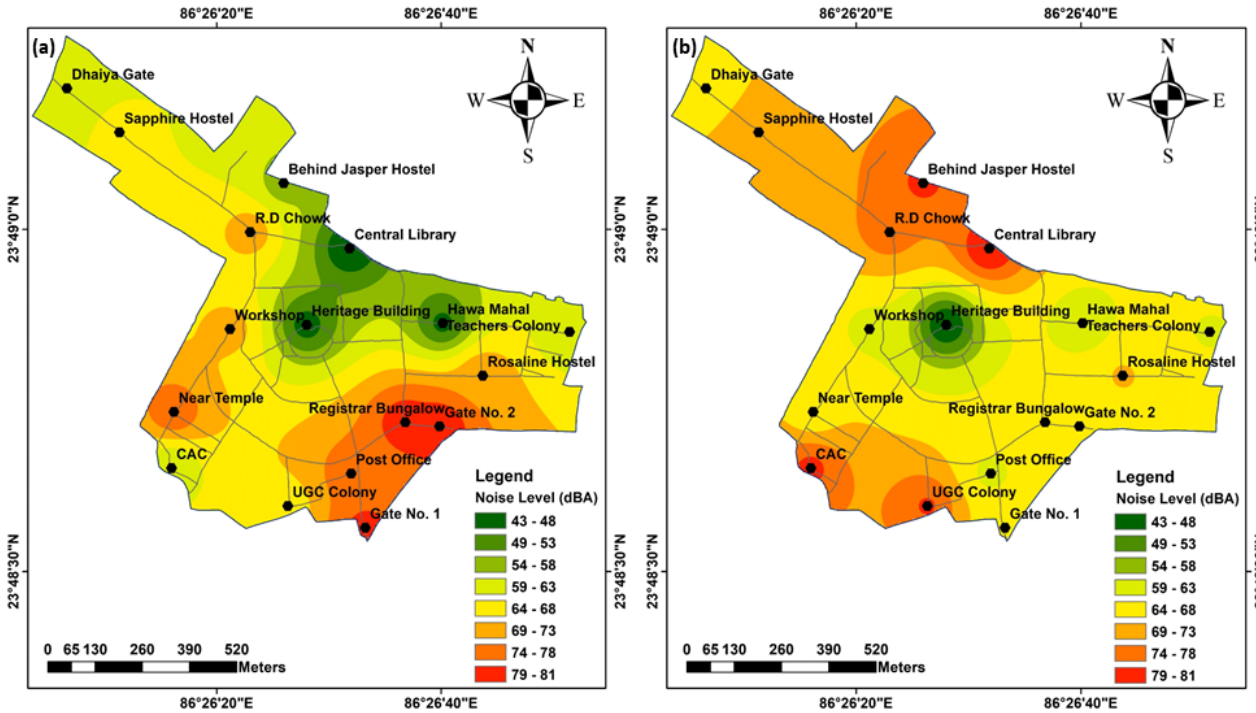

Figure 4. Noise map for Nighttime (a) Pre-Diwali and (b) Diwali.

- Prior to the Diwali festival, public awareness campaigns should be hosted to spread awareness about the environmental consequences of noise pollution.

6. Conclusion

In the present study, it has been depicted that during the daytime of measurement on the Pre-Diwali and Diwali day, the average noise level was 62.0 and 69.3 dBA, respectively, which are greater than the standard value of 50.0 dBA prescribed by CPCB for daytime in the silence zone. Moreover, the average noise level during nighttime was 58.6 and 74.5 dBA on the Pre-Diwali night and Diwali night, respectively, which also exceeded the standard value of 40.0 dBA prescribed by CPCB for nighttime in the silence zone. Through the present study, it is concluded that if this is the situation of an educational institute, then the condition of large cities throughout festive and non-festive occasions may be severe. People cannot stop themselves from lighting firecrackers despite the Honourable Supreme Court of India's stricter rules and regulations. The findings show that, despite established CPCB requirements, existing noise measures during festivals are ineffective. It demonstrates the necessity for specific measures, such as prohibiting high-decibel firecrackers and limiting late-night music systems, especially in sensitive locations.

This study is limited to a single campus; however, the methodology employed can be extended to larger urban settings in the future to enhance its applicability. Moreover, the current research assessed annoyance and sleep disturbances using indirect measures. Future studies could incorporate a comprehensive socio-acoustic survey, encompassing a wider range of noise-induced health impacts, to provide more extensive insights.

Acknowledgments. The authors are thankful to the Indian Institute of Technology (Indian School of Mines), Dhanbad — 826004, India for providing facilities, guidance and cooperation carrying out the work.

Appendix A: Key Terms.

IDW - Inverse distance weighted
L_{eq} - Equivalent sound pressure level
L_{cpkmax} - Peak sound level
NC - Noise climate
LNP - Noise pollution level
L_{10} - Noise level exceeding 10% of the time of the measurement
L_{90} - Noise level exceeding 90% of the time of the measurement
%HA - Percentage of people highly annoyed
%HSD - Percentage of people facing high sleep disturbance
DNL - Day-night noise level
GIS - Geographic information system
CPCB - Central pollution control board

References

Ahirwar, A. V. and Bajpai, S. (2015). Assessment of noise pollution during Deepawali Festival in Raipur City of Chhattisgarh, India. *International Conference on Chemical, Environmental and Biological Sciences*, 88-90. https://doi.org/10.15242/iicbe.c0315137

Alam, W. (2011). GIS based assessment of noise pollution in Guwahati City of Assam, India. *International Journal of Environmental Sciences.* 2(2), 731-740. https://doi.org/10.6088/ijes.00202020034

Babisch, W. (2011). Cardiovascular effects of noise. *Noise and health*. 13(52), 201-204. https://doi.org/10.1016/B978-0-444-63951-6.0024 4-8

Biel, R., Danieli, C., Shekarrizfard, M., Minet, L., Abrahamowicz, M., Baumgartner, J., Liu, R., Hatzopoulou, M. and Weichenthal, S. (2020). Acute cardiovascular health effects in a panel study of personal exposure to traffic-related air pollutants and noise in Toronto, Canada. *Scientific Reports.* https://doi.org/10.1038/s41598 -020-73412-6

Chauhan, A., Pawar, M., Kumar, D., Kumar, N. and Kumar, R. (2010). Assessment of noise level status in different areas of Moradabad City. *Report and Opinion*, 2(5), 59-61.

Eze, I. C., Foraster, M., Schaffner, E., Vienneau, D., Héritier, H., Pieren, R., Thiesse, L., Rudzik, F., Rothe, T., Pons, M., Bettschart, R., Schindler, C., Cajochen, C., Wunderli, J. M., Brink, M., Röösli, M. and Probst-Hensch, N. (2018). Transportation noise exposure, noise annoyance and respiratory health in adults: A repeated-measures study. *Environment International.* https://doi.org/10.1016 /jenvint.2018.10.006

Garg, N., Chauhan, B. S. and Singh, M. (2021). Normative framework of noise mapping in India: Strategies, implications and challenges ahead. *Acoustics Australia*. 49(1), 23-41. https://doi.org/10.1007/s40 857-020-00214-1

Guski, R., Schreckenberg, D. and Schuemer, R. (2017). WHO environmental noise guidelines for the European region: A systematic review on environmental noise and annoyance. *International Journal of Environmental Research and Public Health. 14*(12), 1539. https://doi.org/ 10.3390/ijerph14121539

Hunashal, R. B. and Patil, Y. B. (2011). Environmental noise pollution in Kolhapur city, Maharashtra, India. *Nature Environment and Pollution Technology.* 10(1), 39-44.

Kadhim, H. R., Kadhim, K. R. and Shaker, M. M. (2019). Assessment of noise pollution and its impact on human health in Hilla city. *Journal of Global Pharma Technology.* 11(7), 709-714.

Klompmaker, J. O., Janssen, N. A. H., Bloemsma, L. D., Gehring, U., Wijga, A. H., Brink, C. Vanden, Lebret, E., Brunekreef, B. and Hoek, G. (2019). Associations of combined exposures to surrounding green, air pollution, and road traffic noise with cardiometabolic diseases. *Environmental Health Perspectives.* 127(8), 087003. https://doi.org /10.1289/EHP3857

Lipowicz, A. and Lopuszanska, M. (2005). Marital differences in blood pressure and the risk of hypertension among Polish men. European Journal of Epidemiology. 20(5), 421-427. https://doi.org/10.1007/s10 654-005-1752-x

Mahecha, G. S., Bamniya, B. R., Kapasya, V. and Meena, R. S. (2012). Noise pollution monitoring during Diwali festival in Golden city Jaisalmer of Rajasthan, India. *Environmentalis.* 32(4), 415-419. https: //doi.org/10.1007/s10669-012-9404-7

Mandal, P., Prakash, M. and Bassin, J. K. (2012). Impact of Diwali celebrations on urban air and noise quality in Delhi City, India. Environmental Monitoring and Assessment. 184(1), 209-215. https://doi. org/10.1007/s10661-011-1960-7

Mangalekar, S., Jadhav, A. and Raut, P. (2012). Study of Noise Pollution in Kolhapur City, Maharashtra, India. *Universal Journal of Environmental Research and Technology.* 2(1), 65-69. https://www. Researchgate.net/publiction/284601392_Study_of_Noise_Pollution_in_Kolh apur_City_Maharashtra_India%0Awww.environmentaljournal.org

Miedema, H. M. E. and Oudshoorn, C. G. M. (2001). Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives.* 109(4), 409-416. https://doi.org/10.1289/ehp.01109409

Miedema, H. M. E., Passchier-Vermeer, W., Vos, H. and Delft, C. (2002). *Elements for a Position Paper on Night-Time Transportation Noise and Sleep-Disturbance.* TNO-Inro rapport.

Ministry of Environment and Forest. (2000). *The Noise Pollution (Regulation and Control) Rules.* Government of India.

Mishra, A., Das, S., Singh, D. and Maurya, A. K. (2021). Effect of COVID-19 lockdown on noise pollution levels in an Indian city: a case study of Kanpur. *Environmental Science and Pollution Research.* 28(33), 46007 – 46019. https://doi.org/10.1007/s11356-021-13872-z

Parbat, D. K. and Nagarnaik, P. B. (2008). Assessment and ANN modeling of noise levels at major road intersections in an Indian intermediate city. *Journal of Research in Science, Computing and Engineering.* 4(3), 1-1. https://doi.org/10.3860/jrsce.v4i3.632

Patel, R., Singh, P. K. and Saw, S. (2024). A modeling approach for suitability evaluation of traffic noise prediction under mixed traffic situation in mid-sized Indian cities. *Innovative Infrastructure Solution.* 9(6). https://doi.org/10.1007/s41062-024-01493-7

Patel, R., Singh, P. K., Saw, S. and Tiwari, S. K. (2024). Assessment and prediction of noise pollution-induced health impacts in urban environment: a structural equation modeling (SEM)-based approach. *Arabian Journal of Geosciences.* 17(11), 1-17. https://doi.org/10.1007/s1 2517-024-12114-z

Ranjan, R., Kumar, S. and Singh, R. (2023). Monitoring of traffic noise pollution in urban Patna, Bihar, India. *Noise and Vibration Worldwide.* 54(4-5), 183-193. https://doi.org/10.1177/09574565231161644

Sahu, A. K., Nayak, S. K., Mohanty, J. K., Pradhan, P. K. and Mohanty, C. R. (2021). Evaluation of Noise and Air Pollution During Diwali in Berhampur City, India: An Inclusive Annoyance Study. *Lecture Notes in Mechanical Engineering.* Springer International Publishing, 95-105. https://doi.org/10.1007/978-981-15-7779-68

Sahu, A. K., Pradhan, P. K., Mohanty, C. R. and Pradhan, M. (2020). Analysis of noise and air pollution in Sambalpur City, India, during Diwali. *Journal of Environmental Engineering and Science.* 15(4), 172-179. https://doi.org/10.1680/jenes.20.00006

Sakshi, Neeti, K. and Singh, R. (2023). Diverse Applications of Remote Sensing and Geographic Information Systems in Implementing Integrated Solid Waste Management: A Short Review. *The 4th International Electronic Conference on Applied Sciences,* MDPI: Basel, Switzerland. I-56, 109.

Sharma, V. and Joshi, B. D. (2010). Assessment of noise pollution during Deepawali festival in a small township of Haridwar City of Uttarakhand, India. *Environmentalist.* 30(3), 216-218. https://doi.org/10.1007/s10 669-010-9265-x

Singh, D. P., Gadi, R., Mandal, T. K., Dixit, C. K., Singh, K., Saud, T., Singh, N. and Gupta, P. K. (2010). Study of temporal variation in ambient air quality during Diwali festival in India. *Environmental Monitoring and Assessment.* 169(1), 1-13. https://doi.org/10.1007/10661-009-1145-9

Tiwari, S. K., Kumaraswamidhas, L. A., Patel, R., Garg, N. and Vallisree, S. (2024). Traffic noise measurement, mapping, and modeling using soft computing techniques for midsized smart Indian city. *Measurement: Sensors*. 33, 101203. https://doi.org/10.1016/j.measen.2024. 101203

Town, N. and Debnath, B. (2012). Environmental Noise Pollution in Educational Institutes of Nagaon Town, Assam, India. *Global Journal of Science Frontier Research Enviornment & Earth Sciences*. 12(1), 1-5.

WHO. (2001). Occupational and community noise. World Health Organization.