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ASSESSMENT OF SEASONAL VARIATIONS IN NOISE POLLUTION AT SELECTED LOCATIONS OF AMRAVATI CITY

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Abstract- *The rapid urbanisation, increase in the volume of vehicular traffic and commercial activities have led to the serious environmental problem of noise pollution. In the present study noise pollution level has been measured in the residential, commercial, transport, industrial, silent zones of Amravati and compared with guidelines of Central Pollution Control Board (CPCB). The noise pollution was measured by using sound level meter at 22 monitoring locations during rainy, winter and summer seasons. The performance of several noise indices such as L_{eq}, L_{max}, L_{min}, L_{10}, L_{50}, L_{90}, NC, LNP and TNI were assessed. The results showed that most of the locations of Silent, Residential, Commercial and Transportation zones were above the permissible limits of CPCB while Industrial zones were within the limits. The highest exceedances were recorded at silent zones location S_1 (61.6% above the limit in winter), residential zone R_5 (41.4%), commercial zone C_2 (32.2%) and transport zone T_2 (18.5%). Maximum noise was observed in winter with seasonal variation, followed by rainy and summer seasons because of increased vehicular traffic, honking and roadside commercial activities, crowding and atmospheric conditions (temperature inversion, increased humidity, low wind) that reduce sound dispersion. The study highlights the need for focused traffic management, strict implementation of CPCB rules, public awareness campaigns and constant monitoring to mitigate urban noise pollution.*

1. INTRODUCTION

Noise is the unwanted sound produced by several natural or man-made activities such as construction, industrial, transportation etc, or due to pressure variations in a medium (generally air), arising from vibration or turbulence [1][2]. The word 'Noise' is derived from the Latin word “nausea” meaning Unpleasant Sound, Unwanted Sound, Sound that is loud, A Harsh Sound, and Sound that is unexpected. Noise is an unwanted, loud and unexpected sound with unpleasant, detrimental physiological and psychological effect on human [3]

The sources of noise levels vary with the type of neighbourhood; the level of noise in high density areas is significantly different from that of low density area[4]. The sound or noise may be generated from different sources like transport noise, industrial noise, domestic noise, other activities[5][6].Automobiles, construction, festivals, factories, stations, diesel shades, garages and workshops are sources of noise [7].Noise pollution is caused not only in the urban areas but the suburban and rural areas nearby due to creation of new transportation routes and maintenance and operation of the existing ones [8] .Motor vehicles, industrial activities, street vendors, and public gatherings are sources of environmental noise that causes stress, sleep disturbances, cardiovascular diseases, hearing loss, and cognitive decline [9].The study found vehicular pollution as one of the most prominent cause of noise pollution and loud music as the second most prominent cause of noise pollution[10]. There are many factor which causes the noise pollution in construction site. Noises from machinery or handwork construction such as piling, welding, knocking, hammering or even material transportation[24].

The study shows that female youth are more sensitive as compared to male youth about noise pollution in Delhi. It also shows that noise pollution at night is more detrimental for the cardiovascular health of a human being than noise pollution during the day[10]. According to the latest publication of the World Health Organization (WHO, 2018) at least 100 million people are affected by the road noise in the European Union and at least 1.6 million years of healthy life are lost every year. Noise interferes with communication, concentration, relaxation and sleep[3].

The negative impacts on health include headaches, sleeplessness, psychological disorders, lack of concentration at work, and others like hearing loss, learning difficulties, stroke, hypertension, and reduced quality of life [11]. A report showed that high-intensity noise exceeding the recommended limit of 70 dB can lead to work-related health problems. These issues include noise-related conditions such as headaches and hearing damage. Noise-induced hearing loss is a disorder that cannot be reversed, but it can be prevented[12]. Noise-induced hearing impairment, interference with speech communication, disturbances

during rest and sleep, effects on mental health and performance, changes in residential behaviour, annoyance, and interference with intended activities are all concerns [13].

2. METHODOLOGY

2.1 Study area description

The location for this study was Amravati which is located in Maharashtra, India. It is ranked as the seventh most populated city in Maharashtra and has approximate latitudinal and longitudinal coordinates of 20°56′ N and 77°47′ E, respectively. The Amravati Municipal Corporation has a geographical area of about 121.65 km^2 with a census population of 647,057 according to the 2011 census. Amravati is located on the National Highway (NH 6), which connects the cities of Mumbai in the west to Kolkata in the east, providing a good network of road and railways connecting Amravati with most of the major cities in India[14]. Rapid urbanization, increasing number of motor vehicles, increased commercial activities and mixed land use developments have all contributed to a significant increase in the level of noise. The area within study boundaries includes: residential areas, commercial areas, industrial areas, areas designed as silence zones (hospitals and educational institutions), and busy transportation areas; thus making Amravati an excellent place to assess noise pollution.

2.2 Selection of monitoring locations

Monitoring sites were selected based on the intensity of traffic, level of human activity and the degree of environmental sensitivity that existed in each zone. A total of 22 locations were identified (see tables 1 - 5) as potential locations for monitoring noise in each of the different land use zones. To facilitate mapping of the results, a colour code was assigned for each different land use zone as follows: Silent zone (red), Residential Zone (green), Commercial Zone (yellow), Transport Zone (blue) and Industrial Zone (purple). These sites were plotted on Google Map to illustrate their spatial distribution as shown in fig 1.

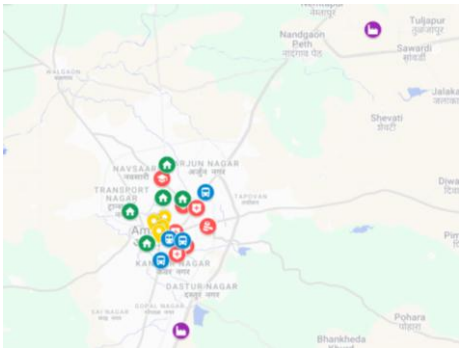


Fig-1: Google Map of selected monitoring locations.

2.2.1 Silent zone

Silence zones are defined as areas within 100 meters of sensitive premises. Such as areas around hospitals, educational institutions, and courts where strict noise control is required to maintain a peaceful environment. These areas are expected to have lower permissible noise limits. The monitoring locations selected for the silent zone are shown in Table 1.

Table-1: Monitoring locations of silent zone.

Sr no	Location	Location Code
1	Irvin Square	S_1
2	Dr. Panjab Rao Deshmukh Memorial Medical College (PDMMC)	S_2
3	Suyash Hospital (Mult speciality)	S_3
4	Swami Vivekanand Colony	S_4
5	District Court Amravati	S_5
6	Katora Naka	S_6
7	Government Polytechnic Amravati (GPA)	S_7

2.2.2 Residential zone

The term "Residential Zone" is used to refer to the land that is intended for housing; Housing is the predominant use of the land within those zones. Residential areas typically have low levels of noise but are very sensitive to levels of noise given the significant potential of continuous exposure of humans. The monitoring locations selected for the residential zone are shown in Table 2.

Table-2: Monitoring locations of Residential zone.

Sr no	Location	Location Code
1	Saraswati Nagar	R_1
2	Behind Rohini park	R_2
3	Rathi Nagar	R_3
4	Amba Gate	R_4
5	Jamil colony	R_5

2.2.3 Commercial zone

Commercial zones refer to a wide variety of markets, shopping centres, and business and commercial districts. Commercial zones are characterized by significant human activity (such as shopping, etc.) and therefore higher levels of noise. The locations of noise monitoring sites in commercial zones are primarily determined by the commercial density, the amount of traffic and the frequency of pedestrian traffic at those locations, monitoring locations selected for the commercial zone are shown in Table 3.

Table-3: Monitoring locations of Commercial zone.

Sr no	Location	Location Code
1	Cotton Market	C_1
2	Itwara Bazar	C_2
3	Jaistambh Chowk	C_3
4	Rajkamal Square	C_4

2.2.4 Transport zone

Transport zones refer to the major roads/highways, Bus Stops, Train Stations and Bus /Truck Transport and TRANSIT STOPS (Intersections) where vehicles make noise. The monitoring locations selected for the transport zone are shown in Table 4.

Table-4: Monitoring locations of Transport zone.

Sr no	Location	Location Code
1	Amravati Railway Station	T_1
2	Amravati Main ST Bus Stand (Central)	T_2
3	Rajapeth MSRTC Bus Stand	T_3
4	Welcome Point	T_4

2.2.5 Industrial zone

Industrial zones are defined by the presence of manufacturing processes and heavy duty vehicles that create noise. The sites selected for Noise Monitoring in Industrial Zones are based on the location of Industrial areas with active manufacturing and traffic. The selected industrial monitoring sites are listed in Table 5.

Table-5: Monitoring locations of Industrial zone.

Sr no	Location	Location Code
1	MIDC Amravati	I_1
2	MIDC Nandgaon Peth	I_2

2.3 Instrumentation

The KOICO Sound Level Meter was used to measure ambient noise. It was inspected and calibrated by following the manufacturer's instructions and guidance. Ambient noise was measured in A-weighted decibels (dB) it measure the ambient sound levels for sounds that are typically heard by people.

2.4 Data collection procedure

Ambient noise level data were collected on a systematic basis at the designated measurement sites over three seasons to provide for environmental variation in ambient sound. Three distinct periods of the day (morning, afternoon, and evening) formed the basis for sampling all measurement locations during three separate sampling events for each of the three seasons (morning—08:30–10:30, afternoon—13:00–15:00, and evening—17:30–19:30) in order to obtain measurements of various levels of activity occurring at those locations.

Standard operating protocol was followed for all sampling. At each sampling location KOICO sound level meter was placed 1.2–1.5 m above the ground and at least 3.5 m away from reflecting surfaces; special care was taken to provide for no obstructions or interference, as well as to assure that each sampling period was no less than approximately 15–20 min[15]. The 15–20 minute sampling period was used to provide for establishing a stable equivalent sound level (L_{eq}) for a particular location and time period, which is consistent with previous studies and recommended by British Standard BS:3425-1966[16][17].

All data collected were compiled in an Excel spreadsheet. Using daily averaged sound level (L_{eq}) and other noise

indices for all sound level data averaged on a daily basis for three-day L_{eq} measurements were obtained based upon the location of the study site and time of year the measurements were collected. Noise indices and statistical analyses were completed per season and include: L_{eq}, L_{max}, L_{min}, L_{10}, L_{50}, L_{90}, NC, LNP, and TNI.

2.4.1 Seasonal monitoring frame work

A seasonal comparative framework was used to study variations in noise in each zone[22][23]. The seasons studied were rainy from October 6 – November 16, 2025, winter: December 15, 2025 – January 4, 2026, and summer: March 23 – April 12, 2026. The primary area of focus of the study was the seasonal variation of average Leq, and the identification of a peak noise season for each zone.

2.4.2 Quality control and precautions

The following procedures were established to maintain high quality and dependable data:

- Calibration of instruments was completed prior to taking readings.
- Selecting appropriate monitoring locations that are representative and unobstructed.
- Excluding measurements where the weather conditions at the time of measurement (i.e., rain or strong winds) have been adverse.
- Taking multiple short-term readings in order to reduce random error.
- Excluding data associated with abnormal or temporary events (i.e., traffic congestion, excessive horn honking).

These procedures were taken to minimize external interference and to obtain state noise level data that is consistent and comparable across all sites and seasons.

2.5 Description of noise indices

A number of metrics were calculated from the data on recorded noise in order to provide an understanding of noise. They are: L_{eq}, L_{max}/L_{min}, percentile levels (L_{10}, L_{50}, L_{90}), NC, LNP, TNI[20][21]. The calculated metrics provide a clear indication of the characteristics of noise, identify the areas that are being most impacted by them, indicate seasonal variations in performance as well as compare performance to CPCB accepted limits.

- **L_{eq} (Equivalent Continuous Noise Level)**
  $= L_{50}+[(NC)^2/ 60]$
- **L_{max} = maximum value of data set**
- **L_{min} = minimum value of data set**
- **Percentile Levels (L_{10}, L_{50}, L_{90})**
- **NC (Noise Climate)**

$= L_{10}-L_{90}$

- **LNP (Noise Pollution Level)**

$= L_{eq} + NC$

- **TNI (Traffic Noise Index)**

$= 4 (L_{10}-L_{90}) + (L_{90}- 30)$

2.6 CPCB ambient noise standards

The computed noise indices are compared with permissible limits prescribed by the CPCB for different zones as shown in Table 6. The **CPCB** has prescribed **Ambient Air Quality Standards in respect of Noise** under the **Noise Pollution (Regulation and Control) Rules, 2000** (under the Environment Protection Act, 1986). These standards are widely used in **environmental impact assessment.** These limits are defined as **equivalent continuous sound level (L_{eq})**, representing average noise over a period. And is crucial for assessing compliances and planning effective noise mitigation strategies. Since CPCB does not prescribe a separate category for transport zones, traffic/transport-dominated areas were considered under the Commercial Area category as per CPCB Ambient Noise Standards and mixed land-use provisions.

Table-6: CPCB Ambient Noise Standards (India) [18][19].

Area code	Category of area /Zone	Limit in dB(A) L_{eq}	
		Day time	Night time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silent Zone	50	40
E	Transport Zone	65	55

3. RESULTS AND DISCUSSION

The measured noise levels were evaluated against CPCB permissible limits as shown in table 7 and analysed seasonally to assess environmental influences also illustrated in fig 2.

3.1 Zone wise comparison with CPCB ambient noise standards

3.1.1 Silent zone:

Findings from the analysis of Silent Zones (S_1 - S_7) indicated that all three seasons were above the CPCB permissible level of Sound Emission. All three seasons were found to have the highest level of L_{eq} levels in winter when the levels of L_{eq} exceeded by an average of 42% to 62%. The study found that S_1 had the highest level of L_{eq} in winter (80.80); all other stations measured lower levels specifically S_4 and S_5. The reason for exceedance can be attributed to continuous vehicular movement, frequent horn use, commercial businesses along the roadside from the movement of people on the street, the transporting of people on the street, urbanization of the area nearby and little enforcement of the Silent Zone Regulatory Guidelines. The overall concentration of continuous noise is impacting the Silent Zone area as a result of traffic congestion and commercial activity around sensitive areas.

3.1.2 Residential zone:

It was found that all the Residential Zone locations (R_1 – R_5) analyzed, had noise levels exceeding the Central Pollution Control Board (CPCB) permissible limit of 55 dB(A) during all seasons; the R_5 location had the maximum level of L_{eq} of 77.7 dB(A) during the rainy season; this represents an exceedance of 41.4%, while the R_2 location was observed to have the minimum level of noise; the average level of noise was higher for rainy and winter seasons than for summer season. The most significant contributors to excessive noise included heavy vehicular traffic, traffic congestion, mixed land use, commercial activities along roads, pedestrian activity, classes for private tuition, and rapid urban sprawl. Overall, significant levels of noise pollution existed in residential areas as a result of increased density of traffic and other human activities.

3.1.3 Commercial zone:

The analysis of Commercial Zones (C_1-C_4) shows that noise levels were above the CPCB allowable 65 dB(A) for all Seasons. C_2 had the highest recorded L_{eq} values of 86.0 dB(A) during the Rainy Season and exceeded the allowable level by 32.2%. Overall, the Rainy Season produced the highest noise level across all Commercial Sites. The major sources of excessive noise in the Commercial Zones were heavy vehicular traffic, congested markets, roadside vendors, signalized intersections, loading/unloading activity's, congestion, and high-volume of public movement. Based on these results, the Commercial Zones were found to have the highest noise pollution of all of the studied zones due to the continual commercial and transportation activities.

3.1.4 Transport zone:

The Transport Zone location (T_1 to T_4) analysis indicated an excess of the CPCB prescribed 65 dB(A) commercial area noise limit for all seasons. The T_2 site generated the highest noise levels averaging approximately 77 dB(A) L_{eq} specifically during the monsoon season and with the highest maximum exceedance. The winter season exhibited generally higher noise levels compared to other seasons as well, which can be attributed to traffic density causing an increase in congestion and decreased atmospheric dispersal of sound. Key contributors to the noise included the continuous movement of buses/trains; excessive honking; large crowds of people in motion; roadside vendors; and nearby commercial establishments. Therefore, transport zones have high levels of noise pollution from a combination of both heavy transportation activity and traffic congestion, primarily around bus terminals and rail stations.

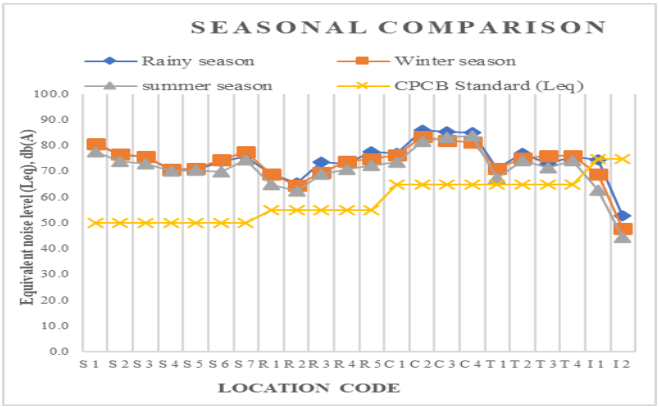
3.1.5 Industrial zone

Industrial Area (I1-I2) Noise level Analysis: all seasons's noise levels were within the CPCB permissible limit of 75 d.B(A).

3.1.6 Zone-wise seasonal variations:

Noise pollution varied significantly across different zones and seasons in Amravati. Silent zones recorded the highest noise levels, followed by Commercial, Residential, and Transport zones, while Industrial zones remained within CPCB limits as shown in Fig 2.

Chart – 1: Comparison of average weekly Leq of rainy, winter and summer season with CPCB.



Winter showed the highest noise levels due to poor atmospheric dispersion, increased traffic, and public activity, whereas summer recorded comparatively lower noise levels.

Rainy season also experienced high noise because of congestion, wet roads, potholes, and frequent honking. The most affected locations were S_1 (Silent zone), R_5 (Residential zone), C_2 (Commercial zone), and T_2 (Transport zone) as shown in table 7.

Table-7: Seasonal Comparison of Weekly Average L_{eq} with CPCB Standards.

Location code	CPCB Standard (L_{eq})	Rainy season L_{eq} dB(A)	Exceeded limits from CPCB by (%)	Winter season L_{eq} dB(A)	Exceeded limits from CPCB by (%)	Summer season L_{eq} dB(A)	Exceeded limits from CPCB by (%)
S_1	50	80.7	61.4	80.8	61.6	77.5	55.1
S_2	50	76.3	52.5	76.6	53.3	74.0	47.9
S_3	50	75.9	51.7	75.8	51.7	72.9	45.7
S_4	50	70.6	41.2	70.9	41.9	70.1	40.2
S_5	50	70.5	41.0	71.2	42.4	70.6	41.1
S_6	50	73.8	47.7	74.4	48.8	69.9	39.9
S_7	50	75.7	51.3	77.7	55.3	74.5	48.9
R_1	55	69.1	25.6	69.0	25.4	64.8	17.9
R_2	55	65.5	19.1	64.6	17.4	62.5	13.7
R_3	55	73.6	33.9	69.7	26.8	68.9	25.3
R_4	55	73.1	32.8	73.9	34.3	70.7	28.6
R_5	55	77.7	41.4	75.0	36.3	72.3	31.4
C_1	65	76.9	18.3	76.5	17.6	73.5	13.1
C_2	65	86.0	32.2	83.6	28.7	81.6	25.5
C_3	65	85.4	31.3	82.0	26.2	83.2	28.0
C_4	65	85.2	31.0	81.4	25.2	83.8	29.0
T_1	65	71.0	9.2	71.1	9.5	67.3	3.5
T_2	65	77.1	18.5	75.1	15.6	74.1	14.1
T_3	65	72.9	12.2	76.0	16.9	71.3	9.8
T_4	65	75.8	16.6	76.1	17.1	74.2	14.2
I_1	75	74.6	Within limit	68.9	Within limit	62.9	Within limit
I_2	75	52.7	Within limit	47.8	Within limit	44.6	Within limit

CONCLUSION

- Ambient noise pollution has been assessed in the Silent, Residential, Commercial, Transport, and Industrial zones of Amravati, and the observed L_{eq} were compared with CPCB permissible limits. The results indicate that in most locations of the Silent, Residential, Commercial, and Transport zones, noise pollution was beyond the given CPCB standards, projecting that its urban state is severely polluted.
- Silent zones registered the highest noise limit exceedance, with peak exceedance level ranging around 40%–62% above CPCB standards. The sites S_1 recorded the maximum exceedance during the rainy season (61.4%), winter (61.6%), and summer (55.1%), while locations S_2, S_3, S_6, and S_7 showed exceedance within the range of 45%–55%.
- There was a large excessive amount of noise above the CPCB noise limit of 55 dB(A), with the exceedance lying between 13.7%–41.4%. The site R_5 recorded the highest exceedance of 41.4% during the rainy season, while R_3 and R_4 with exceedance of 25%–34%, and R_2 with a comparatively lower level of exceedance, within 13.7%–19.1%.
- Commercial zones remained persistently highly polluted in every one of the seasons, with exceedance ranging approximately from 13%–32%. However, C_2 was the site with the worst exceedance of 32.2%, followed closely by C_3 and C_4 with exceedance of around 25%–31%; C_1, meanwhile, showed less-exceedance noise levels of between 13.1%–18.3%.
- The Transport Zones were all proved to be in violation of the maximum allowable noise limits (65 dB(A)). The amount of time that the Transport Zones are in violation ranges from approximately 3.5% to 18.5%. For example, Transport Zone 2 has the highest percentage of time in violation at 14.1% to 18.5%; Transport Zones 3 and 4 have shown a similar percentage of time in violation at 10% to 17%; and Transport Zone 1 demonstrates the least amount of time in violation at 3.5% to 9.5%.
- All of the Industrial Zones (I_1 & I_2) were able to remain below the CPCB's maximum allowable noise limits.
- The winter season was noted to have had the highest overall noise levels at most of the locations, with the second highest being the rainy season. The summer season had the lowest overall noise levels. The increased amount of noise during winter is mainly due to lack of air dispersion, population density, and increased traffic activity.
- The primary contributors to environmental noise pollution in the city of Amravati include: vehicular traffic, excessive/repeated honking, roadside congestion, commercial activities, mixed land use, pedestrian activity, and lack of public education on noise mitigation techniques.
- The need to continue developing effective traffic management plans, enforcing existing noise abatement regulations, developing greenbelts, developing consistent procedures for honking, and conducting continuous monitoring measures will significantly help to reduce the levels of urban noise pollution and improve the overall condition of the Amravati's Environmental Quality.

RECOMMENDATIONS

The study's results emphasize the need for targeted improvements: better traffic management systems, stricter enforcement of noise laws (especially in areas designated as quiet), development of green buffer zones, controls on unnecessary honking, community educational programs, and sustained monitoring of ambient noise levels to help reduce noise pollution and improve the environmental quality of Amravati City.

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