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Assessment of diurnal variation in ambient noise levels at Datt Chowk, Bhavnath, located within the Girnar Eco-Sensitive Zone, Gujarat

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ABSTRACT

Noise pollution is one of the key environmental concerns at tourist and religious destinations. The current study is focused on diurnal variation at Datt Chowk of Bhavnath, located in the foothills of Girnar and within the Girnar Eco-Sensitive Zone in Junagadh, Gujarat, India. Ambient noise levels were monitored for five consecutive days at a regular interval of 2 hours and were compared with the ambient noise level of CPCB, Government of India. Various statistical analyses were done for the significance of the study. The study revealed that none of the noise levels was within the guidelines of CPCB. The study provided the baseline information on the acoustic environment of the Eco-Sensitive Zone and baseline data for sustainable development.

Key Words - Noise Pollution; Girnar Eco-Sensitive Zone; Bhavnath; Sustainable tourism

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INTRODUCTION

Noise pollution can be defined as undesirable sound that effects wellbeing of human physiology and psychology (Nistor & Arghir, 2012). It is a universal pollution that has no traces but degrades the environment due to various activities related to human interference. Prolonged exposure adversely affects the physiology and psychology of well-being, and hence it's alarming all over the world (Jamir *et al.,* 2014; Garg & Maji, 2016).

Industrial development and motorisation have elevated environmental noise. Road traffic, construction activities, commercial activities and industries are key sources of noise pollution. All the activities interact to produce noise pollution (Garg & Maji, 2016; Naik, 2012; Ehrampoush *et al.,* 2012).

In high populated country like India, population density and poor public address systems are key factors for various types of urban pollution, including noise pollution (Jamir *et al.,* 2014; Naik, 2012). With socio-economic development in the past decade, rapid urbanisation and lack of public transport, and growing religious tourism activities are the key contributors to noise pollution. Noise pollution receives less attention and is a bit hard to detect because of invisible and transient.

Numerous studies from almost all parts of the country have supported that the ambient noise level has shown a significant rise in recent years (Table 1) (Charan, 2017; Balashanmugam *et al.,* 2013; Das *et al.,* 2014). Recent studies indicate that noise pollution is not just an urban problem but is also growing in rural areas. Managing Noise pollution will have a positive effect on well-being, sustainable development, and a rich environment (Khaiwal *et al.,* 2016; Sharma & Bhattacharya, 2014; Marale *et al.,* 2011).

Table 1. Sound Source and ambient source level in the study area

Sound Source	Average Noise (Hz)
Air conditioner Outer	76
Ambient sound in a public place	75
Ambulance with siren	98
Auto rickshaw	73
Bus	81
Car	76
Construction Machinery	80
Loudspeaker	80
Mobile Ringtones	70
Motorcycle	66

Health Impacts of Noise Pollution

1. Hearing impairment: Continued exposure to high decibel noise levels causes temporary or permanent hearing loss (Jamir *et al.,* 2014; Ramanathan & Renuka, 2006).
2. Sleep disturbance: Sleep quality is hindered, causing insomnia and sleep efficiency. (Khaiwal *et al.,* 2016; Jamir *et al.,* 2014).
3. Psychological stress: It causes irritability, anxiety, mental fatigue, and emotional stress and reduces work efficiency (Jamir *et al.,* 2014; Ehrampoush *et al.,* 2012).
4. Fatigue: Long-term exposures result in tiredness and reduce performance mentally and physically. (Khaiwal *et al.,* 2016; Ehrampoush *et al.,* 2012).
5. Speech interference: reduces effective communication (Jamir *et al.,* 2014; Nistor & Arghir, 2012).

Environmental Impacts of Noise Pollution

1. Reduction in bird species diversity: High noise causes intolerance, which results in migration of species, and eventually reduces bird diversity (Potoènik & Poje, 2010).
2. Wildlife behavioural changes: It alters mating activities, food patterns and habitat utilisation patterns (Potoènik & Poje, 2010).
3. Ecological imbalance: Irregulated immigration and migration cause imbalance in nature (Saha & Padhy, 2011).
4. Loss of natural soundscape: It masks the environmental, recreational and landscape value of a place. (Garg & Maji, 2016).
5. Visitor experience degradation: Disturbs the spiritual and recreational experience at tourist spots. (Marale *et al.,* 2011; Sharma & Bhattacharya, 2014).

Noise regulation and standards are developed for various places as well as by various agencies worldwide to maintain noise levels at different places. Under the Environmental (Protection) Act, 1986, Noise Pollution (Regulation and Control) Rules, 2000 are framed for industrial, commercial, residential, and silence zones by Central Pollution Control Board (CPCB) and State Pollution Control Board (Table 2) while National Ambient Noise Monitoring Network (NANMN) monitors noise pollution in India (Garg & Maji, 2016; Naik, 2012).

Table 2: Standards for noise levels in different areas Area Code

Area Code	Category of Area / Zone	
	Day Time	Night Time
(A) Industrial area	75	70
(B) Commercial area	65	55
(C) Residential area	55	45
(D) Silence Zone & Eco-Sensitive Zone	50	40

Bhavnath is an important tourist attraction with millions of tourists visiting around the year for adventure and the religious attraction of Girnar hill. Being a part of the Eco-Sensitive Zone, no such studies have been carried out in this region. Hence, temporal assessments will help to monitor and design strategies for a very fast-growing tourist-rich, Eco-Sensitive Zone.

OBJECTIVE

The current study is designed to monitor and quantify the ambient noise levels at Datt Chowk, Bhavnath, using a fixed-point monitoring approach at regular two-hour intervals over five consecutive days. It will evaluate the diurnal variation in ambient noise levels by analysing temporal fluctuations in sound intensity during different periods of the day, which will be compared with the standard Ambient Air Quality of CPCB.

STUDY AREA

The current study is focused on Datt Chawk of the Bhavnath region of Junagadh, Gujarat, India (Figure 1). Bhavnath is located in the foothills of Girnar Hills and is an Eco-Sensitive Zone surrounding Girnar Wildlife Sanctuary. It is located at 21.52° N latitude and 70.46° E longitude at 106 m MSL. The nearest weather station is located in Junagadh Agriculture University, which highlights three seasons with temperatures ranging from 1°C in winter nights to 45°C in hot summer days. Average rainfall is approximately 1000 mm. Datt Chowk is a commercial junction of the area from were road leads to various tourist and religious attractions like Bhavnath Temple, Girnar Foothills, Various Hotels, Various tourist attractions and a shopping area. Hence a potent area for study.

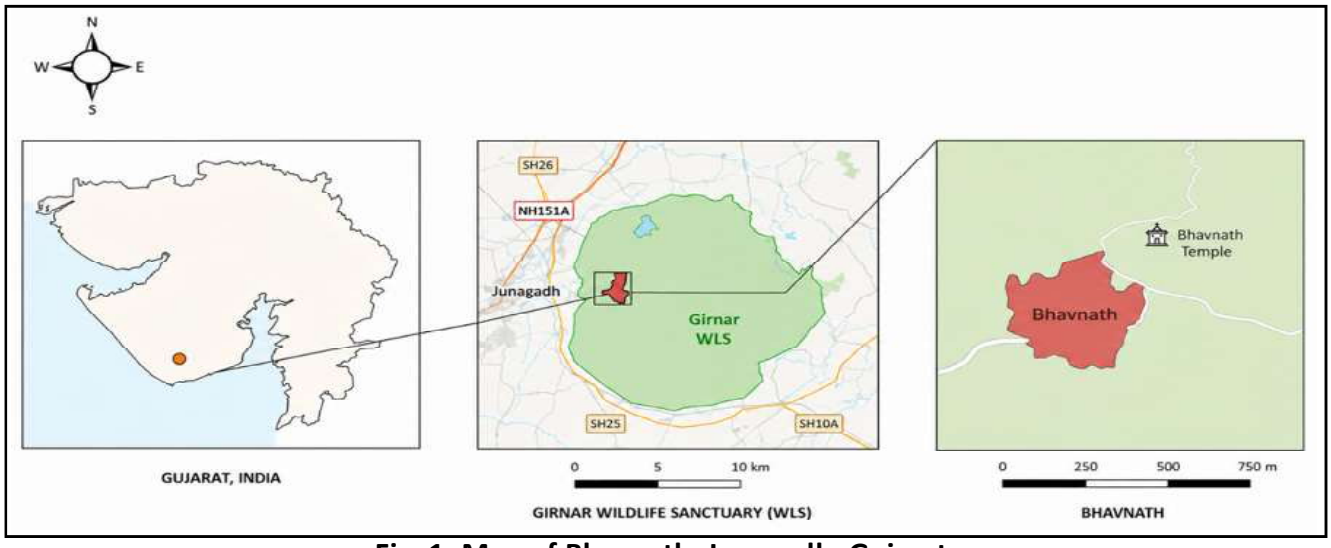

Fig. 1: Map of Bhavnath, Junagadh, Gujarat.

MATERIAL & METHOD

The present study is an observational field-based environmental monitoring study, without altering existing sound sources (Nistor & Arghir, 2012; Garg & Maji, 2016). It gives real-world acoustic conditions due to anthropogenic activities. A mobile monitoring system was fixed at Datt Chowk. A continuous temporal monitoring approach at regular two-hour intervals over five consecutive days was carried out for capturing natural fluctuations in environmental noise. Repeated observations for 5 days and at regular intervals of 2 hours helped to identify long-term and short-term variation. Observations were made at 05:00, 07:00, 09:00, 11:00, 13:00, 15:00, 17:00, 19:00, 21:00, 23:00, 01:00, and 03:00 h, resulting in twelve observations per day and a total of 60 observations during the five-day monitoring period.

At each interval noise level was recorded for 1 minute, in which the maximum and minimum values were noted. The observations were carried out under normal weather conditions and at a stable height of 1.5 m above ground level, away from physical obstruction. To guarantee consistency and repeatability of the recorded data, all measurements were carried out using the same equipment and field techniques. The resulting data were subjected to comparison with CPCB ambient levels. The general guidelines of ISO 1996-1:2016 and ISO 1996-2:2017, which outline the standardised methods for the measurement and evaluation of environmental noise, were followed for conducting ambient noise monitoring.

Ambient noise levels were measured using a portable digital sound level meter (Model: JD-IXFA-7G9V, MCP, China). The instrument measures sound pressure levels over a range of 30–130 dB(A) with a measurement accuracy of ±1.5 dB, a resolution of 0.1 dB, and a frequency response of

31.5 Hz–8 kHz. The sound level meter is equipped with a high-sensitivity condenser microphone, a backlit LCD, and functions including maximum (Max), minimum (Min), data hold, and continuous measurement mode, enabling reliable field measurements of ambient environmental noise. Owing to its portability and ease of operation, the instrument was considered suitable for continuous field monitoring of ambient noise levels during the study period.

RESULT

The result showed distinct temporal variations during the study. Out of the total 12 observations, 6 observations were conducted in the day (L_{day}) with an average of 56.28 two in the evening ($L_{evening}$) with an average of 62.36 and 4 observations at night (L_{night}) with an average of 51.95 (Figure 2). The average of the whole day (L_{den}) was 55.85 (Table 3). The results are far more than the standards of GPCB (Figure 3) (Table 5).

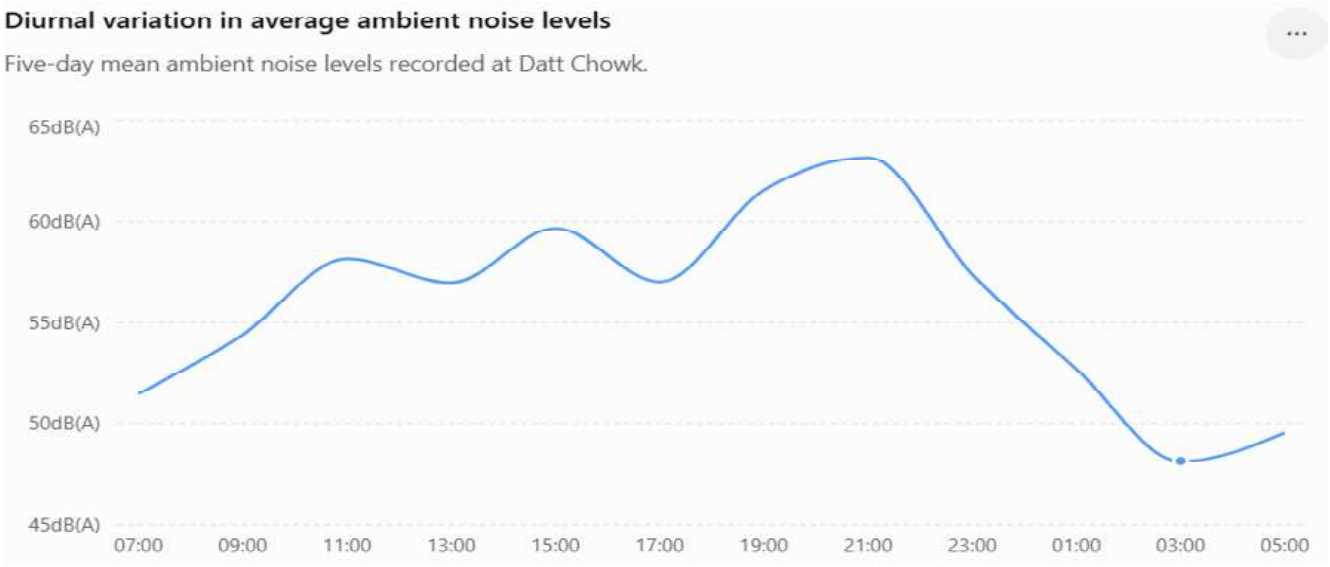

Fig. 2- Diurnal variation in average ambient noise levels

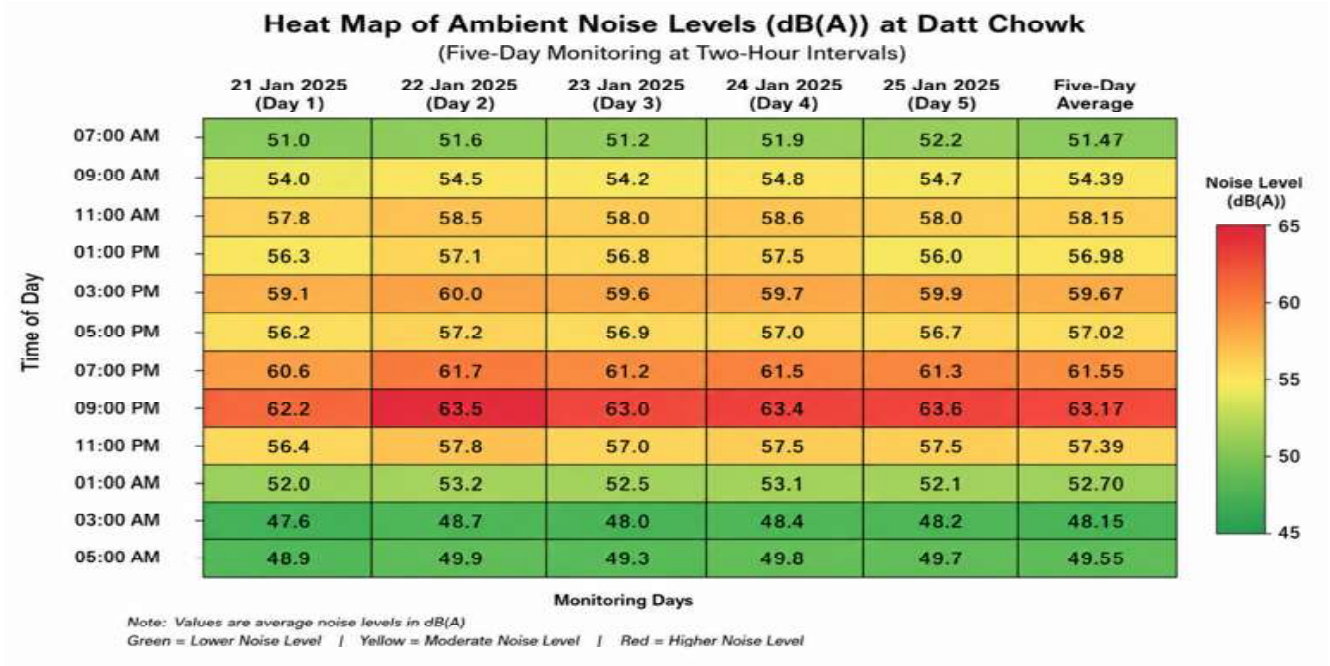

Fig. 3. Heat map at ambient noise level

Table 3. Average Noise (dB) of 5 days with respect to day, evening, night and whole day.

Average of 5 Days	
L_{day}	56.28
$L_{evening}$	62.36
L_{night}	51.95
L_{den}	55.85

The ambient noise levels of Bhavnath, a part of ESZ, exceed CPCB standards. Average Daytime ranges from 51.47 to 63.17 dB(A), exceeding 1.47–13.17 dB(A), whereas for night time the average is 48.15 and 57.39 dB(A), exceeding standards by 8.15–17.39 dB(A). This shows continuous anthropogenic noise in the study area (Table 5).

Table 4. Comparison with GPCB Standards

Time	Mean Noise Level (dB(A))	Eco-Sensitive Zone Standard (dB(A))	Status
7:00 AM	51.47	50	Exceeded (+1.47)
9:00 AM	54.39	50	Exceeded (+4.39)
11:00 AM	58.15	50	Exceeded (+8.15)
1:00 PM	56.98	50	Exceeded (+6.98)
3:00 PM	59.67	50	Exceeded (+9.67)
5:00 PM	57.02	50	Exceeded (+7.02)
7:00 PM	61.55	50	Exceeded (+11.55)
9:00 PM	63.17	50	Exceeded (+13.17)
11:00 PM	57.39	40	Exceeded (+17.39)
1:00 AM	52.7	40	Exceeded (+12.70)
3:00 AM	48.15	40	Exceeded (+8.15)
5:00 AM	49.55	40	Exceeded (+9.55)

Table 5. Key findings from comparison with ambient.

Parameter	Result
Total monitoring periods	12
Time intervals exceeding CPCB ESZ limit	12 (100%)
Highest daytime mean	63.17 dB(A) (09:00 PM)
Lowest mean	48.15 dB(A) (03:00 AM)
Maximum daytime exceedance	+13.17 dB(A)
Maximum night-time exceedance	+17.39 dB(A)
Minimum exceedance	+1.47 dB(A) (07:00 AM)
Compliance with CPCB Silence Zone standards	0% (all observations exceeded the prescribed limits)

Highest mean ambient noise level: 09:00 PM (63.17 ± 0.63 dB(A)), indicating peak evening activity. Second highest: 07:00 PM (61.55 ± 0.92 dB(A)). Lowest mean ambient noise level: 03:00 AM (48.15 ± 0.55 dB(A)), corresponding to minimal human and vehicular activity. The largest range (2.40 dB(A)) occurred at 05:00 PM and 07:00 PM, indicating greater day-to-day variability during these periods. The smallest range (0.80 dB(A)) and lowest coefficient of variation (0.64%) were observed at 11:00 PM, suggesting highly consistent noise levels across the five days. The coefficient of variation (CV) for all time intervals was below 2%, indicating very low variability and excellent consistency in the measurements across the monitoring period (Table 6).

Table 6. Descriptive statistics of the results

Time	Mean (dB(A))	SD	Minimum	Maximum	Range	CV (%)
7:00 AM	51.47	0.9	50.5	52.75	2.25	1.81
9:00 AM	54.39	0.8	53.75	55.75	2	1.44
11:00 AM	58.15	0.7	56.95	58.9	1.95	1.28
1:00 PM	56.98	0.7	56.4	58.05	1.65	1.18
3:00 PM	59.67	0.4	59.2	60.2	1	0.74
5:00 PM	57.02	0.9	55.65	58.05	2.4	1.6
7:00 PM	61.55	0.9	60.4	62.8	2.4	1.5
9:00 PM	63.17	0.6	62.55	64.05	1.5	1
11:00 PM	57.39	0.4	56.95	57.75	0.8	0.64
1:00 AM	52.7	0.7	52.1	53.85	1.75	1.3
3:00 AM	48.15	0.6	47.5	48.9	1.4	1.15
5:00 AM	49.55	0.8	49	50.95	1.95	1.62

As the data was collected from the same location at the same time interval for 5 days, one-way repeated measure ANOVA was performed (Table 7). The p-value is less than 0.05, indicating that there is a highly significant temporal effect on ambient noise level ($F = 208.46$, $p < 0.001$). The highest noise level was observed in the evening (09 pm) and the lowest at late night and early morning (05 am). Hence, a diurnal pattern is observed.

Table 7: One-way ANOVA Results

Source of variation	Value
Number of groups	12
Observations per group	5
Total observations	60
F-value	**208.46**
p-value	**1.40×10^{-36}**
Significance level	$\alpha = 0.05$

DISCUSSION

The study revealed diurnal variation at Datt Chowk, Bhavnath, with statistical significance. Noise is high in the morning progressively decreases in the afternoon and increases and reaches a maximum in the evening, followed by lowest late-night. These result patterns fluctuate with vehicular traffic, temple activities and commercial activities. Similar changes in pattern with respect to commercial activities, pedestrian movement and temple activities are recorded (Charan, 2017; Ehrampoush *et al.,* 2012; Marale *et al.,* 2011). The data was highly consistent and accurate, as the coefficient of variation was low (<2%).

Comparison with CPCB standards, all the observations exceed the standard ambient parameters. Similar exceeding results were recorded at various places showing high anthropogenic activity (Balashanmugam *et al.,* 2013; Khaiwal *et al.,* 2016; Garg & Maji, 2016).

The elevated noise during evening time is due to multiple anthropogenic activities performed simultaneously. These include local tourists visiting Bhavnath, vehicular traffic, vendors, hotels and pedestrians, tea vendors and social gatherings are key reasons. Similar results were observed in Maharashtra and Tamil Nadu (Marale *et al.,* 2011; Ramanathan & Renuka, 2006). Tourist and transportation infrastructure influence temporal dynamics (Sharma & Bhattacharya, 2014).

Higher noise from ambient gives physiological and psychological stress, and various medical conditions were reported (Jamir *et al.,* 2014; Khaiwal *et al.,* 2016). High noise also weakens the spiritual experience of visitors (Ramanathan & Renuka, 2006).

With very close vicinity to Girnar Wildlife Sanctuary, it adversely affects the diversity, habitat quality and behavioural pattern of wildlife (Saha & Padhy, 2011; Potoènik & Poje, 2010). Hence, it is recommended to develop a model with sustainable development that reduces the ecological impact. Hence, this baseline date is important for further sustainable development.

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