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Assessment of Road Dynamics, Environmental Noise Pollution in Urban Corridors

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Abstract: Urbanization and the rapid increase in vehicular traffic have led to heightened noise pollution levels in urban areas. This study aims to analyze the relationship between traffic volume and environmental noise pollution at four major urban locations: ABIDS, JUBILEE HILLS, JEEDIMETLA, and JNTU. Key traffic parameters such as traffic volume, Peak Hour Factor (PHF), and Free Flow Speed (FFS) were recorded, while noise measurements including Equivalent Continuous Sound Level (Leq) were collected during both day and night. Additionally, Traffic Noise Index (TNI) and Noise Pollution Level (Lnp) were computed using established methods. A multiple linear regression analysis was conducted to assess the influence of traffic characteristics on noise levels. The high coefficient of determination (R^2 = 0.905) demonstrates a strong correlation between noise levels and traffic variables like traffic volume, PHF, and roadway capacity. Furthermore, roadway capacity and Level of Service (LOS) were evaluated at each site based on Highway Capacity Manual (HCM) guidelines. LOS values ranged from B to E, reflecting varying degrees of congestion and traffic operational efficiency. The findings highlight the significant role of traffic parameters in contributing to urban noise pollution and road performance. These insights can support urban planners and traffic engineers in designing effective traffic management and noise mitigation strategies, ultimately improving urban environmental quality.
Keywords: Traffic Volume, Peak Hour Factor, Equivalent continuous sound level, Traffic Noise Index, Noise Pollution level.

I. INTRODUCTION

The primary sources of noise pollution in Hyderabad are road traffic and construction activities, excessive honking, industrial activities, and busy commercial areas. High-traffic urban locations such as Abids, Jubilee Hills, JNTU, and Jeedimetla face continuous noise challenges due to a combination of dense populations, high vehicle counts, and ongoing construction projects. This excessive noise not only causes discomfort but also poses significant health risks including hearing impairment, high blood pressure, disrupted sleep, and elevated stress levels. Considering these issues, it is essential to evaluate the patterns, causes, and impacts of noise pollution across various areas of Hyderabad. This report seeks to analyze noise levels in key neighbourhoods, explore the relationship between traffic volume and noise measurements, and offer data-driven insights for improved urban planning and noise management. In addition to environmental concerns, operational efficiency of urban road networks has become a critical area of study. Evaluating roadway capacity, LOS, and PHF provides insight into vehicular movement characteristics and helps in understanding congestion patterns. These parameters assist in assessing the functional performance of road sections in fast-growing urban areas.

A. Objectives

The primary objectives of this study are:
1) To analyze traffic volumes at selected urban sites by determining the Peak Hour Factor (PHF) and subsequently assess roadway capacity and Level of Service (LOS).
2) To examine traffic noise levels across four urban locations.
3) To calculate and evaluate key noise indices.
4) To apply multiple linear regression analysis for identifying the influence of traffic variables such as traffic volume, PHF, and capacity on equivalent noise levels (Leq).

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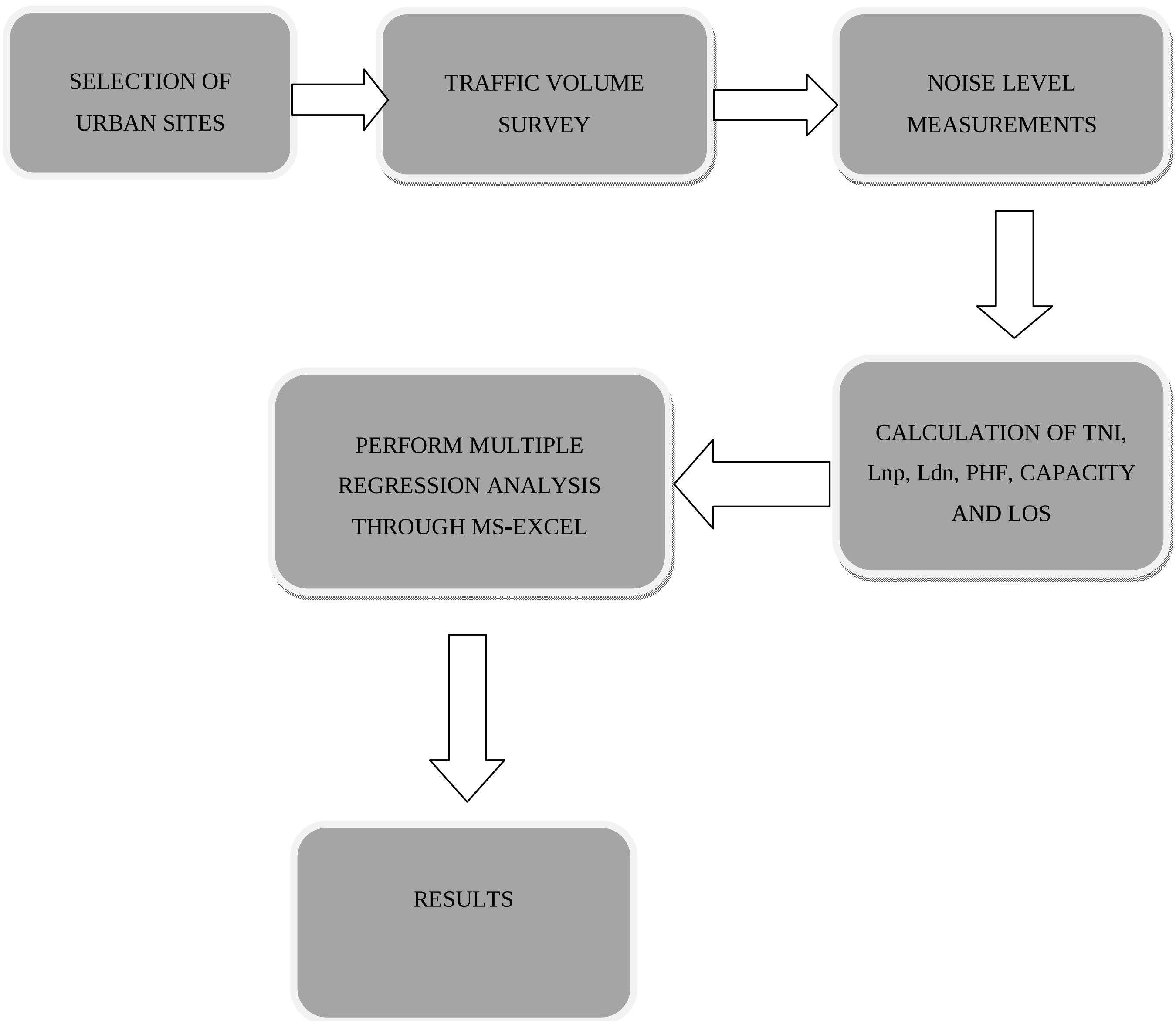
II. METHODOLOGY



A. Traffic Noise Index

The TNI is a statistical parameter used to evaluate the level of disturbance caused by fluctuating vehicular traffic noise.
The Traffic Noise Index (TNI) is computed using the following formula:

$$TNI=4*(L10-L90) + (L90-30)$$

where:

- L10 is the noise level exceeded for 10% of the measurement time,
- L90 is the noise level exceeded for 90% of the time.

B. Noise Pollution Level

Lnp is a composite metric used to evaluate the overall impact of environmental noise, especially in urban settings affected by traffic.The Lnp is calculated by using the following formula;

$$Lnp = Leq + (L10 - L90)$$

C. Day-Night Average Sound Level (Ldn)

The Ldn is a commonly used noise metric that offers a comprehensive measure of noise exposure throughout a full 24-hour cycle. The formula used to compute Ldn is as follows:

$$Ldn = 10 \log10 * [(1/24) * (15 * 10^{Ld/10} + 9 * 10^{(Ln+10)/10})]$$

D. Phf, Capacity And Los

These are calculated as per standards mentioned in the Highway Capacity Manual, 2010.

E. Multiple Linear Regression Analysis

Multiple linear regression (MLR) is a statistical technique that models the relationship between a single dependent variable and multiple independent variables. The multiple linear regression equation is expressed as:

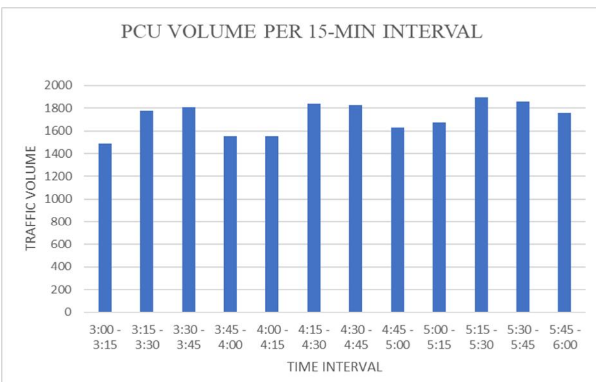
$$Y=\beta0+\beta1X1+\beta2X2+\beta3X3+\cdots+\beta nXn+ \varepsilon$$

Where:

- Y= Dependent variable
- X1, X2, X3, ..., Xn = Independent variables
- β_0 = Intercept
- β1, β2, ..., βn= Regression coefficients
- ε = Error term

III.RESULTS AND DISCUSSIONS

A. Traffic Volume



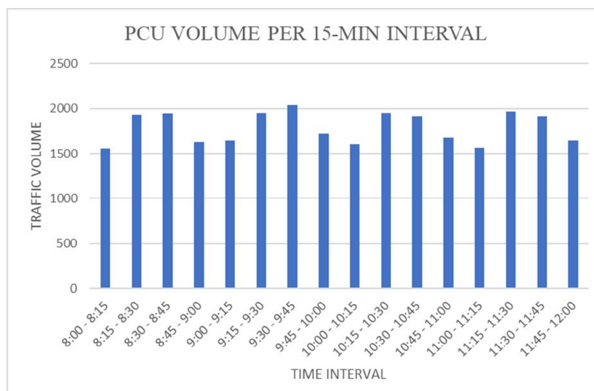
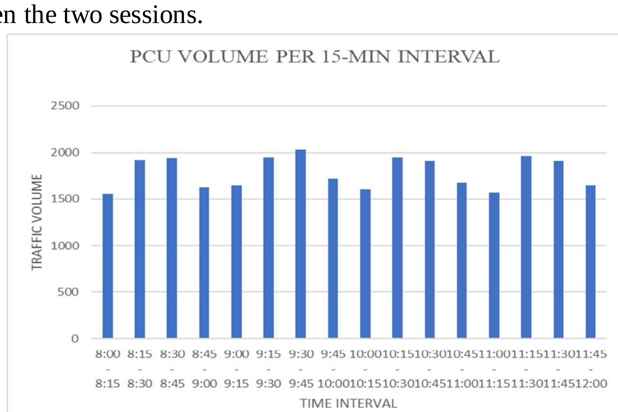


Fig 1: ABIDS, MORNING SESSION

Fig 2: ABIDS EVENING SESSION

At the ABIDS location, traffic volumes were recorded for both morning and evening sessions at 15-minute intervals. In the morning session, peak traffic was observed between 9:45–10:00, with a Peak Hour Factor (PHF) of 0.88, indicating moderate variation within the peak hour. The evening session showed relatively consistent flow, peaking around 5:15–5:30, with a PHF of 0.91, reflecting more uniform traffic distribution compared to the morning period. These variations highlight differing travel patterns between the two sessions.



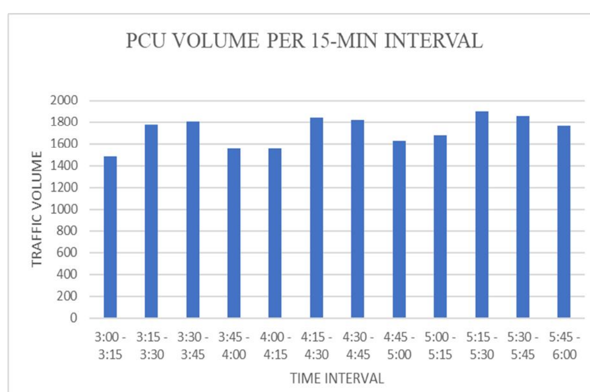


Fig 3: JUBILEE HILLS, MORNING SESSION

Fig 4: JUBILEE HILLS, EVENING SESSION

At the Jubilee Hills location, traffic volumes were recorded for both morning and evening sessions in 15-minute intervals. The morning session experienced its highest flow between 9:00–9:15, with a Peak Hour Factor (PHF) of 0.91, showing stable flow during the peak period.

In the evening session, peak movement occurred around 5:15–5:30, with a PHF of 0.90, indicating slightly higher variation compared to the morning. These results suggest a balanced distribution of traffic across both time slots.

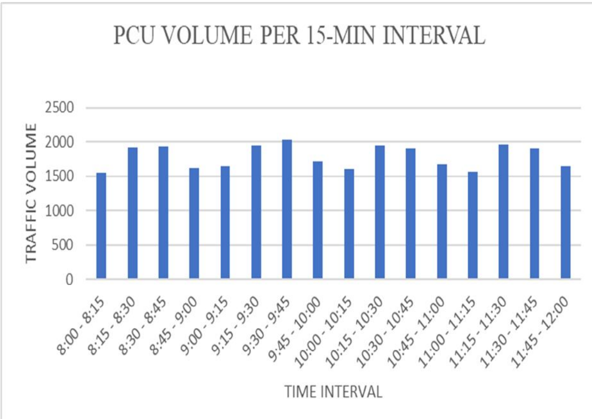


Fig 5: JEEDIMETLA, MORNING SESSION

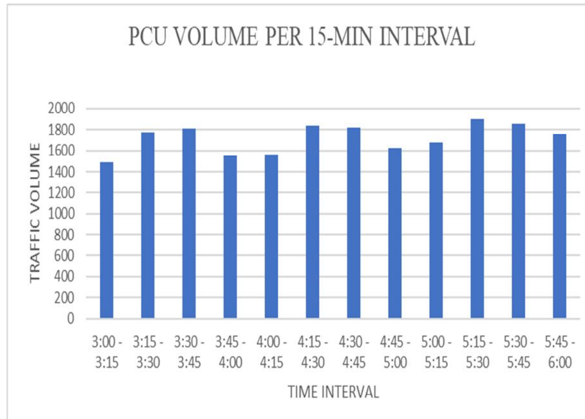


Fig 6: JEEDIMETLA, EVENING SESSION

At the Jeedimetla location, traffic was monitored at 15-minute intervals during both morning and evening sessions. The morning session peaked between 9:45–10:00, with a Peak Hour Factor (PHF) of 0.916, reflecting consistent flow across the peak hour. The evening session recorded its highest volume around 5:15–5:30, achieving a PHF of 0.924, indicating a slightly more uniform distribution than in the morning. This suggests stable traffic patterns throughout both time periods.

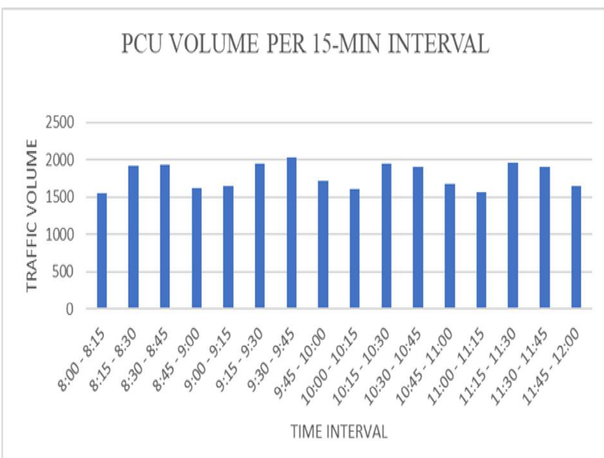


Fig 7: JNTU, MORNING SESSION

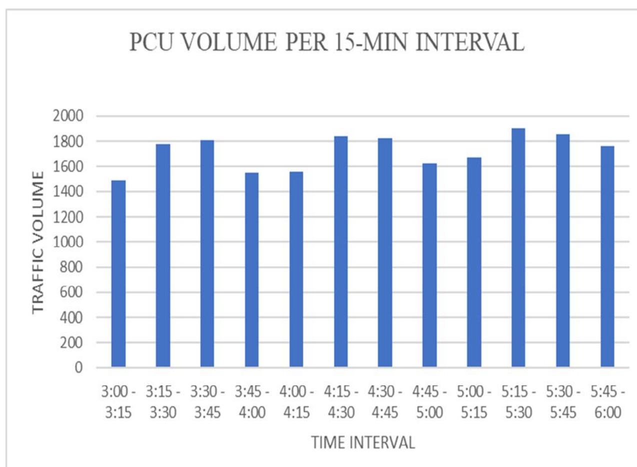


Fig 8: JNTU, EVENING SESSION

At the JNTU location, traffic data was recorded for both morning and evening periods at 15-minute intervals. The morning session reached its highest flow between 9:45–10:00, with a Peak Hour Factor (PHF) of 0.902, indicating moderate variation within the peak. In contrast, the evening session peaked around 5:15–5:30, achieving a PHF of 0.947, reflecting a highly uniform traffic distribution. This points to steadier evening traffic patterns compared to the morning.

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B. Noise Level Analysis

TABLE 1: Noise level Data collection From TGPCB

AREA	NOISE LEVELS		TRAFFI NOISE INDEX (TNI)		NOISE POLLUTION LEVEL (Lnp)		DAY-NIGHT AVERAGE SOUND LEVEL (Ldn)
	DAY (dB)	NIGHT (dB)	DAY (dB)	NIGHT (dB)	DAY (dB)	NIGHT (dB)	
ABIDS	57.59	55.84	60.59	62.84	58.59	56.84	62.547
JUBILEE HILLS	61.88	60.09	68.88	67.09	72.88	71.09	66.805
JEEDIMETLA	70.23	63.70	77.23	70.70	81.23	74.70	71.869
JNTU	72.30	74.31	89.30	91.31	86.30	88.31	80.483

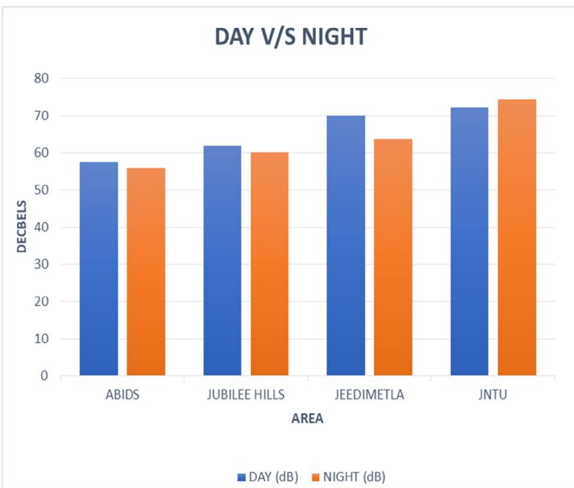

Fig 9: Comparison of DAY-NIGHT Noise levels

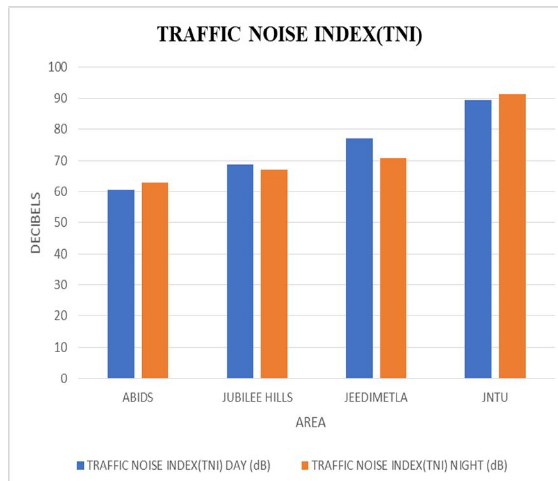

Fig 10: COMPARISON OF TNI OF DAY-NIGHT

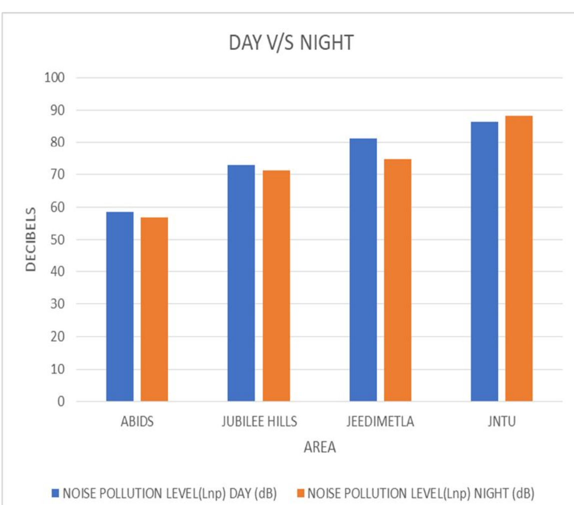

Fig 11: COMPARISON OF DAY-NIGHT Lnp AT 4 LOCATIONS

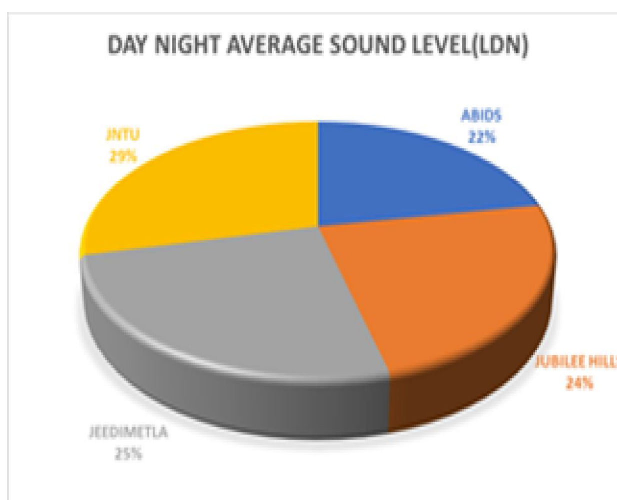

Fig12: CONTRIBUTION OF Ldn AT 4 LOCATIONS

Noise level measurements, obtained from TGPSC, were compared with CPCB permissible limits for commercial areas (65 dB for day, 55 dB for night). ABIDS, with 57.59 dB during the day and 55.84 dB at night, remained within limits. Jubilee Hills exceeded the night-time limit by 5.09 dB, while Jeedimetla and JNTU surpassed both day and night permissible levels. JNTU recorded the highest noise levels, with 72.30 dB in the day and 74.31 dB at night, showing significant exceedance. The bar chart clearly depicts these violations, highlighting areas requiring priority noise mitigation measures.

The Traffic Noise Index (TNI) values were evaluated against the general comfort threshold of 74 dB, beyond which noise is considered highly intrusive. ABIDS and Jubilee Hills recorded TNI values well below this limit during both day and night, indicating comparatively lower disturbance. In contrast, Jeedimetla exceeded the threshold during the day (77.23 dB) but remained slightly lower at night (70.70 dB). JNTU showed the highest TNI values, with 89.30 dB in the day and 91.31 dB at night, far above the comfort limit, reflecting severe noise annoyance. The bar chart emphasizes these exceedances, particularly at high-traffic sites like JNTU.

The Noise Pollution Level (Lnp) values were compared against reference comfort limits of 65 dB (day) and 55 dB (night). ABIDS remained within limits during the day (58.59 dB) but slightly exceeded the night limit (56.84 dB). Jubilee Hills crossed both day (72.88 dB) and night (71.09 dB) limits, while Jeedimetla and JNTU showed substantial exceedances in both periods, with JNTU recording the highest values of 86.30 dB in the day and 88.31 dB at night. The bar chart clearly illustrates these violations, emphasizing the severity of noise exposure in high-traffic locations.

The Day-Night Average Sound Level (Ldn) was assessed at all four study locations and compared with the recommended limit of 55 dB for residential and 65 dB for commercial areas. ABIDS, with 62.547 dB, stayed within the commercial limit but exceeded the residential threshold. Jubilee Hills (66.805 dB), Jeedimetla (71.869 dB), and JNTU (80.483 dB) surpassed even the commercial limit, indicating high noise exposure. Among the locations, JNTU contributed the largest share (29%) to overall noise, followed by Jeedimetla (25%), Jubilee Hills (24%), and ABIDS (22%). The pie chart clearly depicts this distribution, highlighting that the majority of noise impact comes from highly trafficked urban zones.

C. Multiple Linear Regression Analysis

Table 2: Parameters From Ms Excel

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-277.3670037	65.97964916	-4.20383	0.0136537
Traffic Volume	0.001166164	0.000284485	4.099215	0.0148626
PHF	246.5660153	67.45501468	3.655266	0.0216706
capacity	0.045785762	0.035689251	1.282901	0.2688176

Table 3: Regression Statistics

Multiple R	0.951580124
R Square	0.905504732
Adjusted R Square	0.834633281
Standard Error	2.832447789
Observations	8

$$Leq=277.367+(0.001166\times \text{Traffic Volume})+(246.566\times \text{PHF})+(0.045786\times \text{Capacity})$$

The multiple linear regression analysis was conducted to examine the relationship between Leq (dependent variable) and independent variables: traffic volume, PHF, and capacity. The model achieved a high coefficient of determination ($R^2 = 0.9055$), indicating that approximately 90.55% of the variation in Leq can be explained by the selected predictors. Traffic volume and PHF were found to be statistically significant ($p < 0.05$), whereas capacity did not show significant influence. The high R^2 value reflects the strong predictive capability of the model for noise levels in the study area.

D. Capacity And Los Analysis

TABLE 4: CAPACITY AND LOS ANALYSIS

LOCATION	FREE FLOW SPEED(FFS) (KMPH)	BASE FFS (KMPH)	PEAK HOUR VOLUME	DENSITY (pc/km/ln)	CAPACITY (Pc/h/ln)	LEVEL OF SERVICE(LOS)
ABIDS	80	88	2162.47	26.53	2015	LOS D
JUBILEE HILLS	80	88	1210.40	14.689	2024	LOS B
JEEDIMETLA	80	88	2137.55	25.94	2024	LOS D
JNTU	80	88	2289.85	28.09	2015	LOS E

The traffic performance analysis across the selected locations shows varying levels of service (LOS). At Abids, the free-flow speed (FFS) is 80 kmph with a peak hour volume of 2162.47 pc/h/ln, resulting in a density of 26.53 and an LOS D, indicating approaching unstable flow. Jubilee Hills exhibits better conditions with a lower volume of 1210.40 pc/h/ln, density of 14.69, and LOS B, suggesting reasonably free flow. Jeedimetla records 2137.55 pc/h/ln, density 25.94, and LOS D, showing moderate congestion like Abids. Meanwhile, JNTU faces the highest demand at 2289.85 pc/h/ln, with density 28.09 and LOS E, reflecting unstable flow and poor service. Overall, Jubilee Hills performs best, while JNTU experiences the most critical traffic conditions.

IV. CONCLUSION

1) Peak Hour Factor (PHF) values across study sites ranged between 0.88 and 0.947, with JNTU showing the highest uniformity during the evening peak hour.
2) Noise levels at Jeedimetla and JNTU consistently exceeded CPCB permissible limits during both day and night, while ABIDS and Jubilee Hills occasionally crossed the night-time limits.
3) Traffic Noise Index (TNI) indicated severe noise disturbance at JNTU (day and night) and Jeedimetla (daytime), with values above the 74 dB comfort threshold.
4) Lnp and Ldn analyses confirmed that most study locations—except ABIDS (daytime)—experienced noise levels beyond the recommended standards, with JNTU recording the highest exposure.
5) The multiple regression model (R^2 = 0.9055) showed that traffic volume and PHF are strong predictors of Leq, whereas capacity had minimal influence on noise levels.
6) Capacity and LOS evaluation revealed:

- LOS E (severe congestion) at JNTU,
- LOS D (unstable flow) at Jeedimetla and Abids.
- LOS B (smooth operation) at Jubilee Hills.

7) Overall, locations with higher traffic volumes and poor LOS were found to exhibit elevated noise pollution, highlighting the urgent need for integrated traffic management and noise mitigation strategies in urban areas.

V. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed for urban traffic planners, policymakers, and environmental management authorities:

1) Implementation of Noise Barriers and Green Buffers: Installing sound-absorbing barriers along busy roads and promoting the plantation of dense vegetation (green belts) can significantly reduce the propagation of traffic noise into nearby residential and commercial areas.
2) Traffic Flow Management: Measures such as synchronized traffic signals, diversion of heavy vehicles during night hours, and promotion of public transportation can help reduce congestion and subsequently decrease noise levels.
3) Incorporation of Noise Criteria in Urban Planning: Urban development projects should include noise impact assessments in their planning stages, especially for infrastructure projects near sensitive locations such as schools, hospitals, and residential zones.

4) Public Awareness and Community Involvement: Citizens should be educated about the harmful effects of noise pollution and encouraged to avoid unnecessary honking and maintain their vehicle silencers properly.
5) Traffic Demand Management during Peak Hours: For sites experiencing LOS E and high peak-hour volumes, time-based vehicle restrictions, staggered office timings, or congestion pricing can be considered to reduce overload.
6) Upgradation of Poor LOS Corridors: Immediate attention should be given to locations with deteriorating LOS (like ABIDS and JNTU) by redesigning geometry, improving signage, and synchronizing traffic signals.
7) Encouragement of Public Transport and Modal Shift: Reducing dependency on private vehicles through improved public transport accessibility can ease congestion and enhance LOS in urban centers.
8) Regular LOS and Capacity Assessment as a Policy Tool: Municipal bodies should adopt periodic LOS and capacity evaluations to monitor operational performance and plan timely upgrades to avoid critical failures.

VI. ACKNOWLEDGMENT

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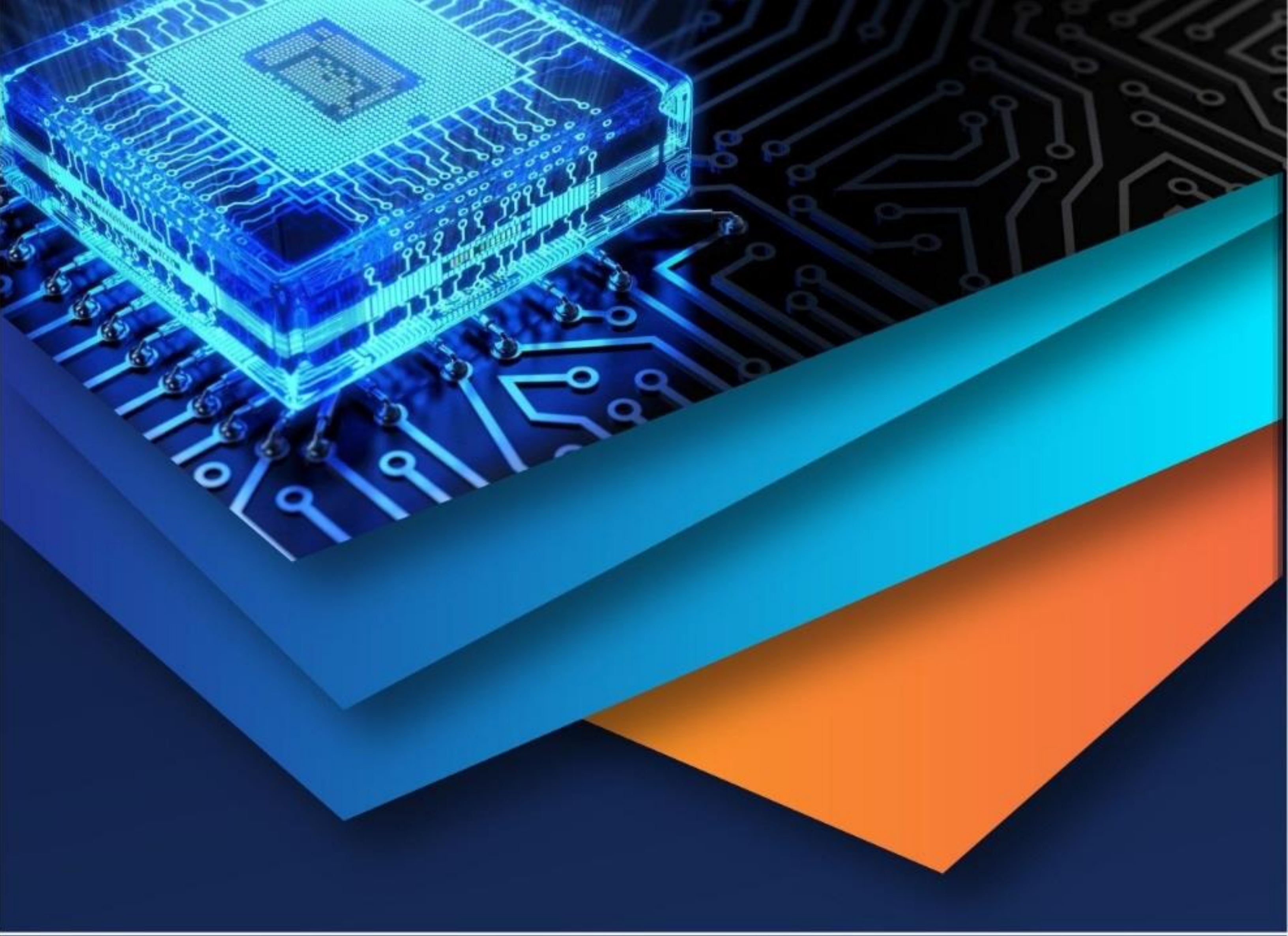

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