Particulate Matter (PM) Analysis During Diwali 2025

Sub-Study under the Project:

Vertical Pollution Dispersion Estimation

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Abstract

This sub-analysis investigates particulate matter (PM2.5 and PM10) concentration patterns observed during the Diwali 2025 period, as part of the larger Vertical Pollution Dispersion Estimation project. The sensor node was fixed approximately 12 meters above ground level—close enough to capture near-surface pollution caused by fireworks and human activity. The study focuses on the temporal dynamics, event-driven pollution peaks, and their correlation with meteorological factors like temperature and humidity. Findings show a sharp and short-lived pollution surge during Diwali celebrations, confirming strong event dependency and the role of boundary layer behavior in trapping pollutants near the ground.

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1. Introduction and Objectives

This report presents an in-depth analysis of particulate matter (PM2.5 and PM10) data collected during the Diwali 2025 period in Hyderabad. The data were collected from a low-cost PM sensor positioned at a fixed height of approximately 12 meters above ground level—a critical position to assess near-surface pollution behavior relevant to vertical dispersion studies. The main goal is to identify significant pollution peaks, analyze their causes, and connect these variations to real-world events and atmospheric phenomena.

2. Graphical Analysis of PM Data

2.1. Primary Event Analysis: Time-Series Trend

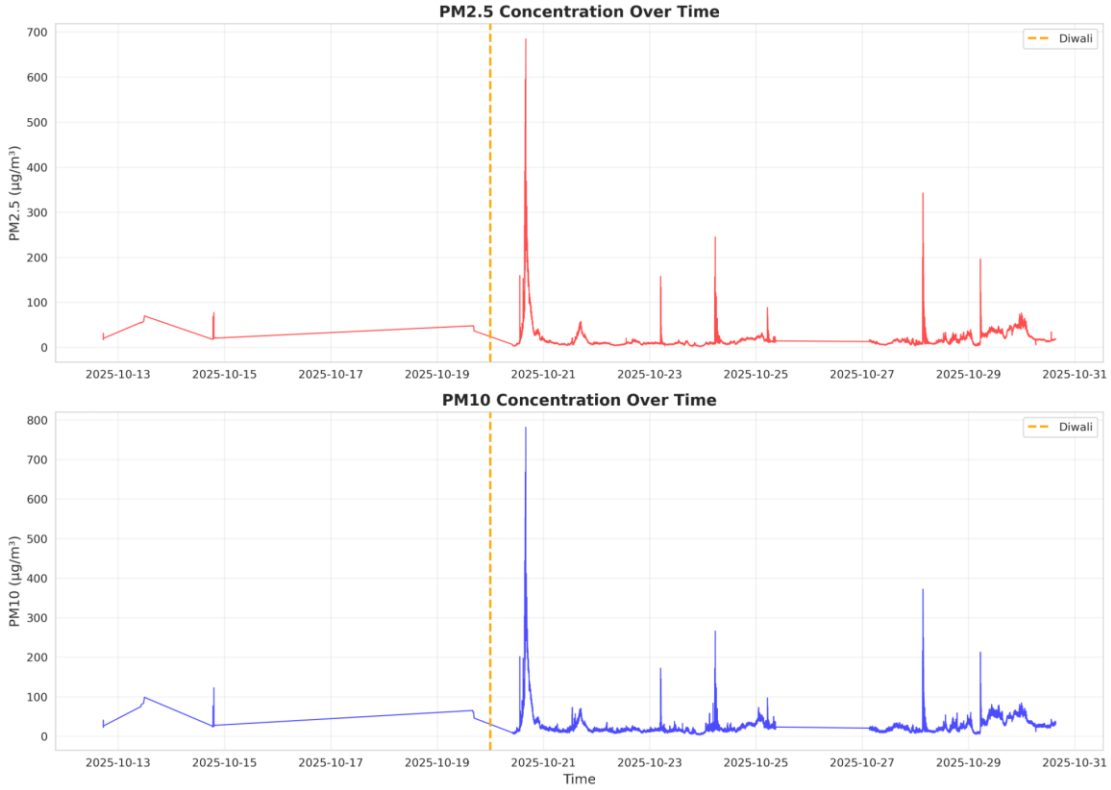

Figure 1: PM2.5 (red) and PM10 (blue) concentrations over time.

This time-series shows the temporal variation of PM concentrations over 18 days. The sharp and prominent spike around October 20th corresponds precisely with Diwali celebrations. The readings surge from ~50 µg/m³ to nearly 700 µg/m³, indicating an extreme short-duration event. Secondary peaks observed on later dates (Oct 23, 27, 29) suggest localized burning, traffic activity, and atmospheric stagnation.

2.2. Event Impact: Pre/During/Post Diwali Comparison

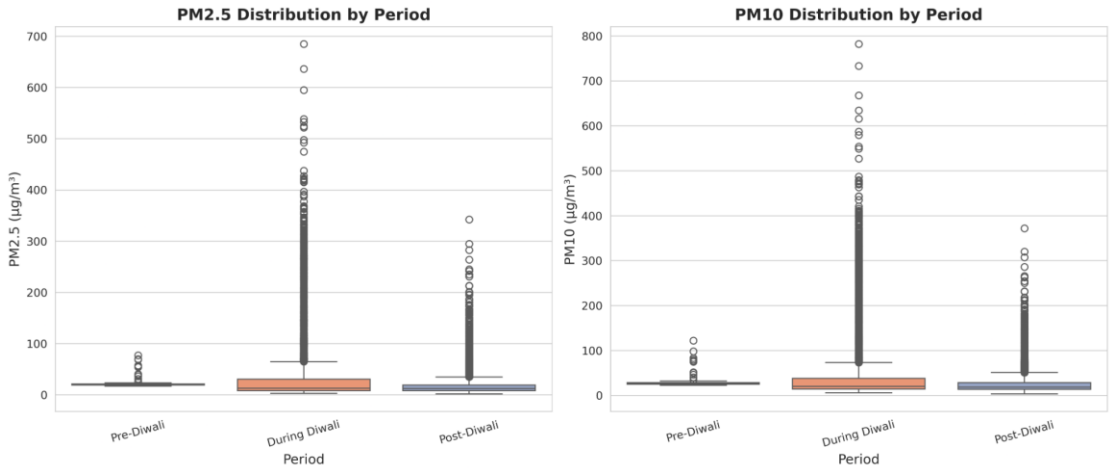

Figure 2: Box plots showing PM levels before, during, and after Diwali.

Box plots illustrate the statistical distribution of PM concentrations across the three event periods. The 'During Diwali' phase exhibits the highest median and widest interquartile range, confirming intense but short-lived pollution. Outliers above the boxes represent extreme events—almost exclusively during the Diwali period—showing the episodic nature of these spikes.

2.3. Cumulative Exposure Analysis

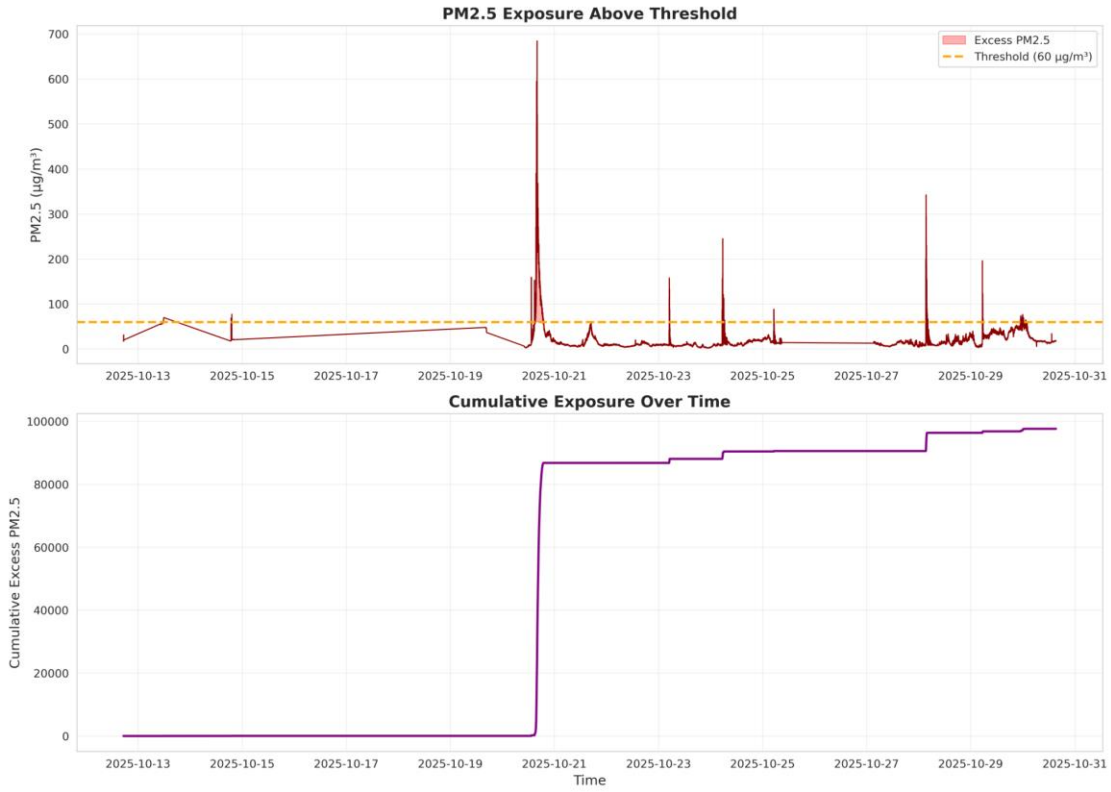

Figure 3: Cumulative PM2.5 exposure showing rapid rise during Diwali.

This plot quantifies total exposure to pollution levels exceeding 60 µg/m³. The cumulative exposure curve remains flat until Diwali night, when it jumps dramatically, indicating that most of the period's total pollution load occurred in just a few hours.

2.4. Overall Air Quality Context: AQI Distribution

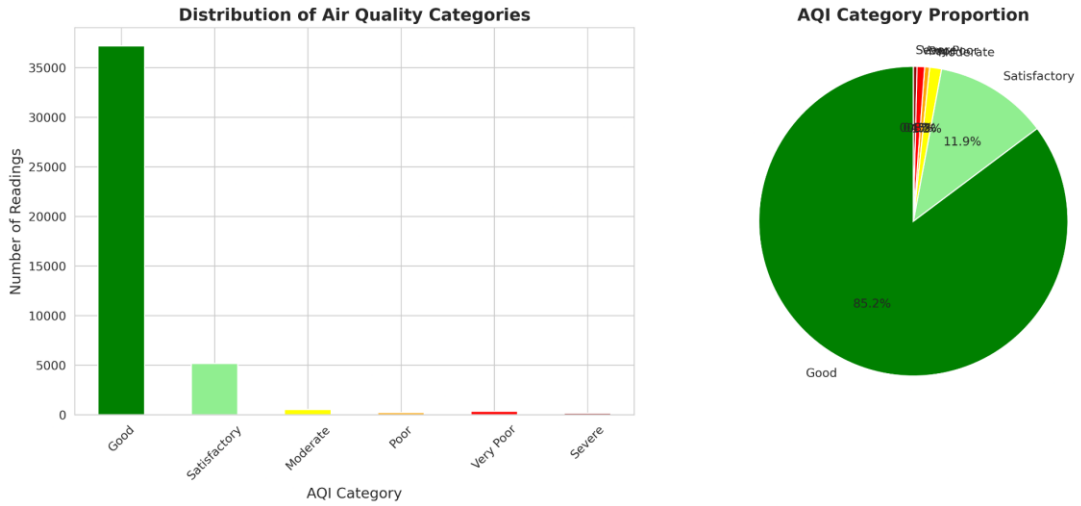

Figure 4: AQI category distribution across the observation period.

The AQI analysis reveals that air quality remained 'Good' or 'Satisfactory' for over 85% of the time. The 'Poor' to 'Severe' categories constitute less than 2% of total readings, directly linked to Diwali spikes. This highlights that pollution during this period was acute rather than chronic.

2.5. Daily Patterns: Diurnal Variation

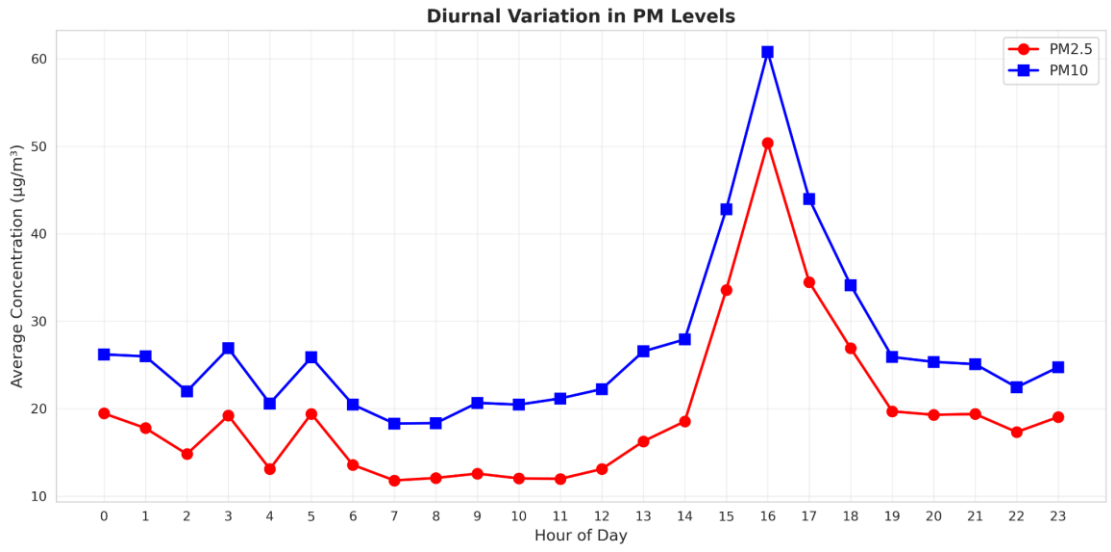

Figure 5: Average diurnal variation of PM levels across 24 hours.

This diurnal analysis shows a clear evening peak between 15:00–17:00, aligning with rush-hour emissions and a lowering atmospheric boundary layer. Daytime dips between 08:00–14:00 correspond to enhanced vertical mixing, allowing pollutants to disperse more effectively.

2.6. Meteorological Factor 1: Temperature Inversion

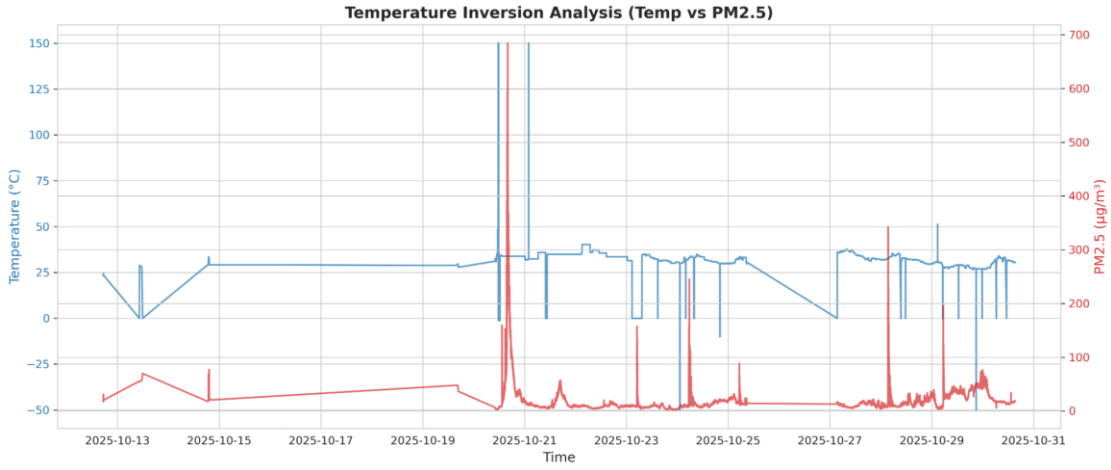

Figure 6: Temperature and PM2.5 co-variation showing inversion effects.

When temperature stabilizes or drops after sunset, the vertical dispersion capacity decreases. This temperature inversion traps cold air and pollutants near the surface, amplifying ground-level PM concentrations. This phenomenon is particularly visible during Diwali night.

2.7. Meteorological Factor 2: Variable Correlation

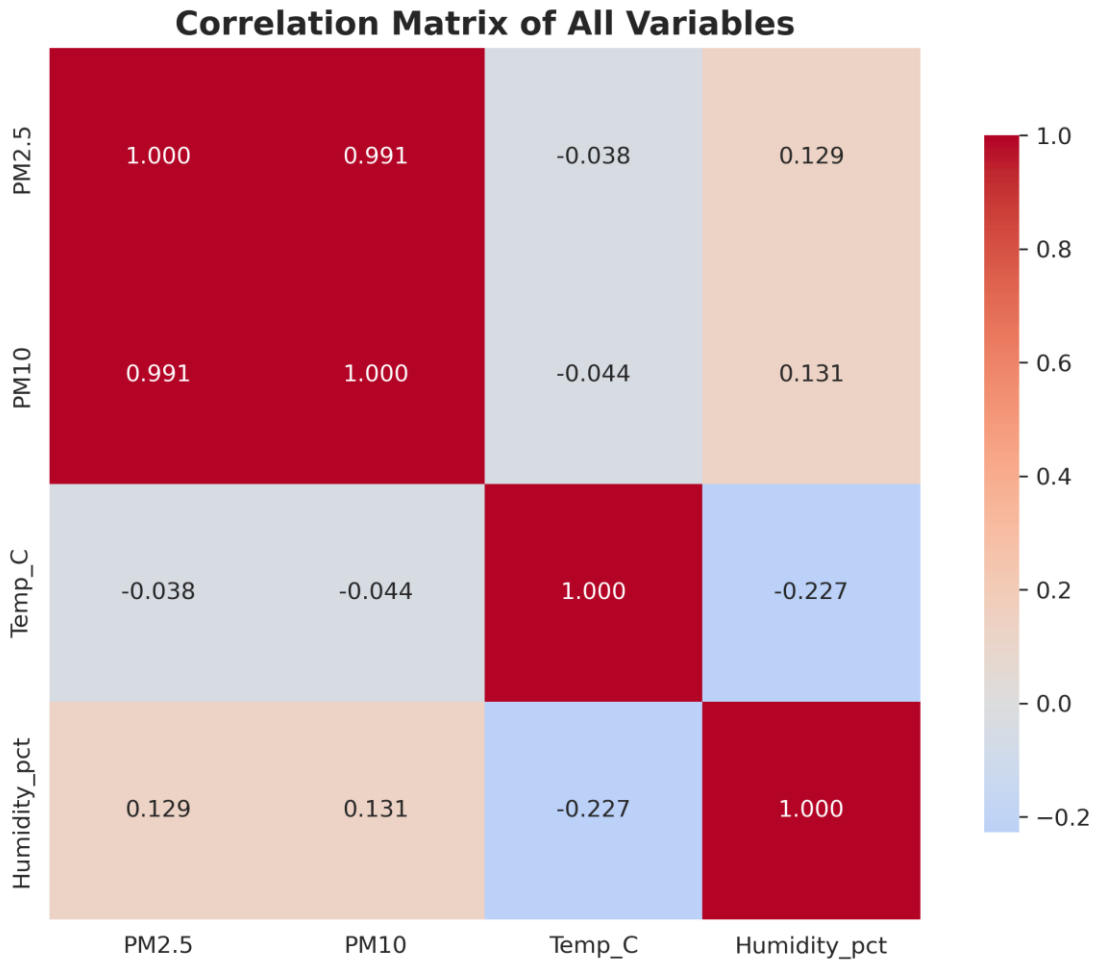

Figure 7: Correlation matrix showing relationships among environmental variables.

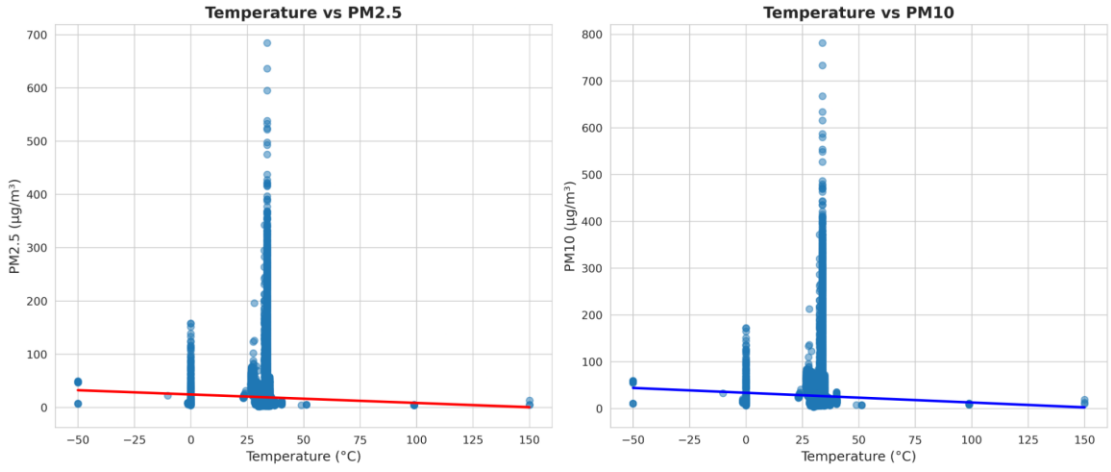

Figure 8: Temperature vs PM relationship showing weak inverse correlation.

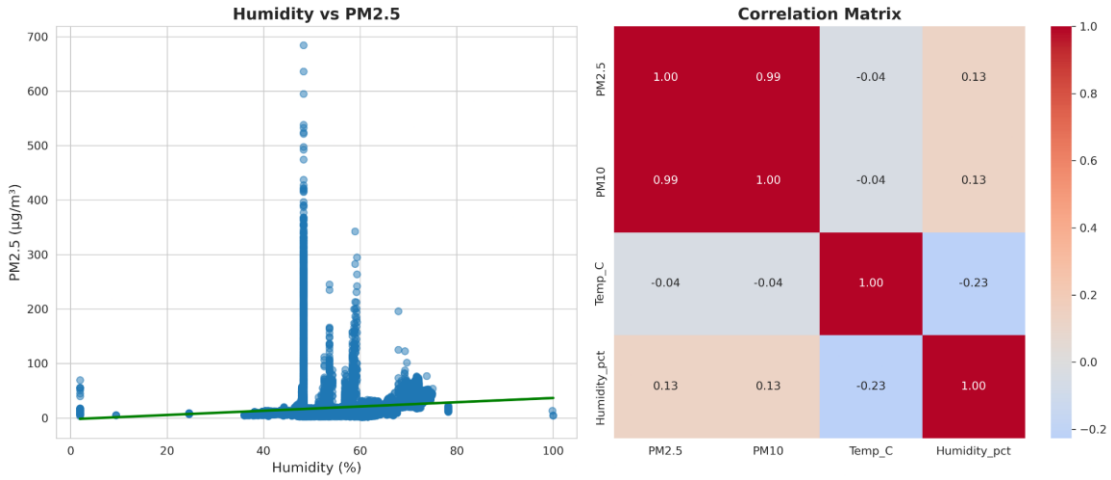

Figure 9: Humidity vs PM relationship indicating mild positive correlation.

The correlation matrix quantifies how variables interact. PM2.5 and PM10 show a near-perfect positive correlation (0.991), confirming shared sources. A slight negative correlation with temperature (-0.038) supports the inversion hypothesis, while a weak positive correlation with humidity (+0.129) indicates hygroscopic particle growth in moist conditions.

2.8. Project Context: Hypothetical Vertical Dispersion

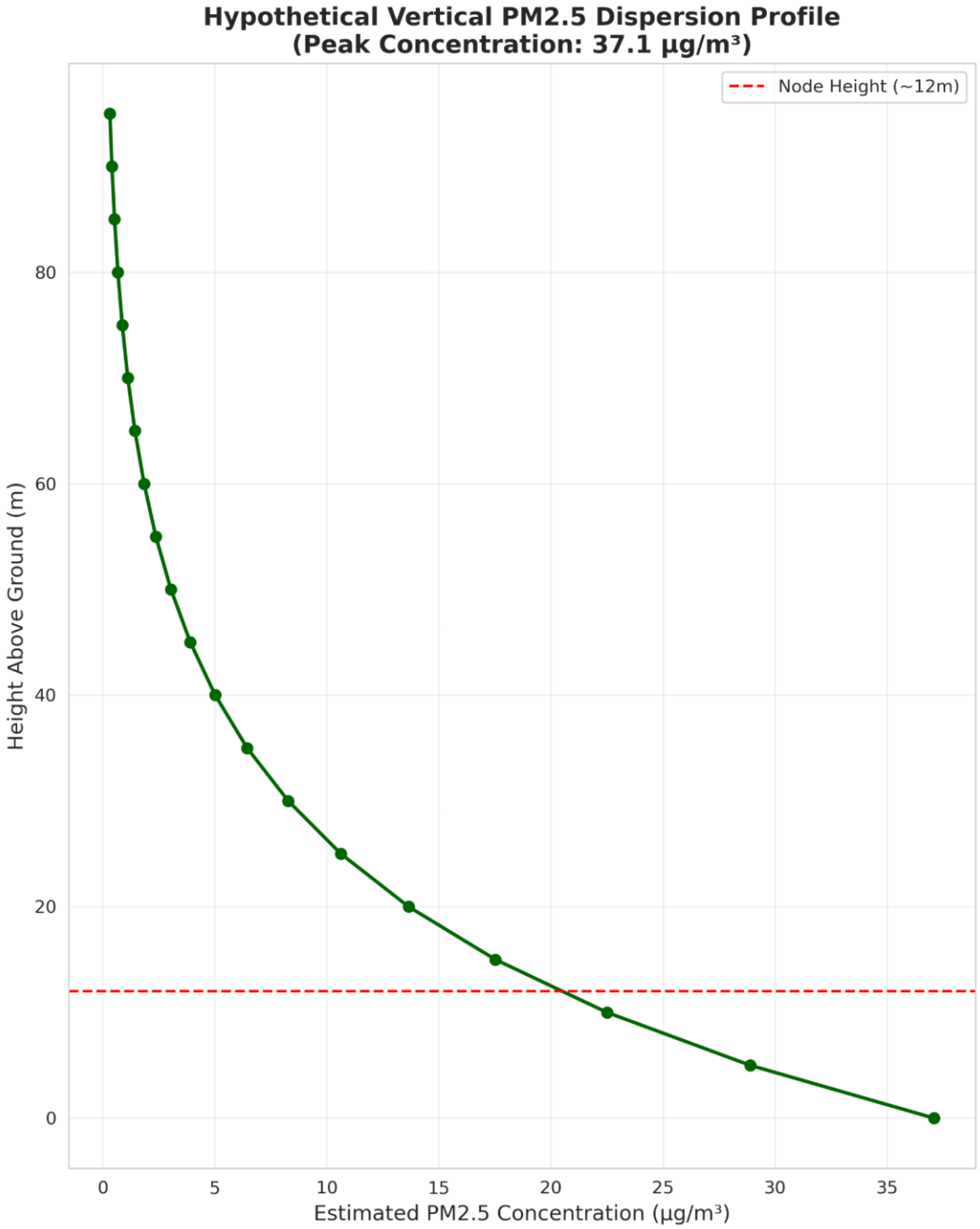

Figure 10: Hypothetical vertical concentration profile illustrating dispersion.

This model visualizes how PM concentration decreases with altitude. Ground-level emissions show peak values (~37.1 µg/m³), dropping to about 20 µg/m³ at 12 m—the sensor height. This illustrates why our fixed sensor node provides a valuable lower-bound measurement for dispersion modeling.

3. Overall Conclusions

This Diwali sub-study provides clear evidence of event-driven pollution behavior, emphasizing the role of human activities and meteorological conditions in vertical dispersion dynamics. The Diwali 2025 spike was a dominant, short-term pollution event, while daily traffic contributed to recurring minor peaks. Temperature inversions and humidity variations intensified these effects. These insights will inform the broader Vertical Pollution Dispersion Estimation project, aiding future calibration and modeling efforts.

Appendix A: Summary Statistics

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DIWALI AIR QUALITY ANALYSIS - SUMMARY STATISTICS
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Data Range: 2025-10-12 06:49:25+00:00 to 2025-10-30 15:21:13+00:00
Total Records: 43671
Valid PM2.5 Readings: 43615
Valid PM10 Readings: 43615

Overall PM2.5 Statistics:
count 43615.000000
mean 19.253729
std 27.678640
min 1.800000
25% 8.200000
50% 12.100000
75% 20.200000
max 684.500000

Overall PM10 Statistics:
count 43615.000000
mean 26.898913
std 31.069986
min 3.400000
25% 13.700000
50% 18.600000
75% 29.800000
max 781.700000

PM Statistics by Period:
PM2.5 PM10
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	mean	median	max	mean	median	max
Period						
During Diwali	32.035204	12.900	684.5	40.715423	19.8	781.7
Post-Diwali	16.307374	12.000	342.3	23.714691	18.3	371.8
Pre-Diwali	23.088796	20.305	77.1	30.806389	26.9	122.3

AQI Category	Distribution:
Good	37170
Satisfactory	5172
Moderate	542
Very Poor	345
Poor	223
Severe	163