

## RESEARCH BRIEF

# Beyond Ambient Air: Addressing the Indoor Air Quality Policy Gap in Jodhpur, Rajasthan

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12 months

Monitoring Period

24

Air Quality Monitors

6

Land-Use Categories

24/7

Continuous Sensor Data

## BACKGROUND

Air pollution is a major environmental risk factor contributing to disease burden and premature mortality in India. Although ambient air pollution receives significant policy attention, indoor air pollution remains inadequately addressed, even though individuals spend most of their time indoors. Jodhpur, located on the fringe of the Thar Desert, experiences unique air quality challenges arising from desert dust, industrial emissions, vehicular pollution, and rapid urbanisation.

Indoor air pollution comprises chemical, physical, and biological contaminants, including bioaerosols such as bacteria, fungi, pollen, and viruses, which can account for a substantial proportion of indoor particulate matter. Elevated levels of PM10 and PM2.5 pose significant health risks, particularly for vulnerable populations. Understanding pollutant distribution within household environments is critical, as residents experience the greatest exposure indoors. Continuous monitoring across residential, commercial, industrial, and slum areas has demonstrated persistent particulate pollution across diverse urban settings.

To address these critical concerns, the Jodhpur Urban Air Quality Monitoring Project (JUMP) was initiated to assess indoor and outdoor air quality comprehensively and generate evidence-based insights for strengthening environmental health policy in Rajasthan.

## CURRENT SITUATION

Jodhpur faces severe air quality challenges, with the city ranking 45th globally according to IQAir's World Air Quality Report 2021. This ranking reflects India's broader air pollution crisis, with 12 of the 15 most polluted cities in Central and South Asia located within the country. Jodhpur's geographical position at the edge of the Thar Desert, combined with proximity to open-cast stone mines and a significant industrial hub in its western sector, creates multiple pollution sources that persistently degrade air quality.

**Critical Infrastructure Gap:** Only one real-time ambient air quality monitoring station, operated by the Central Pollution Control Board, serves the entire city of Jodhpur. This single monitoring point fails to capture spatial and temporal variation in pollution levels across different residential, commercial, and industrial microenvironments. The true exposure levels experienced by residents in their homes, workplaces, and commuting routes remain poorly understood.

## ABOUT THE STUDY

### Study Objectives

- To study the indoor and ambient air quality in different micro-environments of Jodhpur
- To assess the level of awareness about air pollution among residents of Jodhpur

### Study Design and Area

A prospective longitudinal air quality monitoring study was conducted across the municipal area of Jodhpur City over 12 months (June 2022–June 2023).

**Sampling Sites:** Twelve households were selected from six distinct land-use types: industrial (Basani), commercial (Mahamandir), slum (Rajiv Colony), high-income (Shastri Nagar), middle-income (Partap Nagar), and low-income (Jhalamand) areas. Two households were monitored per area.

#### Data Collection:

- **Air Quality Monitoring:** Twenty-four laser sensor-based monitors (AirVisual Pro) were deployed, one indoor and one outdoor per household, measuring PM<sub>1.0</sub>, PM<sub>2.5</sub>, PM<sub>10.0</sub>, CO<sub>2</sub>, temperature, and relative humidity continuously (24×7).
- **Bioaerosol Sampling –1. Petri Dish Method:** Using blood agar (bacteria) and Rose Bengal Potato Dextrose Agar (fungi), placed in five locations per household (kitchen, bathroom, bedroom, living area, outdoors), once every three months. **2. Anderson Cascade Impactor:** Size-selective PM sampling conducted once per season.
- **Awareness Assessment:** Structured questionnaire administered to adults at baseline and end-line.

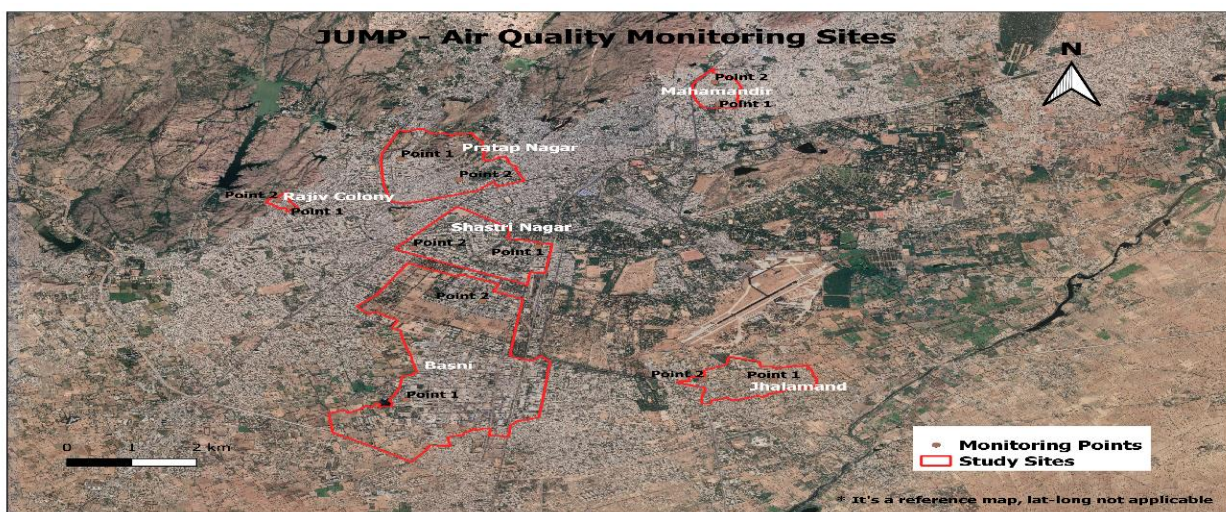


Fig: Project Air Quality Monitoring Sites of Jodhpur City

## KEY EVIDENCE FROM JUMP

Year-long monitoring across six land-use categories in Jodhpur revealed that PM<sub>2.5</sub> concentrations frequently exceeded national standards, with peak levels above 200 µg/m<sup>3</sup> during winter months and lowest levels during the monsoon season.

- **Indoor vs. Outdoor Pollution:** Indoor PM<sub>2.5</sub> levels were consistently higher than outdoor concentrations in all settlements except high-income colonies, indicating that residents face greater exposure indoors. Slum and industrial areas experienced the highest pollution burden.
- **Bioaerosol Contamination:** Bacterial and fungal bioaerosols were detected across all monitored households, with higher concentrations in kitchens, bathrooms, and overcrowded dwellings. Potentially pathogenic species were identified, highlighting serious health risks from biological indoor pollutants.
- **Housing and Ventilation:** Housing conditions and ventilation quality significantly influenced exposure levels.
- **Awareness Outcomes:** Community awareness interventions improved residents' understanding of air quality risks.

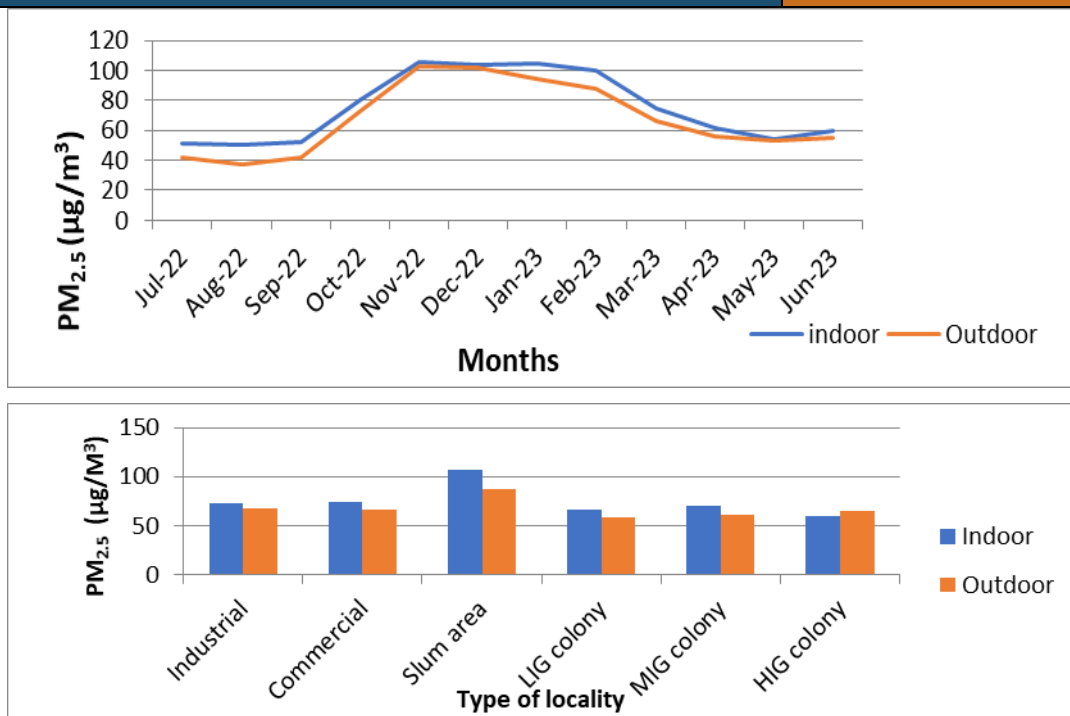


Fig: Comparison of Avg. PM<sub>2.5</sub> levels of indoor & outdoor locations across the year and the type of locality

## PUBLIC HEALTH IMPLICATIONS

Exposure to elevated PM<sub>2.5</sub> is associated with asthma, chronic obstructive pulmonary disease, cardiovascular disease, stroke, diabetes, adverse pregnancy outcomes, reduced lung function in children, and premature mortality. Vulnerable populations including children, elderly persons, and people with pre-existing illnesses face disproportionate risks.

**Compounding Risks:** Indoor bioaerosols may contribute to respiratory infections, allergic diseases, and asthma exacerbations. The combined exposure to particulate matter and microbial contaminants creates an additional public health burden that is often overlooked in conventional environmental policies.

## POLICY GAPS

- **Ambient Focus:** Air quality management efforts continue to focus primarily on ambient air pollution, with limited attention given to indoor environments where people spend most of their time.
- **Absent Indoor Standards:** Comprehensive indoor air quality standards for residential settings are largely absent, creating a significant regulatory gap.
- **Monitoring Deficit:** Existing monitoring networks are insufficient to capture fine-scale spatial variations in pollution levels across neighbourhoods and microenvironments.
- **Low Awareness:** Public awareness of indoor pollution sources, associated health risks, and effective mitigation measures remains low.

## RECOMMENDATIONS

- Expand air quality monitoring networks across Rajasthan and other regions.
- Incorporate ventilation standards into building codes and housing regulations.

- Enhance dust suppression, road cleaning, and industrial emission controls.
- Implement regular bioaerosol monitoring in public buildings and high-risk communities.
- Develop and promote public awareness campaigns and citizen engagement initiatives.
- Maintain air quality as a key factor in urban planning, transportation, and housing policies.
- Focus interventions on slums and low-income settlements as a priority.

## CONCLUSION

The evidence generated through JUMP provides a strong foundation for action. Air quality should be treated as a public health priority and integrated into development planning. Investment in monitoring, housing improvement, awareness, and pollution control will generate substantial health, social, and economic benefits for the people of Rajasthan.

## ACKNOWLEDGEMENTS

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## PUBLISHED ARTICLES FROM THIS STUDY

- Huda RK, Kumar P, Gupta R, Sharma AK, Toteja GS, Babu BV. Air Quality Monitoring using low-cost sensors in Urban areas of Jodhpur, Rajasthan. *International Journal of Environmental Research and Public Health*. 2024 May 14;21(5):623.
- Huda RK, Gupta R, Kumar P, Singh J, Sharma AK, Toteja GS, Babu BV. Impact of Housing Conditions and Air Quality Awareness with Indoor PM<sub>2.5</sub> Levels in Urban Jodhpur. *Indian Journal of Community Medicine*. 2025 Nov 13:10-4103.
- Huda RK, Gupta R, Kumar P, Singh J, Sharma AK, Toteja GS, Babu BV. Sociospatial Analysis of Indoor Bioaerosol Variation Across Diverse Residential Zones in Jodhpur. *Scientific Reports*. 2025 Dec.