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Cleaning India's Air: A Roadmap from Science to Solutions

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Air pollution in India is a major driver of ill-health, with population exposure linked to about 1 million annual, premature excess deaths and an economic impact estimated at 1.36% of GDP, against a total health expenditure in India of 3.8% of GDP (Pandey et al. 2021). Global experience in air quality management relies on a combination of air pollution monitoring, emissions inventories, source apportionment modeling and other assessment tools to determine emissions reductions needed to protect public health. In India, while there is an emerging network for air pollution monitoring stations, the nascent state of analysis tools and models, along with a paucity of long-term particulate chemical composition records, has restricted the understanding of ambient air pollution.

The heterogeneous, multi-scale nature of particulate air pollution will be explored through an amalgamation of findings from the **Carbonaceous Aerosol Emissions, Source Apportionment, and Climate Impacts (COALESCE)** network in India (Venkataraman et al. 2024) combining measurements and a hierarchy of models, including energy-emissions estimation, top-down receptor models (positive matrix factorization, PMF) and bottom up chemical transport models (CTMs like WRF-Chem). The combined evidence reveals PM_{2.5} chemical composition dominated by primary species and carbonaceous constituents at geographically diverse stations. Source apportionment ascertains diverse regional signals from residential biofuel combustion and agricultural biomass burning in north and central India, but coal-fired energy generation in eastern India, with varying strengths of the industrial and vehicular sources across India (Venkataraman et al. 2024).

The newly developed, computationally efficient, PAVITRA platform (**Air Pollution Management and Intervention Tool for India**) will be presented, relying on a rapid computation model with $\sim 10^5$ times shorter simulation time than a CTM, enabling thousands of policy relevant simulations (Balasubramanian S., Rojas-Mendoza et al. 2026; Barman et al. 2026). Strategies for coordinated air quality management across state, airshed and city scales will be discussed.

Implications for air quality policy, suggest the need for a new paradigm expanding urgently beyond city scales, centering on non-urban geographies and informal economic sectors, and accounting for the complex interplay between localized and regional air pollution sources.

Pandey, A. et al. (2021). Health and economic impact of air pollution in the states of India: The Global Burden of Disease Study 2019. *The Lancet Planetary Health*, 5(1), e25–e38. [https://doi.org/10.1016/S2542-5196\(20\)30298-9](https://doi.org/10.1016/S2542-5196(20)30298-9)

Venkataraman, C. et al. (2024) Drivers of PM_{2.5} episodes and exceedance in India: A synthesis from the COALESCE network. *Journal of Geophysical Research: Atmospheres*, 129, e2024JD040834. <https://doi.org/10.1029/2024JD040834>

Balasubramanian, S., Rojas-Mendoza, L. et al.(2026). Spatially Differentiated Multi-Sectoral Mitigation Strategies Needed to Reduce PM2.5 Exposures in India. <https://doi.org/10.26434/chemrxiv.15008347/v1>

Barman, N. et al. (2026). Targeted mitigation strategies for critically polluted PM2.5 regions in India using spatially constrained airsheds. <https://doi.org/10.26434/chemrxiv.15008124/v2>