Prakriti- The International Multidisciplinary Research JournalYear 2026, Volume-3, Issue-1 (Jan-Jun)

Air Pollution in India: Sources, Impacts and Policy Responses

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ARTICLE INFO

Key words: Crises, Pollution, Climate, Resources, Reforms

doi:10.48165/pimrj.2026.3.1.2

ABSTRACT

Air pollution is one of the most critical environmental and public health challenges confronting India in the 21st century. Rapid urbanization, industrialization, motorization, and unsustainable agricultural practices have resulted in dangerously high levels of air pollutants across much of the country. India today houses several of the world's most polluted cities, with particulate matter (PM2.5 and PM10) levels routinely exceeding both national and international safety standards. The health, environmental, and economic consequences are profound, ranging from millions of premature deaths each year to crop yield losses, climate disturbances, and GDP reduction. This paper reviews the major causes of air pollution in India, outlines its wide-ranging impacts, and critically examines existing policy measures such as the National Clean Air Programme (NCAP). Using secondary data from government agencies, peer-reviewed journals, and global assessments, this research highlights both progress and persistent gaps. The paper concludes with policy recommendations that stress the importance of integrating technological solutions, governance reforms, and community engagement to address the air pollution crisis.

Introduction

Air pollution has emerged as a silent yet severe environmental crisis in India. The World Health Organization (WHO, 2022) reports that 14 of the world's 20 most polluted cities are located in India. The problem transcends geographic, social, and economic boundaries, affecting both rural and urban populations. In major metropolitan areas like Delhi, Mumbai, Kolkata, and Bengaluru, vehicular traffic, industrial emissions, and construction activities create smog that often renders the air unbreathable. In rural India, practices like stubble burning, the use of biomass fuels for cooking, and dust storms exacerbate pollution. Meteorological conditions during winter in northern India trap pollutants close to the surface, creating extended periods of hazardous air quality. Air pollution is not just an environmental issue; it is deeply intertwined with public health, social equity, and economic growth. The poorest communities often face the greatest exposure while lacking resources to mitigate their effects. This paper aims to examine the scope of India's air pollution crisis in detail, reviewing causes, impacts, and responses.

Literature Review

Scholarly literature and policy reports on air pollution in

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India cover a wide spectrum:

1. Health Burden: The Global Burden of Disease Study (2020) estimates that 1.6 million deaths in India annually are linked to air pollution. This makes air pollution the country's second-largest risk factor for premature mortality.

2. Sources and Distribution: Guttikunda & Jawahar (2018) demonstrated that coal-fired power plants contribute over 80,000 premature deaths annually. Other studies highlight the role of vehicular congestion and construction dust in urban air quality deterioration.

3. Climate Impacts: Aerosol research from the Indian Institute of Tropical Meteorology (IITM) shows that high levels of particulate matter affect the Indian monsoon by altering cloud microphysics and rainfall distribution.

4. Economic Impacts: The World Bank (2021) estimates that air pollution costs India approximately $150 billion annually, or about 8.5% of GDP, through lost productivity and increased healthcare expenditure.

5. Policy Assessments: The National Clean Air Programme (NCAP), launched in 2019, is India's most ambitious attempt at coordinated air quality management, but scholars argue it lacks legal enforcement and sufficient funding.

Methodology

This paper employs a qualitative review methodology based on secondary sources. Data were drawn from:

1. Government agencies such as the Central Pollution Control Board (CPCB) and the Ministry of Environment, Forest and Climate Change (MoEFCC).
2. International organizations such as the WHO, UNEP, and the World Bank.
3. Academic journals covering atmospheric science, environmental health, and public policy.
4. City-level case studies from Delhi, Mumbai, Bengaluru, and Varanasi.
5. The review integrates findings across these sources to construct a multi-dimensional picture of India's air pollution crisis.

Causes of Air Pollution in India

Air pollution in India is the result of both anthropogenic activities and natural factors.

1. Vehicular Emissions

India has one of the fastest-growing vehicle populations in the world. Vehicular emissions account for nearly 20–30% of PM2.5 levels in large cities. Diesel-powered vehicles are particularly problematic due to their high NOx and particulate output. Despite Bharat Stage VI (BS-VI) emission norms being adopted in 2020, older vehicles remain in circulation, and enforcement remains inconsistent.

2. Industrial and Energy Sector Emissions

India's reliance on coal for electricity generation is a major contributor to air pollution. Thermal power plants emit sulfur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter. Smaller industries, such as brick kilns and tanneries, often operate with minimal pollution controls.

3. Agricultural Practices

Stubble burning in Punjab, Haryana, and Uttar Pradesh is a seasonal but severe source of PM2.5 and carbon monoxide emissions. It contributes significantly to Delhi's infamous winter smog episodes.

4. Domestic Sources

In rural India, nearly 40% of households still rely on biomass fuels (wood, dung, crop residues) for cooking and heating. This not only contributes to outdoor air pollution but also causes high levels of indoor air pollution, disproportionately affecting women and children.

5. Construction and Road Dust

Rapid urbanization has increased dust emissions from construction sites, unpaved roads, and waste burning. This source is often underestimated but contributes significantly to PM10 levels in urban areas.

6. Natural and Meteorological Factors

Dust storms from the Thar Desert and winter inversions in northern India worsen the problem by trapping pollutants near the surface. Climate change is also altering wind and precipitation patterns, influencing dispersion.

Impacts of Air Pollution

1. Health Impacts

- Air pollution is directly linked to a wide range of health conditions:
- Cardiovascular diseases, stroke, and hypertension.
- Respiratory diseases such as asthma, bronchitis, COPD, and lung cancer.
- Developmental impacts on children, including stunted lung growth and impaired cognitive function.
- Higher susceptibility to infectious diseases due to weakened immunity.

2. Environmental Impacts

- Crop yield losses: Ground-level ozone damages crops like wheat, rice, and soybeans.
- Acid rain: Emissions of SO_2 and NOx contribute to soil and water acidification, harming forests and aquatic ecosystems.
- Climate change: Black carbon and aerosols influence radiative forcing, with both cooling and warming effects.

3. Economic Impacts

♦Healthcare burden: Rising hospital admissions and long-term treatment costs.
♦Productivity losses: Sick days and reduced labor efficiency.
♦Agriculture: Annual crop losses valued at billions of dollars.
♦Global competitiveness: Pollution reduces foreign investment and deters tourism.

Case Studies

Delhi

Delhi regularly records AQI levels in the "severe" category during winter. The crisis is driven by stubble burning in nearby states, vehicular congestion, and industrial emissions. Odd-Even traffic schemes have been tried, but with mixed results.

Mumbai

While coastal winds help disperse pollutants, Mumbai faces rising levels of vehicular and industrial pollution. Informal settlements located near highways are particularly vulnerable.

Bengaluru

Known as India's technology hub, Bengaluru struggles with traffic congestion and construction dust. AQI levels regularly cross "poor" thresholds, especially during dry months.

Varanasi

One of India's oldest cities, Varanasi, faces unique pollution sources: vehicular emissions, industrial discharge, biomass burning, and ritual fires along the Ganges.

Policy Responses

1. India has adopted multiple measures to address air pollution:
2. National Ambient Air Quality Standards (NAAQS) – sets permissible pollutant levels.
3. Bharat Stage (BS) Vehicle Emission Norms – BS-VI norms introduced in 2020 align with global best practices.
4. National Clean Air Programme (NCAP) – launched in 2019 to reduce PM levels by 20–30% by 2024.
5. Renewable Energy Promotion – focus on solar and wind power to reduce coal reliance.
6. Odd-Even Traffic Scheme – experimental vehicle rationing in Delhi.
7. International Cooperation – India participates in regional air pollution agreements and climate change commitments under the Paris Agreement.
8. Challenges in Policy Implementation
9. Weak enforcement capacity of state pollution boards.
10. Fragmented governance and inter-state conflicts.
11. Limited funding for NCAP (far below requirements).
12. Overemphasis on end-of-pipe solutions rather than systemic reforms.

Conclusion

Air pollution in India is a complex, multi-sectoral problem with devastating consequences for health, the environment, and the economy. While initiatives like NCAP and BS-VI emission standards are steps in the right direction, they fall short of addressing the magnitude of the crisis.

Moving forward, India needs:

1 Stronger enforcement of emission norms.
2 Investments in public transport and electric mobility.
3 Greater focus on agricultural reform to curb stubble burning.
4 Transition from coal to renewable energy.
5 Integration of community participation and awareness campaigns.
6 Without urgent, coordinated, and sustained action, air pollution will continue to undermine India's progress toward sustainable development.

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