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AIR POLLUTION GOVERNANCE IN INDIA

Policy Responses, Implementation Challenges and the Way Forward

Dr. Raghuraj Khullar

Assistant Professor

Jagran Lakecity University, Bhopal, India

Abstract: Air pollution has emerged as one of the most critical environmental and public health challenges in India. Rapid population growth, unplanned urbanization, industrialization, vehicular emissions, agricultural residue burning, construction activities, waste burning, and household fuel use have contributed significantly to deteriorating air quality across both urban and rural areas. This paper examines the major sources of air pollution in India and analyses its adverse consequences for human health, the environment, and overall societal well-being. Exposure to air pollutants, particularly particulate matter, is associated with respiratory and cardiovascular diseases, increased mortality and morbidity, and other serious long-term health impacts. The paper also reviews major governmental and institutional measures for controlling air pollution, including the role of the Central Pollution Control Board, National Clean Air Programme, vehicle emission standards, promotion of alternative and renewable energy, electric vehicles, agricultural residue management, and clean cooking initiatives. Despite these measures, technological limitations, uneven regulatory enforcement, inadequate public awareness, unsustainable agricultural practices, rapid urbanization, socio-economic disparities, and the transboundary nature of pollution continue to pose significant challenges. The paper argues for a comprehensive and multi-stakeholder approach involving government, industry, civil society, and citizens. Strengthening implementation, sustainable urban planning, technological innovation, environmental education, renewable energy, and effective monitoring can contribute substantially to achieving cleaner air and a healthier environment in India.

Index Terms - air pollution, public health, environmental policy, particulate matter, sustainable development

Introduction

Air pollution has become one of the most serious environmental and public health concerns confronting India in recent decades. It is now recognized internationally as a major threat to human health and is regarded by organizations such as the World Health Organization (WHO) and governments across the world as a significant environmental health hazard. Although air pollution has affected India for nearly a century, its intensity has increased considerably during the past few decades. Rapid population growth, uncontrolled urban expansion and industrial development have played an important role in aggravating the problem.

As one of the world's most populous countries, India faces particularly severe air-quality challenges in its rapidly growing cities. Several Indian cities frequently appear among the world's most polluted urban centres. In large metropolitan areas, pollution concentrations often rise beyond permissible levels, creating substantial health risks for residents. Most Indian cities that systematically monitor outdoor air quality continue to experience pollution levels that do not conform to WHO-recommended standards. Consequently, urban populations are increasingly exposed to unhealthy environmental conditions.

Although air pollution is commonly associated with cities, it is not exclusively an urban phenomenon. Rural and non-urban areas are also affected, particularly by particulate pollution. Satellite-based assessments and estimates of associated health impacts indicate that particulate matter can pose significant risks to populations outside major cities as well.

Air pollutants may be classified as either primary or secondary pollutants. Primary pollutants are released directly into the atmosphere from their sources. These include particulate matter such as PM_{2.5}, PM₁₀, suspended particulate matter (SPM) and respirable particulate matter (RPM), along with sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon monoxide (CO), ammonia and dust. Secondary pollutants, on the other hand, are formed through atmospheric chemical reactions and include substances such as ozone, smog and peroxyacyl nitrates (PANs).

Causes of Air Pollution

Air pollution in India results from a combination of transportation, industrial, agricultural, construction, waste-management and household activities. The principal sources are discussed below.

1. Vehicular Emissions

Motor vehicles powered by petrol and diesel are an important source of air pollution. The rapid expansion in the number of cars, buses, trucks and two-wheelers has increased the volume of pollutants released into the atmosphere. Vehicle exhaust contains pollutants such as nitrogen dioxide and carbon monoxide, which adversely affect air quality. The paper identifies vehicular emissions as a particularly significant contributor to air pollution.

2. Industrial Activities and Power Plants

Industrial establishments such as factories, oil refineries and brick kilns release considerable quantities of pollutants. Coal-fired thermal power plants are also major sources of atmospheric emissions. These activities can release harmful gases, particulate matter, soot and other pollutants into the surrounding environment.

3. Crop-Residue and Stubble Burning

The burning of agricultural residues is another important contributor to air pollution. In several northern states, particularly Punjab and Haryana, farmers burn crop residues during the period between agricultural seasons. Smoke and particulate matter generated through this practice can contribute to deteriorating air quality, especially during seasonal episodes of elevated pollution.

4. Construction and Road Dust

Construction activity, demolition work, road development and the presence of unpaved roads generate substantial quantities of dust. Poorly managed construction sites and loose materials can allow coarse particulate matter to become airborne, thereby increasing local pollution levels.

5. Open Burning of Waste

Improper disposal and management of solid waste can also contribute to air pollution. In many places, waste is burned in the open. Such burning releases smoke and potentially harmful gases into the atmosphere and consequently worsens local air quality.

6. Household Air Pollution

Household energy practices remain an important source of indoor air pollution, particularly in rural areas. Traditional cooking devices, including chulhas, are often operated using firewood, coal, cow-dung cakes and other solid fuels. Combustion of these fuels produces smoke and other pollutants that can adversely affect household air quality.

Effects of Air Pollution

Air pollution has serious consequences for human health and the environment. It contributes to increased morbidity and mortality and is also associated with climate-related changes. Research on exposure to polluted air has identified both immediate and long-term health consequences.

Short-term exposure may cause irritation of the eyes, nose and throat and can contribute to respiratory infections such as bronchitis and pneumonia. Prolonged exposure can have much more serious consequences, including chronic respiratory illnesses, cardiovascular problems and lung cancer. The paper also highlights the possibility of damage to organs and systems such as the brain, liver, kidneys and nervous system.

Certain sections of the population are particularly vulnerable to the harmful effects of air pollution. Children, older people and residents of heavily polluted urban areas face greater risks. Poor air quality can consequently affect not only individual health but also the productivity and overall well-being of the population.

The WHO classified outdoor air pollution as carcinogenic to humans in 2013. The paper further points to the relationship between rising temperatures and deteriorating air quality and notes that poor air quality can adversely affect cardiovascular health and contribute to the progression of cardiovascular disease.

POLICY MEASURES TO ADDRESS AIR POLLUTION

India has developed a broad range of measures to address air pollution. These include national programmes, sector-specific regulations, regional mechanisms and schemes aimed at particular sources of pollution. Major interventions focus on transport, industries, power generation, agricultural residue burning, dust and household energy use.

1. Central Pollution Control Board

The Central Pollution Control Board (CPCB) is a statutory institution created under the Water (Prevention and Control of Pollution) Act, 1974. It also performs important functions under the Air (Prevention and Control of Pollution) Act, 1981. The CPCB occupies a central position in India's system of air-pollution monitoring, regulation and coordination.

Its responsibilities include establishing national ambient air-quality standards and emission standards for industries. It operates air-quality monitoring systems to assess pollutant concentrations and provides information such as the Air Quality Index (AQI). It also provides technical advice to the Union Government regarding pollution-control policies.

The CPCB assists and coordinates with State Pollution Control Boards and supports the resolution of regulatory issues involving different states. It also undertakes enforcement-related activities, including action against non-compliance, and participates in emergency mechanisms such as the Graded Response Action Plan (GRAP) during periods of severe pollution. In addition, the institution supports research into pollution-control technologies and undertakes public-awareness activities.

2. National Clean Air Programme

The National Clean Air Programme (NCAP) was introduced in 2019 as a comprehensive national initiative to address air pollution. Under the programme, 130 cities were expected to formulate city-specific Clean Air Plans and undertake appropriate mitigation measures.

The programme provides a broad framework for both Union and State governments to address air pollution through coordinated and time-bound interventions. The paper identifies a target of achieving up to a 40 percent reduction in PM10 levels in the targeted cities by 2026.

3. National Auto Fuel Policy

Vehicle emissions constitute an important source of air pollution, and India has progressively introduced stricter fuel and vehicle-emission standards. Since 2000, the country has moved towards emission and fuel standards based on European regulatory approaches for light- and heavy-duty vehicles.

The National Auto Fuel Policy, introduced in 2003, outlined interventions concerning vehicle-emission standards, fuel quality, measures for controlling emissions from vehicles already in use, automobile technology, air-quality information and research and development.

4. Commission for Air Quality Management

The Commission for Air Quality Management (CAQM) was established through the CAQM Act, 2021, to promote coordinated action on air pollution in the National Capital Region and adjoining areas. Its jurisdiction covers Delhi and specified areas of Haryana, Punjab, Rajasthan and Uttar Pradesh.

The Commission issues directions and advisories and has developed sector-specific measures for controlling air pollution. These measures include restrictions relating to older vehicles, promotion of cleaner public transportation and controls concerning certain petrol- and diesel-powered vehicle fleets.

5. Transition to BS-VI Standards

India moved directly from BS-IV to BS-VI fuel and vehicle-emission standards nationwide in April 2020. The transition to these cleaner standards was intended to reduce emissions, particularly pollutants such as sulphur compounds and nitrogen oxides, and thereby improve vehicular air quality.

6. Development of Alternative Fuel Infrastructure

The government has encouraged the use of alternative fuels, including CNG, LPG/LNG, biodiesel and other biofuels. The objective is to expand alternative-fuel production and reduce reliance on conventional fossil fuels. Greater use of cleaner alternatives can contribute to lower emissions and improved air quality.

7. Ethanol-Blended Petrol

India has experimented with ethanol-blended petrol since the beginning of the 2000s, while the formal Ethanol Blended Petrol Programme was introduced in 2003. According to the paper, E20 petrol, containing 20 percent ethanol and 80 percent petrol, has been deployed as a standard fuel offering from April 2026.

The use of ethanol blending is intended to lower certain vehicular emissions, particularly carbon monoxide and hydrocarbons, and thereby contribute to pollution reduction.

8. Vehicle Scrappage Policy

The government has introduced measures intended to remove older and highly polluting vehicles from circulation. The vehicle scrappage policy seeks to reduce emissions by encouraging the phase-out of older commercial and private vehicles.

9. Restrictions on Older Vehicles

Additional restrictions have been introduced for older vehicles, particularly in parts of the National Capital Region. These include restrictions or fuel-denial measures affecting certain petrol and diesel vehicles beyond specified age limits. Such measures seek to reduce emissions from older, more polluting vehicles.

10. Renewable Energy for Power Generation

The promotion of renewable energy is another important component of India's efforts to reduce pollution. Solar, wind and hydropower projects are being encouraged to meet growing energy requirements while reducing dependence on fossil fuels.

The paper emphasizes that renewable energy sources generate little or no direct air pollution and can therefore support both environmental protection and cleaner energy production.

11. Industrial and Power-Sector Emission Controls

Emission standards have been established for numerous industrial sectors under the Environment (Protection) Rules. The government has also introduced Online Continuous Emission Monitoring Systems (OCEMS) for highly polluting industries and other specified establishments. Such monitoring mechanisms are intended to improve oversight and compliance with prescribed emission standards.

12. Promotion of Electric Vehicles

The government is encouraging the adoption and manufacture of electric vehicles through various policy measures, including incentives and subsidies. In addition to encouraging private electric vehicles, efforts are being made to increase the use of electric buses in public transportation and expand charging infrastructure.

Since electric vehicles do not produce direct tailpipe emissions, their increased use can help reduce pollution arising from conventional internal-combustion vehicles.

13. Air-Quality Monitoring

Air-quality monitoring systems are being expanded to provide information about pollution levels in different cities. The monitoring network has increasingly focused on particulate matter, which is identified in the paper as a particularly important pollutant in India. Air Quality Index information can help authorities and citizens understand prevailing air-quality conditions.

14. Agricultural Residue Management

To address pollution arising from crop-residue burning, government programmes provide farmers with machinery and financial assistance for managing agricultural residues through in-situ techniques. These measures seek to provide alternatives to open burning and reduce seasonal pollution episodes.

15. Pradhan Mantri Ujjwala Yojana

The Pradhan Mantri Ujjwala Yojana was introduced in 2016 to expand access to cleaner cooking fuel, particularly among rural and economically disadvantaged households that traditionally relied on solid fuels.

The expansion of LPG access can reduce household exposure to smoke produced by traditional cooking methods. This has particular significance for women and children who may experience prolonged exposure to indoor cooking smoke.

16. Pradhan Mantri Surya Ghar Muft Bijli Yojana

The Pradhan Mantri Surya Ghar Muft Bijli Yojana was launched in February 2024 with the objective of promoting residential rooftop solar power. The scheme provides financial support for rooftop solar installations and encourages households to meet a greater proportion of their electricity requirements through solar energy.

By promoting renewable electricity and reducing dependence on conventional energy sources, the initiative can contribute to lower emissions and support efforts to control air pollution.

CHALLENGES AND LIMITATIONS

Despite the existence of numerous policies and programmes, India continues to face considerable obstacles in controlling air pollution.

Technological Barriers

One significant limitation is the uneven availability and adoption of pollution-control technologies. Although sophisticated technologies for controlling and monitoring pollution are available, their high cost and limited accessibility can restrict their widespread use.

The problem is particularly relevant in rural and less-developed areas, where the infrastructure required to install, operate and maintain advanced monitoring or pollution-control systems may be inadequate. Reducing this technological gap is therefore important for achieving effective pollution management across the country.

Regulatory and Enforcement Challenges

India has established several laws and regulatory mechanisms to control emissions from industries, vehicles and other sources. However, the effectiveness of these measures is affected by inconsistencies in implementation and enforcement.

Limited resources, administrative and bureaucratic difficulties and inadequate mechanisms for penalizing violations can weaken regulatory effectiveness. Stronger enforcement institutions and more consistent implementation are therefore necessary for ensuring compliance with air-quality regulations.

Public Awareness and Participation

Public involvement is an important component of successful environmental management. However, significant gaps remain in people's understanding of the causes and consequences of air pollution.

Encouraging citizens to adopt environmentally responsible behaviours requires sustained educational campaigns, community participation and awareness programmes. Changing established behavioural patterns and encouraging individuals to reduce their environmental footprint remain important challenges.

Agricultural Practices and Crop Burning

Crop-residue burning continues to be a major environmental concern in agricultural regions. Burning residues releases particulate matter and other pollutants into the atmosphere.

Farmers may rely on this practice because of limited access to affordable alternatives and the short interval available between successive harvesting and sowing operations. Addressing the problem therefore requires practical alternatives, financial support and the promotion of sustainable agricultural practices rather than relying solely on restrictions.

Urbanization and Infrastructure Development

Urbanization and infrastructure expansion are closely associated with economic development but can also intensify air pollution. Construction and related activities generate dust and other pollutants, particularly where environmental safeguards are inadequate.

The challenge is to reconcile economic and infrastructure development with environmental sustainability. Green construction practices, stronger emission controls and urban-planning approaches that explicitly consider air quality can help address this issue.

Cross-Border Pollution

Air pollution can move across political and administrative boundaries. India therefore also experiences the effects of transboundary pollution, particularly during periods when agricultural residue burning generates large quantities of pollutants.

Because such pollution cannot be addressed effectively by one jurisdiction alone, cooperation among neighbouring countries is important. Joint strategies, information sharing and regional coordination can help address the transboundary dimensions of air pollution.

Relationship Between Air Pollution and Climate Change

Air pollution and climate change are closely interconnected, creating both opportunities and complications for environmental policymaking. Some measures designed to improve air quality can also contribute to climate objectives, while others may involve trade-offs.

Consequently, policymaking needs to balance immediate requirements for improving air quality with longer-term objectives related to climate resilience. Integrated environmental policies and coordinated planning are essential for addressing these interconnected challenges.

Socio-Economic Inequalities

The effects of air pollution are not distributed equally throughout society. Economically and socially vulnerable communities may experience greater exposure and may have fewer resources with which to protect themselves from pollution.

Pollution-control interventions therefore need to incorporate principles of social equity. Policies should avoid placing disproportionate burdens on disadvantaged communities while ensuring that poorer populations have access to cleaner technologies and healthier living conditions.

THE WAY FORWARD

India requires a comprehensive and coordinated strategy to address air pollution. Several measures can contribute to improving air quality.

1. Expansion of Renewable Energy

Renewable energy sources such as solar, wind and hydropower can play an important role in reducing air pollution. These technologies generate electricity with minimal direct air emissions and can reduce dependence on fossil fuels.

2. Greater Use of Solar Energy

Solar technologies, including solar panels, solar cookers, solar lamps, solar-powered transportation technologies and solar-based storage and electrical systems, can provide cleaner alternatives to conventional energy sources. Wider adoption of such technologies can help reduce pollution.

3. Afforestation and Forest Conservation

Forests contribute to maintaining environmental quality by absorbing carbon dioxide and other pollutants. Protecting existing forests and expanding forest cover through afforestation and reforestation should therefore form an important component of India's environmental strategy.

4. Promotion of Public Transportation and Vehicle Sharing

Greater reliance on public transportation can reduce the number of private vehicles on roads. Carpooling and vehicle-sharing arrangements can also help decrease congestion and lower transport-related emissions.

5. Encouraging Walking and Cycling

For short-distance journeys, walking and cycling should be promoted as environmentally sustainable alternatives to motorized transport. Increased use of non-motorized transportation can reduce fuel consumption and vehicular emissions.

6. Adoption of Cleaner and Energy-Efficient Vehicles

Greater use of electric, hybrid and fuel-efficient vehicles can contribute to cleaner urban air. Electric vehicles are particularly useful because they do not generate direct tailpipe emissions during operation.

7. Regular Vehicle Maintenance

Regular servicing and maintenance of vehicles can help control the release of pollutants such as carbon monoxide, nitrogen oxides and hydrocarbons. Vehicle owners should ensure that their vehicles remain compliant with applicable emission standards.

8. Use of Standardized and Clean Fuels

The use of good-quality and uncontaminated fuels is important for reducing unnecessary emissions. Adulterated or poor-quality fuels can increase pollutant emissions and negatively affect air quality. Effective monitoring is therefore necessary to discourage fuel adulteration.

9. Improved Solid-Waste Management

Efficient systems for collecting, treating and disposing of solid waste are essential for reducing open waste burning. Proper waste-management infrastructure, particularly in public spaces and urban areas, can prevent the release of harmful pollutants from burning garbage.

10. Reduction in the Use of Plastic

Individuals can contribute to environmental protection by reducing their dependence on disposable plastic products. Reusable alternatives, including paper bags, metal or ceramic containers and reusable glass or steel utensils, can support more sustainable consumption practices.

11. Control of Dust

Dust emissions from mining, construction, road building and related activities should be controlled through appropriate preventive measures. Covering construction materials, using water sprinkling where appropriate and maintaining construction sites properly can reduce the release of particulate matter.

12. Environmental Auditing and Monitoring

Regular environmental audits can help organizations assess their environmental performance and identify areas requiring corrective action. Maintaining systematic records and conducting periodic monitoring can also strengthen compliance with environmental standards.

13. Improved Environmental Management in Industries

Industrial establishments should develop effective internal systems for monitoring and controlling emissions. The adoption of cleaner technologies and compliance with established emission standards can substantially reduce pollution generated by factories and other industrial activities.

14. Promotion of Environmentally Friendly Products

Encouraging environmentally sustainable products and traditional handicrafts can reduce dependence on products manufactured through pollution-intensive processes. Such consumption choices can also contribute to sustainable production and consumption patterns.

15. Public Awareness and Environmental Education

Environmental education and public awareness are fundamental to long-term pollution control. Citizens need to understand the causes, consequences and preventive measures associated with air pollution. An informed population is more likely to adopt environmentally responsible practices and participate actively in pollution-control initiatives.

CONCLUSION

India's air-pollution problem requires an integrated and comprehensive response that combines technological innovation, effective regulation and active participation from society. The scale and complexity of the problem make it necessary to adopt a multi-dimensional strategy rather than relying on a single intervention.

Government action must be complemented by meaningful participation from citizens, industries and civil-society organizations. Modern technologies, including satellite-based monitoring and geospatial techniques, can strengthen the identification and mapping of spatial and temporal patterns of air pollution and their relationship with climate change and health outcomes.

As India continues to expand its cities and develop smart urban infrastructure, environmental considerations must be incorporated into urban planning. Sustainable development practices and appropriate planning can help reduce the adverse health consequences associated with urban air pollution.

Successful implementation of pollution-control measures will depend on political commitment, effective execution and strong compliance mechanisms. Government initiatives should also be complemented by contributions from the private sector through environmentally responsible business practices and climate financing.

Ultimately, the air-pollution crisis cannot be addressed by government alone. It requires coordinated and innovative action involving public institutions, private organizations, civil society, academic institutions, philanthropies and citizens. A multi-stakeholder framework can provide a stronger foundation for achieving cleaner air and protecting public health in India.

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