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Air Pollution in Uttar Pradesh, Innovative Strategies for Sustainable Solutions : A Review

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ABSTRACT

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Air pollution in Uttar Pradesh, a significant issue in low- and middle-income countries, is exacerbated by geographical variability and seasonal weather patterns. Key pollutants include particulate matter (PM), oxides of nitrogen (NO_x), ammonia (NH₃), sulphur dioxide (SO₂), and non-methane volatile organic compounds (NMVOCs), primarily from transport, industry, farming, energy generation, and domestic fuel use. Pollution levels often exceed WHO guidelines, particularly in winter and during crop harvesting. Rapid industrialization, urbanization, climate change, and population growth have intensified these sources. Sources of pollution include industrial emissions, vehicular emissions, agricultural activities like crop residue burning, domestic fuel use, and indoor sources such as smoking and household products. Air pollution significantly impacts health, causing 1.67 million deaths in Uttar Pradesh in 2019, with increased risks of respiratory and cardiovascular diseases. It also affects the environment, leading to acid rain, smog, and reduced agricultural productivity, with substantial economic costs.

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INTRODUCTION

Challenges in addressing air pollution include inadequate enforcement of regulations, rapid urbanization, and socio-economic factors like poverty and lack of access to clean energy. The Uttar Pradesh government has initiated measures like the National Clean Air Program (NCAP) and the Air Quality Index (AQI) tool to combat pollution. Technological advancements, such as air purifiers and electric vehicles, and public awareness campaigns are crucial for mitigation. Successful initiatives from other regions can

serve as models for Uttar Pradesh to adopt a multi-faceted approach to tackle air pollution effectively.

Globally, air pollution presents significant challenges, with over seven million deaths attributed to it annually. Its effects are particularly severe in low- and middle-income countries like Uttar Pradesh. Air quality in Uttar Pradesh, both ambient and household, is significantly influenced by geographical variability and seasonal weather patterns. Key pollutants such as particulate matter (PM), oxides of nitrogen (NO_x), ammonia (NH₃),

sulphur dioxide (SO₂), and non-methane volatile organic compounds (NMVOCs) are predominantly emitted from transport, industrial processes, farming, energy generation, and domestic fuel use for cooking and heating. Alarming, pollution levels in Uttar Pradesh often exceed the World Health Organization's recommended levels, especially during the winter season in cities and harvesting periods in rural areas of northern Uttar Pradesh states. Rapid industrialization, urbanization, climate change, crop burning, and population growth have further diversified and intensified pollution sources. This editorial will briefly explore the sources of air pollution in Uttar Pradesh, its effects on health and the environment, government efforts to address it, technological mitigation strategies, public awareness and engagement, challenges faced, successful intervention case studies, and the future outlook for tackling this critical issue.

SOURCES OF AIR POLLUTION IN UTTAR PRADESH

Air pollution sources in Uttar Pradesh vary widely across geographical regions, including natural (pollen grains, desert dust, mineral dust, etc.) and anthropogenic sources. Some of the primary anthropogenic sources are:

1. **Industrial Emissions:** Many factories and manufacturing units, such as cement factories and brick kiln industries, release harmful atmospheric pollutants, such as particulate matter (PM), sulphur dioxide (SO₂), and oxides of nitrogen (NO_x).
2. **Vehicular Emissions:** The number of vehicles in Uttar Pradesh increased from 128 million to 326 million from 2010 to 2020, significantly contributing to air pollution.
3. **Agricultural Activities:** Crop residue burning, particularly in northern Uttar Pradesh states, releases large amounts of toxic smoke into the air, leading to crop

burning pollution. Small rural industries, such as jaggery plants, also use unprocessed biomass for energy.

4. **Domestic Fuel:** About 60 per cent of the Uttar Pradesh population uses solid fuels for cooking and heating, which is a primary source of household air pollution (HAP), especially in rural areas. Burning biomass fuels such as wood, dung, and crop residues releases pollutants that impact both indoor and outdoor air quality.

5. **Indoor Sources:** Indoor Air Pollution (IAP) poses significant health risks, particularly in urban areas where people spend over 70 per cent of their time indoors. IAP includes a wide range of physical, biological, and chemical agents, with sources such as water ingress, pets, building materials, furniture, smoking, paints, varnishes, glues, cleaning products, air fresheners, deodorants, perfumes, pesticides, fungicides, burning mosquito coils, and candle or incense burning. The extent of IAP exposure depends on structural factors like ventilation and insulation, proximity to ambient air pollution sources, crowding, and personal behaviors.

EFFECTS OF AIR POLLUTION

The Global Burden of Diseases study estimates that air pollution attributed to 1.67 million deaths in Uttar Pradesh in 2019, accounting for 17.8 per cent of total deaths in the country. While deaths due to HAP decreased by 64 per cent from 2010 to 2020, deaths attributed to Ambient Air Pollution (AAP) increased by 115 per cent. Substantial evidence indicates that even low-level exposure to air pollution adversely affects cardiovascular and respiratory health. Exposure during pregnancy and childhood is linked to an increased risk of asthma and impaired lung development, potentially leading to long-term respiratory issues and lower life expectancy. Children, older people,

and individuals with pre-existing multi-morbidities such as cardiovascular or respiratory conditions are particularly vulnerable. Daily exposure to PM has been associated with increased hospitalization and mortality due to acute exacerbations of heart disease, chronic obstructive pulmonary disease (COPD), and asthma. Long-term exposure to air pollution increases the risks of developing lung cancer, heart disease, diabetes, stroke, and dementia.

Beyond its health impacts, air pollution has significant environmental consequences and economic implications. With over 45 per cent of the population engaged in agriculture, the detrimental effects on agricultural productivity are enormous. Air-borne pollutants can cause acid rain and smog formation, damaging ecosystems, including forests, water bodies, and wildlife habitats. The economic costs associated with air pollution are substantial, including healthcare expenses, lost productivity due to illness, and damage to infrastructure and crops. Poor air quality can discourage foreign investment and reduce tourism, hindering a country's overall economic development.

CHALLENGES IN ADDRESSING AIR POLLUTION

Combating air pollution is a complex task requiring sincere and coordinated efforts from many stakeholders. Some challenges that hinder air pollution control in Uttar Pradesh are:

1. **Lack of Enforcement:** Inadequate enforcement of environmental regulations leads to non-compliance by industries, vehicle owners, and other polluting entities. Uttar Pradesh lacks stringent air pollution standards, relying on country-specific guidelines, which are higher than WHO-recommended guidelines.

2. **Rapid Urbanization:** Urbanization in Uttar Pradesh has resulted in increased pollution levels due to higher energy consumption, vehicular traffic, and industrial activities concentrated in urban centers, posing a significant challenge to air quality management.

3. **Socio-economic Factors:** Poverty, lack of access to clean energy sources, and inadequate infrastructure in rural areas contribute to the persistence of HAP and AAP in Uttar Pradesh, exacerbating the air pollution problem.

Government Initiatives to Combat Air Pollution

The scale of air pollution in many countries, including Uttar Pradesh, is huge, requiring a collaborative effort from the government, industries, civil societies, and the general public. The Uttar Pradesh government has initiated several measures to combat and reduce HAP and has developed policies and regulations that are likely beneficial if implemented.

The Uttar Pradesh government launched the National Clean Air Program (NCAP) in 2019 to combat air pollution comprehensively. The program aimed to formulate a plan to reduce PM concentrations by 20-30 per cent by 2024 through source apportionment studies in 102 cities nationwide. The Government of Uttar Pradesh has formulated various policies and regulations to control air pollution, including emission standards for industries and vehicles, restrictions on crop burning, and measures to promote cleaner fuels and renewable energy sources. Transitioning to renewable energy sources such as solar, wind, and hydropower can help reduce reliance on fossil fuels and lower greenhouse gas emissions, mitigating air pollution and combating climate change. Uttar Pradesh has an ambitious target of getting 500 GW of energy from renewable sources by 2030. As of March 2024, it has already

achieved 190 GW, with targets likely to be met ahead of schedule.

In 2015, Uttar Pradesh launched the Air Quality Index (AQI) tool to communicate air quality levels to the public in an easily understandable format. AQI monitoring and reporting are currently established in 34 of 36 States and Union Territories. The primary aim is to raise awareness about air pollution and its health impacts, encouraging individuals to take preventive actions. Educating the public about the causes and consequences of air pollution and advocating for policy changes and sustainable solutions are essential in raising awareness and fostering a collective effort to combat this environmental challenge. Several technological advancements have enabled citizens and industries to find solutions to minimize airborne pollutants released into the atmosphere or protect vulnerable individuals. In the short term, when AAP or HAP cannot be lowered, susceptible individuals are advised to use air purifiers equipped with HEPA (high efficiency particulate air) filters and activated carbon to improve indoor air. Individuals can play a crucial role in reducing air pollution by adopting sustainable practices such as avoiding burning domestic waste in their gardens, carpooling, using public transportation, conserving energy, and supporting clean air initiatives in their communities. Similarly, adopting electric vehicles (EVs) and hydrogen fuel as alternatives to traditional gasoline two-stroke and diesel vehicles can significantly reduce vehicular emissions in urban areas. However, infrastructure upgrades are necessary to meet the demand of the large population.

Other Initiatives

Several cities in Uttar Pradesh have successfully implemented initiatives to reduce air pollution, such as introducing cleaner fuel

standards, promoting public transportation, and establishing air quality monitoring systems to track pollution levels and inform policy decisions. Learning from other countries that have effectively tackled air pollution through a combination of stringent regulations, technological innovations, public awareness campaigns, and international collaborations to address transboundary pollution issues, Uttar Pradesh can adopt a similar multi-faceted approach. To address air pollution effectively, Uttar Pradesh must adopt comprehensive strategies, including stricter enforcement of environmental regulations, investment in clean technologies, promoting sustainable urban planning, and public participation in pollution control efforts

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