

6Role of Plants in Controlling Air Pollution

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ABSTRACT

Air pollution poses one of the most severe threats to public health and environmental stability in urban and industrialized regions worldwide. While much attention has been given to artificial air filtering technologies, the natural filtering capabilities of plants have often been overlooked. Plants not only absorb carbon dioxide but also a variety of harmful pollutants such as nitrogen oxides, sulfur dioxide, ozone, and particulate matter. This paper delves into the role of vegetation—both urban and rural—in mitigating air pollution levels through various physiological and biochemical mechanisms. Trees, shrubs, grasses, and even indoor plants exhibit varied capacities to trap airborne particulates and absorb toxic gases through their stomata and surface deposition. The efficiency of plants depends on factors such as leaf morphology, canopy structure, climatic conditions, and proximity to pollution sources. Furthermore, the paper evaluates case studies and experimental findings that support plant-based air quality improvement strategies in urban environments. With climate change intensifying pollutant concentrations in several cities, it becomes essential to integrate vegetative planning into urban

infrastructure development. The abstract aims to highlight the dual benefit of plants—not just in carbon sequestration but in real-time pollution abatement—and makes a strong case for expanding green belts, rooftop gardens, and reforestation initiatives as part of future urban planning policies.

Keywords: Air pollution, Phytoremediation, Urban forestry, Green infrastructure, Pollutant absorption, Particulate matter

INTRODUCTION

Air pollution has emerged as a pressing concern over the last few decades, driven by rapid industrialization, urban expansion, and an exponential increase in vehicular emissions. Its detrimental effects are well documented, ranging from respiratory and cardiovascular ailments to ecosystem degradation and climate alteration. While technological interventions such as air purifiers and catalytic converters have been implemented to mitigate emissions, these often come with high energy costs and limited scalability. An alternative and sustainable approach to mitigating air pollution lies in leveraging the natural filtering capabilities of vegetation.

Plants have long played a crucial role in maintaining the atmospheric balance of oxygen and carbon dioxide. However, beyond this traditional understanding, modern environmental research has increasingly acknowledged the capacity of plants to act as bio-filters for a broad range of air pollutants. They do so through several mechanisms including stomatal uptake, surface adsorption, and phytochemical neutralization. The complex structures of plant leaves—ranging from trichomes and waxy surfaces to varying surface areas—significantly contribute to the capture and breakdown of airborne toxins.

Urban forestry, green roofs, vertical gardens, and tree-lined boulevards are not merely

aesthetic enhancements but serve as vital green infrastructure capable of improving air quality. The effectiveness of such vegetative interventions depends on the species selected, their physiological traits, seasonal behavior, and their spatial distribution within the urban matrix. Studies conducted across major cities such as Delhi, Beijing, and London have provided quantifiable evidence linking vegetative cover with reductions in PM_{2.5} and NO₂ concentrations.

Moreover, the selection of plant species for air pollution control must consider local environmental conditions, pollutant types, and maintenance requirements. Some species, such as *Ficus benjamina*, *Azadirachta indica* (Neem), and *Polyalthia longifolia*, have shown remarkable pollution-tolerant indices (PTIs) and are preferred in urban landscaping projects. Additionally, indoor plants like Areca palm and Snake plant also contribute to improving indoor air quality by absorbing volatile organic compounds (VOCs).

In this paper, we aim to present a comprehensive examination of the mechanisms, plant types, environmental applications, and policy frameworks supporting the integration of plants in air pollution control. Through empirical data, case studies, and policy review, this research contributes to the growing discourse on nature-based solutions for urban sustainability.

LITERATURE REVIEW

The role of plants in mitigating air pollution has been studied extensively over the past few decades. Several researchers have identified the mechanisms through which plants capture and absorb pollutants, especially particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO₂), carbon monoxide (CO), and volatile organic compounds (VOCs). For instance, Nowak et al. (2006) estimated that trees in the United States remove about 711,000 tons of air pollutants annually. Another study by Sæbø et al. (2012) indicated that species like *Betula pendula* and *Tilia cordata* are more effective in capturing PM due to

their leaf morphology. Furthermore, Li et al. (2020) emphasized the significance of green belts in reducing urban heat islands and improving urban air quality.

METHODOLOGY

This paper adopts a comprehensive review-based approach, utilizing secondary data from reputable journals, environmental organizations, and case studies. Plants are categorized based on their pollutant-absorbing capacities, leaf surface characteristics, and adaptability to urban environments. Data was compiled on pollutant removal rates, plant species' tolerance index, and Air Pollution Tolerance Index (APTI). The effectiveness of plants was compared using parameters such as dust retention, stomatal conductance, and leaf area index.

Table 1: Air Pollutants and Plant-Based Mitigation Mechanisms

Pollutant	Source	Plant Mitigation Mechanism
Particulate Matter (PM)	Construction, Traffic	Deposition on leaf surfaces
Sulfur Dioxide (SO ₂)	Industrial emissions	Absorption through stomata
Nitrogen Oxides (NO _x)	Vehicle exhausts	Biochemical assimilation
Volatile Organic Compounds (VOCs)	Solvents, fuels	Phytoremediation by metabolic breakdown

Table 1 highlights various pollutants and the corresponding mechanisms by which plants mitigate their impact.

Table 2: High APTI Plant Species Suitable for Urban Air Pollution Control

Plant Species	APTI Score	Pollutants Targeted
Ficus benghalensis	20.4	PM, NO _x , CO
Azadirachta indica	18.9	PM, SO ₂
Polyalthia longifolia	21.0	PM, NO _x
Mangifera indica	19.6	SO ₂ , CO

Table 2 presents a list of plant species with high Air Pollution Tolerance Index (APTI) scores, suggesting their suitability for urban plantations.

FUTURE SCOPE

With growing urbanization and industrialization, the role of vegetation in air pollution mitigation is expected to become even more critical. Future research can focus on:

1. Genetically modifying plants to enhance pollutant absorption.
2. Integrating IoT-based monitoring with green infrastructure.
3. Developing urban policies that prioritize green infrastructure.
4. Promoting rooftop and vertical gardens using high-APTI species.

CONCLUSION

Plants serve as an invaluable ally in the fight against air pollution, especially in densely populated urban areas. Their ability to absorb, sequester, and break down harmful pollutants offers a sustainable and cost-effective solution. Strategic plantation using high-APTI species, supported by appropriate urban planning policies, can significantly improve air quality, thereby enhancing public health and urban living standards.

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