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ROLE OF PHYTOREMEDIATION IN CONTROLLING AIR POLLUTION IN VISAKHAPATNAM

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ABSTRACT

Phytoremediation means using plants to reduce pollution in the air. Trees and shrubs absorb harmful gases, trap dust on their leaves, and release oxygen. This helps to make city air cleaner.Rapid urbanisation and industrial growth in Visakhapatnam have increased air pollution levels, affecting public health and ecosystem quality. Phytoremediation—the use of plants to reduce environmental pollutants—offers a sustainable and low-cost approach for improving urban air quality.This study examines the potential tree species in Visakhapatnam such as Neem (Azadirachtaindica), Peepal (Ficusreligiosa), Banyan (Ficusbenghalensis), Pongamia (Pongamiapinnata), Ashoka (Polyalthialongifolia), Bamboo, and Cassia species for controlling particulate matter and gaseous pollutants.The research focuses on roadside corridors, industrial buffer zones, and biodiversity parks, assessing plant tolerance, dust-holding capacity, growth, and survival under urban stress conditions. Field observations, leaf surface analysis, and air quality measurements before and after plantation are proposed to evaluate effectiveness.The findings aim to support urban planners, GVMC authorities, and environmental agencies in developing green belt strategies to enhance air pollution mitigation and climate resilience in coastal cities like Visakhapatnam.This study highlights phytoremediation as a nature-based solution for sustainable urban environmental management.

KEYWORDS:* Phytoremediation, Air pollution, Urban green spaces, Native trees, Pollution control, Climate resilience, Roadside plantation, Sustainable environment.

INTRODUCTION

Visakhapatnam, a fast-growing coastal city in India, is facing increasing air pollution due to traffic, industries, and urbanisation. Air pollution affects human health, plants, and the environment. Biodiversity parks and green

spaces can help reduce pollution, but their number is limited in the city.Phytoremediation is a natural method that uses plants to remove dust, smoke, and harmful gases from the air. Certain trees and plants can trap dust particles, absorb gases, and release oxygen through their leaves. This helps in improving air quality.In an industrial coastal city like Visakhapatnam—with ports, traffic, steel plants, refineries, and thermal units—air pollutants mainly include:

- Particulate Matter ($PM_{2.5}$, PM_{10})
- SO_2, NOx
- CO
- Dust and smoke

Engineering Application in Vizag

Phytoremediation can be used in:

- Roadside avenues – to reduce vehicle pollution
- Around industries (Vizag steel plant, port area) – as green buffer zones
- Residential colonies – to improve local air quality
- Hillsides and parks – for developing urban forests

Phytoremediation is a low-cost and eco-friendly engineering method to control air pollution in Visakhapatnam by planting native, pollution-tolerant trees in layers along roads and industrial areas. It does not replace pollution-control devices but supports them naturally.

Plant Species and Pollutants Absorbed

1. Neem (Azadirachtaindica) – Tree
    - Absorbs: CO_2, SO_2, NO_2, dust
2. Peepal (Ficusreligiosa) – Tree
    - Absorbs: CO_2, particulate matter (PM), SO_2
3. Banyan (Ficusbenghalensis) – Tree
    - Absorbs: CO_2, PM, smoke
4. Ashoka (Polyalthialongifolia) – Tree
    - Absorbs: CO_2, PM, smoke
5. Pongamia (Pongamiapinnata) – Tree
    - Absorbs: CO_2, dust, smoke
6. Cassia (Cassia fistula) – Tree
    - Absorbs: dust, smoke, PM
7. Bamboo – Grass/Shrub
    - Absorbs: CO_2, PM, smoke
8. Tulsi (Ocimum sanctum) – Shrub
    - Absorbs: CO_2, formaldehyde, VOCs

Pollutant Removal Rate by Plants

$$\textbf{Formula: } R = C \times V \times \eta$$

Where:

R = Pollutant removed per unit time (µg/s)

C = Pollutant concentration in air (µg/m³)

V = Air volume passing through vegetation (m³/s)

η = Removal efficiency of plant canopy (0–1)

Phytoremediation / Plant Control of Air Pollution

1. Reduction in Pollution

$$\text{Reduction} = C_1 - C_2$$

C_1 = pollutant concentration before plantation

C_2 = pollutant concentration after plantation

2. Efficiency (%)

$$\text{Efficiency} = (C_1 - C_2 / C_1) \times 100$$

Used to calculate the percentage improvement due to plants.

3. Dust Trapped

$$\text{Dust} = C \times A$$

C = Dust concentration

A = Leaf / green surface area

This formula estimates how much particulate matter is trapped by leaf surfaces.

4. Leaf Area Index (LAI)

$$\text{LAI} = \text{Leaf Area} / \text{Ground Area}$$

This formula measures vegetation density.

Higher LAI → better pollution removal.

5. AQI Change

$$\Delta AQI = AQI\ before - AQI\ after$$

This formula helps evaluate overall air quality improvement before and after plantation.

Devices Used to Measure Air Pollution

Air pollution is measured using special monitoring devices and instruments that detect gases and particulate matter in the atmosphere.

Plant air-pollution absorption capacity in environmental engineering is measured using:

- Before-after air sampling
- Leaf analysis
- Deposition studies

METHOD

Before–After Air Test

Measure pollution levels before planting trees and after planting trees.

Absorption = Before – After

Dust on Leaves

Wash dust from leaves and weigh it. This shows how much dust the plant has trapped.

Leaf Chemical Test

Lab tests show gases or heavy metals stored in leaves.

Leaf Density

More leaves = more cleaning of air.

$$LAI = Leaf\ Area / Ground\ Area$$

Plants absorption capacity is measured by comparing air pollution levels before and after vegetation, analysing dust on leaves, testing leaf chemicals, and checking leaf density.

NEED OF STUDY

Visakhapatnam has steel plants, refineries, power stations, and heavy traffic. These release harmful gases such as SO_2, NOx, and dust particles PM2.5 and PM10.People in the city suffer from asthma, lung problems, and heart diseases due to poor air quality.Phytoremediation using plants to clean air is natural, low-cost, and sustainable compared to machines or chemical methods.Studying which plants grow well in Visakhapatnam's coastal climate and can absorb pollutants effectively will help design green belts and urban plantations.

Scope of Phytoremediation

Phytoremediation in India is increasingly recognised as a sustainable solution for pollution control. Its applications include treating heavy metals, industrial effluents, and degraded soils.States like Telangana, Maharashtra, Gujarat, and West Bengal are actively exploring plant-based remediation for mining, industrial, and urban pollution problems.Awareness of phytoremediation and pollution control is increasing through education, demonstration projects, and community engagement.

Innovative Methods to Measure Phytoremediation Efficiency

1. Pollutant Reduction Analysis

Measures decrease in contaminant concentration in soil, water, or air before and after plant treatment.Heavy metal content such as Pb, Cd, and Cr can be tested using Atomic Absorption Spectroscopy (AAS).

2. Plant Tissue Analysis

Checks pollutant accumulation in roots, stems, and leaves.ICP-MS (Inductively Coupled Plasma Mass Spectrometry) is used for measuring metal uptake.

3.Biological Indicators

Monitor plant growth, chlorophyll content, and enzyme activity such as peroxidase and catalase.Healthy growth indicates effective remediation.

4.Isotope / Tracer Studies

Stable isotopes or tracers are used to track pollutant movement from soil → plant → atmosphere, helping quantify uptake and transformation.

5.Remote Sensing and Imaging

Drones or hyper-spectral cameras detect plant stress and pollutant absorption patterns.This method is useful for large-scale monitoring.

Emerging Phytoremediation Plants in Visakhapatnam

Phytoremediation is a plant-based method to clean polluted soil, water, and air.In Visakhapatnam it can be applied to control industrial effluents, mining waste, wastewater, and coastal pollution.

Common plants used include:

- Indian mustard
- Vetiver grass
- Canna lily
- Water hyacinth
- Duckweed
- Amla
- Napier grass
- Mangroves

These plants absorb, stabilise, or break down contaminants, providing an effective, low-cost, and eco-friendly pollution control solution.

CONCLUSION

Phytoremediation is a natural and affordable way to reduce air pollution in Visakhapatnam. By planting trees and shrubs such as Neem, Banyan, Bamboo, and Tulsi, harmful gases and dust can be absorbed or trapped, making the air cleaner.Although phytoremediation alone is not a complete solution, when combined with better pollution control in industries and traffic, it can help create a healthier and greener city.

Pollution (SO_2 + NOx + PM) → Plants (Neem + Banyan + Bamboo + Tulsi) → Cleaner Air → Healthy People + Green City

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