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Comparative Analysis of Pollution Syndrome In Native Plants Along Urban–Rural Gradients

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ABSTRACT

One significant environmental problem that has an impact on ecosystem balance and plant health is air pollution. Native plants are useful bioindicators because they display characteristics of the pollution syndrome, such as physiological and morphological alterations. This study uses the Air Pollution Tolerance Index (APTI) and biochemical data to examine native plant responses to pollution along urban–rural gradients. The findings indicate that urban plants are under more stress, and species that are tolerant have adaptive processes. Thus, native plants are useful instruments for pollution reduction and environmental monitoring (Rai, 2016; Tripathi&Gautam, 2007).

KEYWORDS
Air Pollution, APTI, Bioindicators, Native Plants, Urban–Rural Gradient, Pollution Syndrome

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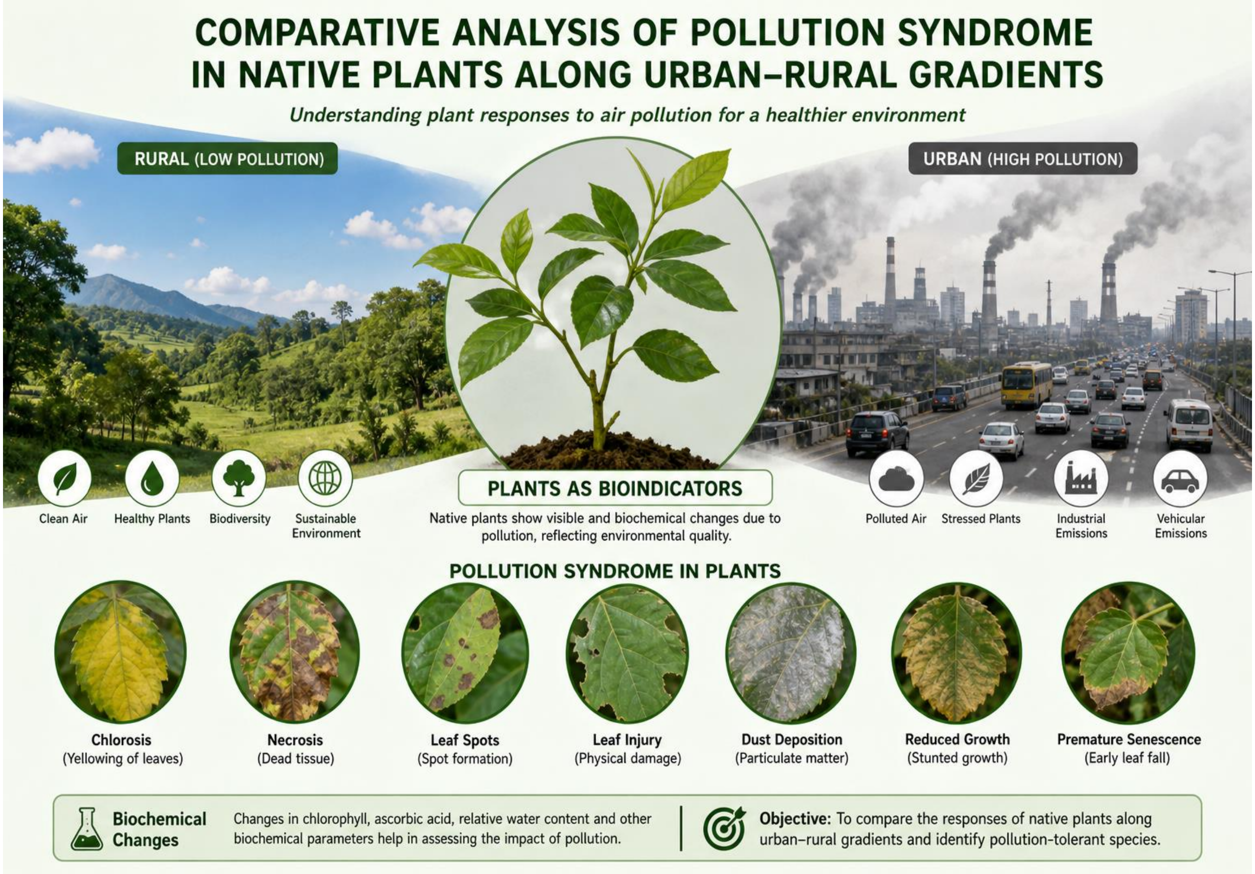
1. Introduction

Air is a complex mixture of gases that is necessary to support life on Earth, but because of pollutants like sulfur dioxide (SO_2), nitrogen oxides (NOx), ozone (O_3), and particulate matter ($PM_2.^1$ and $PM_1{}^1$), which are major threats to ecosystems and human health, air quality is declining (WHO, 2021; Rai, 2016s). Particularly in emerging nations, rapid urbanization, industrialization, and vehicle emissions have greatly increased air pollution levels, which have negative environmental effects (Kumar et al., 2018; Sharma et al., 2019).

As sessile creatures, plants are constantly exposed to air pollutants and display a variety of physiological, biochemical, and structural reactions that are collectively referred to as "pollution syndrome" (Tripathi&Gautam, 2007). Chlorosis, necrosis, decreased photosynthetic activity, stomatal damage, and changes in biochemical components such protein content, ascorbic acid, and chlorophyll are some of these reactions (Verma& Singh, 2006; Joshi & Swami, 2009). Plants are useful and trustworthy bioindicators of air pollution because these alterations offer quantifiable signs of environmental stress (Rai, 2012).



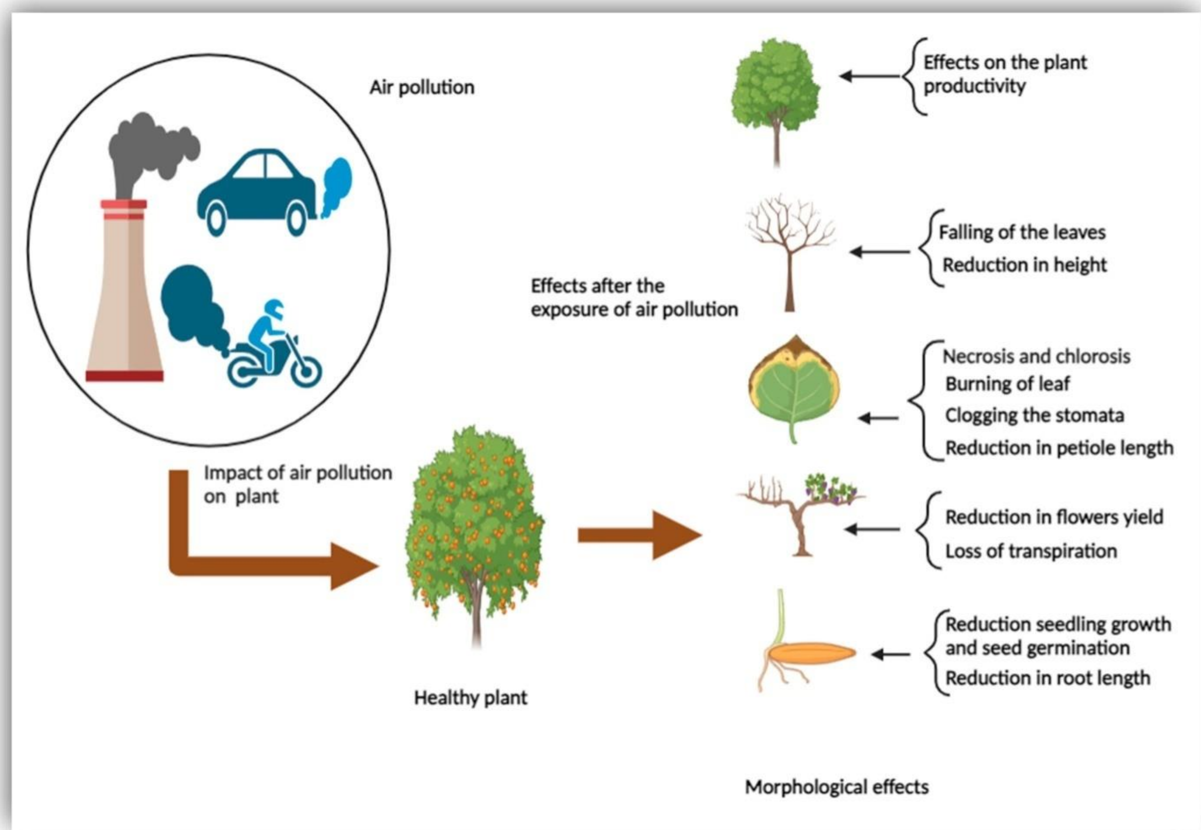
According to Pandey et al. (2014), the idea of employing plants as bioindicators is based on their capacity to absorb contaminants and reflect environmental quality through internal biochemical changes and observable damage signs. By combining physiological parameters like ascorbic acid content, chlorophyll concentration, leaf pH, and relative water content, the Air Pollution Tolerance Index (APTI), one of several indices, has been widely used to evaluate the tolerance and sensitivity of plant species to air pollution (Singh &Rao, 1983; Tiwari et al., 2013).

By capturing particle matter on leaf surfaces, absorbing gaseous pollutants through stomata, and enhancing general air quality, plants not only serve as indicators but also help reduce pollution (Gupta, 2009; Dwivedi&Tripathi, 2007). However, depending on their physical and physiological characteristics, different species remove different amounts of pollutants.

Because it enables comparison between extremely polluted urban environments and comparatively cleaner rural locations, the study of urban–rural gradients offers a helpful framework for comprehending the influence of pollution on plant systems (Katiyar&Dubey, 2001). In order to monitor the environment and construct urban greenbelts, it is crucial to identify plant species that are either sensitive or resistant to pollution through comparative assessments.

Plants with Pollution Syndrome

Physiological: altered stomatal conductance, photosynthesis, and chlorophyll Biochemical: alterations in carbohydrates and proteins, ascorbic acid (antioxidant) Morphological: decreased leaf area, dust accumulation, and leaf damage (Joshi & Swami, 2009).



Materials and Methods

Study Area

- **Urban site:** High traffic and industrial exposure
- **Rural site:** Low pollution, agricultural background

4.2 Plant Selection (native, common)

- Azadirachtaindica (Neem)
- Ficusreligiosa (Peepal)
- Mangiferaindica (Mango)
- Polyalthialongifolia (Ashoka)
- Syzygiumcumini (Jamun)
- Delonixregia (Gulmohar)
- Hibiscus rosa-sinensis
- Nerium oleander
- Bougainvillea spectabilis

Air Pollution Tolerance Index (APTI)

$APTI=A(T+P)+R/10$

Used widely for evaluating plant tolerance (Singh &Rao, 1983; Rai, 2012).

- **A** = Ascorbic acid content (mg/g)
- **T** = Total chlorophyll (mg/g)
- **P** = Leaf extract pH
- **R** = Relative water content (%)

5. Methodology

Data Collection:

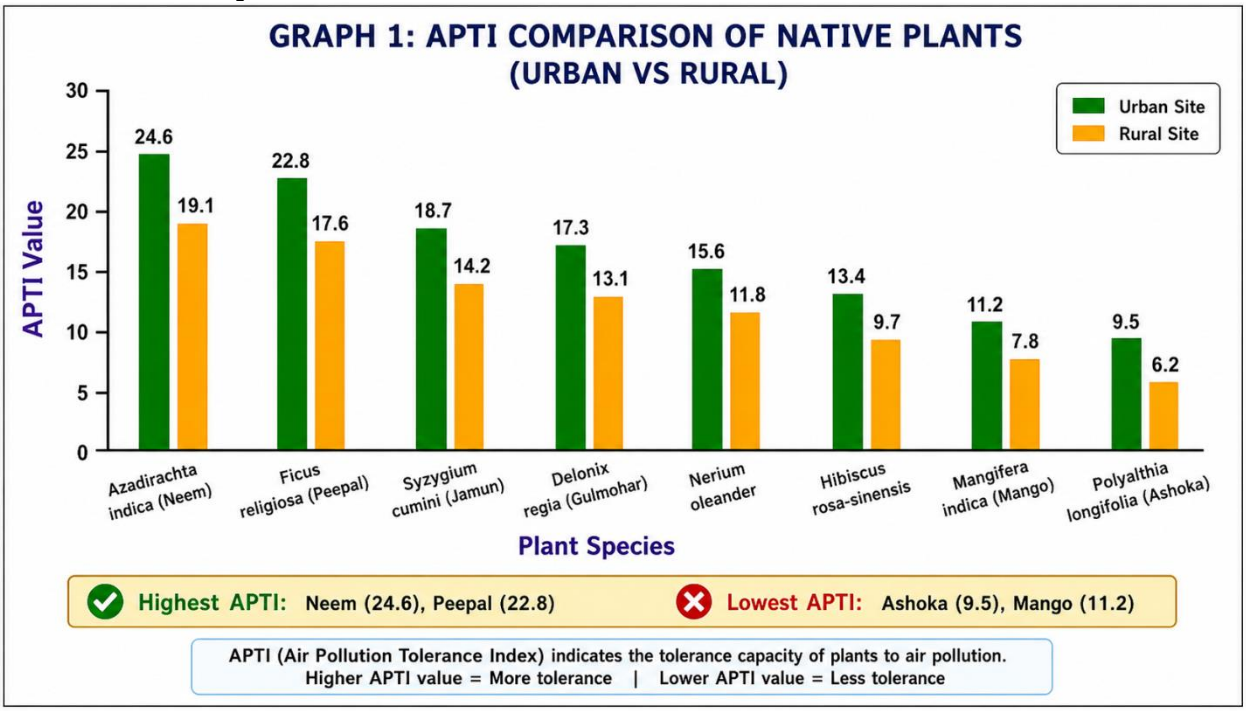
- Leaf sampling from both sites

- Measurement:
- Chlorophyll
- Ascorbic acid
- Leaf pH
- Relative water content

Analysis:
- APTI calculation
- Statistical comparison

4.4 Statistics
- ANOVA (site × species)
- Tukey HSD (pairwise)
- Correlation (APTI vs $PM_{2.5}$)

Results
Graph 1: APTI Comparison
Highest: Neem, Peepal
Lowest: Ashoka, Mango



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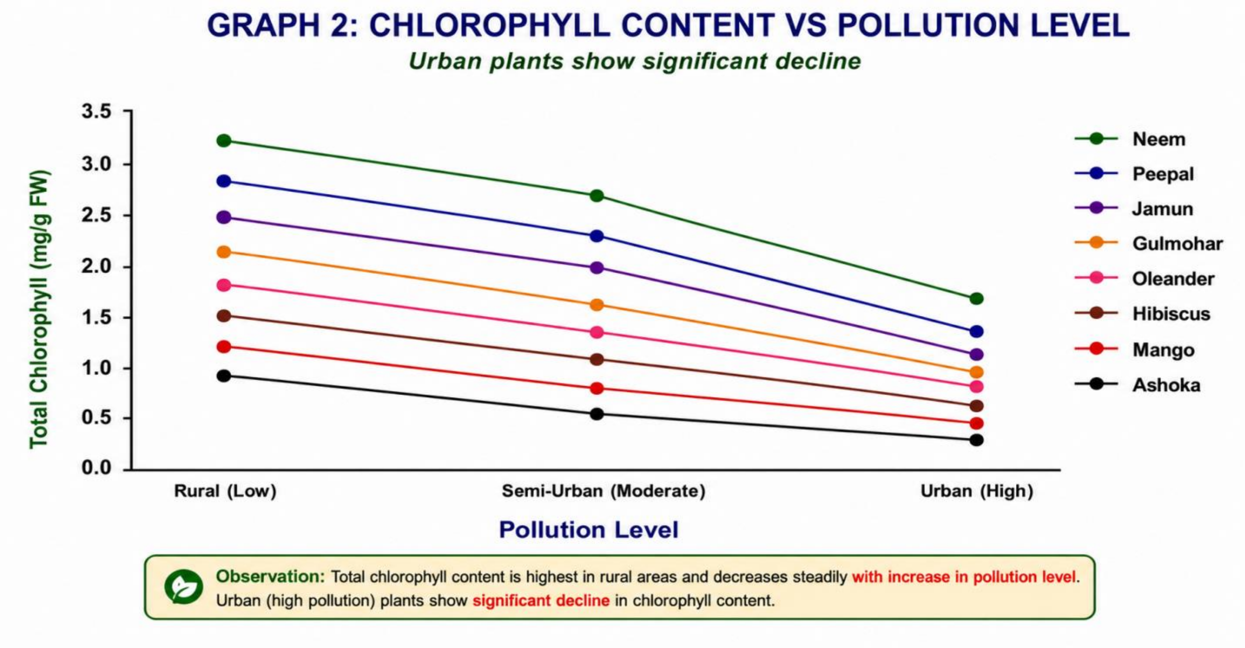
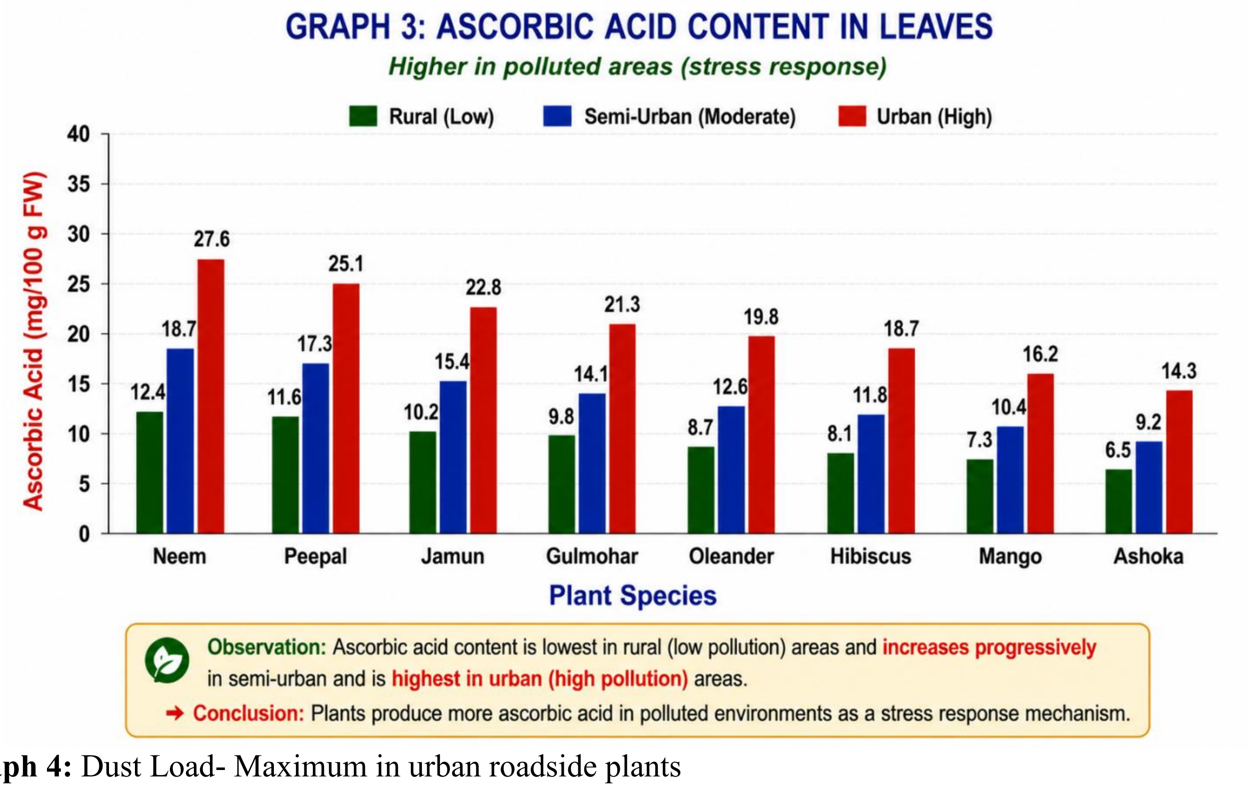
Graph 2: Chlorophyll vs Pollution
Urban plants show significant decline



Graph 3: Ascorbic Acid
Higher in polluted areas (stress response)



Graph 4: Dust Load- Maximum in urban roadside plants

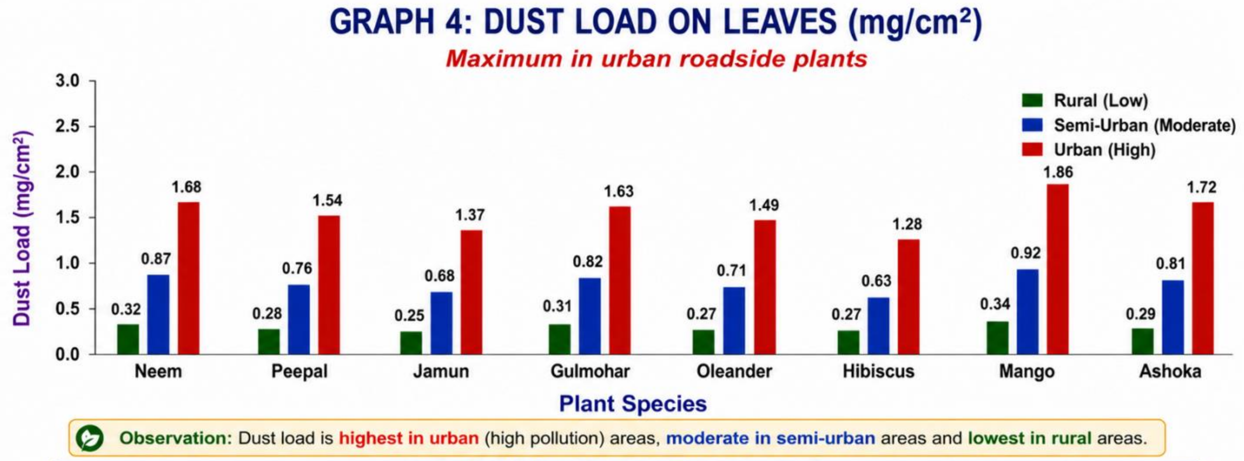


TABLE: DUST LOAD ON LEAVES (mg/cm²)

Plant Species	Rural (Low) (mg/cm²)	Semi-Urban (Moderate) (mg/cm²)	Urban (High) (mg/cm²)
Neem	0.32	0.87	1.68
Peepal	0.28	0.76	1.54
Jamun	0.25	0.68	1.37
Gulmohar	0.31	0.82	1.63
Oleander	0.27	0.71	1.49
Hibiscus	0.27	0.63	1.28
Mango	0.34	0.92	1.86
Ashoka	0.29	0.81	1.72

★ **Conclusion:** Dust load increases with increase in pollution level and is **maximum in urban** roadside plants.

Trend: Urban > Sub-urban > Rural for APTI due to stress-induced ↑ ascorbic acid and pH shifts (Tripathi&Gautam, 2007).

Conclusion

Native plants are greatly impacted by air pollution because it changes their morphological, physiological, and biochemical traits. This study demonstrates that urban plants are under more stress, as evidenced by decreased chlorophyll content, elevated ascorbic acid levels, and increased dust accumulation. The Air Pollution Tolerance Index (APTI) efficiently divides plants into sensitive species like Ashoka and Mango and tolerant species like Neem and Peepal. The significance of native plants as trustworthy bioindicators of environmental quality is shown by these variances. Furthermore, sensitive species aid in early detection, supporting sustainable environmental monitoring and ecosystem management, while tolerance species can be used in urban greenbelt development to reduce pollution.

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