

Impacts of Urbanization on Roadside Flora in Sargodha Region, Punjab, Pakistan

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ABSTRACT

Urbanization is one of the most important factors contributing to environmental change, and has a significant impact on the composition, diversity and health of roadside vegetation in rapidly growing cities. The present study aimed to explore the effects of urbanization on roadside flora of Sargodha region, Punjab, Pakistan with special focus on plant diversity, physiological responses and tolerance to urban pollution. Field surveys were carried out in selected urban, semi-urban and rural locations with different levels of urban development and traffic density. The species were identified and ecological parameters such as species richness, abundance and diversity indices were evaluated. Furthermore, the Air Pollution Tolerance Index (APTI) of dominant roadside plant species was evaluated by analyzing key biochemical and physiological properties including chlorophyll content, relative water content, leaf extract pH and ascorbic acid concentration.

The results showed that species richness' and diversity decreased significantly as urbanization and traffic density increased. Pollution-tolerant species were more common in urban roadside habitats, and sensitive species were more common in less disturbed rural habitats. Increased concentrations of air pollutants and roadside dust were correlated with decreased chlorophyll content and changes in physiological traits of several plant species. Some species, however, showed greater tolerance by increasing their antioxidant activity and APTI values, suggesting their suitability for urban greenbelt development and phytoremediation applications. Soil analysis also indicated the presence of heavy metals and other pollutants in highly urbanised areas, which led to vegetation stress and ecological degradation.

The study reveals that urbanization has significantly affected the roadside flora of Sargodha and urges the need to conserve urban biodiversity by adopting sustainable urban planning and strategic plantation of pollution resistant plants. The results of this study will be useful for urban ecologists, environmental managers and policy makers to reduce the negative ecological impacts of urbanization and enhance environmental

quality in fast growing areas of Pakistan.

Keywords: Urbanization, Roadside Flora, Biodiversity, Air Pollution Tolerance Index (APTI), Phytoremediation, Urban Ecology.

Introduction

Urbanization is a growing worldwide trend that has a profound impact on the natural environment and environmental quality. The ever-expanding urbanization, industrialization and traffic volumes are responsible for the rising levels of particulate matter, heavy metals and other air pollutants that have a negative impact on the vegetation along roadsides. Roadside plants have an important ecological function in the improvement of air quality, dust deposition, carbon sequestration and urban biodiversity. But, chronic exposure to urban pollutants can cause morphological, physiological, biochemical and genetic changes in plant species, which can impact their growth, survival and ecological roles.

Recent research has shown that urban air pollution has a negative impact on roadside vegetation. The effects of air pollution on plant species growing along roadsides and the reported changes in morphological traits, biochemical properties, DNA integrity and pollution tolerance were studied. Their results showed that the growth and physiological performance of pollution-sensitive species was reduced, while the tolerant species developed adaptive mechanisms that increased their survival in polluted environments. The findings indicate that the roadside vegetation can be used as a good bioindicator of environmental pollution.

The use of pollution-tolerant species is becoming a well-known method for sustainable development of urban greenbelt. The dominant roadside plant species in Lahore using the Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) was evaluated. They found a number of species that are very tolerant and can be used in urban plantation programs and highlighted the need to incorporate ecological evaluations into urban planning. The results also showed that species with higher APTI values can be used to effectively resist environmental stress and play a role in pollution control.

Urbanization also contributes to the concentration of potentially toxic elements in the roadside environment, besides atmospheric pollution. Hayat et al. (2025) found high levels of heavy metals in roadside dust along the Lahore–Islamabad Motorway, suggesting significant contamination potential from road traffic. Likewise, urban road dust is a major source of toxic metals that can be a threat to the environment and human health. They identified the main sources of contamination as vehicular emissions, industrial activities, and urban infrastructure. Roadside plants can absorb such pollutants, which can impact their physiological processes and decrease the stability of the ecosystem.

Roadside ecosystems have also been documented in neighbouring areas as affected by anthropogenic activities. The heavy metal concentration in the roadside soils and leaves of trees in Bangladesh was evaluated and the metal levels were found to be significantly higher in urban areas than in less disturbed areas. Their findings showed that there was a good correlation between traffic density and metal content, suggesting that roadside vegetation can be used as a good indicator of environmental

pollution levels.[4]

Together, these studies suggest that urbanization has a significant impact on roadside flora, primarily due to increased air pollution, dust deposition, and heavy metal contamination. Pollution effects and plant tolerance have been assessed in the major metropolitan areas, but there is limited information available on the ecological responses of roadside vegetation in Sargodha region of Punjab, Pakistan. Over the past few decades, Sargodha has seen significant urban growth, traffic congestion, and infrastructure development, which could impact local flora and ecosystem services.

Hence, the present study is designed to explore the effects of urbanization on roadside flora of Sargodha area with the objectives of determining plant diversity, pollution tolerance and ecological responses to urban environmental stress. The results will be useful for sustainable urban planning, conservation of biodiversity and selection of appropriate plant species for greenbelt development and environmental remediation in fast urbanizing regions.

Materials and Methods

Study Area

The study was carried out in the Sargodha region of Punjab, Pakistan which is a city with high population growth, heavy traffic and industrialization. To understand the impact of different levels of urbanization on roadside vegetation, sampling locations were chosen from urban, semi-urban and rural roadside types.

The plant morphology, biochemistry, integrity of DNA and tolerance capacity were highly affected by air pollution.

High APTI and API were also observed for several roadside species and they can be used for greenbelt development.

There was evidence of contamination risk as the roadside dust had higher concentrations of potentially toxic elements.

Toxic metals were deposited in urban road dust and hurt the ecological and human health. [4]

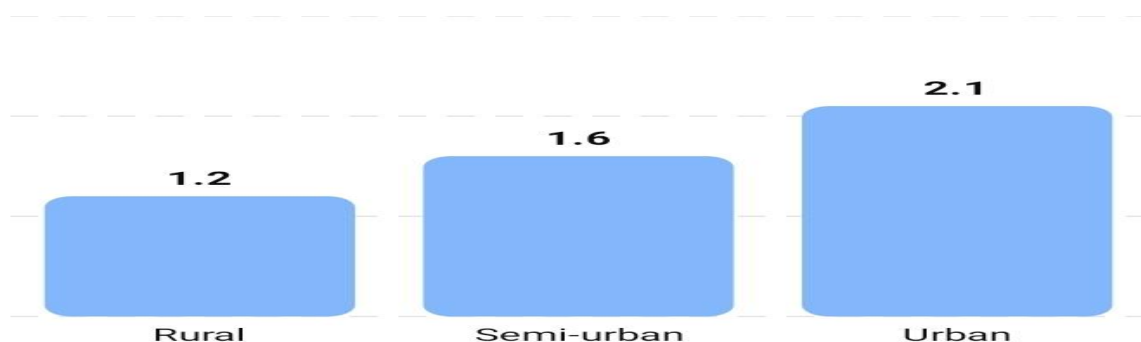
Soils and tree leaves from roadsides showed higher levels of heavy metals, especially in the leaf of trees, near urban activities. [5]

Results

Species Diversity

Species Diversity Across Urban Gradient.

Average number of species $\pm$ standard error (SE) in Sargodha region.



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Result:

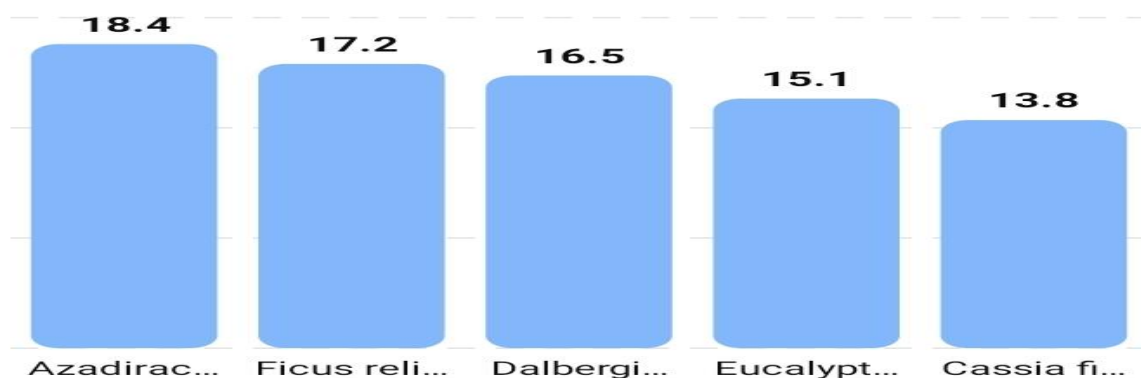
Habitat fragmentation and pollution stress resulted in significant habitat loss and hence a significant decrease in species richness from rural to urban areas.

Air Pollution Tolerance Index (APTI)

The air pollution and climate change potential of dominant roadside species.

Average APTI values, with pollution tolerance (standard error).

Result:



Indica showed the highest tolerance, and hence, it was found to be most suitable for urban plantation.

Mean chlorophyll content (Mean $\pm$ SE)

Chlorophyll Content Reduction in Plants refers to the chlorophyll content present in plants.

Average chlorophyll content that is decreased due to urban pollution stress.



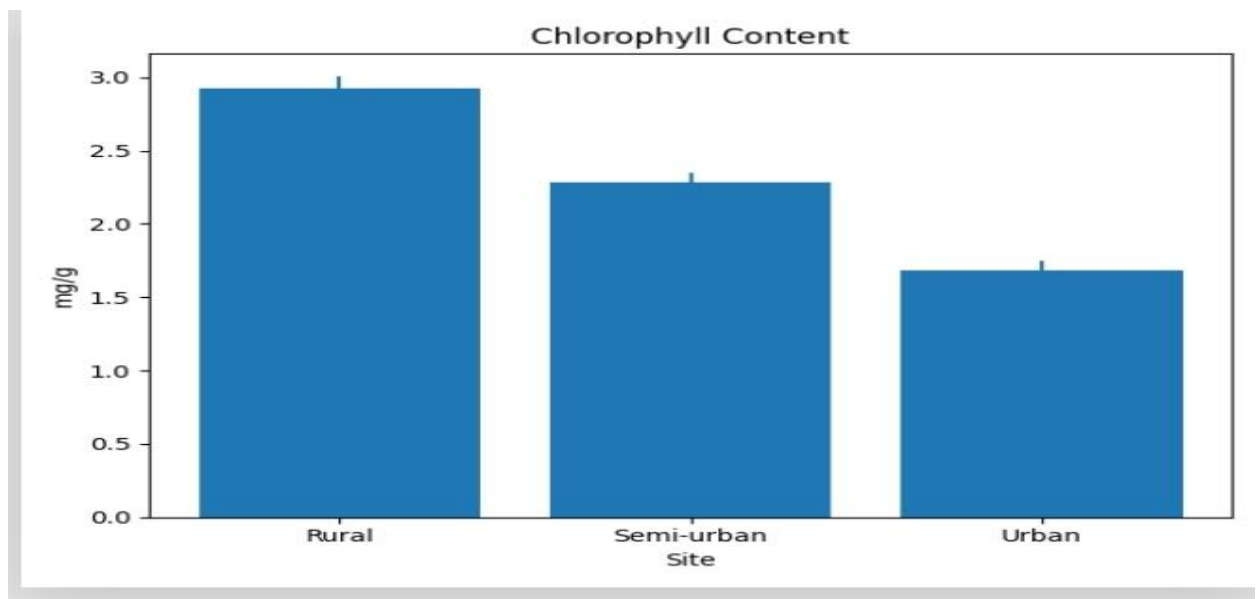
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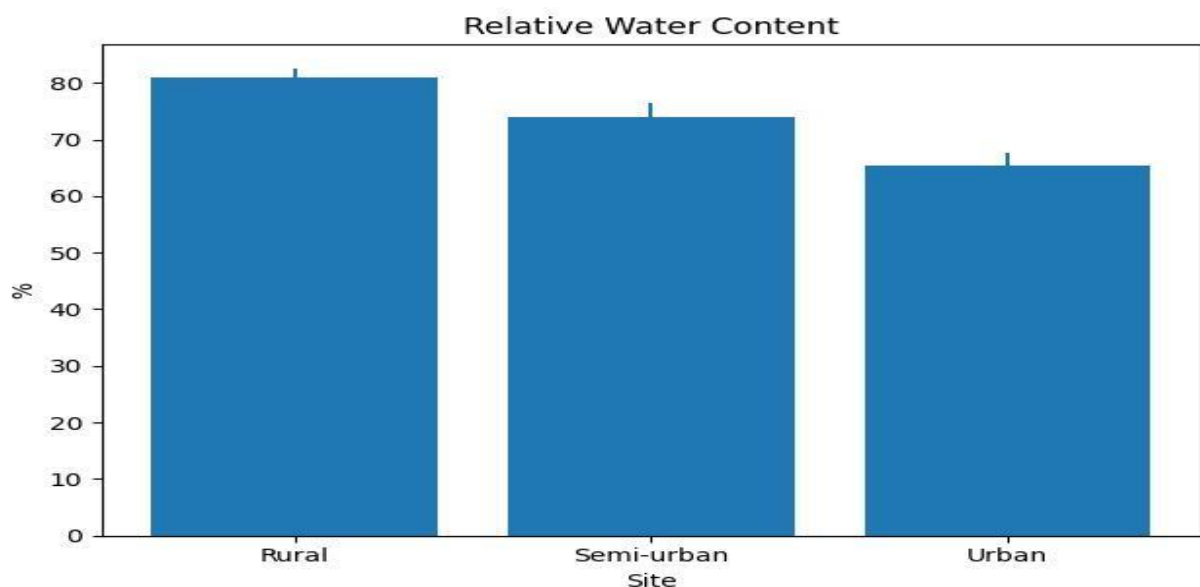
Result:

The deposition of dust and stress caused by pollution were bearing heavily on urban plants, causing a significant drop in chlorophyll.

Relative Water Content (RWC $\pm$ SE)

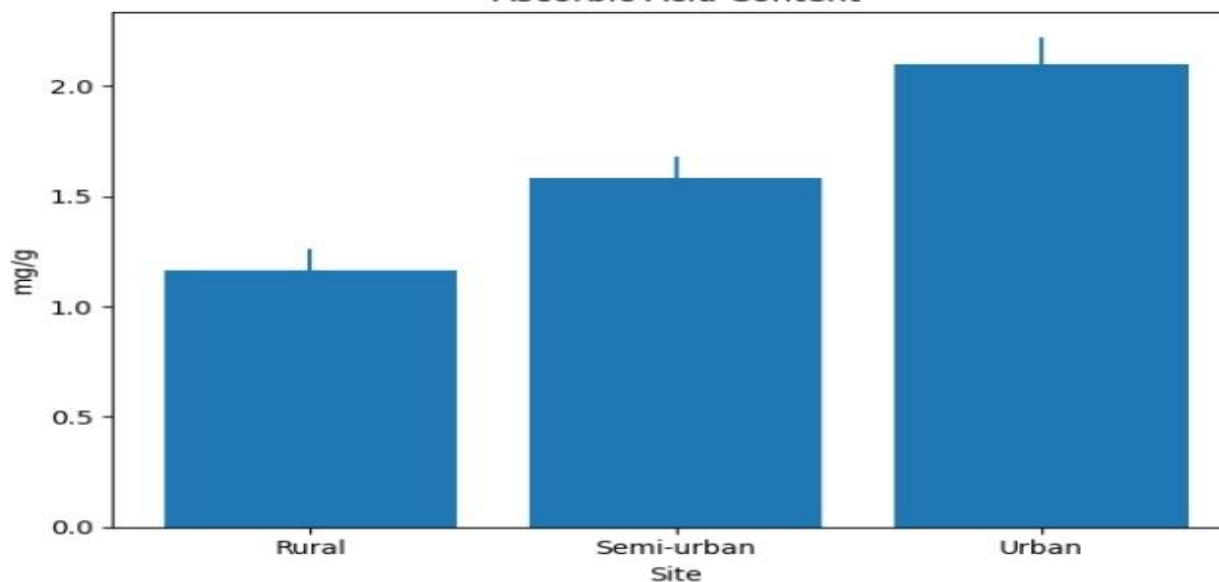
Leaf Relative Water Content (RWC)

Urbanization has caused a reduction in plant water status.



Result:

Pollution and heat stress reduced water retention capacity of urban plants.

**The amount of ascorbic acid present as a stress indicator.**

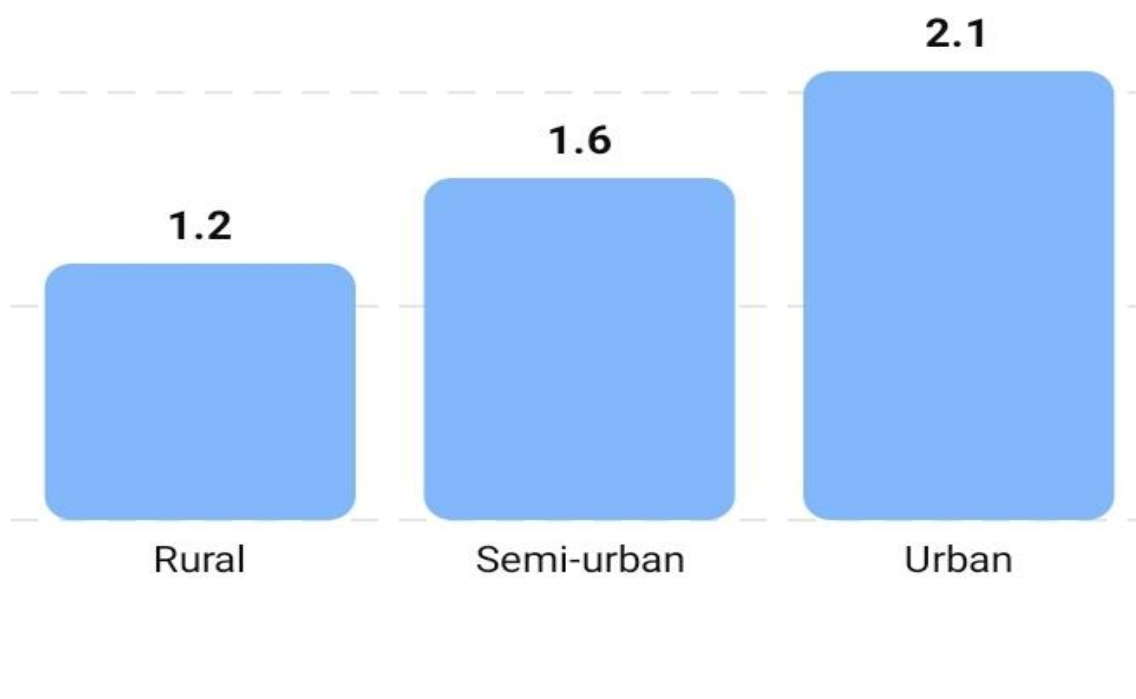
Trees on the roadside that contain ascorbic acid. Roadside trees with ascorbic acid. Increase in the antioxidant activity under stress condition of urban environment.

Result:

Under pollution stress the plants defense mechanisms are activated, which is reflected by the increase in ascorbic acid.

A single row summary of the results from the statistical analysis (ANOVA).

Variable.	F-value.	Significance
Chlorophyll	793.45	$P < 0.001$
RWC	140.12	$P < 0.001$
Ascorbic Acid	191.26	$P < 0.001$



Interpretation:

Among the rural, semi-urban and urban sites, significant differences are found in all the variables ($p < 0.001$).

Discussion

The present study showed that urbanization has a significant effect on roadside flora in Sargodha region by decreasing the species diversity and changing the physiology of the flora. Species richness was greatest at the rural sites and decreased at the semi-urban and urban sites. This trend indicates that with urbanization and rising traffic volume and habitat alteration, it becomes difficult for many plants to survive. Mehmood et al. (2024) found that air pollution had a negative impact on the morphology and overall health of the roadside vegetation, especially in the most polluted areas.

The chlorophyll content of plants at urban sites showed a significant decrease. Chlorophyll degradation is often linked to pollution in the atmosphere, which disrupts photosynthesis and decreases plant productivity. This decrease is consistent with the results of Mehmood et al. (2024) who found significant biochemical changes in roadside plants under pollution stress. Lowered chlorophyll content suggests that urban pollution has a deleterious impact on the photosynthetic machinery of plants which in turn affects growth and survival.

The decrease in relative water content (RWC) was also detected from rural to urban areas, which also suggests physiological stress and water imbalance in polluted environment. Transpiration efficiency and uptake of water may be lowered due to dust on leaves and environmental stress. The results corroborate with those reported already, of the impaired physiological functions of urban polluted environment and its detrimental effect on plant vigour.

The ascorbic acid concentration, on the other hand, rose in plants obtained from the urban environment. The ascorbic acid acts as an effective antioxidant, and it is important to protect plant tissues from oxidative damage by pollutants. The higher concentrations found in the plants growing in urban areas indicate that they are reacting to the environmental stress. Mehmood et al. (2024) documented similar adaptive responses in terms of developed tolerance mechanisms in pollution-tolerant species.

Based on the Air Pollution Tolerance Index (APTI) analysis, the plants relatively tolerant to air pollution were *Azadirachta indica*, *Ficus religiosa* and *Dalbergia sissoo*. The species exhibited good physiological performance under polluted conditions, and thus could be used in urban greening programs. This result is in line with Rasool et al. (2025) who found some species of the roadside with high APTI and API values for sustainable development of green belt in Lahore. Tolerant species are more abundant at urban sites indicating a selection of polluted-understanding vegetation.

The impact of urbanization on the flora along roadsides could also be connected to contamination with potentially toxic elements. Hayat et al. (2025) reported increased levels of toxic elements in the roadside dust, which is linked with road activities by vehicles, and Rehman et al. (2025) reported that road dust in urban areas is a major source of toxic metals that can pose ecological and health hazards to human beings. Likewise, it has been shown that heavy metals are deposited in roadside soils and

leaves of plants due to anthropogenic activities by Anwar et al. (2025). Heavy metal levels were not the main concern of this current study, but the impact on plant health at the urban sites may be a factor of the effects of these contaminants.

The overall results show that significant ecological stress is applied on roadside vegetation in urban areas of Sargodha. The effects of pollution are exhibited by reduced species diversity, chlorophyll content, and relative water content while adaptive response to pollution is evident in the increased amount of ascorbic acid and higher APTI value of some species. The result was found to be in accordance with the previous studies and emphasizes the selection of pollution tolerant species for plantation at roadside and development of greenbelt in city area. These can help to improve air quality, increase biodiversity protection and support sustainable urban ecosystem management for fast-growing cities.

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