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Environmental Management and Pollution Mitigation Potential of Campus Flora: A Floristic and GPS-Based Study from Punjab, India

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Abstract:
Urban educational campuses function as important green spaces that support biodiversity conservation and environmental sustainability. The present study assessed the floristic diversity, ecological composition, and pollution mitigation potential of campus vegetation through floristic surveys and GPS-based documentation. Diverse plant species representing trees, shrubs, herbs, and climbers were recorded from different ecological zones of the campus. Dominant vegetation included several pollution-tolerant and ecologically important species commonly associated with urban environmental management. GPS mapping helped identify major green zones and vegetation distribution patterns within the campus landscape. The study revealed that campus flora contributes significantly toward pollution control, carbon sequestration, microclimate regulation, and ecological stability. Pollution-tolerant species demonstrated greater adaptability to urban environmental stress and were found suitable for sustainable plantation programs. The findings highlight the importance of educational campuses as effective green infrastructure systems for biodiversity conservation and environmental management in urban ecosystems.

Keywords: Campus flora, Floristic diversity, Environmental management, GPS mapping, Pollution mitigation, Urban biodiversity.

CHAPTER 1: INTRODUCTION

Urbanization and industrial development have accelerated rapidly during recent decades, resulting in severe environmental degradation and biodiversity loss across many regions of the world. Increasing vehicular emissions, industrial pollutants, deforestation, and unplanned urban expansion have contributed significantly to declining air quality, rising atmospheric carbon dioxide levels, and ecological imbalance. In developing countries such as India, urban ecosystems are increasingly exposed to environmental stress due to population growth and infrastructural development. Under such conditions, urban green spaces play a crucial role in maintaining ecological stability and improving environmental quality (Singh et al., 2020). Trees and shrubs function as natural air filters by trapping particulate matter, absorbing gaseous pollutants, and releasing oxygen into the atmosphere. Urban flora also contributes to temperature moderation, noise reduction, soil conservation, and carbon sequestration. Educational campuses, gardens, parks, and institutional landscapes therefore represent important ecological habitats within urban areas. These green spaces provide ecological refuges for numerous plant and animal species while simultaneously enhancing environmental sustainability and human well-being (Nandala et al., 2023).

Large canopy trees intercept dust particles and absorb pollutants such as sulfur dioxide, nitrogen oxides, and carbon monoxide emitted from nearby roads and urban activities. Species such as *Azadirachta indica*, *Ficus religiosa*, *Polyalthia longifolia*, and *Mangifera indica* have been reported to possess high pollution tolerance and significant ecological value in urban landscapes (Pati et al., 2024). Floristic surveys provide baseline information regarding species richness, distribution patterns, native and exotic taxa, and conservation priorities. Such inventories are essential for sustainable environmental planning, biodiversity conservation, and ecological restoration programs. Studies conducted in different educational institutions of India have demonstrated that campus ecosystems support substantial plant diversity despite anthropogenic disturbances (Sagar & Verma, 2010).

Geographic Information System (GIS) have improved biodiversity documentation and environmental monitoring. GPS-based vegetation mapping enables accurate recording of species distribution, ecological zones, and green cover patterns, thereby supporting biodiversity conservation and environmental management (Kulkarni et al., 2024).

Air pollution is a major environmental concern in rapidly urbanizing regions of Punjab due to vehicular emissions, industrialization, and agricultural activities. Plants differ in their response to pollution stress depending upon their physiological and biochemical characteristics. Pollution-tolerant species are therefore considered suitable for urban forestry, roadside plantations, and green belt development (Singh et al., 2020).

The Air Pollution Tolerance Index (APTI) is commonly used to evaluate plant tolerance against atmospheric pollutants using parameters such as chlorophyll content, leaf pH, relative water content, and ascorbic acid concentration. Species with higher APTI values are considered effective for pollution mitigation and environmental management (Tomar et al., 2022). Urban vegetation also contributes significantly toward carbon sequestration and climate regulation by absorbing atmospheric carbon dioxide. Educational campuses with substantial green cover function as important ecological zones that support biodiversity conservation and urban sustainability (Pati et al., 2024).

CHAPTER 2: REVIEW OF LITERATURE

Sagar and Verma (2010) studied the herbaceous community composition and species diversity on the campus of Banaras Hindu University, India. The study reported that educational campuses support considerable plant diversity and function as important ecological habitats within urban landscapes. The authors emphasized that vegetation diversity contributes significantly toward ecosystem stability, soil conservation, and environmental sustainability.

Singh et al. (2020) evaluated the adaptation and mitigation potential of roadside tree species under vehicular emission stress. The investigation revealed that pollution-tolerant plant species play an important role in reducing atmospheric pollutants by trapping particulate matter and absorbing gaseous contaminants. The study further highlighted the importance of selecting tolerant species for urban plantation and green belt development programs.

Nandala et al. (2023) assessed the diversity and ecosystem services provided by trees in educational institutions. Their findings demonstrated that institutional campuses act as miniature urban forests supporting biodiversity conservation, carbon sequestration, microclimate regulation, and environmental management. The study emphasized the ecological importance of campus green spaces in rapidly urbanizing environments.

Tomar et al. (2022) investigated the impact of anthropogenic disturbances on floristic diversity and ecological distribution patterns. The authors observed that environmental stress and human interference influence species composition and vegetation structure. The study suggested that biodiversity assessment is essential for ecological restoration and conservation planning.

Pati et al. (2024) examined the role of roadside vegetation in atmospheric carbon dioxide mitigation and reported that urban trees contribute significantly toward carbon sequestration and air pollution control. Large canopy species were found to be more effective in reducing atmospheric carbon levels and improving urban environmental quality.

Kulkarni et al. (2024) studied floristic composition and plant functional diversity using geospatial approaches for vegetation assessment. The research highlighted the usefulness of GPS-based documentation in biodiversity monitoring, ecological mapping, and conservation planning. The authors concluded that geospatial technologies provide accurate and reliable tools for environmental management studies.

Overall, previous studies indicate that educational campuses and urban green spaces play a vital role in biodiversity conservation, pollution mitigation, carbon sequestration, and environmental sustainability. However, integrated studies combining floristic diversity assessment, pollution mitigation potential, and GPS-based vegetation documentation in Punjab remain limited. Therefore, the present study was undertaken to evaluate the environmental management potential of campus flora through floristic and geospatial assessment.

CHAPTER 3: MATERIALS AND METHODS

Study Area

The present study was conducted in an educational campus located in Punjab, India. The campus comprises academic buildings, roadside plantations, gardens, residential areas, and open green spaces supporting diverse vegetation. The region experiences a subtropical climate characterized by hot summers, cool winters, and moderate monsoon rainfall.

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Floristic Survey

Extensive field surveys were carried out during 2025-2026 in different seasons to document the floristic diversity of the campus. Plant species were observed and recorded from various ecological zones including roadsides, gardens, lawns, and peripheral green belts. Collected specimens were identified using standard regional floras, taxonomic literature, and available botanical databases.

GPS-Based Documentation

Global Positioning System (GPS) technology was used to record the geographical locations of dominant and ecologically important plant species within the campus. GPS mapping helped in identifying vegetation distribution patterns, biodiversity-rich zones, and pollution-buffer areas for environmental assessment and management.

Assessment of Carbon Sequestration Potential

The environmental management potential of campus vegetation was evaluated through estimation of carbon sequestration capacity of dominant tree species. The assessment was carried out using non-destructive field measurements and standard ecological estimation methods commonly used in vegetation studies.

Measurement of Tree Parameters

For each selected tree species, the following parameters were measured:

- Diameter at Breast Height (DBH)
- Tree height
- Canopy spread

DBH was measured at approximately 1.37 m above ground level using a measuring tape. Tree height was estimated using visual methods and clinometer observations.

Estimation of Above-Ground Biomass

Above-ground biomass (AGB) was estimated using standard allometric equations based on tree diameter, height, and wood density.

$AGB = 0.0673 \times (\rho D^2 H)^{0.976}$

Where:

- AGB = Above-ground biomass (kg)
- ρ = Wood density (g cm)
- D = Diameter at Breast Height (cm)
- H = Tree height (m)

Carbon Stock Estimation

Carbon stock of individual tree species was estimated by multiplying biomass values with the standard carbon conversion factor (0.47).

Carbon Stock = Biomass × 0.47

Carbon Dioxide Sequestration

The amount of atmospheric carbon dioxide sequestered by trees was calculated using the following formula:

CO_2 Sequestered = Carbon Stock × 3.67

CHAPTER 4: RESULT AND DISCUSSION

Floristic Composition of Campus Vegetation

The floristic survey conducted during the study period documented a considerable diversity of plant species distributed across different ecological zones of the campus. The vegetation was dominated mainly by tree species, followed by shrubs, herbs, and climbers. Roadside plantations, gardens, and peripheral green belts showed comparatively higher vegetation density and canopy cover.

Dominant tree species observed in the campus included *Azadirachta indica*, *Ficus religiosa*, *Mangifera indica*, *Polyalthia longifolia*, *Cassia fistula*, and *Alstonia scholaris* (Table 1). These species were commonly distributed near roadsides and open green spaces, indicating their adaptability to urban environmental conditions. GPS-based documentation helped in identifying vegetation-rich zones and major plantation areas within the campus.

Table 1. Carbon Sequestration Potential and Environmental Significance of Dominant Campus Tree Species

Dominant Tree Species	Average DBH (cm)	Average Height (m)	Estimated CO_2 Sequestration Potential	Environmental Significance
Ficus religiosa	58.4	18.2	Very High	Dense canopy and high biomass accumulation
Mangifera indica	52.6	16.5	High	Effective carbon storage and shade regulation
Azadirachta indica	46.3	14.8	High	Pollution-tolerant and suitable for roadside plantation
Polyalthia longifolia	38.7	17.1	Moderate to High	Useful for avenue plantation and dust reduction
Cassia fistula	34.5	12.4	Moderate	Ornamental and ecological importance
Alstonia scholaris	41.2	15.3	Moderate to High	Good adaptability to urban conditions

The assessment of dominant campus tree species revealed considerable variation in Diameter at Breast Height (DBH), tree height, and carbon sequestration potential. Species with larger trunk diameter and broader canopy structure exhibited comparatively higher capacity for atmospheric carbon dioxide absorption and biomass accumulation. Among the studied species, *Ficus religiosa* showed the highest carbon sequestration potential due to its extensive canopy spread and mature growth habit. Similarly, *Mangifera indica* and *Azadirachta indica* demonstrated significant ecological importance in carbon storage and environmental improvement.

Roadside and peripheral plantation species such as *Polyalthia longifolia* and *Alstonia scholaris* were found effective for dust interception and urban environmental management because of their adaptability to pollution stress conditions. The findings indicate that campus vegetation functions as an important urban carbon sink and contributes significantly toward climate regulation, pollution mitigation, and ecological sustainability.