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# Impact of Invasive Plant Species on Soil Physico-chemical Properties in Agricultural and Roadside Habitats of Lakhimpur District, Assam, India

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## ABSTRACT

*Invasive alien plant species (IAPS) are major ecological threats affecting biodiversity that alter soil fertility and ecosystem stability in disturbed habitats. The present study was conducted to evaluate the effects of invasive plant species on soil physicochemical properties in agricultural and roadside habitats of Lakhimpur district, Assam, India. Field surveys were carried out during the pre-monsoon, monsoon, and post-monsoon seasons of 2024 using quadrat sampling methods to document invasive species diversity and dominance. Soil samples were collected from invaded sites at 0-20 cm depth and analysed for pH, organic carbon, available nitrogen, and phosphorus using standard laboratory methods. The study provides the first comparative assessment of invasive plant-associated soil properties in agricultural and roadside ecosystems of Lakhimpur district. A total of 14 invasive plant species were recorded, among which Eichhornia crassipes, Mikania micrantha, Chromolaena odorata, and Parthenium hysterophorus showed greater dominance. Invaded soils exhibited higher organic carbon (0.76-0.87%) and available nitrogen (230-260 kg ha$^{-1}$), whereas soil pH ranged from 5.6 to 6.2, indicating slight acidification. Seasonal variation showed higher nutrient accumulation during monsoon and post-monsoon periods. The findings indicate that invasive plant species significantly alter soil nutrient dynamics and may contribute to ecological imbalance and suppression native vegetation. Continuous monitoring and effective management strategies are necessary to minimize the spread and ecological impacts of invasive plant species in Assam.*

***Keywords:*** *Invasive alien plants, Soil physicochemical properties, Biodiversity, Assam.*

## 1. Introduction

Invasive alien plant species are one of the major ecological threats affecting biodiversity, ecosystem stability, and agricultural productivity worldwide. These species establish rapidly in disturbed habitats and often outcompete native vegetation through fast growth, efficient resource utilisation and allopathic interactions. Agricultural lands, roadside habitats, wetlands, and forest margins are particularly vulnerable to biological invasions due to continuous anthropogenic disturbances and habitat modification. Invasive plant species can alter ecosystem processes by modifying soil physicochemical properties, nutrient cycling, microbial activity, and vegetation structure, thereby affecting native biodiversity and ecosystem functioning.

Several invasive species such as *Mikania micrantha*, *Chromolaena odorata*, *Lantana camara*, *Parthenium hysterophorus*, and *Eichhornia crassipes* have become dominant in different regions of India, particularly in disturbed landscapes of northeastern India. Previous studies have reported that invasive plants influence soil fertility by increasing organic matter accumulation and nutrient turnover through rapid litter decomposition and biomass production [1, 2]. Invasive species also contribute to soil acidification and changes in microbial composition, creating favourable conditions for further invasion and suppression of native vegetation [3].

Roadside habitats are considered important corridors for invasion because vehicular movement, wind dispersal, and continuous disturbance facilitate rapid spread of invasive species. In Assam studies have documented the occurrence and distribution of invasive plant species in roadside and wetland ecosystems [4, 5]. However, limited information is available regarding their effects on soil physicochemical properties in agricultural and roadside habitats of Lakhimpur districts. Comparative assessment of invasive plant-associated soil characteristics is essential for understanding ecological impacts and developing suitable management strategies.

Therefore, the present study was undertaken to document invasive plant species and evaluate their effects on soil physicochemical properties in agricultural and roadside habitats of Lakhimpur district, Assam, India.

## 2. Materials and Methods

### 2.1 Study area

The present study was conducted in Lakhimpur district, Assam, India, located in the northeastern region of the country. The district experiences a humid subtropical climate with average annual humidity of approximately 75.1% and temperature ranging from 17.16$^0$C to 27.44$^0$C throughout the year [6]. Agricultural fields and roadside habitats were selected for the study because these areas are highly susceptible to invasion by alien plant species due to continuous anthropogenic disturbances and habitat modification.

Field investigations were conducted during pre-monsoon (March-May), monsoon (June-August), and post-monsoon (September-November) seasons of 2024.

**2.2 Field survey and Soil sampling**

Field surveys were conducted in selected agricultural and roadside habitats of Lakhimpur district to document invasive plant species. Quadrant sampling method described by Odum [7] was used to assess species occurrence and relative frequency. Invasive species were identified based on field observations and available floristic literature. Soil samples were collected from invaded sites at a depth of 0-20 cm using a soil auger, samples were collected in triplicate during each season and stored in sterile polythene bags for laboratory analysis. The collected samples were air-dried, crushed, and passed through a 2 mm sieve before analysis. Field observations including habitat condition, invasive species dominance, and vegetation characteristics were also recorded during the study period.

**2.3 Analysis of soil physicochemical properties**

**2.3.1 Soil pH**

Soil pH was determined in a 1:2.5 soil-water suspension using a digital pH meter.

**2.3.2 Organic carbon**

Organic carbon content was estimated by the Walkley and Black wet oxidation method [8].

**2.3.3 Available Nitrogen**

Available nitrogen was determined using the Kjeldahl digestion-distillation method described by Kalembasa and Jenkinson [9].

**2.3.4 Available Phosphorus**

Available phosphorus was estimated by the Olsen method using sodium bicarbonate extraction followed by spectrophotometric analysis [10].

**2.4 Statistical analysis**

All analyses were carried out in triplicate and results were expressed as a mean ± standard deviation (SD). Statistical analysis of variance (ANOVA) was used to determine significant differences among variables at $p < 0.05$.

## 3. Results and Discussion

**3.1 Invasive plant species recorded**

A total of 14 invasive plant species belonging to different growth forms were recorded from agricultural and roadside habitats of Lakhimpur district, Assam (Table. 1). The identified species included *Eichhornia crassipes*, *Mikania micrantha*, *Chromolaena odorata*, *Parthenium hysterophorous*, *Lantana camara*, *Ageratum conyzoides*, *Alternanthera philoxeroides*, *Mimosa pudica*, *Chamaesyce hirta*, *Argemone mexicana*, *Datura innoxia*, *Eclipta prostrata*, *Lemna minor*, and *Cyperus difformis*. Roadside habitats exhibited greater invasive species richness and dominance compared to agricultural fields due to continuous anthropogenic disturbances and enhanced dispersal opportunities.

**3.2 Relative frequency of Invasive species**

The relative frequency of invasive species varied between agricultural and roadside habitats. *Eichhornia crassipes* showed the highest occurrence in both agricultural fields (60%) and roadside (80%). *Mikania micrantha* and *Chromolaena odorata* were more dominant in roadside habitats, whereas *Ageratum conyzoides* and *Mimosa pudica* were commonly observed along agricultural bunds. The higher invasive dominance in roadside areas indicated that disturbed habitats facilitated rapid colonization and spread of invasive species.

**3.3 Seasonal variation in soil physicochemical properties**

Seasonal variation in soil physicochemical properties of invaded habitats is presented in Table 2. Soil pH ranged from 5.6 to 6.2, indicating slightly acidic conditions in both habitats. Organic carbon and available nitrogen contents increased during monsoon and post-monsoon seasons in comparison to pre-monsoon season. Similar observations were reported in invaded ecosystems by Ehrenfeld [1].

In agricultural fields, organic carbon ranged from 0.76 to 0.82%, while available nitrogen varied from 240 to 260 kg $ha^{-1.}$ statistical analysis revealed significant seasonal variation ($p<0.05$) in soil physicochemical properties among the studied habitats.

**3.4 Soil nutrient variation associated with invasive plant species**

The increase in nutrient availability in invaded soils may be related to rapid litter accumulation and decomposition by invasive plants. Similar findings were reported by Gibbons et al. [2]. Variation in soil nutrient characteristics associated with different invasive plant species is presented in Table 3. Wetland-associated species such as *Eichhornia crassipes* and *Alternanthera philoxeroides* showed comparatively higher organic carbon and nitrogen content than other invasive species. Soil associated with *Eichhornia crassipes* exhibited organic matter up to 4.5% and nitrogen content ranging from 20 to 30 mg $kg^{-1}$.

In contrast, soils associated with *Argemone mexicana* showed relatively lower nutrient enrichment. Phosphorus content varied from 12 to 22 mg kg-1 among the studied invasive species. Significant differences ($p < 0.05$) were observed in soil nutrient characteristics associated with different invasive plants.

**3.5 Ecological implications of invasive species**

The present study demonstrated that invasive plant species significantly influenced soil physicochemical properties in agricultural and roadside habitats of Lakhimpur district. Increased organic carbon and nitrogen content in invaded soils may be associated with rapid litter accumulation and decomposition under invasive vegetation. Lower soil pH observed in invaded habitats indicated possible alterations in nutrient cycling and microbial activity [1].

Roadside habitats showed greater invasion intensity because of frequent disturbances, vehicular movement, and favourable conditions for seed dispersal. Same invasion patterns in disturbed habitats were reported by Rai [3]. Dense growth of *Mikania micrantha* and *Chromolaena odorata* suppressed native vegetation through shading and competition for resources. Similar observations were reported by Sharma and Paul [11]. The observed changes in soil properties and vegetation structure indicated that invasive plant species contributed to ecological imbalance and habitat degradation in the study area.

***Table 1: Invasive Plant Species Recorded from Agricultural and Roadside Habitats of Lakhimpur District, Assam***

| Scientific name | Habitat | Growth form | Mode of spread |
|---|---|---|---|
| *Eichhornia crassipes* | Wetlands, agricultural fields | Aquatic, herb | Vegetative propagation, seeds |
| *Mikania micrantha* | Roadsides, agricultural fields | Climber | Seeds, runners |
| *Chromolaena odorata* | Roadsides, farms | Shrub | Wind dispersal |
| *Parthenium hysterophorus* | Roadsides, agricultural fields | Herb | Wind, seeds |
| *Lantana camara* | Forest edges, fields | Herb | Seeds, vegetative propagation |
| *Ageratum conyzoides* | Roadsides,agricultural fields | Herb | Seeds |
| *Alternanthera philoxeriods* | Wetlands | Herb | Vegetative propagation, seeds |
| *Mimosa pudica* | Roadside, agricultural fields | Herb | Seeds |
| *Chamaesyce hirta* | Roadsides | Herb | Seeds |
| *Argemone mexicana* | Fields, roadsides | Herb | Seeds |
| *Datura innoxia* | Fields, roadsides | Herb | Seeds |
| *Eclipta prostrata* | Wetlands, agricultural fields | Herb | Seeds |
| *Lemina minor* | Wetlands | Aquatic herb | Vegetative propagation |
| *Cyperus difformis* | Wetlands, agricultural fields | Sedge | Seeds, rhizomes |

***Table 2: Seasonal Variation in Soil Physico-chemical Properties of Invaded Habitats in Lakhimpur District, Assam***

| Habitat | Season | pH (Mean ± SD) | Organic carbon (%) (Mean ± SD) | Available nitrogen (kg $^{ha-1}$) (Mean ± SD) |
|---|---|---|---|---|
| Agricultural field | Pre-monsoon | 5.8 ± 0.1 | 0.76 ± 0.03 | 240 ± 10 |
| Agricultural field | Monsoon | 5.6 ± 0.2 | 0.82 ± 0.04 | 260 ± 12 |
| Agricultural field | Post-monsoon | 5.9 ± 0.1 | 0.79 ± 0.02 | 250 ± 11 |
| Roadside habitat | Pre – monsoon | 6.1 ± 0.1 | 0.81 ± 0.05 | 230 ± 9 |
| Roadside habitat | Monsoon | 6.0 ± 0.2 | 0.87 ± 0.03 | 245 ± 10 |
| Roadside habitat | Post-monsoon | 6.2 ± 0.1 | 0.83 ± 0.02 | 255 ± 12 |

*Values are expressed as mean SD of triplicate observations, significant at $p < 0.05$.*

***Table 3: Soil Physico-chemical Characteristics Associated with Invasive Plant Species in Lakhimpur district, Assam***

| Scientific name | Soil pH (Mean ± SD) | Organic matter (1%) (Mean ± SD) | Nitrogen (mg kg$^{-1}$) | Phosphorus (mg kg-1) (Mean ± SD) |
|---|---|---|---|---|
| *Eichhornia crassipes* | 6.2 ± 0.65 | 4.5 ± 0.40 | 20 – 30 | 18 ± 1.0 |
| *Mikania micrantha* | 5.8 ± 0.50 | 3.8 ± 0.30 | 18 -26 | 22 ± 1.2 |
| *Chromolaena odorata* | 6.5 ± 0.90 | 4.2 ± 0.45 | 25 -35 | 19 ± 1.0 |
| *Parthenium hysterophorus* | 6.1 ± 0.85 | 3.5 ± 0.25 | 15 -25 | 15 ± 1.1 |
| *Lantana camara* | 6.3 ± 0.65 | 4.0 ± 0.30 | 20 – 30 | 17 ± 0.9 |
| *Ageratum conyzoides* | 5.9 ± 0.55 | 3.9 ± 0.25 | 17 -27 | 16 ± 1.1 |
| *Alternanthera philoxeriods* | 6.0 ± 0.45 | 4.1 ± 0.30 | 22 -32 | 20 ± 1.2 |
| *Mimosa pudica* | 6.2 ± 0.55 | 3.7 ± 0.20 | 18 -28 | 18 ± 1.0 |
| *Chamaesyce hirta* | 5.7 ± 0.50 | 3.6 ± 0.35 | 12 -22 | 14 ± 1.2 |
| *Argemone mexicana* | 5.5 ± 0.60 | 3.4 ± 0.30 | 10 -20 | 12 ± 0.9 |
| *Datura innoxia* | 6.4 ± 0.65 | 4.3 ± 0.35 | 24 -34 | 21 ± 1.1 |
| *Eclipta prostrata* | 6.1 ± 0.70 | 3.8 ± 0.40 | 19 -29 | 19 ± 1.2 |
| *Lemina minor* | 6.0 ± 0.40 | 4.0 ± 0.35 | 15 – 25 | 17 ± 0.9 |
| *Cyperus difformis* | 5.8 ± 0.45 | 3.9 ± 0.30 | 14 - 24 | 15 ±1.1 |

*Values are expressed as Mean ± SD of triplicate observations and significant at $p < 0.05$.*

## 4. Conclusion

The present study demonstrated that invasive plant species significantly influenced soil physicochemical properties in agricultural and roadside habitats of Lakhimpur district, Assam. dominant invasive species such as *Eichhornia crassipes*, *Mikania micrantha, Chromolaena odorata*, and *Parthenium hysterophorus* altered soil pH, organic carbon, nitrogen, and phosphorus levels in invaded habitats. Roadside ecosystems exhibited greater invasive dominance than agricultural fields due to continuous anthropogenic disturbances and enhanced dispersal opportunities. Increased organic carbon and nitrogen content in invaded soils indicated that invasive plant species modified nutrient dynamics and ecological processes. The findings highlighted the potential ecological risks associated with invasive plant spread and emphasized the need for continuous monitoring, habitat management, and effective control measures to conserve native biodiversity and maintain ecosystem stability in Assam.

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