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# Ecological Investigation on Plant Diversity and Soil Characteristics of Invasive *Ageratum conyzoides* and Introduced *Eucalyptus globulus* Ecosystems in an Indian Dry Tropical Region

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## ABSTRACT

Alien flora in urban ecosystems may have differing impacts on plant diversity and soil. In this study, vegetation and soil characteristics were investigated under the two contrasting herb layer conditions influenced by exotic invasive herb *Ageratum conyzoides* and introduced alien tree *Eucalyptus globulus* in an Indian dry tropical urban ecosystem. Phytosociological analysis of 120 randomly sampled quadrats (each of size 1m × 1m, n=60 at each site) was carried out. Nine random seasonal soil samples (0–10 cm) from both study sites were analyzed for soil pH, moisture content, organic carbon, total nitrogen, exchangeable Na, K and Calcium. A total of 82 species were recorded, representing 32 families. Poaceae and Fabaceae constituted dominant families. *Cynodon dactylon* dominated all sites and seasons. Number of rainy flora was comparable but varied distinctly in drier months. Alpha diversity, estimated higher at EG site in rainy season, ranked sites differently in drier months. Beta diversity, indicative of heterogeneity, was higher at AC sites in drier months in summer. Soil moisture content varied significantly with site and season. EG site recoded higher organic carbon and total nitrogen compared to AC site. In conclusion, the observed variations highlight the complex interplay of environmental factors, seasonal dynamics, and species interactions shaping plant community structure and composition and emphasize the need for further research to elucidate underlying mechanisms driving observed patterns.

**Keywords** Plant diversity, Beta diversity, Dry tropics, Spatio-temporal dynamics, Tropical soils.

## INTRODUCTION

The seasonally dry tropical ecosystems despite its ecological significance, it remains one of the least protected ecosystems due to various anthropogenic and economic pressures (Janzen 1986, 1988, Mooney *et al.* 1995, Quesada and Stoner 2004). Often overlooked, the herbaceous layer within these ecosystems plays a crucial role in ecosystem processes, possessing distinct features that set it apart from the dominant woody vegetation (Vidyashree and Kumar 2023). Such ecosystems, renowned for their unparalleled biodiversity, face threats from both

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natural and anthropogenic processes and the resultant anthropogenic climate change has influenced considerably species distributions, community composition, and overall diversity structure through adaptive and evolutionary responses (Sanjeewani *et al.* 2024). The conservation status of species within these ecosystems is intricately linked to environmental changes and habitat alterations across gradients. In fact, floristic compositions of weed communities and species adaptations are greatly influenced by temporal changes in environmental conditions, shaped by the interplay of climatic variables (Srivastava and Singh 2005).

Overstory tree species may play a pivotal role in mediating the impacts of environmental conditions and disturbances on the richness of understory species richness (Li *et al.* 2018). Tropical dry ecosystems, especially the urban and peri-urban ecosystems in India have been witnessing increasing loss of native biodiversity on account of accelerated plant invasions by alien flora here (Agrawal and Narayan 2017). Many of such flora have turned invasive or are turning invasive in course of time e.g. *Chenopodium murale* (Gupta and Narayan 2012) of the several herbaceous alien flora in India, *Parthenium hysterophorus* has invaded India at very large scale and now has spread to almost every part of India. Despite having short life cycle, it is found round the year in India as it completes 3-4 generations in a year (Gupta 2008). *Ageratum conyzoides*, another prominent annual exotic flora in India has also expanded its area of occurrence rapidly and is now considered an invasive alien species in India (Chaudhary and Narayan 2013). On the other hand introduced tree species *Eucalyptus globulus* from Australia has been a plantation favorite to India since long, first time planted T Nandi hills near Bangaluru by Tipu Sultan around 1790 (Shyam Sundar 1984) and is presently common in nearly every segment of India. However, it is physiologically considered a criminal consumer of water. Thus, under the present impending water scarce conditions felt across the diverse world, it may be considered a worth investigating tree flora ecologically for its impact on vegetation and soils in vicinity.

Present ecological investigation aimed to assess the impact of vegetation and soils of exotic invasive *Ageratum conyzoides* and introduced tree *Eucalyptus globulus* on the vegetation structure and soils in vicinity in a dry tropical region of India.

## MATERIALS AND METHODS

### Study area

The study area was located in a dry tropical region of Meerut at Chaudhary Charan Singh University (28° 59' N lat and 77°42' E long) spread over the total area of 22 acres in India. Two permanent study sites were selected for the present investigation, *Ageratum conyzoides*-dominated site (AC) and *Eucalyptus globulus*-planted site (EG). At each site, 1 $km^2$ of area was marked for this ecological study.

### Plant sampling

An extensive field study of floristic composition was done from July 2021 to June 2022 for listing the above ground flora in different seasons. The recorded plant species were identified according to Sharma (1980), Gaur (1999), Duthie (1960). Phytosociological study of both the study sites was carried out through 120 randomly laid quadrats in three seasons (each of size 1m × 1m; n=20×3×2). For the density estimation of grasses, every emergent tiller was considered as one individual. Density of each species was calculated according to Phillips (1959).

### Relative density

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of quadrats studied}}$$

$$\text{Relative density (RD)} = \frac{\text{Density of species}}{\text{Sum of density of all species}} \times 100$$

### Similarity coefficient

Similarity among the study sites within and across different seasons was estimated using the Modified Sorenson similarity coefficient (Southwood 1978) according to the following formula :

$$SC = \frac{2jN}{aN + bN}$$

Where, jN = Sum of lesser values of RD in two communities, aN = Sum of RD values of all species in community A, bN = Sum of RD values of all species in community B.

**Species diversity**

Relative density-diversity curves were prepared by plotting values of relative density of species against the sequence of species (from highest to lowest RD) (Whittaker 1975).

α diversity of each study site across different seasons was estimated, using nine diversity indices ($D_1$ - $D_9$). The symbols used in computing $D_1$ to $D_9$ are: S = Total number of species, N = Total sum of RD of all species, pi= Proportional RD of $i^{th}$species (ni/N), ni = RD attribute of each species and Nmax =RD attribute of the most important species. Species diversity indices were calculated by using RD values.

**Species richness indices**

$D_1$, Species count (Number of species/area in the present study the no. of species that occurred in quadrats sampled). $D_2$, Margalef index (Clifford and Stephenson 1975).

$$D_2 = \frac{S-1}{1n\ N}$$

$D_3$, Menhinick index (Whittaker 1977)

$$D^3 = \frac{S}{\sqrt{N}}$$

**Information statistic indices**

$D_4$, Shannon-index (H') (Shannon and Weaver 1949)

$$D_4 = -\sum pi \ln pi$$

$D_5$, Evenness (Pielou 1966)

$$D_5 = \frac{D_4}{\ln S}$$

$D_6$, Brillouin index (HB) (Brillouin 1962)

$$D_6 = \frac{\ln N! - \Sigma \ln ni!}{N}$$

$D_7$, Evenness (Brillouin 1962)

$$D_7 = \frac{HB}{HB_{max}}$$

Where,

$$HB_{max} = \frac{1}{N} \ln \frac{N!}{\{[N/S]!\}^{s-r} \{([N/S]+1)!\}^{r}}$$

N/S = integer of N/S

r = N-S (N/S)

**Dominance measures**

$D_8$, Berger-Parker index (Berger and Parker 1970)

$$D_8 = \frac{N_{max}}{N}$$

$D_9$, Simpson index (Simpson 1949)

$$D_9 = \sum pi^2$$

**β diversity**

β diversity was calculated within a vegetation at a study site by dividing the total number of species at a site by the average number per sample (Whittaker 1972).

**Soil analysis**

Nine representative surface soil samples (0–10 cm) were collected from each study site in the months of October 2021 (Rainy), February 2022 (winter), and June 2022 (summer). The soil samples were air-dried and sieved (2 mm). The soil moisture content, pH, total organic carbon (Walkley and Black method), available and total nitrogen (microkjeldahl's method), exchangeable Na, K and Ca of each soil sample were estimated by flame photometer according to Piper (1944).

**Table 1.** Seasonal changes in relative density (RD) of top five dominants at four different sites in an Indian dry tropical region. RD values of these species are also shown at the sites of their occurrence irrespective of their dominance rank.

| Botanical Name | Rainy | | Winter | | Summer | |
|---|---|---|---|---|---|---|
| | AC | EG | AC | EG | AC | EG |
| *Acalypha indica* L. | - | 7.54 | - | 1.17 | - | - |
| *Ageratum conyzoides* L. | 21.95 | - | 14.15 | - | 12.66 | - |
| *Anisomeles indica* (L.) Kuntze | 0.44 | - | 10.88 | - | - | - |
| *Avena sativa* L. | 2.19 | - | - | - | - | - |
| *Cannabis sativa* L. | 2.67 | 4.19 | 1.08 | 2.57 | - | 5.14 |
| *Cenchrus ciliaris* L. | - | 1 | - | 1.62 | - | 0.96 |
| *Chenopodium album* L. | 0.73 | 0.63 | 2.22 | - | 0.96 | - |
| *Commelina benghalensis* L. | 3.05 | 2.6 | 1.95 | - | 1.92 | - |
| *Cynodon dactylon* (L.) Pers. | 39.32 | 22.94 | 33.62 | 22.27 | 29.13 | 30.16 |
| *Dactyloctenium aegyptium* (L.) Willd. | - | 0.05 | - | 1.76 | - | 0.64 |
| *Echinochloa colonum* (L.) Link | 1.55 | 0.85 | - | - | - | - |
| *Euphorbia hirta* L. | 2.29 | - | - | - | - | - |
| *Gamochaeta pensylvanica* (Willd.) Cabrera | 0.38 | 0.63 | 6.48 | 20.05 | - | - |
| *Holoptelea integrifolia* (Roxb.) Planch | 0.41 | 0.85 | 0.22 | - | 0.8 | - |
| *Indigofera linnaei* Ali | 1.24 | 4.14 | 0.54 | 1.17 | 0.64 | 3.85 |
| *Lantana camara* L. | 1.36 | - | 1.08 | - | 2.08 | - |
| *Lepidium didymum* L. | 0.54 | 5.2 | 1.95 | 2.43 | - | 3.69 |
| *Oldenlandia corymbosa* L. | - | 1.16 | - | 2.16 | - | 2.25 |
| *Oplismenus undulatifolius* (Ard.) P. Beauv. | 0.06 | 1 | 0.36 | - | - | 1.12 |
| *Oxalis corniculata* L. | 1.52 | 1.38 | 11.16 | 11.24 | 5.12 | 11.73 |
| *Parthenium hysterophorus* L. | 4 | 3.93 | 3.58 | 2.84 | 10.09 | 8.19 |
| *Phyllanthus amarus* Schumach and Thonn. | 3 | 4.4 | 1.9 | 1.94 | 2.08 | 4.34 |
| *Senna obtusifolia* (L.) HS Irwin and Barneby | - | 2.6 | - | - | - | - |
| *Sida rhombifolia* L. | - | 2.7 | - | 1.86 | - | - |
| Other species (No in parenthesis) | 13.3<br>(32) | 32.21<br>(34) | 8.83<br>(23) | 26.92<br>(16) | 34.52<br>(13) | 27.93<br>(5) |

## RESULTS

### Dominant species composition

A total of 82 plant species distributed over 32 families (30 dicot and 2 monocot) were documented. Notably, the highest number of species was recorded during the rainy season (79), followed by winter (54) and summer (32). Among herbaceous species, families such as Poaceae (15), Fabaceae (9), Amaranthaceae (6), Asteraceae (6), Malvaceae (6), Lamiaceae (4), and Moraceae (4) collectively accounted for over 60% of the total flora. It is worth mentioning that Poaceae alone contributed to more than 18% of the total species.

Analysis of species occurrence in different seasons showed a diversity order of rainy > winter > summer (Table 1) at each site, with the EG site showing higher diversity compared to the AC site during the rainy season. However, during the winter and summer seasons, the AC site exhibited higher diversity compared to the EG site. Notable shared species across all seasons and sites included *Cynodon dactylon*, *Indigofera linnaei*, *Oxalis corniculata* and *Parthenium hysterophorus*.

In the rainy season, dominant species at the AC site included *Cynodon dactylon*, *Ageratum conyzoides* and *Parthenium hysterophorus,* while at the EG site, *Cynodon dactylon*, *Acalypha indica* and *Lepidium didymum* were dominant. During the winter season, *Cynodon dactylon* emerged as the top leading dominant at both sites, with *Oxalis corniculata* ranking third. In the summer season, *Cynodon dactylon* remained dominant at both sites, with *Parthenium hysterophorus* ranking third. These findings highlight the dynamic nature of species dominance across seasons and sites within the study area.

### Vegetation similarity across site and season

AC and EG sites varied in their similarity with vege-

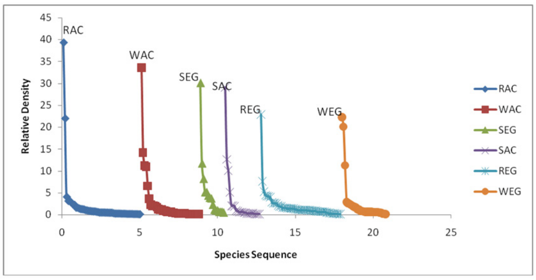


**Fig. 1.** Dominance-diversity curve of vegetation across different sites and seasons. The first letter of the code indicates season (R: Rainy, W: winter, S: summer) and the next two letters indicate study sites (AC: *Ageratum conyzoides*, EG: *Eucalyptus globulus* site).

tation of the other with change of seasons (Table 2). AC site in rainy season had relatively high similarity with its own vegetation in summer and winter vegetation compared to vegetation at EG sites in different seasons. In contrast, the EG site in rainy season had much lesser similarity with AC sites in different seasons. In fact, rainy EG site had lesser similarity with its own vegetation too with change of seasons. AC sites in winter and summer showed the least similarity with EG site in rainy season. Maximum similarity was recorded between EG sites in winter and summer. However, in the winter and summer seasons, the vegetation at both sites exhibited much higher similarity, with coefficients of 0.61 and 0.75, respectively. Notably, during the summer season, the similarity between the sites was particularly pronounced, indicating a distinct similarity with a coefficient below 0.50. These findings suggest varying levels of similarity in vegetation composition between the AC and EG sites across different seasons, with the summer season showing the most pronounced resemblance between the two sites.

**Table 2.** Spatial and seasonal similarity of the site vegetation based on similarity coefficient applying Modified Sorenson Index (using species relative density values).

| | REG | WAC | WEG | SAC | SEG |
|---|---|---|---|---|---|
| RAC | 0.46 | 0.66 | 0.54 | 0.66 | 0.53 |
| REG | | 0.39 | 0.48 | 0.35 | 0.51 |
| WAC | | | 0.61 | 0.64 | 0.60 |
| WEG | | | | 0.54 | 0.75 |
| SAC | | | | | 0.67 |

## Soil properties

The soil characteristics changed with site and season (Table 3). It revealed significant changes in soil moisture content with change of season. Organic C and total N of soils at EG site recorded to be higher in all seasons compared to AC site soils. However, C:N ratio did not show significant change. Exchangeable cations also did not exhibit significant changes.

## Dominance-diversity structure

The dominance (in terms of density)-diversity curves for the investigation vegetation across different seasons, revealed a comparable trend (Fig. 1). Top 1-3 dominant species were identified as major resource utilizers across all study sites, indicating a concentrated resource exploitation pattern. This trend persisted across vegetation at both the AC and EG sites throughout all three seasons, exhibiting a near geometrical distribution pattern. However, this geometrical pattern of resource share was sharpest in rainy and winter seasons at AC site.

At both sites, *Cynodon dactylon* emerged as a

**Table 3.** Soil characteristics (mean ± SE) of four different sites in an Indian dry tropical region (n=9). Means with common letters are not significantly different at p≤ 0.05 according to Tukey's HSD test.

| Parameters | Rainy AC | Rainy EG | Winter AC | Winter EG | Summer AC | Summer EG |
|---|---|---|---|---|---|---|
| pH | 7.1±0.12ab | 6.4±0.14a | 7.0±0.13ab | 6.5±0.19a | 7.3±0.22b | 6.9±0.16ab |
| Mositure content | 14.9±0.74c | 14.5±0.62c | 8.6±0.43b | 9.6±0.42b | 4.6±0.26a | 5.3±0.32a |
| Organic carbon | 1.1±0.09ab | 1.7±0.26b | 0.9±0.10a | 1.5±0.22ab | 1.22554±0.08ab | 1.80265±0.24b |
| Total nitrogen | 0.05±0.003a | 0.07±0.005b | 0.04±0.003a | 0.05±0.002ab | 0.05±0.003a | 0.06±0.003b |
| C:N ratio | 23.0±2.08a | 24.6±2.98a | 23.6±2.46a | 29.0±4.74a | 27.5±3.00a | 27.4±3.15a |
| Exchangeable Na | 0.07±0.009a | 0.09±0.019a | 0.05±0.005a | 0.07±0.007a | 0.04±0.003a | 0.09±0.013a |
| Exchangeable K | 0.10±0.015a | 0.10±0.016a | 0.11±0.009a | 0.15±0.016a | 0.10±0.012a | 0.12±0.019a |
| Exchangeable Ca | 0.36±0.073a | 0.67±0.076b | 0.54±0.034ab | 0.33±0.054a | 0.47±0.045ab | 0.46±0.050ab |

**Table 4.** Diversity estimates of the vegetation at various study sites in three seasons using different diversity indices. Codes: AC: *Ageratum conyzoides*, EG: *Eucalyptus globulus* site).

| Diversity indices | Rainy | | Winter | | Summer | | |
|---|---|---|---|---|---|---|---|
| | AC | EG | AC | EG | AC | EG | Max/Min |
| $D_1$ (Species count) | 50 | 53 | 38 | 29 | 23 | 16 | 3.31 |
| $D_2$ (Margalef index) | 10.64 | 11.29 | 8.03 | 6.08 | 4.78 | 3.26 | 3.47 |
| $D_3$ (Menhinick index) | 5.00 | 5.30 | 3.80 | 2.90 | 2.30 | 1.60 | 3.31 |
| $D_4$ (Shannon's index) | 2.37 | 3.28 | 2.35 | 2.07 | 1.56 | 1.84 | 2.10 |
| $D_5$ (Evenness pielou) | 0.61 | 0.83 | 0.65 | 0.62 | 0.50 | 0.66 | 1.66 |
| $D_6$ (Brillouin index) | 2.03 | 2.87 | 2.12 | 1.83 | 1.38 | 1.70 | 2.08 |
| $D_7$ (Evenness (Brillouin) | 0.62 | 0.79 | 0.63 | 0.59 | 0.47 | 0.66 | 1.66 |
| $D_8$ (Berger- Parker index) | 0.39 | 0.23 | 0.34 | 0.22 | 0.29 | 0.30 | 1.77 |
| $D_9$ (Simpson's index) | 0.21 | 0.08 | 0.17 | 0.24 | 0.38 | 0.28 | 5.06 |
| Beta Diversity | 1.59 | 2.81 | 1.72 | 1.31 | 3.69 | 2.57 | 2.81 |

prominent exploiter of major resources, evident from its largest share of relative density. Additionally, at the AC site, *Ageratum conyzoides* demonstrated consistent higher resource utilization across all seasons. Conversely, at the EG site, *Oxalis corniculata* was one of the top most the major resource utilizers during the winter season. However, *Parthenium hysterophorus* dominated during the summer season. These observations underscore the dynamic nature of resource utilization patterns across different species and seasons within the dry tropical region, highlighting the ecological significance of key plant species in shaping vegetation dynamics.

**Species diversity**

Table 4 provides a comprehensive overview of seasonal diversity levels across different sites, utilizing nine diversity indices based on the relative density of species (i.e., N = 100). Notably, different indices ranked site diversity differently, reflecting the multifaceted nature of biodiversity assessment.

Richness indices, including species count ($D_1$), Margalef index ($D_2$), and Menhinick's index ($D_3$), exhibited maximum values during the rainy season at the EG site. Similarly, information statistic indices such as Shannon index ($D_4$) and Brillouin index ($D_6$) also showed maximum values at the EG site during this season, highlighting the richness and evenness of species distribution. Moreover, the EG site demonstrated the highest range of diversity variation across seasons, with $D_4$ consistently surpassing $D_6$. Dominance measures, including Berger-Parker index ($D_8$) and Simpson index ($D_9$), displayed higher values for sites with lower diversity. Specifically, the highest values of dominance concentration ($D_9$) were observed at the AC site during the rainy and summer seasons, and at the EG site during the winter season.In terms of discriminant ability to discern subtle differences in diversity, the dominance measure Simpson index exhibited the highest maximum: Minimum ratio (5.06), followed by Margalef index (3.47) and Menhinick index (3.31). In contrast, the widely used Shannon index showed a comparatively lower ratio (2.10).

**β diversity**

β diversity varied three times ranging between 1.31 and 3.69 (Table 4). Notably, the lowest values were observed at the EG site during the winter season. Generally, β diversity at the AC site tended to be higher compared to the EG site, except during the rainy season. Interestingly, β diversity exhibited a gradual increase during the summer season at both sites. However, no such consistent pattern was observed in the other seasons. These findings suggest dynamic fluctuations in species richness and turnover between different samples within the same site across seasons, underscoring the complex ecological dynamics at play in the studied area.

## DISCUSSION

Seasonal variation in species richness and changing dominants with site and season, as observed in the present study is reflective of spatio-temporal dynamics of the vegetation here. Agrawal and Narayan (2017) reported a comparable nature of vegetation dynamics in peri-urban areas of Bulandshahr in the vicinity of Delhi. In fact, the mosaic nature of vegetation organization discernible even at relatively lower spatial scale has often been reported in Indian dry tropics, especially across diverse anthropo-ecosystems here (Gupta and Narayan 2006). Larger number of rainy florain the study area followed by winter and summer, as evinced in this study, possibly indicative of homogenization impact of rains favoring growth and establishment of larger variety of species at relatively spatial scale, and nature's selection of species varying with their stress tolerance across different site-stress conditions. The dominance of certain families, such as Poaceae, Fabaceae, and Asteraceae, underscores their ecological significance and potential influence on community dynamics. While Poaceae could be attributed to dominance of graminoids in disturbed ecosystems, the dominance of Fabaceae ostensibly is reflective of adaptive significance under dry tropical conditions (Gupta and Narayan 2010).

The comparison of species composition between the AC and EG sites demonstrated notable variations across seasons. While moderate similarity was observed during the rainy season, higher similarity indices were recorded during winter and summer, indicating convergence in plant community composition during these periods. Interestingly, the distinct high similarity observed in the summer season suggested unique environmental conditions or ecological processes influencing species composition at both sites during this period. Observed values of Sorensen's similarity index were different in the results of Girmay *et al.* (2024) whose observed sorensen's similarity index values ranged between 0.22-0.40 for vegetation in a botanical garden in Ethiopia, with pronounced dominance of invasive flora.

Varying soil characteristics across site-season conditions revealed temporal variability, with significant changes observed with the change of season, although change was not significant between the sites in the same season, thus signifying importance of seasonal dynamics here. Furthermore, the EG site soils exhibited consistent richness in organic carbon and total nitrogen in all three seasons compared to the soils at AC site, highlighting potential differences in soil fertility and nutrient cycling dynamics between the two sites.This finding suggests that the EG site may have higher organic matter content and nitrogen availability, which could influence soil fertility and plant growth dynamics throughout the year. Meng *et al.* (2023) reported the understory species, as evinced in herbaceous layer under Eucalyptus trees, influencing soil characteristics in the urban forests of Beijing. However, across the two major study sites varying in dominant alien flora, no significant difference was observed in C:N ratio and exchangeable sodium and potassium levels in soils.

The dominance (in terms of density in this study) diversity curves depicted a pattern where a limited number of species, notably monocot grass species *Cynodon dactylon* in herb layer, exhibited high resource utilization across all study sites and seasons; herb communities showed dominance of a single species (unimodal pattern) also in the study of Xu *et al.* (2021). This suggested potential dominance of certain species in resource acquisition and utilization, influencing community structure and composition. The near-geometrical pattern observed in the density-diversity curves underscores the importance of understanding species interactions and resource partitioning within plant communities. Dominance-diversity curves for vegetation across diverse anthropo-ecosystems in peri-urban areas also been reported to indicate only a few dominant species in urban sprawl areas exploiting major share of resources (Gupta and Narayan 2006, 2010)

Differing diversity index values across varying site-soil conditions and seasons revealed varying patterns of species richness and diversity between the vegetation at AC and EG sites in different seasons. The EG site exhibited higher diversity, particularly in the rainy season, indicating greater species richness and evenness compared to that at AC site. However, differences in dominance measures highlighted contrasting patterns of species dominance and community structure between the two sites across seasons, emphasizing the need for comprehensive assessments of biodiversity metrics. Patel *et al.* (2022) reported varying diversity attributable to disturbance regimes under dry tropical conditions. β diversity that ranged from 1.31 to 2.69 indicated spatial and temporal variability in species composition at the AC and EG sites, with differing patterns observed across seasons. While AC site harboring relatively lower alpha diversity generally exhibited higher β diversity compared to EG. However, exceptions were noted during the rainy season, where homogenization impact of rainy seasons appears to have been interfered with other anthropic factors. The observed complex patterns underscore the influence of environmental factors, spatial heterogeneity, and species interactions on community composition and turnover across seasons. Higher disturbance level and poor species pool have often been considered responsible for lower beta diversity in herbs (Sekar *et al* 2023).

In conclusion, the comparative analysis of plant species composition, soil properties, density and diversity structure between the exotic invasive *Ageratum conyzoides* dominated AC site and herb layer under introduced *Eucalyptus globulus* EG study site provided valuable insights into the ecological dynamics of these ecosystems. The observed variations highlight the complex interplay of environmental factors, seasonal dynamics and species interactions shaping plant community structure and composition. These findings underscore the importance of considering temporal and spatial scales in biodiversity assessments and conservation strategies, emphasizing the need for further research to elucidate underlying mechanisms driving observed patterns.

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