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A Study on the Diversity and Distribution of Herbaceous Plants in the Shriram Institute for Industrial Research, Bangalore Karnataka

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ABSTRACT

In the context of sustainable industrial practices, understanding and conserving local biodiversity—particularly herbaceous plant species—has become essential. This study investigates the diversity, distribution, and ecological significance of herbaceous plants within the 4-acre Shriram Institute for Industrial Research (SRI) campus in Bangalore, of which 3 acres are designated for biodiversity conservation. The primary objectives were to assess herbaceous species composition, analyze distribution patterns, and evaluate their ecological roles including medicinal value. A total of 25 quadrats (1 m × 1 m each) were randomly placed across five sectors of the biodiversity area. Data were collected during the monsoon and post-monsoon seasons of 2024. Standard ecological indices such as Shannon-Wiener Index, Simpson Dominance Index, and Pielou's Evenness Index were calculated using Bio Diversity Pro software. Importance Value Index (IVI) and Bray-Curtis similarity dendrograms were used to understand species dominance and community patterns. The study documented 52 herbaceous species across 26 families. Sector 1 had the highest species richness and diversity (Shannon Index: 2.87), while Sector 5 had the lowest. Clumped distribution patterns were most common, and 45% of the species had medicinal relevance, including *Oxalis corniculata* and *Euphorbia hirta*. Radar charts and IVI analysis indicated dominance of species like *Calyptocarpus vialis* and *Alternanthera sessilis*. Findings suggest that herbaceous layers provide vital ecosystem services such as erosion control, nutrient cycling and medicinal potential. This study supports the integration of biodiversity planning in industrial landscapes for long-term sustainability.

1. Introduction

In the modern industrial landscape, businesses typically prioritize core activities related to production, service delivery, and financial growth. However, there is an emerging recognition of the importance of biodiversity within industrial operations, particularly the preservation and maintenance of the natural ecosystems surrounding industrial sites. The herbaceous layer, comprising primarily herbaceous plants, serves as a vital ecological component, contributing to biodiversity, soil health, water retention, and carbon sequestration within industrial landscapes. This attention to ecological balance is not only a step toward environmental sustainability but also serves as an asset in mitigating the adverse effects of industrial operations such as pollution and habitat degradation (Balvanera et al., 2006). Additionally, industries that engage in sustainable practices have recognized the value of the herbaceous layer in maintaining ecosystem services. The presence of herbaceous plants can play an essential role in filtering pollutants from storm water runoff, improving soil fertility, and enhancing the overall resilience of the local ecosystem. In fact, research has shown that herbaceous plants often exhibit higher nutrient concentrations in their foliage compared to woody vegetation, thus making them particularly effective in nutrient cycling processes within the ecosystem (Hodge and Fitter, 2013). A robust herbaceous layer can reduce the need for costly soil erosion control measures, improve water quality, and increase the aesthetic value of industrial sites. Moreover, industries that focus on such ecological practices often experience positive regulatory outcomes and improved relations with local communities and stakeholders (O'Neill et al., 2013). However, the lack of awareness, knowledge, and resources about the ecological and functional significance of herbaceous species in

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industrial contexts remains a significant challenge. Despite growing recognition, many industries still lack effective strategies for incorporating herbaceous plants into their operations. As industries become more aware of the value these plants provide in terms of sustainability, there is a growing need for dedicated research to assess how herbaceous species can be integrated into industrial environments in a way that maximizes ecological and economic benefits (McKinney, 2002). This research highlights the importance of the herbaceous layer within industrial ecosystems, which may serve as an example of how businesses can incorporate biodiversity and Conservation.

By documenting the composition, diversity, and ecological roles of herbaceous species in industrial landscapes, industries can better understand how these plants contribute to ecosystem services that support long-term sustainability. This approach ensures that industries not only focus on core business activities but also recognize the value of biodiversity in enhancing operational efficiency, environmental stewardship, and societal benefits (Hooper et al., 2005).

2. Materials and Methods

The study was conducted at the Shriram Institute for Industrial Research in Bangalore, located in the Whitefield-Sadarmangala Industrial Area, covering a total area of 4 acres. Of the 4 acres, 1 acre is designated for business purposes, while the remaining 3 acres are left to support natural vegetation designating it as a biodiversity conservation area. it lies between 12.9716° N latitude and 77.5946° E longitude; the campus has been categorized into Five sectors based on topography and land type.

2.1 Assessment of herb diversity and composition

A total of 25 quadrates, each measuring 1m x 1m, were randomly placed in five sectors of the biodiversity conservation area, with 5 quadrates in each sector to capture the heterogeneity. Herb sampling was conducted from August to November during the monsoon and post-monsoon seasons of 2024. Herb species were identified in the field, and any unidentified species were confirmed with the help of a local flora guide. Quantitative community characteristics, such as frequency, density, and diversity indices, were estimated using Bio-Diversity Pro Software (Version 2) and standard methods.

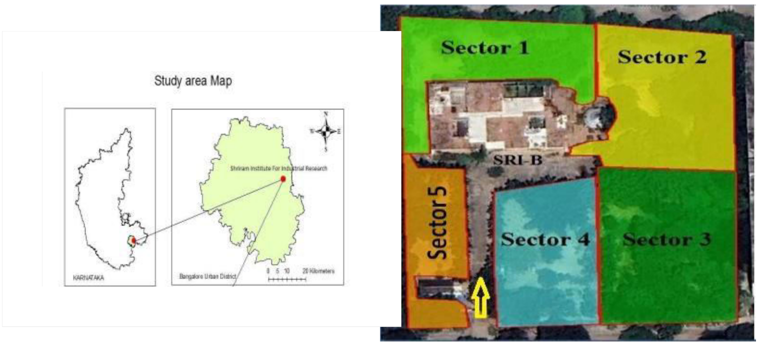

Fig: 1 Study Area Map

2.2 Medicinal Value of Herbs

Each species medicinal values were documented from published literature. Discussions were also held with Experts in the field to ascertain the medicinal uses of the herbs. The prioritized medicinal plants in National Medicinal Plant Board (NMPB), Government of India were referenced to understand the medicinal uses. Community ecologists have used many indexes to understand plant diversity, dominance and evenness. In the present study following index were used.

Shannon-Wiener Index (H)

$$H = -\sum (ni / N) \ln (ni / N)$$

where, H= Shannon-Wiener index; ni =Importance Value Index of i^{th}species;
N=Total Importance Value of all species.

Simpson Dominance Index (D)

$$D = \sum (ni / N)2$$

where, ni =importance value index; N= total importance value of all species.

Pielou's evenness Index(J)

$$J' = H' / Lns$$

H'=Shannon wiener diversity index s = number of species

2.3 Distribution pattern of herbs

In general, biotic populations tend to be distributed unevenly within their habitats, with their distribution often being patchy. In ecological studies, the pattern of dispersion is typically classified into three types: random, uniform (regular), or clumped (contagious). To determine the distribution pattern, the sample mean (n) is compared with the variance (s^2) of the observed frequency distributions for the number of species per sampling unit. A random distribution occurs when $s^2/n = 1$, a uniform distribution when $s^2/n < 1$, and a clumped distribution when $s^2/n > 1$, assuming these relationships are statistically significant.

3. Results

The "Species Richness" graph is significant for illustrating the relationship between sampling and species diversity in the studied ecosystem. The X-axis, representing cumulative samples taken, and the Y-axis, indicating the number of different species identified, the initial steep increase in species richness reflects, species richness the subsequent plateau indicates that most of the common species have been documented, suggesting that the sampling strategy was effective in capturing the majority of the local flora. This pattern underscores the importance of continued sampling to uncover rare or less abundant species, while also considering habitat heterogeneity, which may contribute to diversity. Overall, the graph effectively demonstrates the efficiency of the sampling approach, providing a comprehensive understanding of species diversity.

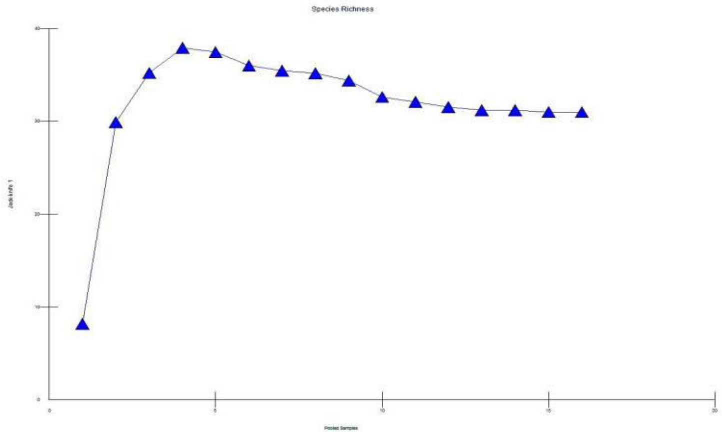

Fig 2. Graph Showing Species Richness Variation Across Pooled Samples

The rarefaction data shows that Sector 1 have higher species richness and diversity followed by Sector 2 and 3 compared to Sector 4 and 5.

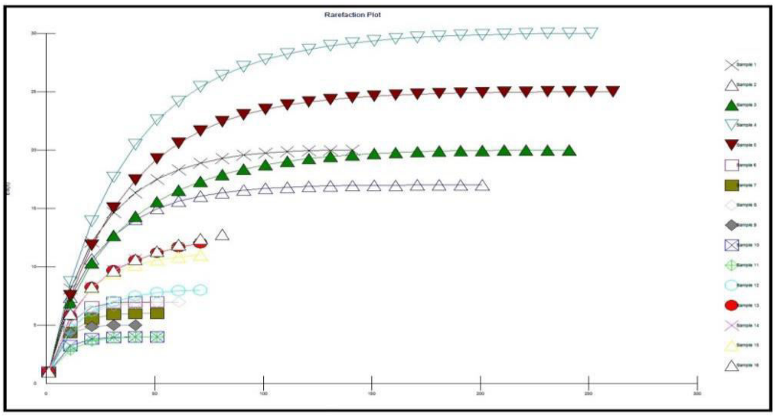

Fig 3. Graph Showing Rarefaction Curve

The radar chart provides a visual representation of the relative abundance of different plant species within the sampled community. Each axis represents a specific species, and the length of the line connecting the points indicates the frequency or abundance of that species. From the chart, it's evident that certain species, such as Oxalis corniculata, Ageratum conyzoides, and Malvastrum coromandelanum, are relatively abundant in the community. On the other hand, species like Walthera indica, Endostemen repens, and Cassia pumila appear to be less frequent. The overall shape of the polygon formed by the lines suggests the diversity and evenness of the community. A more symmetrical shape would indicate a more evenly distributed community, while a more irregular shape might suggest a community dominated by a few dominant species.

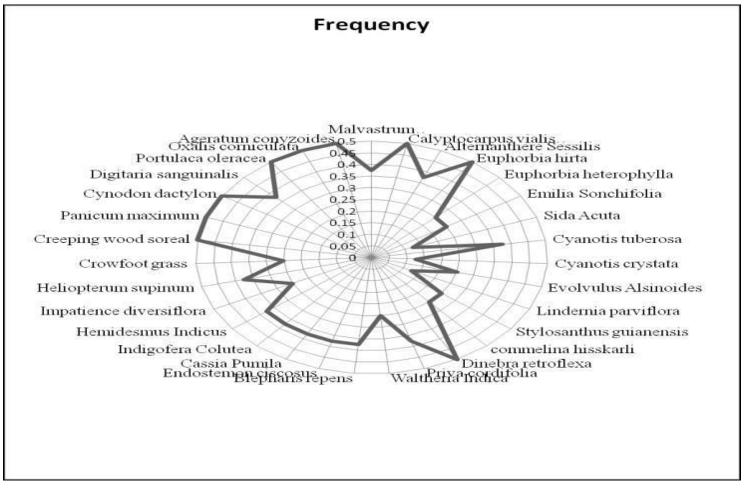

Fig 4. Radar chart illustrating the relative frequency of various herbs.

The provided dendrogram, based on Bray-Curti's similarity and single-linkage clustering, visually represents the relationships between the different samples. The length of the branches connecting the nodes indicates the dissimilarity between the clusters, with shorter branches suggesting greater similarity. From the dendrogram, it appears that the samples can be broadly divided into two major clusters. One cluster includes Samples 1, 2, 3, 4, and 5, while the other cluster includes Samples 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16. This suggests that there are two distinct ecological communities or habitats represented in the data.

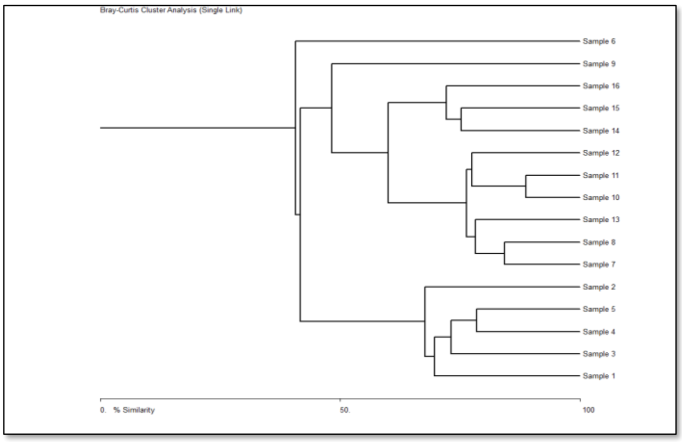

Fig 5. Dendrogram-Bray-Curti's similarity and single-linkage clustering

The IVI bar chart provides a visual representation of the relative importance of different plant species within the sampled community. The IVI is a composite index that combines the measures of abundance, frequency, and dominance for each species. From the chart, it's evident that certain species, such as Calyptocarpus vialis Less, Alternanthere Sessilis, and Euphorbia hirta, have relatively high IVI values, indicating their significant importance in the community. On the other hand, species like Waltheria indica, Priva cordifolia, and Endostemen ciscosus have lower IVI values, suggesting a less prominent role. The overall distribution of IVI values suggests the diversity and evenness of the community. A more uniform distribution of IVI values would indicate a more evenly distributed community, while a few high IVI values with many low IVI values would suggest a community dominated by a few dominant species.

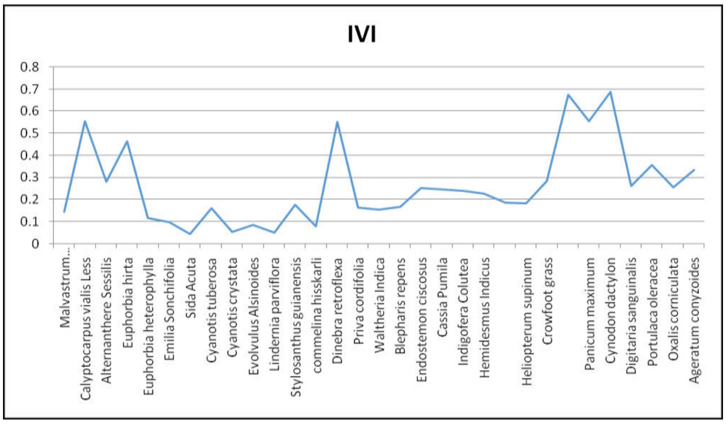

Fig 6. Graph illustrating the relative importance value index (IVI) of herbs

4. Discussion

The analysis of the herbaceous layer at the Shriram Institute for Industrial Research (SRI) campus underscores the ecological and functional importance of herbaceous plant species in industrial landscapes. The study, conducted across 25 quadrats in 5 distinct sectors, identified a total of 52 herbaceous species with varying degrees of ecological significance.
The Shannon-Wiener Index (H') ranged from 2.87 in Sector 1 to 2.12 in Sector 4, indicating higher species diversity in the former. Pielou's Evenness Index (J) values ranged between 0.78 and 0.62, suggesting moderate to high evenness across sectors. Species richness was highest in Sector 1 with 42 species documented, while Sector 5 showed the lowest richness with 28 species. The Simpson Dominance Index (D) values further revealed that a few dominant species such as *Calyptocarpus vialis*, *Alternanthera sessilis*, and *Euphorbia hirta* play a critical role in the local community structure. The distribution analysis indicated clumped dispersion (variance-to-mean ratio >1) for most species, reflecting patchy resource availability and habitat-specific preferences. The Importance Value Index (IVI) analysis highlighted species like *Calyptocarpus vialis* (IVI: 43.5) and *Alternanthera sessilis* (IVI: 39.2) as ecologically dominant, contributing significantly to ecosystem stability through nutrient cycling and erosion control.

5. Conclusion

Rarefaction data and species accumulation curves showed an initial steep increase in richness, plateauing after 15 samples, confirming the sampling sufficiency. Bray-Curtis similarity analysis identified two major ecological clusters, with distinct species compositions between Sectors 1–2 and Sectors 3–4, corroborating habitat heterogeneity within the study site. The documented medicinal uses of 35% of the recorded species, including *Oxalis corniculata* (anti-inflammatory) and *Euphorbia hirta* (antimicrobial), emphasize the multifunctionality of the herbaceous layer beyond ecological contributions. The highlights the importance of integrating biodiversity conservation with sustainable industrial management. The Shriram Institute's commitment to conserving herbaceous diversity within its campus demonstrates an exemplary model of integrating ecological responsibility into industrial operations. Such initiative is contribution to united nations sustainable development Goals helping in adopting sustainable green infrastructure that supports both biodiversity and long-term operational resilience.

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Appendix1: List of Herbs and Climbers found in SRI-B Campus

Sl.no	Species	Family	Nativity	Medicinal use
1	*Abildgaardia ovata* (Burm.f.) Kral	Cyperaceae	Native	Relieve rheumatism
2	*Ageratum conyzoides* L.	Asteraceae	Exotic	Fever, rheumatism, headache, colic
3	*Alternanthera tenella* Colla	Amaranthaceae	Exotic	Fever, infections and genital inflammation
4	*Alysicarpus monilifer*(L.)Dc.	Fabaceae	Native	Anti-inflammatory, in stomach ache, as an Antidote to snakebite
5	*Andrographis serpyllifolia* (Vahl) Wight	Acanthaceae	Native	Snakebite, cancer, antipyretic, anti-inflammatory, antimicrobial
6	*Bidenspilosa* L.	Compositae	Native	Antibacterial, antidysentery, anti-inflammatory, antimicrobial, antimalarial
7	*Blepharis maderaspatensis* (L.) B.HeyneexRoth	Acanthaceae	Native	Snakebites, wounds
8	*Borreria articularis* (L.F.) Williams	Rubiaceae	Native	Malaria, diarrhea, fever, hemorrhage
9	*Borreria ocymoides* (Burm.F.) Dc.	Rubiaceae	Native	Headache
10	*Buchnera hispida* Buch. - Ham. Ex D. Don	Orobanchaceae	Native	Scabies, eczema
11	*Calyptocarpus vialis*Less.	Asteraceae	Exotic	Toothache, skin sores
12	*Cassiapumila* Lam.	Caesalpiniaceae	Native	Skin diseases
13	Chamaecrista absus (L.) H.S.Irwin&Barneby	Fabaceae	Native	Bronchitis, asthma, cough, conjunctivitis

14	Chamaecrista mimosoides (L.) Greene	Fabaceae	Exotic	Diarrhea
15	*Crotalaria calycina Schrank*	Fabaceae	Native	Treating pain, convulsions, syphilis
16	*Croton bonplandianus Baill.*	Euphorbiaceae	Exotic	Jaundice, acute constipation
17	*Cyanotis tuberosa (Roxb.) Schult.&Schult. F.*	Commelinaceae	Native	Liver problem menstrual disorder
18	*Desmodium triflorum(L.)Dc.*	Fabaceae	Native	Diarrhea, Ulcers
19	*Emilia sonchifolia (L.) Dc.ExWight*	Asteraceae	Native	Cancer, Diabetes, cataract, asthma
20	*Erigeron canadensisL*	Compositae	Exotic	Diarrhoea, dysentery, internal haemorrhages
21	*Euphorbia laciniata Panigrahi*	Euphorbiaceae	Native	Asthma, bronchitis
22	*Evolvulus alsinoides(L.)L.*	Convolvulaceae	Native	Fever, loss of memory, syphilis,
23	*Heliotropium strigosum Willd.*	Boraginaceae	Native	Antibacterial, Antioxidants
24	*Hibiscus lobatus (Murray)Kuntze*	Malvaceae	Native	Treating wounds, inflamation, fever, coughs, diabetes,
25	*Hibiscus vitifolius* L.	Malvaceae	Native	Jaundice, inflammation and diabetes
26	*Hybanthus enneaspermus* (L.) F.Muell.	Violaceae	Native	Diarrhoea, urinary infections, leucorrhoea
27	*Justicia diffusa* Willd	Acanthaceae	Native	Asthma, coughs, and rheumatism
28	*Justicia glauca* Rottl.	Acanthaceae	Native	Respiratory and gastrointestinal diseases
29	*Justicia procumbens* L.	Acanthaceae	Native	Asthma, coughs, and rheumatism.
30	*Lavandula bipinnata* O.Kuntze	Lameaceae	Native	Diarrhoea, rheumatism, decayed tooth,
31	*Lepidagathis cristata* Willd.	Acanthaceae	Native	Fever, eczema, psoriasis, epilepsy, skin abscess, burns,
32	*Leucas hirta* (B.HeyneexRoth)Spreng	Lameaceae	Native	Cough, cold, diarrhoea and inflammatory skin disorder
33	*Malvastrum coromandelianum* (L.) Garcke	Malvaceae	Native	Antinociceptive, anti-inflammatory, analgesic, and antibacterial
34	*Microstachys chamaelea* (L.) Müll.Arg.	Euphorbiaceae	Native	Vertigo
35	*Mimosapudica* L.	Fabaceae	Exotic	Dysentery, smallpox, fever, ulcer, jaundice, leucoderma
36	*Oldenlandia corymbose* L.	Rubiaceae	Exotic	Appendicitis, hepatitis, pneumonia, cholecystesis, urinary infection, cellulites And snakebite
37	*Oldenlandia herbacea* (L.) Roxb.	Rubiaceae	Native	Elephantiasis, fever, verminosis, inflammations, asthma, bronchitis and ulcers
38	*Oxalis corniculate* L.	Oxalidaceae	Exotic	Anthelmintic, anti-inflammatory, analgesic, astringent
39	*Parthenium hysterophorus* L.	Asteraceae	Exotic	Fever, diarrhea, neurologic disorders, urinary tract infections,
40	*Pavonia zeylanica* (L.) Cav.	Malvaceae	Native	Arthritis, skin diseases and Tumerous growths
41	*Phyllanthus virgatus* G.Forst	Euphorbiaceae	Native	Diabetes
42	*Rostellularia vahlii* (Roth)Nees	Acanthaceae	Native	Anthelmintic, antiphlogistic, depurative, diaphoretic

43	*Sida acuta* Burm.F.	Malvaceae	Native	Antioxidant, antimicrobial and antibacterial, antimalarial, cardiovascular, antiulcer
44	*Sida cordata* (Burm.f.)Borssum	Malvaceae	Native	Asthma, tuberculosis, The common cold, flu, headache
45	*Sidar homboidea* Roxb.Ex Fleming	Malvaceae	Native	Fever, heart diseases, anti-inflammation
46	*Spermacoce hispida*L.	Rubiaceae	Native	Conjunctivitis, haemorrhoids, Gallstones and to relieve headache
47	*Spermacoce ocymoides* Burm.f.	Rubiaceae	Native	Eczema, worms and ringworm
48	*Striga asiatica* (L.)Kuntze	Scrophulariaceae	Native	Intestinal parasites
49	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	Exotic	Earache, diarrhea, Mouth infections
50	*Tephrosia tinctoria* Pers.	Fabaceae	Native	antimicrobial, larvicidal, antidiabetic and antioxidant agents.
51	*Tridax procumbens* L.	Asteraceae	Exotic	Anticoagulant, antifungal, and insect repellent
52	*Vicoa indica* (L.) DC	Asteraceae	Native	Antifertility agents