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Phytosociological analysis of Hamirgarh Eco-Park of Bhilwara district, Rajasthan state, India

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Abstract
Phytosociological study of Hamirgarh Eco-Park of Bhilwara district of Rajasthan was conducted during the period of July 2024 to July 2025 showed a significant management and reappearance of native and disappearance of invasive vegetation. The floristic analysis revealed the existence of more than 50 species in which 33 are dominant species belongs to 36 genera distributed across 24 families. The plant species diversity is measured by IVI and various indices. The research reveals four different communities, which were recorded by using TWINSPAN classification each characterized by unique dominance patterns and rich in tree diversity. The field number S_1 and S_2 shows plant association of Terminalia pendula- Boswellia serrate (Kali-Dhonk-Salar) on hill top and Senegalia-Vachellia (Khair-Ronjh) in down-hill area. The field number S_3 and S_4 shows Senegalia catechu, Vachellia leucophloea, Vachellia nilotica (Khair-Ronjh-Babul) association. All field number shows Neltuma juliflora (Vilayati Babul) in transition zone or edge while Lantana camara (Badbeena) shows uniform distribution in study area as invasive species which is dangerous to ecological health of Hamirgarh Eco-Park.

Keywords: Eco Park, plant biodiversity, phytosociology, invasive species, communities

Introduction

Phytosociology is a subset of vegetation science and a branch of ecology that focuses on the study of plant communities and their inter-relationships involves the use of analytic and synthetic methods to characterize vegetation and their patterns of distribution that can provide a valuable insight into the degree of naturalness, dynamics of communities, including their response to environmental changes such as climate change, land use pattern and invasion of new species. Hence it is an important tool for environmental management and conservation, as it can help identify key plant species and ecological processes that support biodiversity and sustainable ecosystem functioning.

Eco-Parks are the sites which not only restore and preserve native vegetation but also provide an opportunity to attract tourists, students and nature lovers. Hamirgarh Eco-Park is a conservation reserve forest block notified on April 26, 2023 under Wildlife (Protection) Act 1972 as amended. Hamirgarh Eco Park is situated 15 km away from Bhilwara city towards south on Hamirgarh- Mangrop road, which lies between Latitude 25º19'33''N to 25º20'53" N and longitudes 74º 65' 47''E to 74º 67' 10''E, spread an area of 566.15 hectare which spread 500–900-meter width and 6-7 km length and divided into Compartments 1 to 5. It stands at an altitude of 425 meters above the sea-level. The stony and rocky soil is covered on hill tops while plain and foothills with a sandy loam. The climate is monsoonal receive approximately 500-600 mm rain in a year. May and June are hottest month with 45^{0}C while January is coldest month with 5^{0}C. Although taxonomical, floral and phytosociological studies on vegetation of Hamirgarh Eco Park and its environs have not adequately been studied so far. It is therefore, the present investigation has been undertaken.

Material and Methods

Phytosociological studies, plant diversity, and its distribution, assessment of vegetation threats and conservation strategies related to community structure and its composition summarized by various workers includes (Braun Blanquet, 1932; Hanson and Churchill, 1961 [6]; Misra, 1968 [12]; Menon and Shah, 1982 [11]; Lemos *et al*., 2015; Cavalcante *et al*., 2000; Guedes *et al*, 2001; Packialakshmi *et al*., 2022) [13]. Ecological studies particularly on vegetation diversity of Rahasthan have been carried out by different workers (Gena and Sharma, 1988 [5]; Kikim and Yadav, 2001 [7]; Dadhich, 2016 [3]; Singh, 2019 and Sharma, 2023) [14, 15]. Furthermore, the phytosociological characters, including the including various indices have not been observed yet in study area.

The study area divided into S_1, S_2, S_3 and S_4 field number for phytosociological analysis. The studies conducted through a meticulous survey with 500 meter transect line and 31.9 × 31.9 m quadrat in each field number. For each selected site, 10 quadrates were laid down randomly along transect line left and right alternatively. Circumference at breast height (CBH) of tree species was measured at 1.37 m from ground level has been taken. Shrubs were measured at 5 cm above the ground level. Community character analysis of noted and tabulated observation was recorded and assessed as per formulas given by Shahid and Joshi 2016.

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Total Density of all the species}} \times 100$$

$$\text{Relative frequency(R. F.)} \frac{\text{Frequency of the species}}{\text{Total frequency of all the species}} \times 100$$

$$\text{Relative Dominance (basal area)} = \frac{\text{Basal area of the species}}{\text{Basal areas of all the species}} \text{x } 100$$

$$\text{IVI} = \text{R.D.} + \text{R.F.} + \text{R. Dom.}$$

Shannon- Wiener's Index of General Diversity (1963)

$H = -\sum P_i (\ln P_i)$; Where: H= Shannon Index, Σ = A Greek symbol that means "sum", ln = Natural log, P_i = Proportion of individuals of species and $Pi = \frac{ni}{N}$

Dominance Index/ Concentration of Dominance (CD)/ The Simpson Index (1949)

$CD = \sum_{i=1}^{s} [\frac{Ni}{N}]^2$ the value of $\frac{Ni}{N}$ is same as Shannon- Wiener value; Where: CD = Concentration of Dominance, Ni= Total number of individuals of each species, N= Total number of individuals of all species

Index of similarity (S)/ Sorenson's Coefficient (1948)

$S = \frac{2C}{S^1+S^2}$ Where; C= the number of common species in two communities, S^1= the total number of species found in community first, S^2= the total number of species found in community second

Indices of Species Richness/ Menhinick's Index (1964)

$D = \frac{S}{\sqrt{N}}$; Where: S = number of individual species, N = sum total of all the individual species

Indices of Species Evenness/ Pielou Index (1966)

$J = \frac{H}{\ln s}$; Where: H= Shannon Index and S= number of individuals

Whitford Index (1949) $WI = \frac{Abundance}{Frequency}$; It is used to calculate abundance to frequency ratio [A/F]

Result

Hamirgarh Eco-Park characterized by unique tree dominance patterns. Total 42 species reported during field survey out of which 07 species recorded outside the sample plots are *Aegle marmelos* (Bil-Patra/Billa), *Ailanthus excelsa* (Ardu), *Bauhinia racemosa* (Kachanar/ Jinjha), *Cassia fistula* (Amaltas), *Ficus benghalensis* (Bargad), *Ficus racemosa* (Goolar/Umra) and *Senna siamea* (Cassia). Twenty-Seven dominant species reported inside the sample plots. The results of the information collected for various parameters are discussed below (Table 1 & Table 2).

Table 1: Phytosociological analysis with floristic parameter at Hamirgarh Eco-Park of Bhilwara, Rajasthan

S.N.	Species Name	Local name	family	Flowering & fruiting	Quadrates of 31.9 m (average of 10 quadrats at each site)				No. of sps. in quad	Sps. in no. of quad
					S_1	S_2	S_3	S_4		
1.	*Azadirachta indica*	Neem	Meliaceae	Feb.-May	2	1	3	2	8	4
2.	*Boswellia serrate*	Salar	Burseraceae	Dec.-Apr.	4	5	-	-	9	2
3.	*Balanites aegyptiaca*	Hingota	Zygophyllacea (Balanitaceae)	Aug-Mar.	4	6	4	6	20	4
4.	*Butea monosperma*	Palash	Fabaceae	Feb.-May	1	2	4	6	13	4
5	*Calligonum polygonoides*	Phogda	Polygonaceae	Aug.-Nov.	1	-	-	1	2	2
6	*Capparis sepiaria*	Kanthar	Capparaceae	Mar.-Jun	1	1	-	-	2	2
7	*Cassia fistula*	Amaltas	Fabaceae	Feb.-May	1	1	-	-	2	2
8	*Crateva magna*	Barana	Capparaceae	Dec.-Mar.	1	-	-	-	1	1
9	*Dichrostachys cinerea*	Goya Khair	Fabaceae (Mimosaceae)	Nov.-May	1	1	4	2	8	4
10	*Diospyros melanoxylon*	Tendu	Ebenaceae	Jan.-April	1	-	-	-	1	1
11	*Flacourtia indica*	Kakun	Salicaceae (Flacourtiaceae)	Jan.-April	-	-	1	2	4	3
12	*Haloptelea integrifolia*	Churel	Ulmaceae	Jan.-May	2	1	3	3	9	4
13	*Lannea coromandelica*	Gurjan	Anacardiaceae	Dec.-Apr.	1	1	-	-	2	2
14	*Lantana camara*	Badbeena	Verbinaceae	Jan.- Dec.	2	2	5	6	14	4
15	*Mitragyna parvifolia*	Kalam	Rubiaceae	Aug.-Apr.	-	1	-	-	1	1
16	*Moringa oleifera*	Sahajan	Moringaceae	Jan.-Dec.	1	-	-	-	1	1
17	*Neltuma juliflora (Prosopis juliflora)*	Vilayati Babul	Fabaceae (Mimosaceae)	Dec.-Apr.	3	2	3	4	12	4
18	*Phoenix sylvestris*	Khajur	Arecaceae	Aug- Jan.	-	1	-	-	1	1
19	*Santalum album*	Chandan	Santalaceae	Aug.-Feb.	-	1	-	-	1	1
20	*Senegalia catechu (Acacia catechu)*	Khair/Khatta	Fabaceae (Mimosaceae)	May-Sept.	4	8	12	8	32	4
21	*Senegalia Senegal (Acacia Senegal)*	Kumatha	Fabaceae (Mimosaceae)	July-Mar.	-	-	1	1	2	2
22	*Sterculia urens*	Kadaya	Sterculiaceae	Jan.- April	-	1	-	-	1	1
23	*Terminalia pendula (Anogeissus pendula)*	Kali Dhok	Combretaceae	July-Nov.	25	20	4	2	51	4
24	*Vachellia leucophloea (Acacia leucophloea)*	Ronjh	Fabaceae (Mimosaceae)	Aug.-Feb.	2	2	5	6	14	4
25	*Vachellia nilotica (Acacia nilotica)*	Babul	Fabaceae (Mimosaceae)	July-Mar.	2	1	4	6	13	4
26	*Wrightia tinctoria*	Dudhi	Apocynaceae	Aug.-Jan.	1	-	-	-	1	1
27	*Ziziphus nummularia*	Jhari Ber	Rhamnaceae	Jan.-April	2	1	3	4	10	4
28	*Ziziphus xylopyrus*	Ber	Rhamnaceae	Jan.-April	1	1	2	2	6	4

Table 2: Phytosociological parameter for quantitative analysis of quadrat study at Hamirgarh Eco-Park of Bhilwara, Rajasthan

S. N	Species Name	Frq.	Den.	Abun.	BA m^2	Dom.	R.F.	R.D.	RDom	IVI
1.	*Azadirachta indica*	100	2.0	2	0.06	0.12	5.26	3.29	6.11	14.66
2.	*Boswellia serrate*	50	2.5	4.5	0.08	0.10	2.63	4.11	5.10	11.84
3.	*Balanites aegyptiaca*	100	5.0	5.0	0.01	0.05	5.26	8.23	2.55	16.04
4.	*Butea monosperma*	100	3.25	3.25	0.04	0.13	5.26	5.34	6.62	17.22
5	*Calligonum polygonoides*	50	0.50	1.0	0.01	0.005	2.63	0.82	0.25	3.7
6	*Capparis sepiaria*	50	0.50	1.0	0.01	0.005	2.63	0.82	0.25	3.7
7	*Cassia fistula*	50	0.50	1.0	0.02	0.01	2.63	0.82	0.51	3.96
8	*Crateva magna*	25	0.50	1.0	0.02	0.01	1.31	0.82	0.51	2.64
9	*Dichrostachys cinerea*	100	2.0	2.0	0.02	0.04	5.26	3.29	2.04	10.59
10	*Diospyros melanoxylon*	25	0.25	1.0	0.02	0.005	1.31	0.41	0.25	1.97
11	*Flacourtia indica*	75	1.0	1.33	0.01	0.01	3.94	1.64	0.51	6.09
12	*Haloptelea integrifolia*	100	2.25	2.25	0.09	0.20	5.26	3.70	10.19	19.15
13	*Lannea coromandelica*	50	0.50	1.0	0.04	0.02	2.63	0.82	1.01	4.46
14	*Lantana camara*	100	3.50	3.50	0.04	0.14	5.26	5.76	7.13	18.15
15	*Mitragyna parvifolia*	25	0.25	1.0	0.02	0.005	1.31	0.41	0.25	1.97
16	*Moringa oleifera*	25	0.25	1.0	0.02	0.005	1.31	0.41	0.25	1.97
17	*Neltuma juliflora*	100	3.0	3.0	0.03	0.09	5.26	4.93	4.58	14.77
18	*Phoenix sylvestris*	50	0.25	1.0	0.03	0.007	2.67	0.41	0.35	3.43
19	*Santalum album*	25	0.25	0.33	0.01	0.002	1.31	0.41	0.10	1.82
20	*Senegalia catechu*	100	8.00	8.0	0.02	0.16	5.26	13.16	8.16	26.58
21	*Senegalia Senegal*	50	0.50	1.0	0.01	0.005	2.63	0.82	0.25	3.7
22	*Sterculia urens*	25	0.25	1.0	0.02	0.005	1.31	0.41	0.25	1.97
23	*Terminalia pendula*	100	12.75	12.75	0.05	0.638	5.26	20.98	32.53	58.77
24	*Vachellia leucophloea*	100	3.50	3.50	0.01	0.035	5.26	5.76	1.78	12.8
25	*Vachellia nilotica*	100	3.25	3.25	0.03	0.097	5.26	5.34	4.94	15.54
26	*Wrightia tinctoria*	25	0.25	1.0	0.02	0.005	1.31	0.41	0.25	1.97
27	*Ziziphus nummularia*	100	2.50	2.50	0.01	0.025	5.26	4.11	1.27	10.64
28	*Ziziphus xylopyrus*	100	1.50	1.50	0.02	0.037	5.26	2.46	1.89	9.61

Discussion

The top ten tree and shrub species of Hamirgarh Eco-Park in term of IVI value are *Terminalia pendula* (58.77), *Senegalia catechu* (26.58), *Haloptelea integrifolia* (19.15), *Butea monosperma* (17.22), *Balanites aegyptiaca* (16.04), *Vachellia nilotica* (15.54), *Azardirachta indica* (14.66), *Vachellia leucophloea* (12.80), *Boswellia serrata* (11.84) and *Ziziphus xylopyrus* (9.61) (Figure1). The top five herbs reported in sample plots are *Oplismenus burmanni* (34.34), *Abutilon indicum* (14.34) *Cynodon Dactylon* (12.17) and *Aristida funiculate* (09.65). The most dominant plant family reported as Fabaceae. *Lantana camara* (18.15), *Neltuma juliflora* (14.77), *Parthenium hysterophorus* (10.74) showed highest IVI as exotic species category.

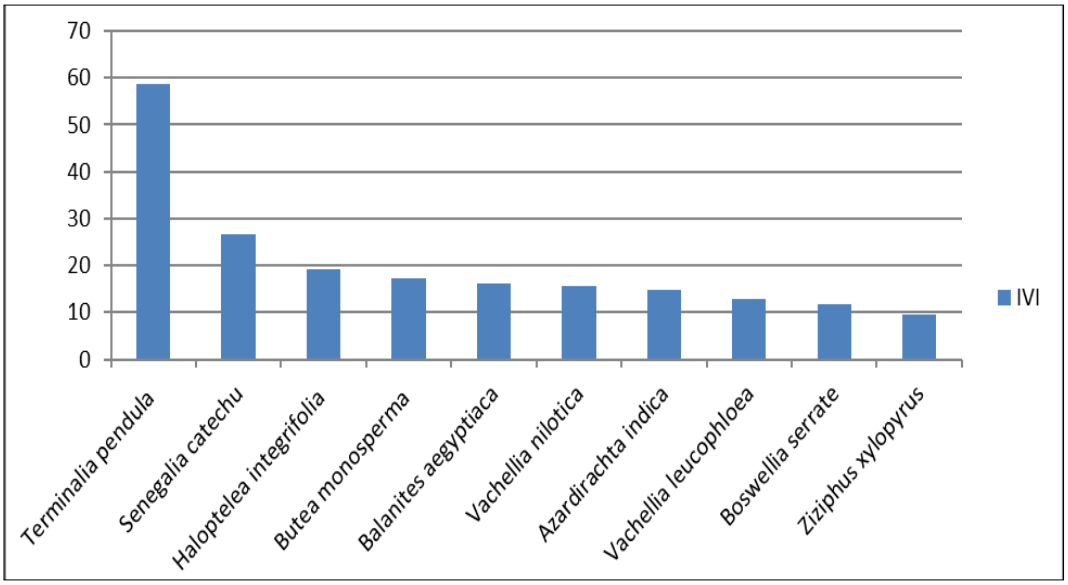

Fig 1: Top ten native tree species repoted in Hamirgarh Eco-Park in term of IVI

The Sorenson's Coefficient / Index of similarity maximum value recorded between S_3 and S_4 which is 96% followed by S_1 and S_2 which is 79% and between S_2 and S_3 is 72%. The maximum value Index of dissimilarity recorded between S_1 and S_4 communities which is 32% and marked difference in the distribution of plant species between S_1 and S_4 while site S_3 marked as site of transition zone. The current findings suggested that an active supervision program would publicise in the S_3 and S_4 communities to eradicate invasive species to proliferate feasible species.

Terminalia pendula and *Senegalia catechu* shows dominant as well most ecological successful species of study site The various indexes of phytosociological analysis of plants of Hamirgarh Eco-Park like Shennon-Wiener Index, Simpson Index, Pielou Index Whitford Index, Menhinick's Index calculated as given below (Table 3)

Table 3: Various indices of phytosociological analysis of Hamirgarh Eco-Park of Bhilwara, Rajasthan

Name of Species	No. of Indivisual /Quadrat	(H) Shannon and Wiener Index	(D) Simpson Index	Pielou Index H/lnS	Whitford Index A/F	Menhinick's Index D=S/√N
Terminalia pendula	51	1.054	0.111	0.020	0.12	3.446
Senegalia catechu	32	0.907	0.056	0.028	0.08	2.162
Haloptelea integrifolia	9	0.785	0.035	0.087	0.02	0.608
Lantana camara	14	0.728	0.033	0.052	0.03	0.946
Butea monosperma	13	0.651	0.029	0.050	0.03	0.878
Balanites aegyptiaca	20	0.579	0.026	0.028	0.05	1.351
Vachellia nilotica	13	0.484	0.017	0.037	0.03	0.878
Neltuma juliflora	12	0.411	0.014	0.034	0.03	0.810
Azardirachta indica	8	0.342	0.011	0.042	0.02	0.540
Vachellia leucophloea	14	0.289	0.009	0.020	0.03	0.946
Boswellia serrate	9	0.213	0.005	0.023	0.09	0.608
Ziziphus nummularia	10	0.156	0.004	0.015	0.02	0.675
Dichrostachys cinerea	8	0.095	0.002	0.011	0.02	0.540
Ziziphus xylopyrus	6	0.042	0.0007	0.007	0.01	0.405

Conclusion

This comprehensive phytosociological analysis enhances our understanding of the vegetation dynamics of Hamirgarh Eco-Park with a wide scope which will be useful for researcher's in future in different discipline and provides valuable baseline information related with forest development working plan for special attention would be focused on monotypic families and genera having single species which need to propagate and emphasizes the need of mitigation measures to address eradication of invasive species like *Neltuma juliflora*, *Lantana camara and Parthenium hysterophorus* for habitat quality and ecological significance. The high IVI of a species shows its dominance, power of regeneration and great ecological success. Species which are not recorded in sample plots must be managed by plantation to increase their ecological significance. Documentation of identified keystone or umbrella species may lead to multi-fold benefits for ecotourism and nature lovers.

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