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Phytosociological analysis on tree diversity of natural and developed forest of Bhopal district, Madhya Pradesh, India

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Abstract: *The present study deals with the phytosociological analysis of natural and developed forest sites of district Bhopal, Madhya Pradesh, India. All sites were distinct in field and differed in dominance, composition, diversity and structure. A total of 76 tree species, belonging to 62 genera and 12 families were recorded. Species richness was 16 to 38 ha^{-1} in all six sites. Tectona grandis dominated in all natural forest sites with Anogeissus, Butea, Lagerstroemia, Ougeinia and Terminalia sp. as co-dominants at different sites. In developed forest sites these species were replaced by Cassia siamea, Peltophorum pterocarpum, Samania saman, Dalbergia etc because of biotic interference.*

Key Words: *Diversity, dominance, interference, phytosociological, species richness.*

1. INTRODUCTION:

Trees are amongst the most significant elements of landscape and main components of forest ecosystem, as it provides shade for under-story for their better growth. The future composition of forests depends on potential of regeneration of tree species within a forest stand. Disturbances determine forest species composition, structure and processes as it facilitate changes in resource fluxes and lead to some form of reorganization of the disturbed patch or gap that may be similar or dissimilar to pre-disturbance levels over temporal and spatial scales. Due to introduction of alien species the composition of forest community is changed and sometimes new species replaced old species. An obvious approach to conserve plant biodiversity is to map distributional patterns and look for concentrations of diversity and endemism (Gentry 1992). Further, management of forest requires understanding of its composition in relation to other forests, the effects of past impacts on the present status and the present relationship of the forest with surrounding land uses (Geldenhuys & Murray 1993).

Recent studies have reported major changes in forests, with increase and shifts in plant species composition that favors fast-growing species over slow-growing ones. These pervasive alterations were attributed to global environmental change, and may result in dramatic shifts in the functioning of forest ecosystems. Drastic changes in land use pattern associated with urbanization have resulted in an immense impact on those fringe areas of human habitations where forests are situated. Repeated forest inventories, including detailed taxonomic identification, combined with information on species traits, enable a direct evaluation of the relationship between changes in tree species composition. Earlier Oommachan explored angiosperm flora of Bhopal (1977), since then floristic composition of tree diversity is changed due to plantation by CPA (Capital Project Administration) and urbanization. Therefore, the present study has been undertaken to compare the tree diversity of natural and developed forests and analyzed phytosociologically forest of Bhopal district, Madhya Pradesh, India.

2. MATERIALS & METHODS:

The study site (23°16′N latitude and 75°25′E longitude; altitude 503 m above the mean sea level) is located at Bhopal, the capital of Madhya Pradesh. 11.26 % covers the medium and open forest of total 2772 sq km area of Bhopal district. The forest type of district Bhopal, is tropical dry deciduous type (Champion, H. G. & S. K. Seth, 1968). The forest is dominated by *Tectona grandis* as main constituent in certain areas. Some other species like *Diospyros melanoxylon*, *Terminalia sp.*, *Butea monosperma*, *Dalbergia sp.*, *Lagerstroemia sp.*, *Zizyphus sp.*, are the co-dominants in these forests. In recent past year, the composition of plant species of this area is changed due to urbanization. Many plant species have become endangered and several newly introduced species like *Alstonia scholeris*, *Cassia siamea*, *Gliricidia maculata*, *Peltophorum pterocarpum*, *Samanea saman*, etc. are dominating as avenue and shade trees in Bhopal.

The climate of the area is monsoonal with warm moist summer and cool dry winter. The mean maximum temperature varied from 25.6 ^{0}C (January) to 42.1 ^{0}C (May) and the mean minimum temperature ranged from 8.5 ^{0}C (January) to 27.1 ^{0}C (August). The mean annual rainfall is 1090 mm. During south

east monsoon season relative humidity is generally above 70%. During summer season the relative humidity is less than 20%. Soils of the study area are either black cotton soil or laterite soil. The study was conducted during the year 2008-2010. Six sites, natural protected (I), least disturbed (II), mildly disturbed (III) & highly disturbed forest (IV); Developed Protected (V) & Unprotected forest (VI) were identified for phytosociological analysis . The phytosociological analysis of each site of forest was conducted by using ten randomly placed, 10 x 10 m, Quadrats. In each Quadrat, trees were individually measured for gbh (Girth at breast height, i.e., 1.37 m from the ground). Species were recorded and identified using regional floras (Flora of Madhya Pradesh I, II, III and Flora of Bhopal).

Using the vegetation data, phytosociological parameters such as Frequency, Density, Basal Area, Relative frequency, Relative density, Relative dominance and IVI (Importance Value Index) were calculated by using the formulae as given by Curtis & McIntosh, 1950.

Importance Value Index (IVI) = Sum of relative density + relative frequency + relative dominance.
The index of dominance (Cd) of the community was calculated by Simpson's index (Simpson 1949):

$$Cd = [(Ni / N)^2]$$

Where, Ni = number of individuals of the tree species and N = total number of individuals of the all tree species.
Diversity index for different sites was determined by using Shannon-Wiener information function (H) (Shannon & Wiener, 1963):

$$H = -\sum Pi (lnPi)$$

Where, Pi = Ni / N the proportion of each tree species in the sample, Ni = number of individuals of the tree species and N = total number of individuals of the all tree species.

The evenness index of the community was calculated following Pielou (1966):

$$E = Hi / ln\ s$$

Where, Hi = the Shannon - Wiener index of diversity and s = the number of species.
Species richness (Margalef index) was calculated using a formula given by Margalef (1958):

$$SR = s - 1/ ln\ N$$

Where, s = the number of species and N = the total number of individuals.

Sorenson's Index of similarity measure (Cs) for trees between different sites was calculated following Sorenson (1948):

$$Cs = 2j/a+b$$

Where, a = number of tree species at site A, b = number of tree species at site B and j = number of common tree species to both the sites.

Total variation present in a data set is partitioned or segregated into several components by ANOVA using SPSS (2002).

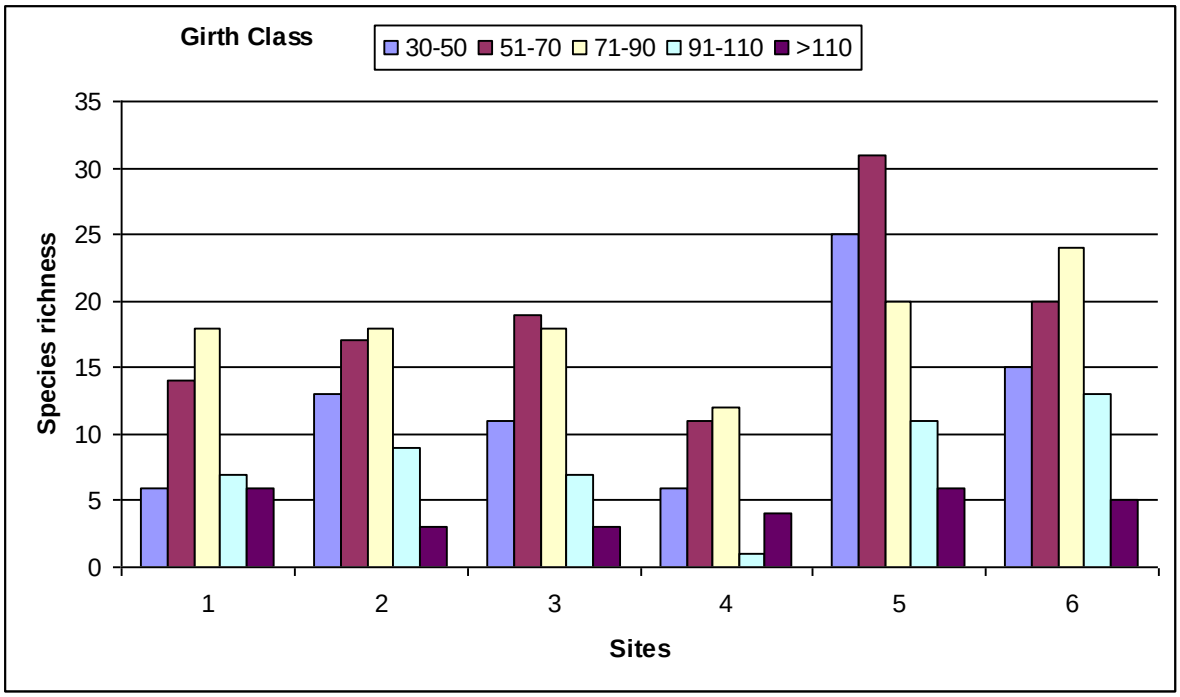
3. ANALYSIS, DISCUSSION AND FINDINGS:

A total 76 tree species belonging to 62 genera and 12 families were recorded. The number of species varies site by site, the number of tree species was recorded higher in site V stand (38 species) followed by site VI stand (30 species), site III stand (29 species), site II stand (23 species), site I stand (19 species) and site IV stand (16 species) respectively.

Phytosociological analysis of district Bhopal reveals that species richness was 16 to 38 ha^{-1} in all six sites. *Tectona grandis* is frequent in all natural forest sites and covers the large area of forest. *Anogeissus* sp., *Butea monosperma, Lagerstroemia parvifolia, Ougeinia oojeinensis* and *Terminalia* sp., present in association with *Tectona grandis* at different sites. In developed forest sites these species are replaced by *Cassia siamea, Peltophorum pterocarpum, Samania saman, Dalbergia* etc because of biotic interference.

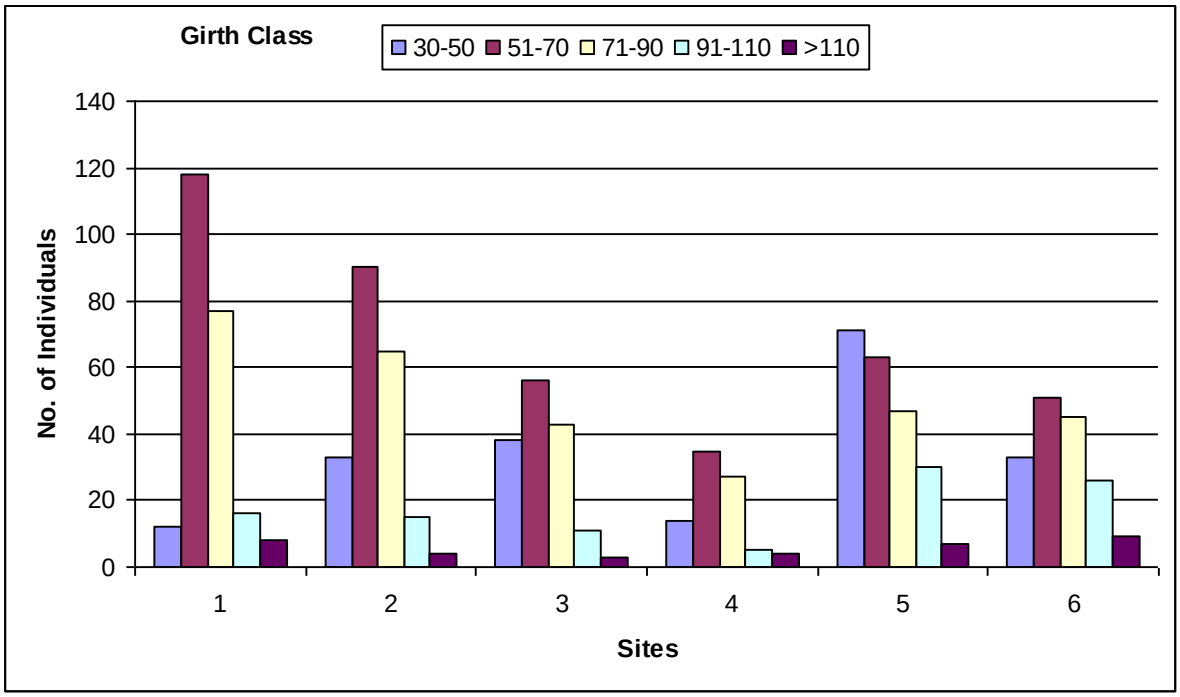
In lower girth class 30-50 cm, species richness varies from 6 species (site I & IV) to 25 species (site V), in girth class 51-70 cm it varies from 11 species (site IV) to 31 species (site V). In medium girth class 71-90 cm species richness varies from 12 (site IV) to 24 (site VI), while in girth class 91-110 cm it varies from 1 species (IV) to 13 species (site VI). But in higher girth class >110 it varies from 3 species (site II & III) to 6 species (site I & V). Highest species richness (31 species) was found in girth class 51-70 cm (site V) and lowest species richness (1 species) in girth class 91-110 cm (site IV) (Fig. 2).

Fig. 2 Species Richness in different girth classes at different sites



The number of tree individuals increases first followed by consistent decrease with increasing girth class of tree species from 30 to >110 cm gbh Girth (Fig.3). The highest tree individuals were recorded in the girth class 51-70 and 71-90 cm gbh in all stands. But in site V stand the highest tree individuals were found in 30-50 cm girth class.

Fig. 3 Tree individuals in different girth classes at different sites



In present investigation the density of tree species recorded 850 to 2310 stems ha-1 is higher to as earlier reported 113 to 407 stem ha^{-1} (Reddy et al., 2008), and lower to as earlier reported 2652 stems ha^{-1} (Mohandas & Davidar, 2009). In present study, site I with higher density (2310 stem ha^{-1}) was because of protection from interference of human activity, whereas study site IV reveals low density (850 stem ha^{-1}) because of selective cutting of straight poles of *Tectona grandis*, *Lagerstroemia parvifolia* and *Ougeinia oojeinensis* for use as poles by villagers.

The tree basal area measured at different study sites 11.10 to 32.97 m^2 ha^{-1} is closer to the values as earlier reported 6.58 to 48.49 m^2 ha^{-1} (Pitchairamu, et al., 2008), 8.55 to 26.89 m^2 ha^{-1} (Reddy et al., 2008), 25.50 m^2 ha^{-1} (Sahu et al., 2007). Decrease in basal area and the density of trees indicated extraction pattern of trees in the forest. Such a selective extraction of trees led to tree regeneration either through coppice or new recruitments by seeds or both in the disturbed stands where population density of young individuals was high and their contribution was more.

In terms of the overall ecological dominance, the high importance value species (IVI) differs from site to site, except for *Tectona grandis*. It commonly dominates in all natural forest sites. Other species like *Anogeissus latifolia*, *Ougeinia oojeinensis*, *Lagerstroemia parvifolia* and *Butea monosperma* showed co-dominance at different sites. In developed forest sites (V &VI) IVI is very low for many tree species, maximum IVI is recorded for *Terminalia tomentosa* at site VI, while at site V maximum IVI is recorded for *Sphathodea campanulata*. These low values of IVI indicate that in developed forests many new tree species have been introduced in different areas from time to time.

The dominance index in the present study ranged from 0.033 to 0.104. The range of dominance index reported for tropical forest of India varies from 0.21 to 0.92. The value reported in present study corresponds well with the reported range for tropical forests. The highest dominance at the site I was due to presence of few species *(Tectona grandis* and *Anogeissus latifolia)* with high number of individuals, whereas at site V the condition was just opposite to site I, hence dominance index was low.

The value of Shannon's diversity index in the present study ranged from 2.503 to 3.509 which is closer to 1.58 to 3.53 earlier reported for old Sal plantations in Gorakhpur (Shukla & Pandey 2000). The diversity index is generally higher in tropical forests, for Indian forests it varies from 0.83 to 4.1. Our observations and calculations are significant as the values lies within the range as per reported diversity index for tropical forests. The highest Shannon diversity index of site V may be due to the plantation of various species by CPA, whereas at site IV it was low because valuable tree species are extracted by local people.

The Pielou's evenness indices was 0.870 (site I) to 0.964 (site V) recorded in present study. Low evenness index (0.870) at site I indicates a more or less regular distribution of plant species and high evenness index (0.964) at site V represents randomly distributed plant species.

Margalef species richness index 3.30 (site I) to 6.87 (site V) was recorded in present study. is closer to those earlier recorded 4.61 to 8.31 by Reddy et al., (2008) and less than 14.11 to 17.33 recorded by Chouhan, et al., (2008).

The low similarities among different forests are understandable, as dominant species are different in different forests. 71.43% common species are present at site I and site II. This similarity is due to closeness and protection of forest area. Site II and site V are less similar because site V is a developed forest site and new plant species were planted there which were different from natural forest species (Table 1).

Table 1. Consolidated summary of plant diversity and analytical characters

S.No. **Variables**	**Natural Forest sites**			**Developed Forest Sites**		
	Site I	**Site II**	**Site III**	**Site IV**	**Site V**	**Site VI**
1 Species richness	19	23	29	16	38	30
2 Number of genera	17	20	24	15	35	27
3 Number of families	11	13	15	11	23	14
4 Density (ha^{-1})	2310	2070	1510	850	2180	1640
5 Basal area(m^2 ha^{-1})	32.97	26.92	17.44	11.10	25.26	23.74
6 Diversity indices: -						
I Shannon index	2.562	2.789	3.055	2.503	3.509	3.162
II Evenness index	0.870	0.889	0.907	0.902	0.964	0.929
III index of dominance	0.104	0.087	0.062	0.103	0.033	0.051
IV Margalef index	3.30	4.12	5.58	3.37	6.87	5.68
V Sorenson Similarity index:						
Site I	100	71.43	50.00	51.43	24.56	44.90
Site II		100	65.38	51.28	22.95	45.28
Site III			100	48.89	29.85	50.85
Site IV				100	25.93	47.83
Site V					100	29.41
Site VI						100

All the results were statistically analyzed by using ANOVA technique. The results obtained are significant and seems to prove the validity of the present investigations.

In natural forest, *Tectona grandis* is the main dominant species, while *Anogeissus* sp., *Buchanania lanzan Butea monosperma, Terminalia* sp., are co-dominants; *Diospyros melanoxylon* and *Maduca latifolia* show clumped distribution; *Gymnosporia rothiana* and *Helicteris isora* form the forest undergrowth. Thorny species such as, *Acacia arabica, Acacia catechu, Acacia leucophloea, Zizyphus jujuba* are present in some areas. *Pongamia pinnata* and *Syzygium cumini* are predominantly seen near ravines.

Exotic and shady tree species: False Asoka (*Polyalthia longifolia*), Copper pod (*Peltophorum pterocarpum*), Gulmohar (*Delonix regia*), Sayami Cassia (*Cassia siamea*), Saman tree (*Samanea saman*), etc are mostly planted in the city on the roadsides. Other tree species which are planted particularly on denuded forest land include *Dalbergia sp., Eucalyptus, Gliricidia* and *Leucaena*. Unfortunately, the increase in population of most of these exotic, ornamental trees has been at the cost of local tree species with decreasing population over the last few decades. These include Banyan (*Ficus benghalensis*), Guava (*Psidium guajava*), Gular (*Ficus glomerata*), Jamun (Syzygium cumini), Mango (*Mangifera indica*), Neem (*Azadirachta indica*), Peepal (*Ficus religiosa*) and Tamarind (*Tamarindus indica*).

4. CONCLUSIONS AND RECOMMENDATIONS:

The phytosociological data related to tree species of district Bhopal will be useful in forest management and conservation in future. The plantation of new introduced species has increased the diversity, but forest areas should be free from new introductions because newly introduced species rapidly increase in their number. In recent years it has become increasingly apparent that the cut forest tree species replaced by invasive species should be avoided to restore the natural community.

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