



Seasonal diversity of natural herbaceous vegetation at three sites in Moradabad, Uttar Pradesh

Prashant Kumar¹, Yashwant Rai², Rajkumar¹

¹ Department of Botany, Hindu College, Moradabad, Uttar Pradesh, India

² Department of Botany, I. P. College, Bulandshahar, Uttar Pradesh, India

Abstract

Present study deals with species diversity parameters for herbaceous natural vegetation around three sites of Moradabad city. The Importance Value Index of species was estimated seasonally for each site. Total 77 species of herbaceous plants have been observed from these three sites which belong to 32 families. All vegetations show more or less striking differences for every few feet. Species diversity index, richness (D_1), Margalef index (D_2), Menhinick index (D_3), evenness (D_4) and beta diversity at each site were highest in rainy season. The β diversity was highest at Kanth Road Site and much lower at Rampur Road and Delhi road Site in rainy season whereas, Concentration of dominance was highest at Rampur road in winter season. The herbaceous vegetation showed a mosaic pattern which was more pronounced in rainy months than in summer and winter months. Species dominance altered with sites and seasons with increasing tendency of species like *Ranunculus scleretus*, *Cynodon dactylon*, *Achyranthus aspera*, *Parthenium hysterophorus*, *Saccharum spontaneum*, *Solanum xanthocarpum*, *Euphorbia hirta*, *Alocasia indica* and *Trianthema portulacastrum*. Similarity coefficient revealed that dominant species composition tended to exhibit distinctness with respect to site and season. Human population and industrial discharge also influenced the species composition and diversity in these habitats.

Keywords: species diversity index, margalef index, menhinick index, beta diversity, concentration of dominance

Introduction

India is known for its plant wealth i.e., large number of diverse type of plants grown in different agro-climatic conditions (Mahalingham *et al.*, 2011). Biodiversity provides enormous direct benefits to humankind and is invaluable for human health. Besides, it is responsible for harboring precious gene library and ecosystem processes that regulates atmospheric gaseous composition, climate water cycle, soil formation, fertility and other processes of ecosystem. Studies indicate that biodiversity has a greater bearing in controlling ecosystem functions and stability (Singh, 1996). There are two mega-centers of biodiversity i.e., Northeastern Himalaya and Western Ghat in India. As a result, our country ranks amongst one of the twelve mega-biodiversity countries of the world and consists of about 17000 flowering plants species. It accounts for 8% of global biodiversity with only 2.4% of the total land area in the world (Hajra and Mudgal 1997 and Reddy 2008) [9]. Plants represent one of the important elements of biodiversity thus the knowledge of plant species found in different areas of the world is pre-requisite to conserve the ecological balance and it helps us to understand the overall structure and function of ecosystem (Sumeet *et al.*, 2010) [31]. The correlation between vegetation and its corresponding environmental parameters provides guidelines for understanding plant species composition and structure in a particular habitat, landscape and region (Munika, 1997) [20]. Spatial patterns of species diversity change over multiple spatial scales. The pattern observed within a local community may be very different from those found over broader areas such as landscapes or regions (Willis & Whittaker 2002) [39]. Beta diversity has been the focus of theories relating species richness and the species-area function to habitat and distance (Arita & Rodriguez 2002;

Balvanera *et al.* 2002; Tuomisto *et al.* 2003) [2, 4, 36]. The herbaceous vegetation showed a mosaic pattern which was more pronounced in rainy months than in summer and winter months. Species dominance altered with sites and seasons with increasing tendency of herbs species like *Parthenium hysterophorus*, *Cannabis sativa* and *Chenopodium murale* (Kumar *et al.*, 2010) [12]. In India Uttar Pradesh is the most populated state. Moradabad, Ghaziabad and NOIDA in the western region of Uttar Pradesh as well as neighboring districts of Haryana and Uttarakhand that comprise the potential emerging satellite cities of Delhi, have witnessed a range of planned and unplanned developmental and human settlement pressure on account of constant interaction, a sharing and trade of resources and burdens with its neighboring area. Moradabad is one of the divisions of western U.P. and well known as brass city. The maximum and minimum atmospheric temperatures are 44.2°C and 4°C respectively. The average rainfall varies between 800 to 1000 mm. The relative humidity is up to 90% in monsoon season and in drier part of the year it decreases to less than 20%. The major industries are Brassware, Steelware, Paper mills, Sugar mills, Dye factories, Pharmaceutical, Textile and a number of ancillaries and small-scale industries related to these industries. Most of the industries are dumping their effluents in the surrounding areas which changes nutrient status of a particular soil (Beena *et al.*, 2018). Plant diversity of this region is adversely affected as a result of rapid expansion of urban areas, increasing human settlements, industrialization and road construction. The urban and semi-urban environment is highly heterogeneous for plant survival and establishment (Pysek *et al.* 2004) [15, 25]. The city floristic is different from semi-natural, natural and man-made habitats outside cities (Kowarik, 1995) [11]. Currently worldwide

attention on biodiversity is basically due to its importance and current alarming extinction rates. It is anticipated that about 20% of all species are expected to be lost within 30 years and 50% or more by the end of 21st century (Myers, 1993). The aim of the study is to highlight the plant diversity in Moradabad city of western U.P.

Material and Methods

Study sites

Moradabad is situated on the bank of river Ram Ganga (a tributary of holy Ganga) at a distance of 167 km from national capital New Delhi. District Moradabad lies between 28° 21' to 28° 16' north latitude and 78° 4' to 79° east longitude. This district occupies an area of 3493 km². It is bounded by Rampur in east, Amroha in west, Bijnor and Nainital in north and Budaun in south. The climate is sub-tropical having three seasons, rainy (July-October), winter (November-February) and summer (March-June). Three sites were selected for the present study (*i.e.* Delhi road area, Kanth road area and Rampur road area) and vegetation is analyzed at each site to get a picture of the entire vegetation falling under the study area.

Methods

A sample unit or quadrat of 1 m × 1 m area was used for observations on community organization. The size and number of the quadrat needed were decided by using species area curve method (Misra, 1968) [18] and the running mean method (Kersey, 1973). Samples were collected from agriculture land, natural habitats, westland road sides railway tracks, river banks and other relevant localities to cover almost all the city area.

The collective data were quantitatively analyzed for density, frequency and abundance (Curtish and Mc In tosh, 1950). The Importance Value Index (IVI) for different species was calculated as a sum of relative frequency, relative density and relative dominance of each species. These values for different species of common habit were summed to compare the species groups within the same stand and those of different stands.

Importance Value Index (IVI) = R. D. + R. Dom. + R. F.

The α & β diversity of each study site across different seasons was estimated, using seven diversity indices. The symbols used in computing these indices are: S = total number of species, N = sum of importance value of all species, pi = proportional importance of ith species (ni/N) and ni = importance value of ith species. Species diversity indices were calculated by using RIVI.

Species diversity was calculated by using Shannon and Wiener information index (Shannon and Wiener, 1963) [27]:

$$H^1 = \sum_{i=1}^s (Ni/N) \log_2 (Ni/N)$$

Where:

H¹ = Shannon and Wiener index

Ni = importance value of ith species

N = Total importance value of all species in a community

β diversity was calculated within a vegetation at a study site by Whittaker, (1975) [37]:

$$\beta D = SC/\bar{S}$$

Where

SC is total number of species occurring in a set of samples counting each species only once whether or not it occurs more than once and \bar{S} is the average number of species per individual sample.

Concentration of dominance (CD) was calculated following Simpson (1949) [28]:

$$CD = \sum_{i=1}^s (Ni/N)^2$$

Where

Ni = importance value of ith species

N = Total importance value of all species in a community

Species richness indices

D1, Species count (Number of species/area; in the present study the no. of species is those species which occurred in quadrats sampled)

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

D2= Margalef index (Clifford & Stephenson 1975)

$$D_3 = \frac{S}{\sqrt{N}}$$

D3= Menhinick index (Whittaker 1977) [38]

$$D_4 = \frac{D_3}{\ln S}$$

D4= Evenness (Pielou 1966) [24]

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

$$SC = 2C/a+b$$

Where,

C = Common number of species in two communities;

a = Number of species in community A

b = Number of species in community B.

Results and Discussion

Total 77 species of herbaceous plants have been observed which belong to 32 families. Amaranthaceae (10), Asteraceae (7), Euphorbiaceae (5), Malvaceae (5) and Poaceae (4) had the maximum number of herbaceous species. Species common to three sites include Ranunculus scleratus, Cynodon dactylon, Achyranthus aspara, Parthenium hysterophorus, Saccharum spontaneum, Solanum xanthocarpum, Euphorbia hirta, Alocasia indica, Bothriocloea persuta and Trianthema portulacastrum. In the rainy season Parthenium hysterophorus, Ranunculus scleratus and Cyperus rotundus were dominant while, in winter season Achyranthus aspara, Ranunculus scleratus and Cynodon dactylon were dominant whereas, in summer season Ranunculus scleratus, Cynodon dactylon, Cannabis

sativa, Euphorbia hirta and Parthenium hysterophorus were dominant at the study sites.

Table 1: Seasonal changes in Relative Importance Value Index (RIVI) of herbs species at three sites in Moradabad.

Species Name	Summer Season			Rainy Season			Winter Season		
	RR	DR	KR	RR	DR	KR	RR	DR	KR
<i>Abrus precatorius L.</i>	-	-	-	0.4031	0.7116	-	-	-	-
<i>Abutilon indicum (L.) Sweet</i>	-	0.6924	0.7083	-	1.1557	0.6297	-	1.1495	1.5785
<i>Acalypha indica L.</i>	0.5023	1.4727	1.2069	.5957	-	0.7765	0.4081	0.5214	-
<i>Achyranthus aspara L.</i>	4.7597	1.9698	3.2156	3.2403	1.5619	1.4085	20.890	-	2.0999
<i>Aerva lanata (L.) Juss</i>	-	-	-	-	-	-	0.4604	0.5966	0.6355
<i>Agave Americana L.</i>	1.2043	0.6206	0.7059	-	-	-	0.4524	0.4130	0.5156
<i>Ageratum conyzoides L.</i>	-	-	-	-	-	-	1.1337	1.0704	2.933
<i>Alocasia indica (Lour.) Schott.</i>	1.4143	0.7126	1.2964	0.365	1.6912	1.4626	-	1.8127	0.8275
<i>Alternanthera polygonoides (L.) R. Br.</i>	-	-	-	1.6199	0.8632	-	-	-	-
<i>Alternanthera pungens</i>	-	-	-	-	0.8878	0.4142	-	-	-
<i>Alternanthera sessilis (L.) R. Br.</i>	-	-	-	0.7662	-	0.7971	-	-	-
<i>Amaranthus spinosus L.</i>	-	-	-	-	3.38	1.4959	-	-	-
<i>Amaranthus viridis L.</i>	2.027	2.6736	5.2272	1.4428	2.0642	-	2.5645	-	3.4185
<i>Argemone mexicana L.</i>	4.9883	5.1491	4.5252	-	-	-	3.3631	3.7128	4.3038
<i>Blumea balsamiphora</i>	-	-	-	1.2469	1.0489	0.5419	0.4082	0.4430	0.6984
<i>Bothriocloa pertusa</i>	0.7199	0.8512	1.8932	2.44	0.2969	0.6868	1.6293	0.5298	-
<i>Boerhavia diffusa L.</i>	-	-	-	-	0.3805	1.7617	-	2.5630	-
<i>Cannabis sativa L.</i>	6.967	3.9329	8.4166	3.1424	5.8643	8.2508	-	-	-
<i>Cassia obtusifolia L.</i>	-	-	-	3.9819	-	-	-	-	-
<i>Catharanthus roseus (L)</i>	-	2.5861	4.5367	-	0.3856	0.7307	-	0.5064	1.6574
<i>Celosia argentea L.</i>	-	-	-	0.5811	1.1071	-	-	-	-
<i>Chenopodium murale L.</i>	-	-	-	-	-	-	-	2.0842	-
<i>Chenopodium album L.</i>	-	-	-	-	-	-	3.7786	2.1341	4.0825
<i>Cleome gynandra L.</i>	-	-	-	0.5294	-	0.7245	-	-	-
<i>Cleome viscosa L.</i>	-	-	-	1.2405	0.9073	-	-	-	-
<i>Cocculus hirsutus</i>	-	-	-	-	-	-	-	-	-
<i>Convolvulus arvensis L.</i>	1.2026	-	0.6363	-	-	-	-	-	-
<i>Croton bonplandianum Baill</i>	4.358	4.4028	1.8944	1.3849	0.8653	1.3005	3.9565	0.7077	-
<i>Cuscuta reflexa Roxb.</i>	-	-	-	-	-	-	-	-	5.2583
<i>Cynodon dactylon (L.) Persoon</i>	5.9545	13.6693	11.549	5.728	4.7314	10.0962	3.7850	7.2128	4.1685
<i>Cyperus rotundus L.</i>	-	-	-	16.4601	8.3443	-	-	-	-
<i>Digera arvensis (Forsk)</i>	-	-	-	-	0.2785	0.4541	-	-	-
<i>Eclipta prostrata L.</i>	-	-	-	0.4475	0.4151	0.5416	0.4825	0.6466	0.5155
<i>Euphorbia hirta L.</i>	3.8419	17.468	1.6930	2.0079	0.9061	1.4228	0.8299	2.6425	1.4691
<i>Evolvulus nummularius L.</i>	-	-	-	1.8242	0.4416	0.6839	-	-	-
<i>Fumaria officinalis</i>	-	-	-	-	-	-	0.9682	0.7322	-
<i>Gomphera celosiodes Mart.</i>	2.1675	-	0.7296	0.7282	1.8778	0.3963	-	0.5298	0.5388
<i>Hyocyamus niger</i>	-	-	-	1.5462	0.3274	0.4311	-	-	-
<i>Ipomea fistulosa (Mart)</i>	-	-	-	-	-	-	0.8079	2.2472	0.6957
<i>Imperata cylindrica</i>	1.0475	0.7704	1.1832	0.5917	0.3441	-	0.9312	1.9907	1.1754
<i>Leucas aspera (Willd) Link</i>	-	-	-	0.4756	-	0.7525	-	-	-
<i>Lindenbergia indica O. Kuntze</i>	-	-	1.4694	-	3.5717	0.6566	-	-	-
<i>Lippia nodiflora L.</i>	0.9471	0.7714	-	-	-	-	-	0.4831	-
<i>Malva sylvestris L.</i>	1.3133	-	1.0038	-	-	-	-	-	-
<i>Medicago sativa L.</i>	-	-	-	-	-	-	3.5041	1.5851	2.1359
<i>Nipeta hindostana (B. Hayne)</i>	0.5427	0.544	4.8818	0.4168	0.2924	0.7748	0.4150	0.4348	-
<i>Ocimum basilicum L.</i>	-	-	-	-	0.3205	-	-	-	-
<i>Ocimum sanctum L.</i>	-	-	-	0.8074	-	-	-	-	-
<i>Oldanlandia corymbosa L.</i>	-	-	-	0.3410	0.4245	0.6231	-	0.4799	0.6985
<i>Oxalis corniculata L.</i>	1.9084	1.9699	2.5689	2.4597	0.7116	2.2485	2.2838	-	2.085
<i>Parthenium hysterophorus L.</i>	15.0395	18.8611	9.8162	14.2628	21.4762	7.4861	11.1638	29.483	9.606
<i>Peristrophe bicalyculata (Retz.) Nees</i>	-	-	-	-	-	-	0.5048	0.4283	0.5155
<i>Phyla nodiflora (L.)</i>	1.6798	0.6629	1.1789	0.3979	0.6377	1.1244	1.2349	0.507	-
<i>Phyllanthus emblica</i>	-	-	-	-	-	-	-	-	-
<i>Phyllanthus niruri L.</i>	-	-	-	1.2697	1.3156	0.7724	-	-	-
<i>Physalis peruviana L.</i>	3.7780	0.9272	1.1720	-	-	-	-	-	-
<i>Pluchea camphorate</i>	2.5271	1.1620	1.7338	-	-	-	-	-	-
<i>Plumbago zeylanica L.</i>	-	-	-	1.1837	0.9180	3.0018	-	-	-
<i>Polygonum glabrum Willd</i>	1.6973	-	0.9583	-	-	-	-	-	-
<i>Portulaca oleracea L.</i>	-	-	-	-	6.9346	7.4369	-	-	-
<i>Ranunculus scleratus L.</i>	17.765	7.1164	15.497	13.0826	8.7865	23.323	19.125	13.732	32.260
<i>Rumex dentatus L.</i>	-	-	-	-	3.0103	4.0544	-	-	-

<i>Rungia repens</i> Nees	-	-	1.0684	0.4159	-	-	-	-	4.999
<i>Saccharum spontaneum</i>	7.7827	7.2869	-	0.4303	4.9120	-	1.6293	9.6506	-
<i>Scoparia dulcis</i> L.	1.0863	0.9811	1.1357	-	-	-	-	-	-
<i>Sesamum indicum</i> L.	-	-	-	0.5932	0.4975	3.3019	-	-	-
<i>Sida acuta</i> Burm. F.	-	-	-	1.3502	0.7776	-	-	-	-
<i>Sida cardifolia</i> L.	-	-	-	0.9327	0.5994	1.2420	-	-	-
<i>Solanum xanthocarpum</i> (Schrad & H. Weendl.)	1.1640	1.0233	1.8849	0.4743	0.8001	1.6962	0.4825	-	0.6526
<i>Spergula arvensis</i> L.	-	-	-	-	-	-	1.3932	0.4430	1.2133
<i>Stellaria media</i> (L.) Villars	-	-	-	5.6783	-	-	7.7510	4.506	5.6895
<i>Trianthema portulacastrum</i> L.	1.0668	0.6638	0.633	1.5466	2.3421	1.8227	1.1672	1.1064	0.6107
<i>Tridax procumbans</i> L.	0.5275	1.163	0.979	0.4246	1.5603	0.9911	-	1.7195	1.7011
<i>Triumpetta rhomboidea</i> Jacq.	-	-	-	-	0.6157	2.1663	-	-	-
<i>Verbena brasiliensis</i>	-	-	-	1.1246	0.6352	1.5227	-	-	-
<i>Vernonia cineria</i> (L.) Less	-	-	-	-	-	-	0.8895	-	1.2618
<i>Vicia hirsuta</i> (L.) Gray	-	-	-	-	-	-	1.6178	1.1829	-

RR=Rampur Road, DR=Delhi Road, KR=Kanth Road

The high RIVI of a species indicates its dominance and ecological success, its good power of regeneration and greater ecological amplitude. Species diversity (H^1) ranging from 3.8604 to 4.9443 and beta diversity (βD) for the different sites ranging from 6.1224 to 11.111. Gupta and Rup Narayan (2006) reported beta diversity from 1.98 to 11.21. The value of beta diversity indicates that species composition vary from one site to another site or seasons. Concentration of dominance ranges from 0.07765 to 01.0865. The values of concentration of dominance were generally low indicating that dominance was shared by more than one or many species. Risser and Rice have

reported value of CD as 0.10 to 0.99 for certain temperate vegetation indicating presence of a few species.

Higher number of species in a community is ecologically important as they showed great heterogeneity within habitat. Results of the present study indicate that vegetation still possess comparatively higher species diversity even after under continuous biotic influences. It may be attributed to greater heterogeneity of physical conditions and a greater potential of regeneration and hardness of the species. Major strategies adopted for biodiversity conservation are *in-situ*, *ex-situ* and reduction of biotic pressure and rehabilitation of sensitive species.

Table 2: Comparative Species richness (D₁), D₂, D₃, D₄, Species diversity, Beta diversity and concentration of dominance at three sites.

Site	Species Richness	Margalef index (D ₂)	Menhinick index (D ₃)	Evenness (D ₄)	Species diversity	Beta diversity	Conc. of dominance
RRR	44	7.5458	2.5471	0.6731	4.3957	8.3019	0.0791
RRW	31	5.260	1.7901	0.5213	3.8885	6.4583	1.0865
RRS	29	4.9082	1.6735	0.4970	4.1482	6.744	0.0820
DRR	46	7.8835	2.6501	0.6922	4.9443	8.0701	0.0806
DRW	35	5.9608	2.0206	0.5684	3.8604	6.8627	0.1287
DRS	27	4.5605	1.5609	0.4736	4.8918	6.4286	0.1046
KRR	40	6.8299	2.3020	0.6240	4.2696	11.111	0.0904
KRW	31	5.2524	1.7827	0.5191	4.1991	7.3809	0.1538
KRS	30	5.0844	1.7321	0.5093	4.5820	6.1224	0.0776

RR=Rampur Road, KR=Kanth Road, DR = Delhi Road, R=Rainy, W=winter, S=summer

This table summarizes the seasonal diversity levels, in terms of seven diversity indices at different sites using IVI of species (i.e. N = 300). Different indices ranked the site diversity differently. The values of richness indices viz. species count (D₁), Margalef index (D₂), Menhinick's index (D₃) and evenness (D₄) were found to be maximal in the rainy season at delhi road. In contrast, the delhi road site in summer season showed the lowest value.

Graph showing variation pattern of diversity indices at three sites in Moradabad.

In the rainy season the intersite differences interms of dominant species varied narrowly. While Kanth road site vegetation showed vary low similarity with other three sites. In summer too high similarity was observed between Rampur road and Delhi road as well as Rampur road and Kanth road. Winter vegetation across different study sites showed that these sites are also not distinct and dissimilar. Highest dissimilarity was observed between Delhi road in rainy season and Rampur road in winter season.

Table 3: Spatial and seasonal similarity of the site vegetation on the basis of similarity coefficient.

	RRW	RRS	DRR	DRW	DRS	KRR	KRW	KRS
RRR	0.480	0.5479	0.7778	0.4810	0.5352	0.7143	0.480	0.5405
RRW		0.600	0.3896	0.7879	0.6207	0.4225	0.7097	0.5574
RRS			0.5067	0.5312	0.8928	0.4927	0.500	0.9152
DRR				0.4938	0.5479	0.8139	0.4675	0.5526
DRW					0.6129	0.4533	0.7273	0.5538
DRS						0.5373	0.6207	0.8772
KRR							0.3944	0.5714
KRW								0.5574

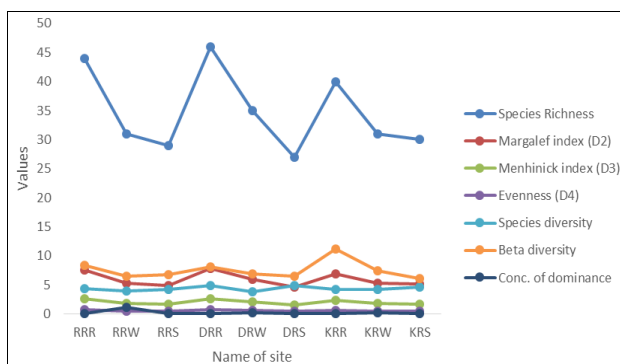


Fig 1

Conclusion

The pattern of diversity change has often been related to the degree of disturbance in nonequilibrium ecosystems. It is reported that low level of disturbance may reduce the competitive ability of dominant species and promote inferior competitors (Pacala & Crawley 1992; Tilman & Pacala 1993). Any given community will have a maximum Shannon index if and only if each species represented is composed of same number of individuals. It was further evident by beta diversity among the three sites indicating no significant difference in composition and structure among the three sites. According to Kumar *et al.*, (2010) ^[12] human population and industrial discharge influence the species composition and diversity in these habitats. Species richness in natural habitat depends on climatic, edaphic and biotic factors (Ayappan & Parthasarathy 1999) ^[3]. As expected, the Delhi road site had the highest species richness followed by Rampur road site. The high species richness on Delhi road site may be attributed to higher soil moisture and nutrients and greater micro-topographic variation. According to Odum (1971) ^[22] in natural conditions contagious distribution is most common, preponderance of regular as well as random distribution reflects the magnitude of biotic interference such as grazing and looping in sites. Similarity coefficient revealed that dominant species composition tended to exhibit distinctness with respect to site and season.

References

1. Alberti M, Marzluff JM, Shulenberg E, Bradley G, Ryan C, Zumbunnen C. Integrating humans into ecology: opportunities and challenges for studying urban ecosystems. *BioScience*,2003;53:1169-1179.
2. Arita H, Rodriguez P. Geographic range, turnover rate, and the scaling of species diversity. *Ecography*,2002;25:541-550.
3. Ayyappan A, Parthasarathy N. Biodiversity inventory of trees in a large scale permanent plot of tropical evergreen forest at Varagalaiar, Anamalais, Western Ghats, India. *Biodiversity and Conservation*,1999;8:1533-1554.
4. Balvanera P, Lott E, Segura G, Siebe C, Islas A. Patterns of β -diversity in a Mexican dry tropical forest. *Journal of Vegetation Science*,2002;12:145-158.
5. Clifford HT, Stephenson W. An Introduction to Numerical Classification. Academic Press, London, 1975.
6. Curtish JT, Mc Intosh RP. The interrelation of certain analytic and synthetic phytosociological characters. *Ecology*,1950;31:434-455.
7. Grimm NB, Grove JM, Pickett ST, Redman CL. Integrated approaches to long-term studies of urban ecological systems. *Bioscience*,2000;50:571-584.
8. Gupta S, Rup Narayan. Species diversity in four contrasting sites in a peri-urban area in Indian dry tropics. *Tropical Ecology*,2006;47:229-241.
9. Hajra PK, Mudgal V. An Overview, 1997. BSI India. <http://www.census2011.co.in>.
10. Khurana P. Community structure and diversity of a tropical dry deciduous forest of Hastinapur region, India. *Journal of applied and natural science*,2009;1(2)227-230.
11. Kowarik I. On the role of alien species in urban flora and vegetation In: P. Pysek, K. Prach, M. Rejmanek & M. Wade (eds.) *Plant Invasions: General Aspects and Special Problems*. SPB Academic Publishing, Amsterdam, NL, 1995, 85-103.
12. Kumar P, Arya RC, Singh NP. Quantitative diversity analysis of herbaceous vegetation around site discharge in district Meerut. *Journal of Scientific and Applied Research*,2010;1(2):48-54.
13. Kumari B, Singh SP, Singh KK. Angiosperm Diversity of Stress Sites of Moradabad district of Rohilkhand Region (Uttar Pradesh). *International Journal of Advanced Scientific Research and Management, Special Issue*,2018;I:48-51.
14. Lososova Z, Danihelka J, Chytrý M. Seasonal dynamics and diversity of weed vegetation in tilled and mulched vineyards. *Biologia*,2003;58:49-57.
15. Lososova Z, Chytrý M, Cimalova S, Kropac Z, Otypkova Z, Pysek P *et al.* Weed vegetation of arable land in Central Europe: gradients in diversity and species composition. *Journal of Vegetation Science*,2004;15:415-422.
16. Mahalingam R, Bharathidasan R, Ambikapathy V, Panneerselvam A. Studies on antibacterial activity of some medicinal plant against Human pathogenic microorganism. *Asian J Plant Sci Res*,2011;1(3):86-90.
17. McNaughton SJ. Serengeti grassland ecology: the role of composite environmental factors and contingency in community organisation. *Ecological Monograph*,1983;53:291-320.
18. Misra R. *Ecology Work Book*. Oxford and IBH Publishing Co., New Delhi, 1968.
19. Misra R. A comparative study of net primary productivity of dry deciduous forest and grassland of Varansi, India. In: P. M. Golley & F. B. Golley (eds.) *Proceedings of Symposium on Tropical Ecology with an Emphasis on Organic Production*. University of Georgia, Athens, USA, 1972, 279-294.
20. Munica L. Classification of vegetation: Past, present and future. *Journal of vegetation*,1997;8:751-760.
21. Myers N. Biodiversity and precautionary principle. *Ambio*,1993;22:74-79.
22. Odum EP. *Fundamentals of ecology*. Oxford IBH publishing co. New Delhi, 1971, 244p.
23. Pacala SW, Crawley MJ. Herbivores and plant diversity. *American Naturalist*,1992;140:243-260.
24. Pielou EC. Species diversity and pattern diversity in the study of ecological succession. *Journal of Theoretical Biology*,1966;10:370-383.
25. Pysek P, Richardson DM, Rejmanek M, Webster G, Williamson M, Kirschner J. Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. *Taxon*,2004;53:131-143.
26. Sala OE, Chapin FS III, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, Huber-sanwald E *et al.* Global biodiversity scenario for the year 2100. *Science*,2000;287:1770-1774.
27. Shannon CE, Wiener W. *The Mathematical Theory of Communication*. University of Illinois Press, 1963.
28. Simpson EH. Measurement of diversity. *Nature*,1949;163:688.
29. Singh R. Structure and net community production of the herbaceous vegetation in the sand dune region around Pilani, Rajasthan. Ph.D. Thesis. BITS Pilani, 1976, 460.

30. Southwood TRE. Ecological Methods with Particular Reference to the Insect Population. ELBS edition, Cambridge, 1978.
31. Sumeet G, Sharma CM, Rana CS, Ghildiyal SK, Suyal S. Phytodiversity (Angiosperms and gymnosperms) in Mandal-Chopta Forest of Garhwal Himalaya, Uttarakhand, India. *Nature and Science*,2010:8:1-17.
32. Thakur AS, Khare PK. Species diversity and composition of forest vegetation of Sager district in central India. *Indian forester*, 2008, 801-813.
33. Tilman D, Pacala SW. The maintenance of species richness in plant communitiesIn: R. E. Ricklefs & D. Schluter (eds.) *Species Diversity in Ecological Communities*. University of Chicago Press, Chicago, 1993, 13-25.
34. Tripathi KP, Singh B. Species diversity and vegetation structure across various strata in natural and plantation forests in Katerniaghat Wildlife Sanctuary, North India *Tropical Ecology*,2009:50(1):191-199.
35. Tripathi S. Plant Diversity of Grasslands of North-Eastern U. P. with Emphasis on Populations of *Parthenium hysterophorus* L. Ph.D. Thesis, University of Gorakhpur, 2000.
36. Tuomisto H, Ruokolainen K, Yli-Halla M. Dispersal, environment and floristic variation of western Amazonian forests. *Science*,2003:299:241-244.
37. Whittaker RH. *Communities and Ecosystems*. 2nd edn. Mac Millan, New York, 1975.
38. Whittaker RH. Evolution of species diversity in land communities. In: M.K. Hecht, W.C. Steere & B. Wallace (eds.) *Evolutionary Biology*. Vol. 10. Plenum, New York, 1977, 1-67.
39. Willis KJ, Whittaker RJ. Species diversity: scale matters. *Science*,2002:295:1245-1248.