Research Journal of Chemical and Environmental Sciences
Res J. Chem. Environ. Sci. Vol9 [4] September 2021: 21-27
Online ISSN 2321-1040
CODEN: RJCEA2[USA]

Website: www.aelsindia.com/rjces.htm

RJCES

ORIGINAL ARTICLE

Plant Species Diversity and Composition in Urban Green Spaces of City Prayagraj-India

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ABSTRACT
This paper is an attempt to quantify the species composition, floristic diversity, amenity ecological characteristics, habitat condition, and performance of trees in urban areas of city Prayagra. Assessments of green spaces in urban areas provide guidance for urban planners to maintain the adequate amount of greenery in cities for human wellbeing as well as to maintain the biodiversity. In this study one hundred thirty two quadrates of dimension 20 m×20 m (5.28 ha) were laid to reveal tree diversity and richness of UGSs. The study was undertaken in ten different green spaces of Prayagraj to access the Phytosociological parameters. A total 607 tree stems, belonging to 36 species, 28 genera and 21 families were recorded. A total 769 shrubs, belonging to 13 species, 10 families and a total 915 herbs, belonging to 11 species, 8 families were recorded in sampling area. Plants with > 10 cm girths at breast height (gbh) were inventoried. Fabaceae is the largest family with 13 species followed by Moraceae (6), Malvaceae (5); Myrtaceae, Rutaceae, Meliaceae (4) each; and Sapotaceae, Arecaceae (3) each. Prayagraj's urban forest has a fairly un-healthy diversity, about 13.25% of total tree density occupied by most abundant species P. longifolia while other five top most species include P. longifolia, P.guajava, M.indica, W. bifurcata and P. pterocarpum contributed about 34.76% to total tree density.
Keywords: *Tree diversity, density, richness, urban green spaces, Prayagraj city etc.*

Received 21.05.2021 Revised 29.05.2021 Accepted 12.06.2021

INTRODUCTION

Natural habitats are transformed by urbanization processes to satisfy housing needs and support human activities [16]. Such man-made systems include physical, biological, and social processes and result in the development of urban infrastructure such as buildings and streets/roads, often leaving little space for vegetation [3] Among urban green patches trees commonly comprise the main component, highly represented by exotic species that can become invasive in per urban areas**.** Thus, urbanization implies not only the alteration of habitat structure, but also the modification of the diversity and composition of its vegetation component [26]**.** Urban vegetation comprised of plants from parks, greenways, median strips, playgrounds, cemeteries, gardens, and sidewalks have important ecological and social implications [1].In particular, trees are critical for the maintenance of some urban ecological processes and have been identified as the most important habitat component known to affect wildlife diversity within urbanized systems. Additionally, aggregated trees in recreational areas (e.g., parks, playgrounds) allow the interaction of people, although they have also been related to socioeconomic barriers [13].Biodiversity in cities is under increasing threat from habitat loss, the introduction of competitive or predatory exotic species, climate change and ecosystem degradation. By 2030, urban land cover is expected to triple what it was in 2000, leading to loss of locally significant or threatened habitats, especially in highly biodiverse regions of the world **.**The retention of native vegetation is an effective strategy to conserve urban biodiversity [14].A recent meta-analysis of factors influencing urban biodiversity [2]concluded that remnant vegetation patches had to be >50 ha to retain threatened or urban-sensitive species. Additionally, city governments world-wide are planting vegetation in streets, parks, gardens and on roofs to help offset the negative impacts of increased urban density [25]. Collectively, protecting existing and planting new native vegetation has great potential to curb urban biodiversity loss. However, despite the costs of managing urban green spaces and the widespread planting of new vegetation, little is known about which vegetation attributes provide quality habitat for a wide range of taxa [17]. Urban green spaces often contain simplified habitats that lack large hollow-bearing trees, decomposing logs or native

ground and mid storey vegetation [24]. Urban green space managers need information on how to better manage vegetation to retain complex habitats but to date, research has focussed on habitat quality for birds [5] & [2]. The loss of large, native trees [5] & [23] and declines in habitat complexity [11] have a negative impact on urban bird communities but little is known about the impacts on other taxa [2]. Rapid urbanization in India is bringing complex changes to ecology, economy and society [9]. During the last 50 years the population of India has grown two and a half times, but the urban population has grown nearly five times. About 60% of this urban population growth is attributable to natural growth, and the remaining 40% is due to migration and spatial expansion. Over the last two and half decades spatial growth of cities has often been three-times faster than the growth of population. Undoubtedly, urbanization will continue to have substantial impact on the ecology, economy and society at local, regional, and global scales. It is logical, then, that scientists, planners and general public now urgently redesign urban systems that necessarily take into account the fact that 50% people are now living in less than 3% of the earth's urbanized surface. In addition, on the face of climate change, adaptation and mitigation actions for cities in India are critically required where the urban population is likely to grow by around 500 million over the next 50 years. Addressing multiple risks due to climate change temperature and precipitation variability, drought, flooding and extreme rainfall, cyclone and storm surge, sea-level rise, and associated environmental health risk is a serious public policy and adaptation management challenge for India. This paper will illustrate Physical and psychological health, social cohesion, climate change mitigation, pollution abatement, biodiversity conservation, and providing of ecosystem products and services to urban residents are all benefits of urban green areas [7]. The word "urban green spaces" is a broad concept that encompasses all urban parks, institutions, woods, and other plants that offer value to the lives of city dwellers. The phrase "urban trees" refers to trees that grow in both the built environment and in public spaces such as avenues and parks.

In this study, it has been examined the changes in tree species richness, assessing patterns of native and exotic species and also evaluated tree density and composition patterns to provide a context for our species richness results [4]. Cities occupy less than 3% of the global terrestrial surface, but account for 78% of carbon emissions, 60% of residential water use, and 76% of wood used for industrial purposes. In 1800, there was only one city, Beijing, in the entire world that had more than a million people; 326 such cities exist 200 years later [15]. Indeed, such rapid has been the pace of growth that in 1900 just 10% of the global population was living in urban areas which now exceeds 50% and is expected to further rise to 67% in the next 50 years [26]. In developing countries, about 44 per cent of the population currently lives in urban areas, but in the next 20 to 30 years, developing countries in Asia and Africa are likely to cross that historic threshold, joining Latin America in having a majority of urban residents**.** Recent reviews have highlighted the biotic characterization of urban residential areas as a research priority in many areas around the world [10] & [6]. Floristic information from residential spaces can provide valuable information about the quality of private gardens as resources for urban biodiversity [13] & [24]. It can also offer information about the functionality and the ecosystem services of that plant species may be providing by being ornamental, nutritional, or medicinal. Studies of residential area with a biodiversity focus are more common in cities located in industrialized countries, whereas studies where the emphasis is on the services provided by urban plants are more common in developing countries and mostly in rural areas [6].

MATERIAL AND METHODS

Study area and sites

Prayagraj is a district in Uttar Pradesh's south-eastern region. It is surrounded by the districts of Pratapgarh and Jaunpur in the north, Varanasi in the east, Kaushambi in the west, Mirzapur and Rewa in Madhya Pradesh on the south, and is between the parallels of North latitudes 24°47' and 25°47' and East longitudes 81°09' and 82°21' (98 M.SL). There are three distinct physical parts of the city, similar to the district itself: (1) Trans-Ganga or the Ganga par Plain, (2) Ganga-Yamuna doab (confluence), and (3) Trans-Yamuna or the Yamuna par tract, all of which are formed by Ganga and its tributary Yamuna, with the latter joining the former at Prayagraj and the confluence is known as sangam. The city's general geography is flat with mild undulations.

Vegetation analysis and identification of Species

The phytosociological studies of plant diversity from ten sites were used to collect data on tree species for urban green spaces of Prayagraj city during the period of 2019 to 2021. The floristic diversity study was made by adopting random sampling approach, under which, quadrates were laid out with size of 20m × 20m in each site for the observation of trees. The vegetative structure of trees in each 10 sites was estimated for the following parameters by using expressions given by Curtis and McIntosh, 1950.

Randomly one hundred thirty two Quadrat plot's area 400m^2 (20 m × 20 m).In each quadrate, the circumference at breast height (dbh at 1.37 m above ground level) of each tree (＞10 cm dbh) was measured and individuals with dbh＜10 cm were recorded as individual tree . A total 10 selected sites the existing plants were identified and categorized as per their phyto-sociological parameter. Ten (fig. 1 and table 1) were selected through an updated Google map (2018) and subsequently confirmed by field visits.

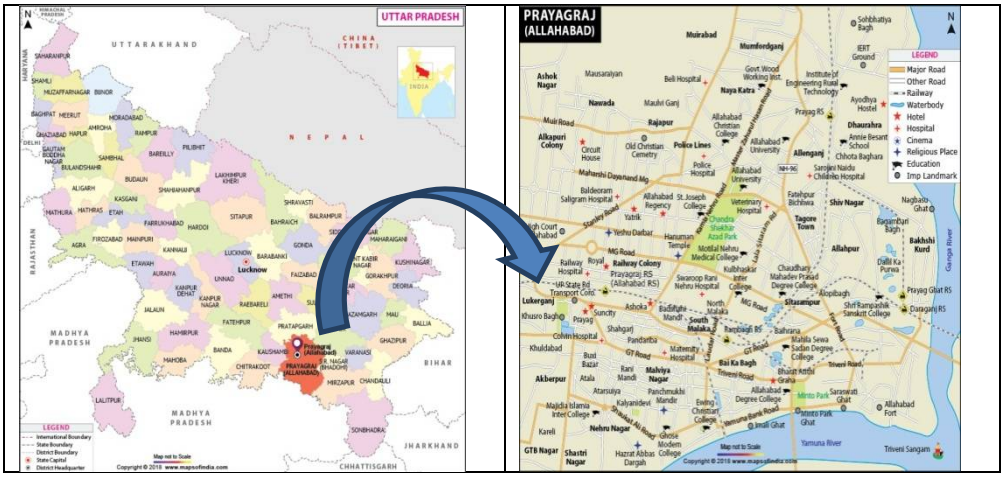


Figure: 1 Map showing the study area

Parameters recorded:

The Phytosociological parameters analysis will be carried out after collecting the data of various species which include the value of Frequency, Density, abundance A/F(Abundance/Frequency), Relative Frequency, Relative Density, Relative Dominance and Importance Value index (IVI) determined for each species of the community according to the formula given by Raunkiaer, [22].

1. Basal area Basal area = $\frac{\pi D^2}{4}$

2. Density $\text{Density} = \frac{\text{Total number of individual}}{\text{Total Number of quadrates studies}}$

3. Frequency $\text{Frequency \%} = \frac{\text{No. of sampling units in which the species occurred}}{\text{Total number of units studied}} \text{X100}$

4. Abundance $\text{Abundance} = \frac{\text{Total No.of individual of the species}}{\textit{Total}\ \text{No.of quadrates in which the species has occurred}}$

5. Relative dominance:- $\text{Relative Dominance (RDO)} = \frac{\text{Dominance}}{\text{Total Dominance of all species}} \text{X100}$

6. Relative Density: $\text{Relative Density (RD)} = \frac{\text{No.of individuals of the species}}{\text{No.of individual of all species}} \text{X100}$

7. Relative Frequency: $\text{Relative Frequency (RF)} = \frac{\text{No.of occurrence of the specie}}{\text{No.of Occurrence of all species}} \text{X100}$

8. Importance value Index:Importance value Index (IVI) = Relative Dominance+ Relative density + Relative frequency

9. Importance Value Index (For Shrub/Herb species)

IVI= Relative Density+ Relative Frequency+ Relative Abundance

Measurement of biodiversity indices

The formulae used in the calculation of various biodiversity indices were:

10. Concentration of dominance was measured by using the formula given by Simpson's (1949). Cd=Σ (ni/N)2

where, ni=Proportion of individuals belonging to the ith species

N=Total number of individuals

11. Shannon's Index

For studying the species richness and diversity Simpson's (1949) and Shannon-Wiener's (1963) indices were used.

Shannon's Index, H' = -Σ Pi log Pi

Pi = the proportion of the important value of the ith species

Pi = ni/N

ni = importance value of i^{th} species.
N = importance value of all the species.

12. Simpson's Index

Simpson's Index gives the probability of any two individuals drawn at random from and infinitely large community belongs to different species.

Simpson's index, $D = 1/ \Sigma Pi^2$

Statistical analysis

To facilitate statistical analysis, all data were entered into a Microsoft Excel database. Basic data analysis was conducted with MS Excel 2000 (Microsoft, Redmond, USA).

RESULTS AND DISCUSSION

The study was undertaken in ten different green spaces of Prayagraj to access the Phytosociological parameters. A total 607 tree stems, belonging to 36 species, 28 genera and 21 families were recorded. A total 769 shrubs, belonging to 13 species, 10 families were recorded and a total 915 herbs, belonging to 11 species, 8 families were recorded.

Table 1: Tree species dominance and diversity of different urban green spaces of Prayagraj

S.N.	Name of site	Total no. Of species reported	Total no. of Families	Shannon Index (H)	Simpson Index (D)
1	Company garden	27	13	3.12	0.05
2	Minto park	24	17	2.34	0.04
3	Khusrubagh	21	8	2.90	0.06
4	PD Tandon park	18	14	2.79	0.066
5	Hathi park	14	9	2.50	0.09
6	SHUATS	25	16	3.09	0.05
7	MLNMC	15	8	2.67	0.08
8	ADC	20	10	2.89	0.07
9	CSFER	18	12	2.63	0.08
10	AU	36	21	3.35	0.03

Trees species dominance and diversity of different urban green spaces of Prayagraj, Total no of family diversity was found in AU as 21 and total species diversity reported as 36 maximum in Allahabad University also present in this study. The Shannon index of tress in Urban Green Spaces in Prayagraj as Allahabad University was the maximum as 3.35 and least in Minto Park as 2.34. Moreover, Simpson Index (D) of tress in Urban Green Spaces in Prayagraj as Hathi Park was the maximum as 0.09 and least in Allahabad University as 0.03.

Table 2:- Shrub species dominance and diversity of different urban green spaces of Prayagraj

S.N.	Name of site	Total no. of species reported	Total no. of Families	Shannon Index (H)	Simpson Index (D)
1	Company garden	8	8	2.05	0.11
2	Minto park	10	7	2.28	0.10
3	Khusrubagh	12	9	2.47	0.08
4	PD Tandon park	6	6	1.77	0.16
5	Hathi park	5	5	1.57	0.20
6	SHUATS	11	10	2.37	0.09
7	MLNMC	9	8	1.99	0.09
8	ADC	9	8	1.95	0.10
9	CSFER	10	10	2.28	0.10
10	AU	10	10	2.17	0.11

Shrub species dominance and diversity of different urban green spaces of Prayagraj, total no of family diversity was found in Shuats as 10 and total species diversity reported as 12 maximum in Allahabad University also present in this study. The Shannon index of shurub in in Prayagraj at KhusruBagh was the

maximum as 2.47 and minimum in Hathi Park as 1.57. Moreover, Simpson Index (D) of tress in Urban Green Spaces in Prayagraj as Hathi Park was the maximum as 0.20 and minimum in Khusru Bagh as 0.03.

Table 3: Herb species dominance and diversity of different urban green spaces of Prayagraj

S.N.	Name of site	Total no. of species reported	Total no. of Families	Shannon Index (H)	Simpson Index (D)
1	Company garden	11	6	2.38	0.09
2	Minto park	7	6	1.92	0.14
3	Khusroobagh	9	6	2.18	0.11
4	PD Tandon park	6	5	1.92	0.14
5	Hathi park	5	5	1.60	0.20
6	SHUATS	11	7	2.28	0.08
7	MLNMC	7	6	1.77	0.10
8	ADC	10	8	2.29	0.10
9	CSFER	8	6	2.07	0.12
10	AU	11	7	2.38	0.09

Herb species dominance and diversity of different urban green spaces of Prayagraj, total no of family diversity was found in ADC as eight and total species diversity reported as 11 maximum in Shuats also present in this study. The Shannon index of Herb in Prayagraj at AU was the maximum as 2.38 and minimum in Hathi Park as 1.60. Moreover, Simpson Index (D) of tress in Urban Green Spaces in Prayagraj as Hathi Park was the maximum as 0.20 and minimum in Khusru Bagh as 0.08. As found in the present study is more when compared tour ban forests of Bangalore metropolitancity [27] and urban forests of Chennai metropolitan city [26]. Forests of high species diversity are believed to be healthier than forests of poor species diversity[25]. Prayagraj's urban forests have an un-healthy diversity, about 13.25% of total tree density occupied by a most abundant species *P. longifolia*. The five top most species *include P.longifolia, P.guajava, M. indica, W. bifurcata and P. pterocarpum* contributed about 34.76% to total tree density. The Shannon index of tress in Urban Green Spaces in Prayagraj as Allahabad University was the maximum as 3.35 and least in Minto Park as 2.34. 1.07 identified in this study is less within the range compared with those of other urban areas in the USA(range 2.1–3.9; average 2.7) [25]; and Bangalore, India (2.68) [27]. However, our study are a holds larger Shannon's diversity (H) 1.07 value than Miami-Dade County of USA.A large contribution(47.67%) of the top ten species to total tree density. *P.longifolia*, an introduced tree from Sri Lanka alone makes about 13.25% of the tree community in Prayagraj UGSs. Government bodies and private building owners prefer this tree for its graceful drooping branches, cone shaped architecture and ever-greenness.
Polyalthia longifolia contributed a larger proportion with highest number of trees than rest of the abundant species, so it holds the top most position in IVI. Tree density found is 3–5 times higher than for other urban forests. Urban forests of Bangalore, India have 45.6(mean) trees in urban parks and 47.5 trees ha^{-1} (mean) in street tree population [27] & [28]. Reported 111.9 trees ha^{-1} from Oakland, while[29] estimated 147 trees ha^{-1} (mean, range = 36–276) from ten cities of USA. Quantified 235 trees ha^{-1} trees for Miami-Dade County. Like the natural forests of Uttar Pradesh, urban forests are also dominated by the members of Fabaceae, Moraceae and Malvaceae. By carrying out similar studies, the role and value of urban green spaces of Prayagraj city can be easily understood. Valuation studies on urban forests and trees are abundant in the Western world, but for the Indian sub-continent it is meagre. Thus, urban forests of India can be considered as a place for urban biodiversity and research has been carried in Prayagraj urban green spaces.

Fig. 2: Diagram showing the tree species dominance and diversity of different green spaces

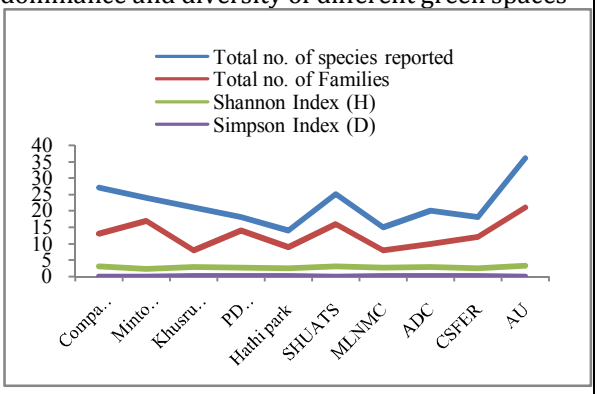


Fig. 3: Diagram showing the shrub species dominance and diversity of different green spaces

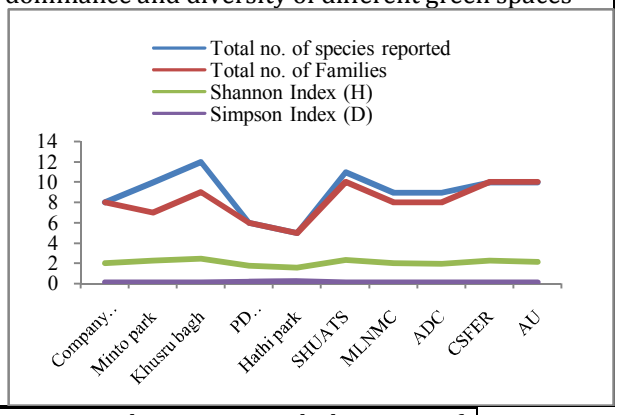
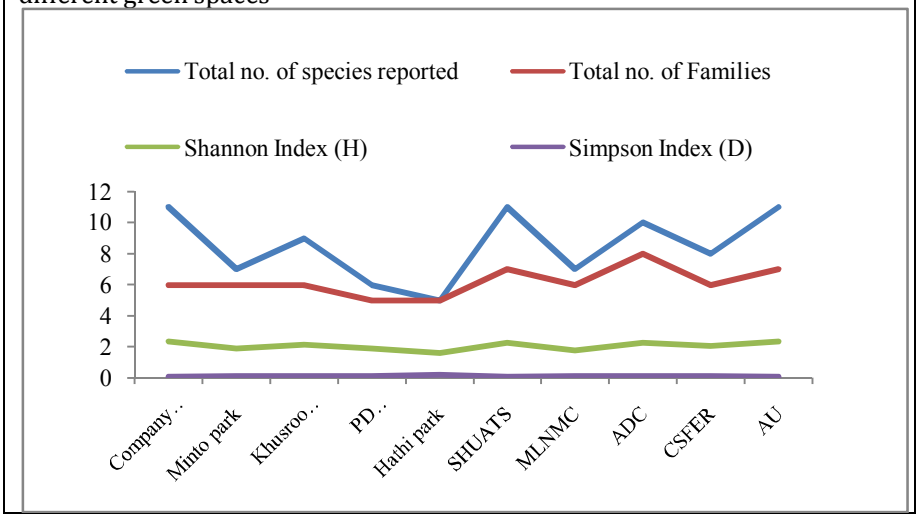


Fig. 4: Diagram showing the herb species dominance and diversity of different green spaces



CONCLUSION

The present study shows that native, abundant tree ssuch as *Polyalthia longifolia, Tamarindus indica, Holoptelea integrifolia, Wodyetia bifurcate, Bauhinia vriegata, Tectona grandis, Alstonia scholaris, Sterculiaurens, Terminalia arjuna and Pongamiapinnata* and conclude that Fabaceae is the largest family with 13 species followed by Moraceae(6), Malvaceae (5); Myrtaceae, Rutaceae, Meliaceae (4)each; and Sapotaceae, Arecaceae (3) each. Prayagraj's urban forest has a fairly un-healthy diversity, about 13.25% of total tree density occupied by most abundant species *P. longifolia*. Other five top most species include *P.longifolia,P.guajava, M.indica, W. bifurcata and P.pterocarpum* contributed about 34.76% to total tree density. The information gathered during field work shows that most parts of the city are degraded area due to variousecological causes and human interference. Hence there require more attention towards maintenance of green space to enhance the quality of air, water and other ecosystem services provided by urban biodiversity.

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CITE THIS ARTICLE

K. Mishra, H. Kumar, N. N. Mishra and S. Chaurasia.Plant Species Diversity and Composition in Urban Green Spaces of City Prayagraj-India. Res. J. Chem. Env. Sci. Vol. 9[5] October 2021. 21-27