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Plant Communities Analysis of Selected Urban Flora of Islamabad

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Abstract: Variation of plant community composition with environmental parameters (Elevation, pH, nutrients in soil etc.) was presented with the aim of determining the relationship of vegetation with environmental parameters in an urban area. Vegetation patterns of an area of 4 km^2 were studied between 1300-1800 m in the selected areas of Islamabad city. This area is relatively having wider open spaces and consequently more species diversity. Taking into consideration the importance of soil characters in determining a certain type of vegetation, soil analysis is given due importance. Cluster analysis showed the existence of two major communities with different dominants due to environmental factors acting upon it. *Broussonetia papyrifera* an invasive species and *Dalbergia sissoo* an indigenous species are dominantly separated in different communities. Canonical Correspondence Analysis (CCA) showed that soil moisture content, electrical conductivity, pH, Elevation, Ca^+ and heavy metals were the major edaphic factors correlated with species distribution.

Key words: Community formation, vegetation analysis, soil analysis, urban ecosystems

INTRODUCTION

Urbanization is a boon providing plentiful food sources and shelter. Due to urban development and land use changes, urban flora is under threat. With the increase in development decrease in native trees and shrub layer, ground cover and tree density results[1]. The balance between plant species and their habitats fluctuates temporarily and spatially, influenced both by natural forces (e.g. climate) and by changes in environmental management[2]. Islamabad, the capital of Pakistan, lies against the backdrop of the evergreen Margallah Hills at the northern edge of Pothwar plateau having differential vegetation structure. It has been seen that the plant communities in urban areas are often more species-diverse than the landscapes they replace however, this usually comes at the cost of native species and plant communities[3]. The variation of ecological conditions also leads to the differentiation of vegetation and its floristic composition in an area[4]. These approaches are useful in evaluating the effect of environmental factors on species composition and abundance of the plant communities.

Species composition can be predicted by local environmental conditions[5]. Environment is made up of the complex of natural and human factors that interact with individuals and plant communities. Due to formation of residential, industrial and other layouts, the natural slopes, natural vegetation and land cover gets disturbed[6]. The soil is one of the most important resource in any country. The nature and quality of the soils determine land productivity level and development potential[7].

Multivariate analysis is the most widely used method that characterizes the composition and distribution of vegetation. Vegetation has strong relation with soil parameters. Dramatic soil change between adjacent area means equally dramatic changes in the vegetation, even when rainfall and altitude are similar[8]. Canonical Correspondence Analysis shows relationships between environmental factors and plant species which can identify community types. However, introduction of new plant species is very important to describe a community type. Multivariate analysis indicates differences in plant species composition[9]. When data of climate, vegetation and soil are combined by CCA then it shows that the distribution of vegetation is closely related to the variety of climates and to soils distribution[10]. Multiple criterion measures are useful for obtaining more complete and detailed description of different factors affecting plant communities in urban environment[11]. The objective of present study was to evaluate the composition of vegetation of the area explaining the properties of soil and factors that are responsible for the variation of vegetation.

MATERIALS AND METHODS

The area where present study emphasizes lies in the Federal Capital Islamabad H-9 sector. In H-9 sector along with different urban structures an open space is also

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Table 1: The total percentage cover of species separated through cluster analysis (Complete Linkage Clustering)

Groups	Species names	Total cover (%)	Number of quadrats
Major Group I	*Broussonetia papyrifera*	410.0	17
	Cannabis sativa	105.0	17
	Avena sativa	4.0	17
	Oxalis corniculata	1.5	17
1.1	*Broussonetia papyrifera*	223.0	10
	Dalbergia sisso	175.0	10
	Cannabis sativa	93.0	10
	Lantana camara	3.0	10
	Vicia spp.	2.0	10
1.2	*Broussonetia papyrifera*	231.0	7
	Cannabis sativa	61.0	7
	Lantana camara	1.5	7
	Saccura spp.	0.5	7
Major Group II	*Dalbergia sissoo*	330.0	22
	Cannabis sativa	230.0	22
	Sonchus asper	1.0	22
2.1	*Broussonetia papyrifera*	112.0	12
	Cannabis sativa	40.0	12
	Rumex spp.	2.2	12
	Saccura spp.	2.0	12
	Amplexicaule	0.05	12
2.2	*Broussonetia papyrifera*	345.0	10
	Cannabis sativa	180.0	10
	Withania spp.	3.0	10
	Cucurbita spp.	1.0	10

present which supports a wide variety of vegetation to grow there. Randomized Complete Block distribution strategy was followed. The total area of site was divided into 81 uniform grids (4 km^2). Grid size was selected by keeping in mind the vegetation and structure of the area and also it should contain almost all plant species existed in that area. A total of 39 grids were sampled as rest of the area (remaining grids) were non vegetative or covered with urban structures (buildings, institutes, mosques, roads etc). Total of 39 samples for vegetation and environmental variables were taken. Quadrat size was 14 m^2 in each grid. Cover was estimated for individual plant species in each quadrat[12]. Along with vegetation composite soil sampling was also done from each quadrat for the analysis of various physico-chemical parameters. Soil samples were taken at the depth of 9 inches. These were placed in air tight polythene bags, labeled in the field and brought to the laboratory where they were air dried and sieved with 2 mm sized sieve. Percentage moisture content in each soil sample was determined placing them overnight in an oven at 105°C[13]. Organic matter was determined by Tyurin's method[14]. pH was determined in soil solution (1:5 soil water ratio) by Thermo Orion 410 pH meter[13]. Electrical conductivity was determined in soil solution (1:5 soil water ratio) using Cybersan 500 EC meter[13]. Soil acid digest was prepared for determination of nutrients and heavy metals in the soil[15]. Extractable nutrients and heavy metals were determined by Atomic absorption spectrometer[16]. Multivariate analysis of

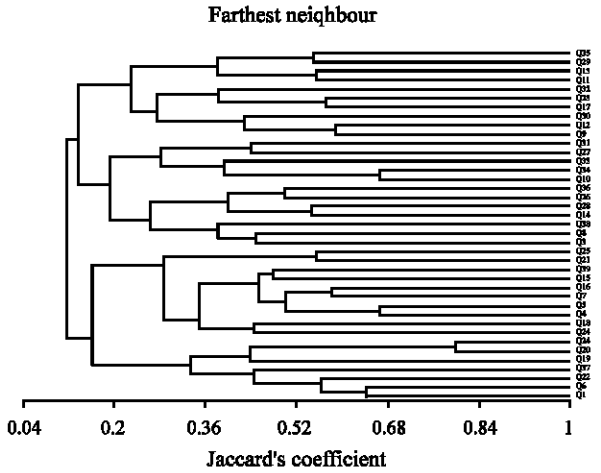

Fig. 1: Dendrogram showing different vegetation clusters in sector H-9, Islamabad (Complete Linkage Clustering)

Variance, analyzed the affect of different factors on plant communities in urban environment[11]. From each quadrat along with collection of vegetation and soil samples, geographical attributes (latitude, longitude and direction) were also noted with GERMIN Etrex GPS.

RESULTS

The vegetation data was analyzed through multivariate statistical package. Two methods, Cluster analysis and canonical correspondence analysis were followed for species analysis and for vegetation environment relationships respectively. Cluster analysis using complete linkage clustering was used for the formation of communities. This method works by finding the most similar pair but further fusions depend upon finding the maximum distance between the furthest points in existing groups. Cluster showed division of whole data into two main clusters/communities/groups (Fig. 1).

- Major Group 1. Broussonetia Cannabis Community
- Major Group 2. Dalbergia Cannabis Community

Major Group I include 17 quadrats separated on the basis of similarity index. *Broussonetia papyrifera* was the most dominant species in these quadrats with a total percentage cover of 410. *Cannabis sativa* was found as co-dominant species in these quadrats with total percentage cover of 105 while the species present on occasional basis were *Avena sativa* and *Oxalis corniculata* with least cover values (Table 1).

Total of 17 quadrats of Major group 1 were further separated into two sub-groups having ten and seven

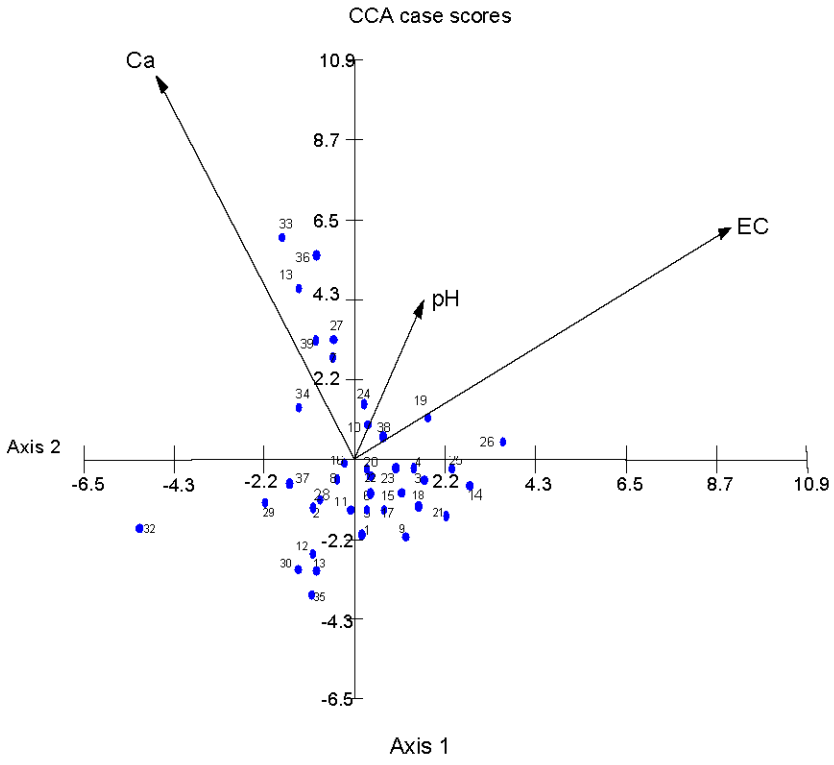

Fig. 2: Interaction of different quadrats with soil chemical properties

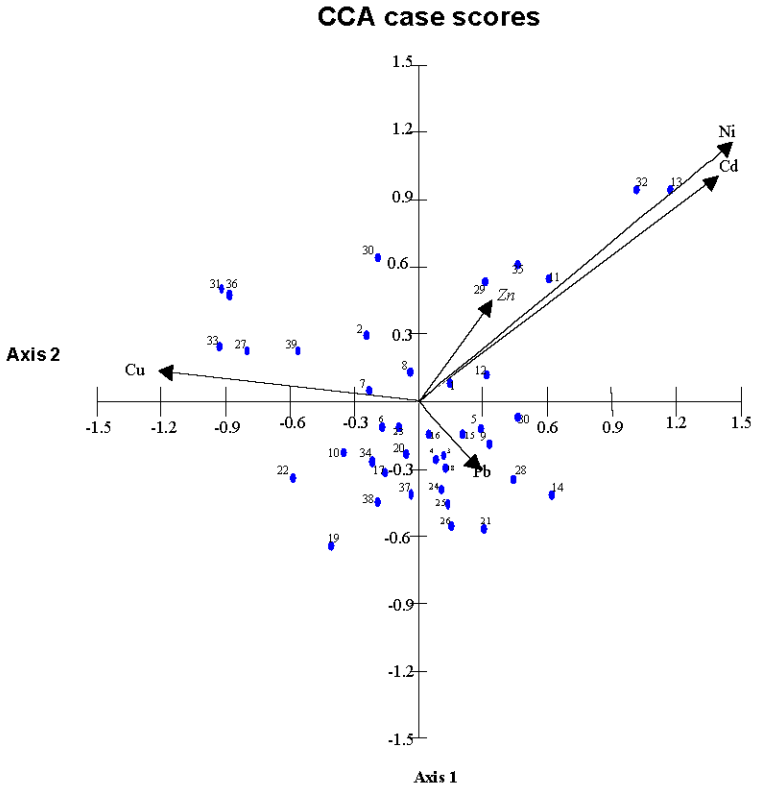

Fig. 3: Interaction of different quadrats with soil heavy metals

Table 2: Mean±SD of physio-chemical parameters of soil

Parameters	Elevation (m)	Moisture contents (%)	Organic matter (%)	pH	EC (µs)	Ca (ppm)
Mean±SD	1685±77	11.8±7.42	0.8±0.59	7.7±0.30	96.2±39.76	363.9±412.43

Table 3: Mean±SD of soil heavy metal concentrations

Parameters	Cu (ppm)	Pb (ppm)	Zn (ppm)	Cd (ppm)	Ni (ppm)
Mean±SD	0.20±0.07	0.62±0.46	1.83±0.48	0.05±0.14	1.04±0.29

quadrats, respectively (Fig. 1). Sub group 1.1 showed a combination of exotic (*Broussontia papayrifera*) and indigenous (*Dalbergia sissoo*) species with 223 and 175 total cover percentage values, respectively. While in sub-group 1.2 *Broussontia papayrifera* and *Cannabis sativa* were the dominant and co dominants (Table 1).

Major group II includes 22 quadrats. Most abundant species was *Dalbergia sisso* (Total %Cover = 330) and *Cannabis sativa* was found as co-dominant species with total percentage cover of 230. The least occurring species of this group was *Sonchus asper* and *Cucurbita* sp. (Table 1). Major group II was further divided into two sub groups 2.1 and 2.2 with 12 and 10 quadrats, respectively (Table 1).

Highest value for calcium was 492.32 ppm and lowest was 127.64 ppm (Table 2). The results of heavy metals and nutrient in soils were obtained from analysis of soil samples through atomic absorption spectrophotometer. Minor and maximum range for copper was 0.262 and 0.184 ppm, respectively. In different samples highest value for lead was 492 ppm and lowest was 0.056 ppm. Zinc values ranged between 2.949 and 1.715 ppm. Cadmium values ranges between 0.883 and 0.02 ppm. Highest value of nickel ranged between 1.47 and 0.74 ppm (Table 3).

Canonical Correspondence Analysis was used for relative relationing of vegetation and environmental parameters (Fig. 2 and 3).

DISCUSSION

Present study indicated different plant communities existing in a definite set of environmental conditions, which did not change over the study period. The focus is given to the formation of communities. The persistent and predictable patterns suggest that there are underlying, controlling factors[17]. Such underlying controlling environmental factors were given emphasis in this study.

The results of farthest neighbour method gives the classification of vegetation into two major communities in the selected area (Fig. 1). Vegetation classified by this method is dominated by that of *Brossounetia papyrifera* and *Cannabis sativa* and the other is by *Dalbergia sissoo* and *Cannabis sativa* clearly indicating the association of both native and exotic plant species in the area. Results show that *Broussonetia papyrifera*, an invasive species, present abundantly and taking hold over the indigenous species of *Dalbergia sissoo* rapidly. It can quickly colonize in any area. Its tremendous range shows its ability to thrive in various climates throughout the world[18]. This species is introduced some years back in Islamabad and eventually it flourished quickly in the whole area putting drastic effects on the local vegetation.

CCA analyzed the correlation and regression between floristic data and environmental factors within the ordination by generating ordination axes that are linear combinations of environmental variables[19]. Patterns of variation of floristic composition in relation with environmental variables are expressed by multivariate methods. Environmental factors are very important in plant communities formation and distribution of species in any area[4]. Some species are more dependent upon environmental parameters and others less. Dependent species are called as sensitive species. Neither elevation nor vegetation canopy had significant individual effects on total species richness, but their interaction was significant[20].

Interaction of different quadrats with soil chemical parameters is observed which showed that the most of the quadrats resistant to soil pH, EC and calcium content belong to group II and further classification is also on the basis of its dependency on these soil parameters. pH and EC are positively correlated to one another but most of the quadrats are not affected by it. Therefore the quadrats of Major Group I are separated irrespective of influence of these soil characteristics. The relationship between the concept of a vegetation continuum and existence of plant communities has long been debated[21]. The frequency of combinations of co-occurring species depends on the frequency of suitable environments for that combination of species in the landscape. Vegetation classification therefore reflects distinctness of habitat conditions as it affect species occurrence[22].

Nutrient uptake is limited in low soil moisture conditions of soil. Calcium is found fairly high along drain and servant quarters where normally debris and heaps of garbage are deposited containing high concentrations of calcium content. Few of the quadrats in the study site were found resistant to calcium concentrations (Fig. 2). The species excessively present in this area are *Convolvulus arvensis, Cucurbita* sp., *Cymbopogon* sp., *Linum amplexicaule, Phalaris minor* and *Ricinus*

communis. These trends affect the abundance of certain species due to differences in physico-chemical soil characteristics and management practices[23].

Most of the sites with higher concentration of organic matter and electric conductivity showed lower values of moisture content. Moisture and organic matter show inverse relation due to multiple factors acting upon it. For example, due to high vegetation cover people living in the neighborhoods use the area as grazing spot for their animals putting negative impact on soil fertility and ability of soil to hold the organic matter. On the other hand, in Islamabad frequent rains occur due to heighted Margallah hills. Being steep and sloppy litter and organic matter hardly get the chance to accumulate in the soil and most of it is flushed away with water[24]. However, urbanization may also play an important role, as some ruderal habitats such as garbage holes, dumps and rubbish tips became strongly reduced and were often replaced by buildings, parks or urban greenery[25]. Soils rich in organic matter have acidic properties but in moist soil due to its dilution, acidity decreases and basicity increase this is mainly the reason that only a single out of 39 soil samples show pH lower than 7 (acidic). A few species show affinity for lower pH. The highest value of organic matter in soil is found to be 3.0% in quadrat 30. Studies showed that it was a disturbed area along zero point so more litter is being accumulated in that area. Soil organic matter is also increased due to the excreta of animals over that area. The species depending upon organic matter are *Sonchus asper, Sisymbrium* spp. etc. Organic matter and soil moisture are the factors most strongly correlated with species richness[26].

Heavy metal analysis is also performed to investigate the heavy metal contamination of soil and its effect on vegetation[27]. Most of the quadrats of Group II are found to be resistant to the concentrations of Cd, Ni and Zn. Results show the highest value of cadmium and nickel in quadrat 13 (Fig. 3). The dominant species in this soil were *Acacia* sp., *Polygonum plebejum* and *Calotropis*. Waste disposal at this site was seen during field visits. Domestic waste contains broken batteries, cells, cigarette fragments etc. All such waste contains cadmium and nickel. Often smokers passing by the area throw the cigarette pieces on the ground without caring to through in the disposal bins which is a major cause of soil contamination with cadmium. Cigarette and nickel in soil comes from cigarette and batteries disposal into the soil[28].

Results show that soils containing relatively greater amount of lead are located mostly along the road side so transportation on roads becomes the reason for accumulation of lead in the surrounding environment. Results show negative correlation of lead with copper. Vegetation of an area is a prominent indicator of the deteriorating soil conditions and is sensitive to such an extent that any contaminant addition by effluents and waste disposal can alter its structure and composition[29]. Results show that *Parthenium hysteriphorus* and *Morus* sp. were present in the soil abundantly containing lead. The complex relationships have been observed. Manipulation of one factor may produce unexpected effects on other factors, which may induce a series of consequences for the whole community. All the values of heavy metals and pH are within the permissible limits. Soil nutrients and other soil parameters influence upon vegetation growth and distribution of plant communities based upon their ecological requirements[30].

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