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Vegetation Dynamics and Diversity Status in Mughal Garden Wah, Pakistan

Khansa Gulshad, Sheikh Saeed Ahmad*, Summra Erum, Hafsa Bashir and Ayesha Ayub
Department of Environmental Sciences, Fatima Jinnah Women University, The Mall Rawalpindi, Pakistan

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Abstract: Classification and ordination of vegetation of Mughal Garden, Wah, Pakistan was done along with assessment of diversity status. A total of 45 species were recorded in vegetation survey belonging to 24 families with Asteraceae and Poaceae being the largest families. Herbs dominated the flora of Wah Garden by 44.4%, shrubs 15.5%, trees 13.3%, grasses 11.1%, creeping herbs 11.1%, ferns 2.2% and aquatic herbs 2.2%. About 35.5% species were annuals, 28.8% perennials, 13.3% annuals or perennials, 8.8% annuals or biennials, 8.8% deciduous, 2.2% coniferous and evergreen species. In case of life form of species, Therophytes and Megaphanerophytes were the most prevalent among species indirect ordination techniques TWINSPAN and DCA were employed that produced two major groups which were further divided into five communities and three major groups, respectively. Shannon-Wiener diversity index, Simpson Index of diversity and Hill's N1 and N2 diversity numbers were calculated and verified by data attribute plot through DCA suggesting reduced species diversity as Shannon-Wiener diversity index ranged between 0 and 1.67 due to increased anthropogenic activity. The outcome of this research will be useful in providing information on identification of species that are present, their distribution patterns, and classification which would help in management and conservation of native vegetation in future.

Keywords: DCA, diversity indices, species diversity, TWINSPAN, vegetation composition

Introduction

Vegetation can be defined as spontaneously growing plants thus not all growing plants form vegetation rather after some years of spontaneous growth and subsequent development form vegetation(Van der Maarel and Franklin, 2012). Individual plants are building blocks of vegetation that together make up species, population and communities. Presence and absence of each specie present within plant communities is very important along with quantity and abundance (Ramsay *et al*., 2006). Vegetation significance in ecosystems, for instance representation of all ecosystems, primary production source and habitat, correspond to its importance in ecology that demonstrate the need for methods of vegetation analysis (Kent, 2012).

With the passage of time, increase in human population and demand for land use resulted in existing vegetation degradation and reduction in quality of ecological environment and human health as well (Jackson, 2003; Jim, 2000). When human activity removes vegetation then they replace it with some form of land use like agriculture, industrialization, urbanization etc. and accordingly, due to these land uses, some vegetation gets completely vanished while some bloom in the form of highly modified vegetation like parks and gardens. Along with these modified vegetation types, remnants of previous vegetation may exist over small areas in modified form (Kent, 2012). Gardens and parks show significant part in ecology and landscape. Those who developed the idea of natural gardens were understood as early ecologists (Conan, 1999). Conversely, little evidence has been found related to gardens vegetation data about arrangement, density in a given period and region (Ruggles, 2008).

Classification and ordination results of Dendrogram Cluster Analysis (DCA) and Two Way Indicator Species Analysis (TWINSPAN) clustered 19 sites into five groups in El-Qaa plain of Egypt (El-Ghanim and Amer, 2003). Identification of vegetation communities was done by TWINSPAN and DCA into six and three groups in Chott El Beida wetland of northeast Algeria (Khaznadar, 2009). Nkosi *et al*. (2016) classified vegetation through TWINSPAN into eleven plant communities within four vegetation structural units. Many diversity indices have been used for measuring species diversity. These diversity indices take into account both species richness and evenness like Shannon-Wiener Diversity Index which is heterogeneity measure (Hollenbeck and Ripple, 2007).

*Author for correspondence; E-mail: drsaeed@fjwu.edu.pk

The present study was conducted with objectives of (1) quantifying vegetation abundance, frequency, density and to classify vegetation using ordination and classification techniques, (2) evaluating diversity indices by calculating species richness, evenness, Shannon-Wiener diversity index, Simpson Index of diversity and Hill's N1 and N2 diversity numbers through data attribute plot.

Materials and Methods

Study area. The present study was carried in Mughal Garden Wah, Pakistan lied at geographical coordinates of 33.8013N, 72.7010E. The study area is located 2 Km east of Hassanabdal on main GT road (Khan, 1997). Being an archaeological and cultural site, it is of immense importance but increased excavation of surrounding limestone, unsustainable land use practices and increased deforestation has threatened the valuable vegetation species survival. Unsustainable tourism practices have effected soil and vegetation quality badly. So, the present study aimed in determining reciprocal effects of soil conditions over species distribution.

Field survey. Several field trips were made for the collection of wild plant species during the month of March and April of 2015 when herbaceous plants were on full bloom. Quadrat method was applied for vegetation sampling for 50 quadrats under stratified random sampling technique. 1×1 square meter quadrats were marked in the field with equipment called quadrat frames. Herbaceous data was collected together with shrubs and few tree species. The cover value(%) of plants was determined by visual estimation, the method called Domain Cover Scale (Kent, 2011). In addition to floristic list and cover value of plants, different other plant attributes were also measured like Specie Richness

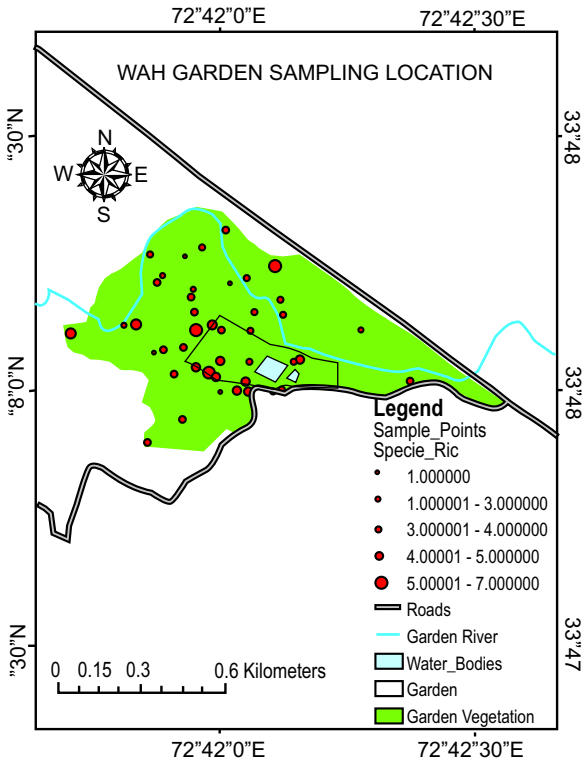

Fig. 1. Location of sample plots where floristic data was collected. The size of symbols corresponds to the species richness in individual samples.

i.e. No of species present in sample and absolute and relative frequency and density (Rodwell, 2006). Absolute and relative values for frequency and density for each plant species was calculated by phytosociological formulas given in equation* 1, 2, 3 and 4 (Mandal and Joshi, 2014).

$$\text{Absolute frequency (AF)\%} = \frac{\text{No of quadrats in which a specie occurs}}{\text{Total number of quadrats}} \times 100 \quad \text{..... (1)}$$

$$\text{Relative frequency (RF)\%} = \frac{\text{Absolute frequency value for a specie}}{\text{Total absolute frequency values for all species}} \times 100 \quad \text{..... (2)}$$

$$\text{Absolute density (AD)} = \frac{\text{Total No of individuals of a species}}{\text{Total number of quadrats}} \times 100 \quad \text{..... (3)}$$

$$\text{Relaive density (RD)\%} = \frac{\text{Absolute density value for a specie}}{\text{Total absolute density value for all species}} \times 100 \quad \text{..... (4)}$$

A general description of sample plot which was recorded included habitat type, longitude, latitude and altitude. All plants species were identified in herbarium of Quaid-e-Azam University, Islamabad.

Data analysis. Multivariate analyses have been used as tools to classify vegetation and to clarify vegetation variability and composition (Zhou, 2004). Classification of vegetation summarize field data in a low dimensional space with similar species and samples plotted together while dissimilar ones far apart thus reduces problems of comprehension (Greig-Smith, 1983). TWINSPAN is hierarchical divisive and polythetic classification approach that classifies vegetation having similarity so it enables to distinguish homogenous groups along with indicator species (Jafari *et al*., 2004). DCA is one of the indirect ordination methods and it identifies variation in species composition from species abundance data (Hill and Gauch, 1980). Two-Way Indicator Specie Analysis (TWINSPAN) was carried out in PC-Ord 5 software for vegetation classification. Results of this analysis were produced in the form of dendrogram. DCA was done in CANOCO 4.5 for further classification of plant species that validates the result of TWINSPAN and it divided species into major and minor groups. A number of diversity indices are used by ecologists to study species diversity in different plant communities. Species richness (Margalef index-M), species diversity (Simpson index of diversity- and Shannon-Wiener index-H′), species evenness (Pielou evenness index-J′), Hill's diversity numbers N1 and N2 were determined through following formulas (Wilson and Khakouli-Duarte 2009; Huang *et al*., 2007; Li Y and Shao, 2005).

$$M = \frac{(S-1)}{LnN}$$

$$D = \frac{\Sigma\, n_i\,(n_i-1)}{N\,(N-1)}$$ Simpson index of Diversity (λ)=1-D

$$H' = \sum_{i=1}^{s} - Pi\ Ln\ (Pi)$$

$$J' = \frac{-\,\Sigma_{i=1}^{s}\, Pi\ Ln\ (Pi)}{LnS} = \frac{H'}{LnS}$$

$$N1 = \exp\,(\Sigma_{i=1}^{s}\, Pi\ Ln\ (Pi)) = \exp\,(H')$$

$$N2 = \frac{1}{D}$$

where:

S is the number of species, Pi is the proportion of species I in sampling plot, N is the total number of individuals for all species.

CANOCO 4.5 was used for verification of these different indices in order to formulate study more precisely and data attribute plots were generated for each index using DCA.

Results and Discussion

Floristic composition. A total of 45 species were recorded in vegetation survey including 18 repeating species which were present more than once in the study area. The identified species belonged to 24 families and 45 genera (Table 1). The most highly represented families were Asteraceae and Poaceae with 6 species followed by Moraceae, Brassicaceae, and Euphorbiaceae which were also prominent having 3 species each. While the remaining families comprised only 2 and 1 species each that represented several important and widespread species.

Vegetation of Wah garden was highly diverse consisting of herbs which comprised 44.4% of recorded flora, shrubs 15.5%, trees 13.3%, grasses 11.1%, creeping herbs 11.1%, ferns 2.2% and aquatic herbs 2.2% (Fig. 2).

As far as life cycle of species is concerned, large number of annuals were present in the study area which correspond to the fact that annuals are tolerant toward unfavorable habitat conditions and they colonize pioneer and disturbed environments (Symonides, 1988). In case of life form of species, most species belong to therophytes i.e. 55.56%, while 15.56% species were hemicryptophytes, 8.89% were nanophanerophytes, 17.78% were megaphanerophytes and 2.2% were geophytes.The dominance of therophytes over the other lifeforms indicates dry climate and human disturbance in study area. As therophytes are adopted to dry climate, less rainfall and spend unfavorable season in seed form (Jain and Singh, 1984). These results are congruent with vegetation of Wadi Al-Noman and Wadi Al-Jufair of Saudi Arabia (Khalik *et al*., 2013; Alatar *et al*., 2012).

Concerning species absolute and relative frequency, it ranged from 2%-56% and 0.5%-15.5% and absolute

Table 1. List of species identified in Mughal Garden Wah

Species	Families	Habit	Life cycle	Life form
Adiantum capillus-veneris L.	Adiantaceae	Fern	Perennial	G
Amaranthus viridis L.	Amaranthaceae	Herb	Annual	Th
Anagallis arvensis L.	Primulaceae	Herb	Annual	Th
Aristida spp. L.	Poaceae	Grass	Annual or Perennial	Th
Avena sativa L.	Poaceae	Herb	Annual or Perennial	Th
Boerhavia diffusa L.	Nyctaginaceae	Creeping Herb	Perennial	H
Calotropis procera (Ait.) Ait. f.	Asclepladaceae	Shrub	Perennial	NP
Cannabis sativa L.	Cannabaceae	Herb	Annual	Th
Capsella bursa-pastoris (L.) Medik.	Brassicaceae	Herb	Annual	Th
Cenchrus biflorus Robx L.	Poaceae	Grass	Annual	Th
Centaurea calcitrapa L.	Asteraceae	Herb	Annual or Biennial	Th
Chenopodium album L.	Amaranthaceae	Herb	Annual	Th
Convolvulus arvensis L.	Convolvulaceae	Creeping Herb	Perennial	H
Cupressus sempervirens L.	Cupressaceae	Tree	Coniferous	MP
Cynodon dactylon (L.) Pers.	Poaceae	Grass	Perennial	Th
Digitaria setigera Roth ex Roem. & Schult	Poaceae	Grass	Annual or Perennial	Th
Eriobotrya japonica (Thunb.) Lindley	Rosaceae	Tree	Ever Green	MP
Euphorbia heliscopia L.	Euphorbiaceae	Herb	Annual	Th
Euphorbia prostrate L.	Euphorbiaceae	Creeping Herb	Annual	Th
Ficus carica L.	Moraceae	Tree	Deciduous	MP
Ficus religiosa (L.)	Moraceae	Tree	Deciduous	MP
Galinsoga parviflora Cav.	Asteraceae	Herb	Annual	Th
Justicia adhatoda L.	Acanthaceae	Shrub	Perennial	NP
Malvastrum coromandelianum (L.) Garcke	Malvaceae	Shrub	Perennial	H
Malva parviflora L.	Malvaceae	Herb	Annual or Perennial	Th
Melilotus indica L.	Fabaceae	Herb	Annual or Biennial	Th
Morus papyrifera L.	Moraceae	Tree	Deciduous	MP
Nasturtium officinale R. Br.	Brassicaceae	Aquatic Herb	Perennial	H
Oxalis corniculata L.	Oxalidaceae	Herb	Annual or Perennial	Th
Parthenium hysterophorus L.	Asteraceae	Herb	Annual	Th
Poa annua L.	Poaceae	Grass	Annual	Th
Polygonum aviculare L.	Polygonaceae	Creeping Herb	Annual	Th
Portulaca oleracea L.	Portulacaceae	Herb	Annual	Th
Ranunculus muricatus L.	Ranunculaceae	Herb	Annual or Biennial	Th
Ricinus communis L.	Euphorbiaceae	Shrub	Perennial	MP
Rumex dentatus L.	Polygonaceae	Herb	Annual or Biennial	H
Senegalia modesta (Wall.) P.J.H. Hurter	Fabaceae	Tree	Deciduous	MP
Silybum marianum (L.) Gaertn.	Asteraceae	Herb	Annual or Perennial	Th
Sisymbrium irio L.	Brassicaceae	Herb	Annual	Th
Solnaum nigrum L.	Solanaceae	Shrub	Perennial	H
Sonchus asper (L.) Hill	Asteraceae	Herb	Annual	Th
Stellaria media (L.) Vill.	Caryophyllaceae	Creeping Herb	Annual	NPh
Taraxacum officinale GH Weber ex Wiggers	Asteraceae	Herb	Perennial	H
Withania somnifera (L.) Dunal.	Solanaceae	Shrub	Perennial	NPh
Ziziphus nummularia (Burn. f.) Wight & Arn.	Rhamnaceae	Shrub	Perennial	MP

MP = Megaphanerophytes; NP = Nanophanerophytes; H = Hemicryptophytes; G = Geophytes; Th = Therophytes.

and relative density of species was found between 0.1%-17.4%. Cover value (sum) ranged from 5-830 in which low cover value is for species having subsided abundance in area while high value is for species having ample occurrence (Table 2).

In case of rare species, their absolute frequency was 2% while relative frequency was 0.5% with cover values ranging from 5-60% (Fig. 3). Among these rare species few of them are *Anagallis arvensis, Senegalia modesta, Stellaria media, Withania somnifera, Amaranthus viridis*

etc. These rare species were confined to specific geomorphologic units like garbage, emerging from architecture of garden, along water bodies and from walls. *Anagallis arvensis* and *Stellaria media* were regarded as rare species in Margalla Hills National Park Islamabad because of their cover value which was less than 10% (Ahmad, 2009). Similarly El-Ghanim *et al*. (2010) stated Anagallis *arvensis* and *Withania somnifera* among infrequent species due to their 11.1% presence in Hail region of Saudi Arabia.

Classification of flora by TWINSPAN. TWINSPAN divided study area into two groups A and B. Group A is further subdivided into community I, II, III, IV while Group B is further subdivided into community V (Fig. 4). These communities were named on the basis of abundant species in each community.

Group A. Community I was the largest community consisting of about 23 species. Dominant species on the basis of cover value of this community were *Digitaria setigera, Parthenium hysterophorus, Silybum marianum,*

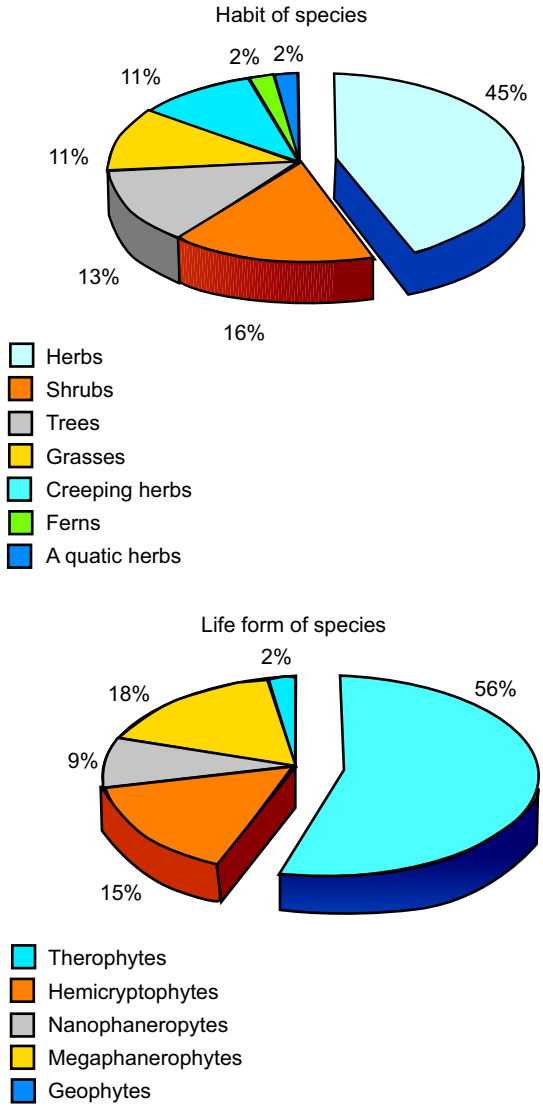

Fig. 2. Habit and life form of identified species.

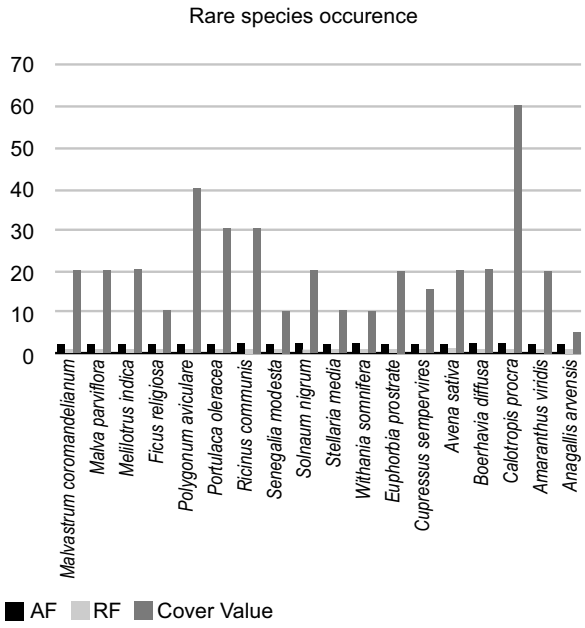

Fig. 3. Occurrence of rare species with absolute, relative frequency and cover value.

Table 2. Dominant species of Mughal Garden Wah with AF, RF, AD, RD and cover values

Dominant Species	AF%	RF%	AD	RD%	Cover value
Cannabis sativa L.	44	12.2	17.4	17.45236	870
Cynodon dactylon (L.) Pers.	56	15.5	11.8	11.83551	590
Oxalis corniculata L.	48	13.3	13.4	13.44032	670
Digitaria setigera Roth ex Roem. & Schult	34	9.4	7.9	7.923771	400
Taraxacum officinale GH Weber ex Wiggers	26	7.2	5.7	5.717151	285

AF= Absolute frequency, RF= Relative frequency, AD= Absolute density, RD= Relative density

Justicia adhatoda and *Aristida* species. The most prevailing species were *Digitaria setigera* having cover value sum of 400 and absolute frequency (AF) of 34% and *Parthenium hysterophorus* having cover value sum of 245 and AF of 16% thus name set for this community was Digitaria-Parthenium (dig-par).

Community II comprise 6 species i.e., *Capsella bursa-pastoris, Euphorbia heliscopia, Chenopodium album, Portulaca oleracea, Malva parviflora* and *Rumex dentatus.* The title given to this community was Rumex-Chenopodium (rum-che) on the basis of dominant species in community II of group A.

Community III of group A was smallest and it include 5 species of *Eriobotrya japonica, Ficus religiosa, Galinsoga parviflora, Ficus carica* and *Poa annua.* Hence name specified to this community was Poa-Eriobotrya (poa-eri) because of prevalent species *Poa annua* with cover value sum of 80 and AF of 6% and *Eriobotrya japonica* with cover value sum of 45 and AF 6%.

Community IV consist of 6 species which were *Boerhavia diffusa, Euphorbia prostrate, Taraxacum officinale, Morus papyrifera, Sonchus asper* and *Oxalis corniculata.* Second most dominating species i.e. *Oxalis corniculata* was residing in this community with cover value sum of 670 and AF of 48%. This community was titled as Oxalis-Taraxacum (oxa-tar).

Group B. Community V was the only community of group B and was smallest community but it consist of first and third most dominant species of study area on the basis of their cover value i.e. *Cannabis sativa* with cover value sum of 830 and AF of 44% while *Cynodon dactylon* with cover value sum of 590 and AF of 56% therefore, this community was given name of Cannabis-Cynodon (can-cyn).

Ordination of flora using DCA. The species were classified to find out distribution pattern and major plant communities. Different species occurring with closely same abundance in the same quadrat had occupied the same point and show similar response to environmental variables for their survival. DCA resulted in three groups along with outliers (Fig. 5).The first axis of DCA have highest Eigen value of 1 indicating high variation in species composition and abundance while DCA second axis have Eigen value of 0.904 also indicating significant floristic variation.

Group A. A total of 22 species were identified in this group therefore it was largest group. The most dominant specie identified in group A was *Cannabis sativa* having cover value (sum) of 830 with absolute frequency of 44% and it was followed by *Digitaria setigera* with cover value (sum) of 400 and absolute frequency of 34%, *Taraxacum officinale* with cover value (sum) of 285 and absolute frequency of 26% and *Rumex dentatus* with cover value (sum) of 170 and absolute frequency of 10%. This group can be distinguished from other groups due to high percentage of occurrence and large number of species presence.

Group B. It was the second largest group with 16 numbers of species. Among these species the most dominant was *Oxalis corniculata* with cover value

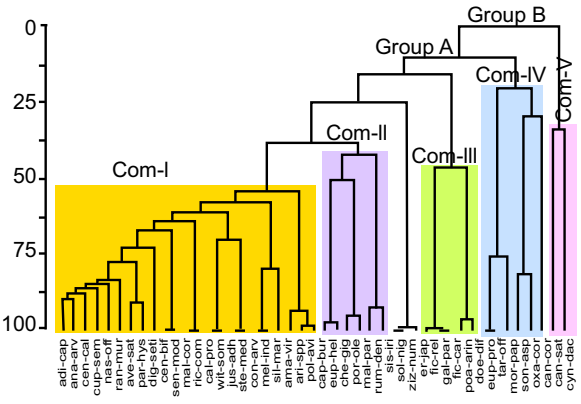

Fig. 4. Two Way Cluster Analysis Dendrogram illustrating presence of five communities of Mughal Garden Wah vegetation.

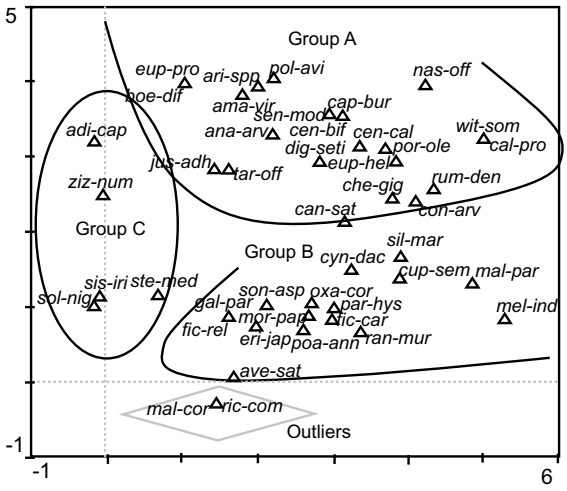

Fig. 5. DCA scatter plot of vegetation.

(sum) of 670 and absolute frequency of 48% along with *Cynodon dactylon* having cover value (sum) of 590 and absolute frequency of 56%, respectively.

Group C. Last group formed by DCA comprised 5 species which were *Adiantum capillus-veneris, Ziziphus nummularia, Sisymbrium irio, Solnaum nigrum* and *Stellaria media.* All these species were less frequent in Wah Garden with less abundance value.

TWINSPAN and DCA analysis of Wadi Al-Noman and Wadi Al-Jufair of Saudi Arabia divided vegetation species into four groups and they were named according to their dominant and subdominant species (Khalik *et al*., 2013; Alatar *et al*., 2012). Dominant species identified by TWINSPAN and DCA were *Cannabis sativa, Oxalis corniculata, Cynodon dactylon* and *Digitaria setigera. Cannabis sativa,*the most frequently occurring specie of study area, is a wild herb and grows in moist and waste places near houses and along roadsides. It is common weed found throughout of Pakistan (Abbasi *et al*., 2011). Riaz and Javaid (2009) studied an invasion of weeds in Wah Cantt and reported *Cannabis sativa* as most frequently occurring species with AF of 86% and RF of 4.28%. *Oxalis corniculata* is found in the temperate areas having moisture and sunlight like waste places, cultivated lands in loamy soil, gardens, yards, driveways and sidewalk cracks (Abbasi *et al*., 2011; Eiten, 1955). Another prevalent species, *Cynodon dactylon* is commonly found in warm and temperate climates of world (Kole, 2011). Natural population are highly tolerant toward soil salinity (Pessarakli, 2007). *Cynodon dactylon* appeared as most dominant specie with RF of 47.5% followed by *Cannabis sativa* with RF of 17.9% in Islamabad as stated by Shabbir and Bajwa (2006). *Cynodon dactylon* was identified as the diagnostic species with cover value of 40% along roadside vegetation of Abbottabad city while cover value of 19.7% in Margalla Hills National Park, Islamabad (Ahmed *et al*., 2009; Ahmed, 2009).

Diversity status. Species diversity is an important component of ecosystem health and is necessary for quantifying ecological status of different habitats (Izsák and Papp, 2000). Many diversity indices have been used for measuring species diversity. These diversity indices take into account both species richness and evenness like Shannon-Wiener Diversity Index which is heterogeneity measure (Hollenbeck and Ripple, 2007). For calculating the diversity of species in the study area, calculation of indexes was done with the help of formulas and after that they were further verified by data attribute plot using DCA. Each diagram comprises of samples index values represented by symbols and size of symbols correspond to value of each index accordingly.

Species richness Margalef index-M is defined as total number of species present and the total number of individuals. The maximum Margalef richness value observed was 6.78 in sample 19 that was sampled from orchards having diverse vegetation while minimum value was 0.78 in sample 4,11,28,38,44 and 49 (Fig. 6a). All these samples having minimum Margalef richness value were sampled from areas having high abundance of single species. On the other hand,Shannon-Wiener index accounts both species abundance and richness. Resulting values ranged between 0 and 1.67 which indicates less species diversity in Mughal Garden Wah.Sample which have highest species richness achieved highest index of 1.67 while those samples which have only one species resulted in 0 value of Shannon index (Fig. 6b)**.**

Evenness of species measures relative abundance of different species making up richness of area and it has maximum value when all species in sample are equally abundant, uniformly distributed comprising homogenous communities. In case of evenness index J′ of species, highest value of 1 was found in sample 8 that has similar relative abundance of species or equal number of individuals belonging to each species while species evenness was 0 in samples that also have 0 value of Shannon index that indicates less species diversity result in only one or few species dominate. Remaining samples have moderately high species evenness (Fig.6c).

As far as Simpson index of diversity is concerned, its value range between 0 and 1, the greater value corresponds to large sample diversity. It indicates the probability that two individuals which are randomly selected from sample belong to different species. Hence, in current research, the minimum value was 0 while maximum value was 0.77. Thus those samples which have large values had greater diversity of species as compared to other samples.

Hill's diversity numbers N1 and N2 measure the effective number of abundant and most abundant species in samples while remaining species are considered as rare species. In case of N1, highest N1 number of 5.35 was observed that indicates maximum number of abundant species in sample 19 (Fig. 6d). This N1 number can be

interpreted as the number of uniformly distributed species (Wilson and Khakouli-Duarte, 2009).However lowest N1 number obtained was 1 that correspond to only 1 abundant species in each sample and also these samples have 0 Shannon and evenness index which specifies less richness and evenness along with less abundant species.

Hill's N2 number ranges between 1 and 4.4. Samples having 1 value indicates only one most abundant species each whereas greater values indicated large number of most abundant species in samples (Fig. 6e). This N2 number can be inferred as the number of uniformly distributed species that would produce identical Simpson index of non-uniformly distributed community (Wilson and Khakouli-Duarte, 2009).

All measured indices showed strong correlation with each other. For instance, samples having less species richness of 0.78, 0 value of evenness index and lowest number 1 of N1 and N2 also indicated 0 value of Shannon diversity index and Simpson index because both these diversity indices are combined measure of evenness and richness. Despite of this relationship between indices, they are not interchangeable and each one has its specific purpose in appropriate context. It is inferred that species richness index and Shannon diversity index values were less for samples of study area demonstrating less diversity in Mughal Garden Wah due to replacement of natural vegetation of garden with ornamental plants, lack of conservation planning and pollution from adjacent mountains and factories. Consequently, competition between species occurred which reduced number of species that are able to survive. The results of current study are justified by Intermediate Disturbance Hypothesis of Connell (1978) which proposes that if the competition between species is same then those species having more resistance to changes of environment would survive in disturbed habitats. Mandal and Joshi (2014) studied plants diversity in deciduous forests of Doon Valley, Western Himalaya, India. Results stated that species richness decreased for native shrubs and trees species due to grazing and cutting pressure that resulted in increase of invasive species while disappearance of native species because of their less competitive ability. Shaheen *et al*. (2012) measured Shannon-Wiener Diversity Index, Simpson Diversity Index and Eveness Index in western Himalaya's moist temperate forests of Kashmir. Also Wangchuk *et al*. (2014) utilized Shannon-Wiener Diversity Index and Margalef Index of richness to

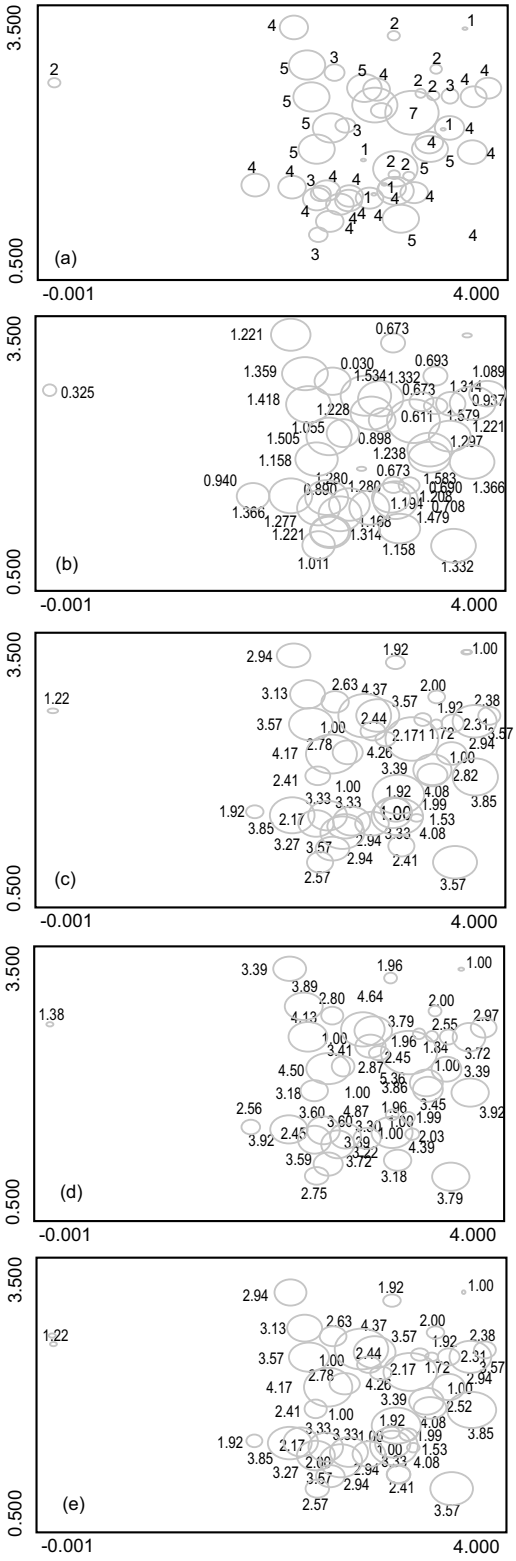

Fig. 6. Number of species (a),Shannon-Wiener index (b), Evenness index J′ of species (c), Hill's diversity numbers N1 (d) and N2 (e) in samples through DCA data attribute plot.

investigate under story vegetation of Himalaya conifer forest along anthropogenic gradients. In these studies particular indices indicated that species diversity is associated with anthropogenic influences along with environmental variables.

No earlier studies were conducted on vegetation and soil of Mughal Garden Wah thus there was lack of knowledge and extensive research on taxonomic studies of herbaceous flora around Mughal Garden Wah. Therefore, it provided base for further study on vegetation distribution in and around Mughal Garden Wah because of its ecological and heritage importance.

Conclusion

In present study, about 45 plant species were identified, belonging to 24 families, in Mughal Garden Wah. Out of these total species, *Cannabis sativa, Oxalis corniculata, Cynodon dactylon* and *Digitaria setigera* were the four most prevailing species on the basis of cover value. According to the intermediate disturbance hypothesis, species colonization occurs at early stages which leads to maximum diversity and after that reduction in diversity occurs due to competition for limited resources (Connell, 1978). This hypothesis is applicable to study area community as due to anthropogenic activities like deforestation, pollution, limestone excavation resulted in creation of microhabitats which promoted the growth of colonizers while eliminating native species. That is why the number of dominant species were less in Mughal Garden Wah along with species richness and evenness leading to less heterogeneity in garden vegetation. Hence, current study emphasizes the need for conservation of Mughal Garden Wah vegetation species before their extinction.

Recommendations

For future perspective, *in-situ* conservation strategy and management of rare and indigenous flora (having medicinal and market value) of Mughal Garden Wah should be done by making inventory of plant species. Such plants species includes *Anagallis arvensis, Senegalia modesta, Stellaria media, Withania somnifera, Amaranthus viridis, Calotropis procera, Solnaum nigrum, Malva parviflora, Galinsoga parviflora, Convolvulus arvensis* and *Centaurea calcitrapa.*

Conflict of Interest. The authors declare no conflict of interest.

References

Abbasi, A. M., Khan, M. A., Ahmad, M., Zafar, M. 2011. *Medicinal Plant Biodiversity of Lesser Himalayas-Pakistan*. 220pp., Spring-verlag, NY, USA.

Ahmed,S. S. 2009. Ordination and classification of herbaceous vegetation in Margalla Hills National Park Islamabad, Pakistan. *Biological Diversity and Conservation*, **2:**38-44.

Ahmed, S. S., Fazal, S., Valeem, E. E., Zafar, I. 2009. Evaluation of ecological aspects of road side vegetation around Havalian city using multivariate techniques. *Pakistan Journal of Botany*, **41:** 53-60.

Alatar, A., El-Sheikh, M. A., Thomas, J. 2012. Vegetation analysis of Wadi Al-Jufair, a hyper-arid region in Najd, Saudi Arabia. *Saudi Journal of Biological Sciences*, **19:** 357-368.

Conan, M. 1999. *Perspectives on Garden Histories*. vol. **21,** 240 pp., Dumbarton Oaks Publications Harward University Press Washington, USA. ISBN 9780884022657.

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs. *Science*, **199:** 1302-1310.

Eiten, G. 1955. The typification of the names "*Oxalis corniculata* L." and "*Oxalis stricta* L". *Taxon*, **4:** 99-105.

El-Ghanim, M. M. A., Amer, W. M. 2003. Soil–vegetation relationships in a coastal desert plain of southern Sinai, Egypt. *Journal of Arid Environments*, **55:** 607-628.

El-Ghanim, W. M., Hassan, L. M., Galal, T. M., Badr, A. 2010. Floristic composition and vegetation analysis in Hail region north of central Saudi Arabia. *Saudi Journal of Biological Sciences*, **17:** 119-128.

Greig-Smith, P. 1983. *Quantitative Plant Ecology,* 374 pp., 3rd edition. John Wiley and Sons Ltd., Oxford, UK.

Hill, M.O., Gauch, H.G. 1980. Detrended correspondence analysis: an improved ordination technique. *Vegetation*, **42:** 47-58.

Hollenbeck, J. P., Ripple, W. J. 2007. Aspen and conifer heterogeneity effects on bird diversity in the northern Yellowstone ecosystem. *Western North American Naturalist*, **67:** 92-101.

Huang, D., Wang, K., Wu, W. L. 2007. Dynamics of soil physical and chemical properties and vegetation succession characteristics during grassland desertification under sheep grazing in an agro-pastoral transition zone in Northern China. *Journal of Arid Environments*, **70:** 120-136.

Izsák, J., Papp, L. 2000. A link between ecological diversity indices and measures of biodiversity. *Ecological Modelling*, **130:** 151-156.

Jackson, L. E. 2003. The relationship of urban design to human health and condition. *Landscape and Urban Planning*, **64:** 191-200.

Jafari, M., Chahouki, M. Z., Tavili, A., Azarnivand, H., Amiri, G. Z. 2004. Effective environmental factors in the distribution of vegetation types in Poshtkouh rangelands of Yazd Province (Iran). *Journal of Arid Environments*, **56:** 627-64.

Jain, S. P., Singh, J. S. 1984. Biological spectrum of the vegetation of North-East Haryana in India. *Nelumbo*, **26:** 145-148.

Jim, C. Y. 2000. The urban forestry program in the heavily built-up milieu of Hong Kong. *Cities*, **17:** 271-283.

Kent, M. 2011. *Vegetation Description and Data Analysis: A Practical Approach*, 428 pp.,2nd edition. John Wiley & Sons, UK.

Khan, M. S. 1997. Estimation of Contaminants in Ground Water and Establishment of Protection Zones in Wah Cantt. *PhD Thesis*. University of Punjab, Lahore, Pakistsn.

Khalik, K. A., El-Sheikh, M., El-Aidarous, A. 2013. Floristic diversity and vegetation analysis of wadi Al-Noman, Mecca, Saudi Arabia. *Turkish Journal of Botany*, **37:** 894-907.

Khaznadar, M., Vogiatzakis, I. N., Griffiths, G. H. 2009. Land degradation and vegetation distribution in Chott El Beida wetland, *Algeria Journal of Arid Environments*, **73:** 369-377. .

Kole, C. 2011. *Wild Crop Relatives: Genomic and Breeding Resources*. Cereals. 247 pp., Springer - verlag Berlin, Heidelberg, Germany.

Li, Y., Shao, M. 2005. Degradation process and plant diversity of alfalfa grassland in North Loess Plateau of China. *The Journal of Applied Ecology*, **16:** 2321-2327.

Mandal, G., Joshi, S. P. 2014. Analysis of vegetation dynamics and phytodiversity from three dry deciduous forests of Doon Valley, Western Himalaya, India. *Journal of Asia-Pacific Biodiversity*, **7:** 292-304.

Nkosi, S. E., Barrett, A. S., Brown, L. R. 2016. Vegetation ecology of the Nooitgedacht section of Loskop Dam Nature Reserve, Mpumalanga. *South African Journal of Botany*, **105:** 79-88.

Pessarakli, M. 2007. *Handbook of Turfgrass Management and Physiology*. 720 pp., CRC Press, USA.

Ramsay, P. M., Kent, M., Reid, C. L., Duckworth, J. C. 2006. Taxonomic, morphological and structural surrogates for the rapid assessment of vegetation. *Journal of Vegetation Science*, 1**7:** 747-754.

Riaz, T., Javaid, A. 2009. Invasion of hostile alien weed *Parthenium Hysterophorus* L. in Wah Cantt, Pakistan. *The Journal of Animal and Plant Sciences* (Pakistan), **19:** 26-29.

Rodwell, J. S. 2006. *National Vegetation Classification: Users'Handbook*. 68 pp., Joint Nature Conservation Committee. (JNEC), UK. ISBN 978-1-86107-5741.

Ruggles, D. F. 2008. Islamic Gardens and Landscapes, 296 pp. University of Pennsylvania Press, USA.

Shabbir, A., Bajwa, R. 2006. Distribution of parthenium weed (*Parthenium hysterophorus* L.), an alien invasive weed species threatening the biodiversity of Islamabad. *Weed Biology and Management*, **6:** 89-95.

Shaheen, H., Ullah, Z., Khan, S. M., Harper, D. M. 2012. Species composition and community structure of western Himalayan moist temperate forests in Kashmir. *Forest Ecology and Management*, **278:** 138-145.

Symonides, E. 1988. On the ecology and evolution of annual plants in disturbed environments. In: *Temporal and Spatial Patterns of Vegetation Dynamics*, J. Miles, W., Schmidt, and E. Van der Maarel, (eds.), vol. **77**, pp. 21-31, Springer, The Netherlands.

Van der Maarel, E., Franklin, J. 2012. *Vegetation Ecology*. 572 pp., 2nd edition, John Wiley & Sons. USA.

Wangchuk, K., Darabant, A., Rai, P. B., Wurzinger, M., Zollitsch, W., Gratzer, G. 2014. Species richness, diversity and density of understory vegetation along disturbance gradients in the Himalayan conifer forest. *Journal of Mountain Science*, **11:** 1182-1191.

Wilson, M. J., Khakouli-Duarte, T. 2009. *Nematodes as environmental Indicators*. 326 pp., CABI, UK.

Zhou, N.M. 2004. Vegetation Soil Relationships as Aids to Soil Survey in Semi-Arid Areas. *Ph.D. Thesis*, University of Zimbabwe, Zimbabwe.