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Multivariate analysis of the ecological data of natural vegetation of Lahore district

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Abstract

A study of vegetation and different parameters of soil and water of Lahore District was carried out in this investigation. Vegetation data was evaluated by using multivariate analysis methods i.e., Tow-way Indicator Species Analysis (TWINSPAN) and Canonical Correspondence Analysis (CCA). About seventy eight species belonging to thirty seven families were recorded from forty quadrats in Lahore district. Two major (plant associations) and six sub plant communities (sub associations) were recognized in the study area. The study also considered the relationship of vegetation structure to certain environmental aspects. This relationship was determined by CANOCO analysis. The distribution of plant species with respect to environmental variables indicated that water pH, soil EC, water content and water table showed a great influence upon species distribution. This study also gives useful information to protect and improve the present vegetation cover for conservation of local flora.

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Introduction

Lahore is bounded on the east by Wagah, on the north and west by Sheikhupura District and on the south by Kasur District. The Ravi River moves on the northern and western side of Lahore. It has a hot semi-arid climate (Köppen climate classification *BSh*) with extremely hot, rainy, and long summers, cold and dry winters, monsoon rainfall during both summer and winter seasons and dust storms during summers. Soil of the area derived from mixed river alluvium, is well drained, brown to yellowish brown in colour and silty loam in texture. Limited general cropping of mainly wheat, rice, sugarcane and fodders is practiced in the area. The geographical location of Lahore district is 31°30′24″N 74°18′506″E.

The purpose of present investigation was to enumerate the vegetation in Lahore district using ordination methods and to measure various hydrological and adaphic characteristics of the area under investigation. The study will develop awareness to protect indigenous flora. Increase in population and demand of land for infrastructure development has resulted in the destruction of vegetation growing there and dearth of new sites for plantation (Jim, 2000); which has adversely affected the quality of ecological environment and human health (Jackson, 2003). Soil, water and vegetation relationship can be determined by applying ordination or multivariate techniques in which species are arranged along gradients. Multivariate techniques are frequently used in phytosociological studies. Two way Indicator Species Analysis (TWINSPAN) is a classification technique, in which, there is a classification of stands and then this classification serve as the base for the classification of species (Hill, 1979).

Ahmad *et al.,* (2010) conducted ecological studies of the vegetation along Motorway (M-2), Pakistan. The phytosociological survey was undertaken and floristic data was analyzed by the TWINSPAN. Two hundred and twenty seven plant species distributed across 75 families were recorded from 397 quadrats. The vegetation of the entire study area was divided into two major and sixteen sub communities down the 358 km long motor way. This study also provided suggestions for the conservation and management measures that should be taken for the preservation of roadside vegetation. A study was conducted by Ahmad and Quratulann, (2011a) in Ayubia National Park, Pakistan to classify and record the abundance and distribution of plant species. About 59 species distributed across 32 families were documented. Two major communities i.e., community 1 consisting of *Hedera nepalensis* and *Adiantum caudatum* while community 2 of *Plantago major* and *Rumex nepalensis* were recognized by TWINSPAN analysis. The study emphasized the urgent need of conservation and protection of the local vegetation. Ahmad and Yasmin (2011) carried out a similar study on natural vegetation along Hana Lake, Baluchistan, Pakistan, to classify the vegetation into plant communities, by analyzing vegetation data through TWINSPAN. The study area was divided into two zones. In both the zones two major and four sub communities were recognized. Ahmad *et al.*, (2014) conducted a survey of Changa Manga Forest (CMF) and recognized 45 species belonging to 24 families from the study area. The TWINSPAN analysis of the vegetation data showed *Parthenium hysterophorus, Oxalis corniculata, Malvastrum coromandelianum, Desmostachya bipinnata* and *Cynadon dactylon* as dominant species in all the four zones.

The determination of species relationship to environment has always been the main focus of ecology (Antoine and Niklaus, 2000). Ecologists have been trying to realize the elements that determine the variation in vegetation composition and floristic distribution for over a century (Glenn *et al.*, 2002). In Canonical Correspondence Analysis (CCA) the floristic data and the environmental variables can be included in the ordination simultaneously (Kashian *et al.,* 2003). Ahmad *et al.,* (2009) conducted a survey on road side vegetation and soil around Havalian city, using Multivariate techniques. The study revealed the vegetation structure and its correlation to selected ecological factors through CANOCO analysis. The

principal factors affecting the road side vegetation were determined to be Pb, Cu, and Zn to some extent. As the topographic factors cause changes in vegetation, a study was conducted by Tamartash *et al,* (2010) in Rangelands of Lasem, Iran to record characteristics of plants and topographic data of each community to see the effect of topographic factors on floristic changes.

Data analyzed by Canonical Correspondence Analysis (CCA) revealed that different plant communities show different relationships to physiographic factors. Shrubs exhibited more correlation with elevation and aspect as compared to grasses while shrubs showed non significant correlation with slope. Another study was conducted by Ahmad and Quratulann (2011b) in Ayubia National Park, Rawalpindi in order to find out the relationship of ecological variables with species abundance. The study area was divided into two zones. Canonical Correspondence Analysis (CCA) results exhibited that the species were in scattered condition in Zone 1 due to the low organic matter and soil moisture content as forest cover was not so dense in this zone, while zone 2 species showed the opposite trend. The study emphasized the need to conserve the local flora.

Although considerable work on ethnobotany and ethnomedicine has been done in different Districts of Punjab Pakistan, but it is without ethnoecological background. Hence there was a need for an integrated and comprehensive study of wild flora in the study area with special reference to the indigenous knowledge of habitat conditions where species occur. The present study was designed to record the ethnoecology of wild flora in Lahore district of Central Punjab, including the indigenous knowledge of the habitat conditions of wild plants. The study sites were selected to record the floristic composition and the principal plant communities existing there. This study would be a significant contribution towards biodiversity conservation as well as the sustainable use of wild plant species.

Materials and methods

The quadrat method was utilized for the collection of floristic data. Quadrat size of 1x1m for grasses, 5x5 m for shrubs and 10x10 m for trees was selected. 40 quadrats were laid down in the study area. Within each quadrat percentage cover of all vascular plant species were recorded by visual estimation according to Domin Cover Scale (Kent and Coker, 1995). The sampling was carried out two times a year i.e., during February and September.

For identification of plant species the Flora of Pakistan was consulted (Nasir and Ali, 1970-1989; Ali and Nasir, 1990-1992; Nasir and Rafique, 1995; Ali and Qaisar, 1992-2010). Soil parameters included EC, pH, texture, colour, water content and water parameters covered pH, EC and water table depth (Allen, 1989). Two way indicator species analysis (TWINSPAN) and Canonical Correspondence Analysis (CCA) ordination methods were applied for quantification and analysis of floristic data.

Results and discussion

The outcomes of this study are divided into two parts. First part describes the results of plant species analysis using multivariate technique of TWINSPAN and second part describes the results of CCA analysis of vegetation data.

TWINSPAN Classification of Species at Lahore Study Area

Based on survey of the study area, that involved collection of vegetation data from 40 quadrats, seventy eight species belonging to thirty seven families were recorded. In order to classify the vegetation types, cluster analysis was performed by TWINSPAN (Hill, 1979). The results clearly divided the vegetation of study area into two major communities, which were further divided into six sub-communities. The results are represented in the form of a dendrogram in Fig. 1. Each community was designated after the leading dominant species. The communities differ from each other due to variation in environmental attributes.

Table 1 shows the abbreviations used for the plant species represented in Fig.1 and 2.

Table 1. Abbreviations for Plant Species Displayed in Fig.1 and 2.

Sr. No.	Species	Abbreviations
1.	*Abutilon indium*	*Abu-ind*
2.	*Acacia nilotica*	*Aca-nil*
3.	*Achyranthes aspera*	*Ach-asp*
4.	*Ageratum houstonianum*	*Age-hou*
5.	*Albizia lebbeck*	*Alb-leb*
6.	*Aloe vera*	*Alo-ver*
7.	*Alternanthera* sessilis	*Alt-ses*
8.	*Amaranthus viridis*	*Ama-vir*
9.	*Anagallis arvensis*	*Ana-arv*
10.	*Asphodelus tenuifolius*	*Asp-ten*
11.	*Azadirachta indica*	*Aza-ind*
12.	*Calotropis procera*	*Cal-pro*
13.	*Cannabis sativa*	*Can-sat*
14.	*Capparis decidua*	*Cap-dec*
15.	*Chenopodium album*	*Che-alb*
16.	*Chenopodium murale*	*Che-mur*
17.	*Convolvulus arvensis*	*Con-arv*
18.	*Conyza bonariensis*	*Con-bon*
19.	*Coronopus didymus*	*Cor-did*
20.	*Cotula hemisphaerica*	*Cot-hem*
21.	*Cynodon dactylon*	*Cyn-dac*
22.	*Cyperus rotundus*	*Cyp-rot*
23.	*Dactyloctenium aegyptium*	*Dac-aeg*
24.	*Dalbergia sissoo*	*Dal-sis*
25.	*Datura fastuosa*	*Dat-fas*
26.	*Dichanthium annulatum*	*Dic-ann*
27.	*Echinochloa colona*	*Ech-col*
28.	*Eclipta prostrata*	*Ecl-pro*
29.	*Eruca sativa*	*Eru-sat*
30.	*Euphorbia helioscopia*	*Eup-hel*
31.	*Euphorbia hirta*	*Eup-hir*
32.	*Euphorbia prostrata*	*Eup-pro*
33.	*Ficus benghalensis*	*Fic-ben*
34.	*Ficus religiosa*	*Fic-rel*
35.	*Fumaria indica*	*Fum-ind*
36.	*Heliotropium crispum*	*Hel-cri*
37.	*Imperata cylindrica*	*Imp-cyl*
38.	*Lathyrus aphaca*	*Lat-aph*
39.	*Launaea procumbens*	*Lau-pro*
40.	*Malva parviflora*	*Mal-par*
41.	*Malvastrum coromandelianum*	*Mal-cor*
42.	*Mazus goodenifolius*	*Maz-goo*
43.	*Medicago polymorpha*	*Med-pol*
44.	*Melilotus indica*	*Mel-ind*
45.	*Morus alba*	*Mor-alb*
46.	*Mukia maderaspatana*	*Muk-mad*
47.	*Nicotiana plumbaginifolia*	*Nic-plu*
48.	*Ocimum basilicum*	*Oci-bas*
49.	*Oxalis corniculata*	*Oxa-cor*
50.	*Panicum antidotale*	*Pan-ant*
51.	*Parthenium hysterophorus*	*Par-hys*
52.	*Phalaris minor*	*Pha-min*
53.	*Poa annua*	*Poa-ann*
54.	*Polygonum aviculare*	*Pol-avi*
55.	*Polygonum plebejum*	*Pol-ple*
56.	*Polypogon monspeliensis*	*Pol-mon*
57.	*Pseudognaphalium luteoalbum*	*Pse-gna*
58.	*Ranunculus muricatus*	*Ran-mur*
59.	*Rhynchosia minima*	*Rhy-min*
60.	*Ricinus communis*	*Ric-com*
61.	*Rumex dentatus*	*Rum-den*
62.	*Saccharum bengalense*	*Sac-ben*
63.	*Salvia plebeia*	*Sal-ple*
64.	*Sisymbrium irio*	*Sis-iri*
65.	*Solanum nigrum*	*Sol-nig*
66.	*Solanum surattense*	*Sol-sur*
67.	*Sonchus asper*	*Son-asp*
68.	*Stellaria media*	*Ste-med*
69.	*Suaeda fruticosa*	*Sua-fru*
70.	*Terminalia* arjuna	*Ter-*arj
71.	*Trianthema portulacastrum*	*Tri-por*
72.	*Trianthema triquetra*	*Tri-tri*
73.	*Tribulus terrestris*	*Tri-ter*
74.	*Trifolium alexandrinum*	*Tri-ale*
75.	*Trifolium resupinatum*	*Tri-res*
76.	*Typha domingensis*	*Typ-dom*
77.	*Withania somnifera*	*Wit-som*
78.	*Zaleya pentandra*	*Zal-pen*

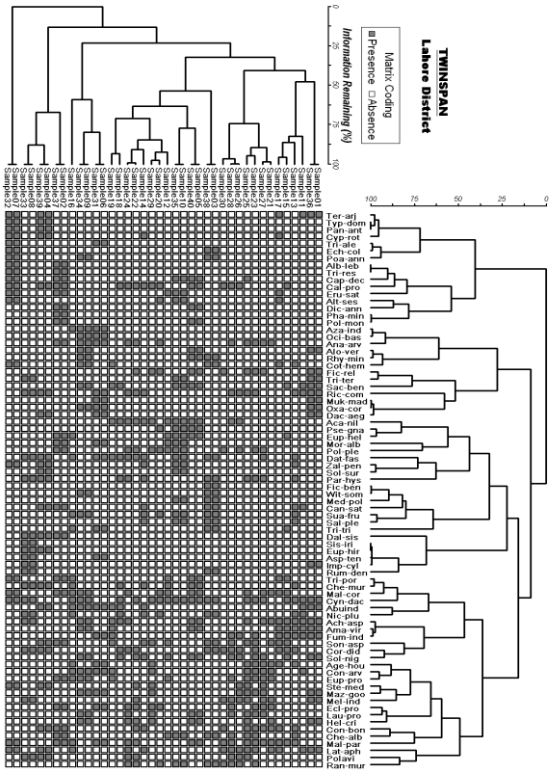

Fig. 1. TWINSPAN Analysis of Species at Lahore District.

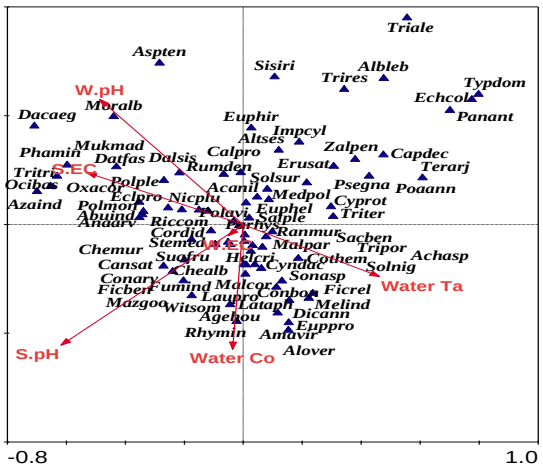

Fig. 2. Biplot Diagram of Species and Environmental Variables for Lahore.

Major Community 1: *Calotropis procera* and *Capparis decidua*

Sub-communities were:

1.1 *Terminalia* arjuna and *Cyperus rotundus*

1.2 *Calotropis procera* and *Capparis decidua*

Major Community 2: *Cynodon dactylon* and *Malva parviflora*

Sub-communities were:

2.1 *Ricinus communis* and *Anagallis arvensis*

2.2 *Datura fastuosa* and *Acacia nilotica*

2.3 *Dalbergia sissoo* and *Euphorbia hirta*

2.4 *Cynodon dactylon* and *Malva parviflora*

1.1 The sub- community *Terminalia* arjuna and *Cyperus rotundus* was a very small group which made its existence in only 11 quadrats laid down along the roads and on the banks of Lahore Canal, near Jallo. This sub community showed its presence throughout the study area on the road along canal. The two species showed fairly good percentage cover values e.g., *Terminalia arjuna* 46 % and *Cyperus rotundus* 10 %. *Terminalia arjuna*, commonly known as arjuna, flourishes well on loose wet, fertile alluvial loams and sandy soils. The soil should have ample water supplies but water should drain properly (www.holistic-herbalist.com/terminalia-arjuna-3.html). *Cyperus rotundus* is a very invasive weed. It is found growing on waste lands, roadsides and agricultural fields. If *Cyperus* is present in the field it can reduce crop yield to a great extent because it competes with the crop for mineral resources of the land. Its roots are also allelopathic, the roots release substances that are injurious to the plants growing in the vicinity (http://en.wikipedia.org/wiki/Cyperus_rotundus).

1.2 The diagnostic species of community were *Calotropis procera* and *Capparis decidua* and comprised of same dominant communities as that of major community 1. This community consisted of nine species that were recorded from Raiwind study area. Both the dominating species of this community, *Calotropis procera* and *Capparis decidua*, were typical of waste lands and were found growing abundantly in disturbed habitat in the study area. *Calotropis procera* is also known as milk weed. It propagates by seeds and grows vigorously where waste lands and disturbed areas are available (www.tncweed.ucdavis.edu/esodocs.documents.html) . *Capparis decidua* is a densely branching thorny shrub of waste lands (www.survivaliq.com.index). The plant is a favorite fodder for goats and cows. It was subjected to uncontrolled cutting from locals for a long period. *Capparis decidua* seemed to withstand the biotic pressure better than other species so it dominated the shrubs.

2.1 This sub- community of *Ricinus communis* and *Anagallis arvensis* was mostly found growing on edges of cultivated beds and waste places in the Laliani, a village on the way from Lahore to Kasur on Ferozpur Road. As the land was undisturbed so the community flourished well over there. *Ricinus communis* is an evergreen shrub that prefers soil that is drained well and grows in clayey soil. Whereas *Anagallis arvensis* is an annual or biennial herb found growing everywhere mostly near fields and waste grounds. The species seemed to be grouped together due to similar microhabitat requirements. The other species that appeared in this sub-community having percentage cover values of more than 10 % were *Azadirachta indica, Ficus religiosa, Saccharum bengalense* and *Ricinus communis*.

2.2 The exclusive species of this sub- community included *Datura fastuosa* and *Acacia nilotica* that developed on the edges of agricultural fields in Soai Asal, a small village on Farozpur Road. All the conditions in 12 quadrats studied favored the existence of these species in the area. A major reason in the association of these species as minor community seemed to be the similarity of habitat and the plants sharing the same ecological requirements. *Datura fastuosa* is herbaceous plant that was found growing in waste lands along the roads, cultivated fields and railways lines throughout the study area (www.himalayahealthcare.com/herbfinder/h_datura.htm). While *Acacia nilotica* is a medium size ever green prickly tree that grew in all kind of habitats. It is very drought resistant and can easily be grown from seed. Other prominent species of this community showing good % age cover were *Parthenium hysterophorus, Polygonum plebejum* and *Euphorbia helioscopia*.

2.3 This sub- community comprised of *Dalbergia sissoo* and *Euphorbia hirta*. It was a very small sub-community consisting of only six species that was found growing mostly around BRB (Bambawali-Ravi-Bedian) Canal. *Dalbergia sissoo* was found growing along roads, rail sides and canals as linear plantations in the study area. It was even retained in the agriculture fields for shade purposes. The farmers in Punjab have been planting *Dalbergia sissoo* since decades in linear form around the fields. It is a deciduous tree, also known as Shisham, Propagation takes place most commonly by root suckers and also by seeds. Its young foliage forms an excellent fodder for livestock. While the herbaceous member of this sub- community, *Euphorbia hirta* is a shrubby plant that prefers dry and hot regions having sandy textured soils. This group appeared in only 10 quadrats but their co- existence indicated that prevailing conditions in these quadrats were favorable enough for their growth.

2.4 *Cynodon dactylon* and *Malva parviflora* group comprised of same dominant communities as that of major community 2. It was the largest sub-community separated by TWINSPAN Clustering for Lahore data. This sub- community showed its presence in quadrats studied mostly after crossing River Ravi in Shahdra. This sub- community comprised of almost twenty seven species. *Cynodon dactylon* and *Malva parviflora* propagate by seeds and this fact was responsible for their flourishing behavior (Nasir and Rafique, 1995). Their seeds are carried by wind and dispersed to long distances. Both the species exhibited fairly good percentage cover values e.g., *Cynodon dactylon* 18 % and *Malva parviflora* 11 %. The dominance of *Cynodon dactylon* was confirmed by the reason that it occurs on almost all types of soils and was frequent on disturbed areas like road sides, areas under heavy grazing pressure, waste lands etc. (Martin *et al.*, 1951). *Malva parviflora* is a prostrate or sprawling herb with round lobed leaves. It grows as a weed of wasteland, cultivated fields, gardens, along road margins, fallow plots and degraded pastures (http://keys.lucidcentral.org/keys/v3/UQCentenary/key/UQ_Centenary/Media/Html/malvaparviflora.htm). Along with these two dominating species the other major species present in this sub- community were *Morus alba, Achyranthes aspera, Sonchus asper, Coronopus didymus, Lathyrus aphaca* etc. all were herbaceous species. This fact confirmed that herbaceous flora was well established.

CCA Analysis of Vegetation and Environmental Variables for Lahore

The overall distribution pattern of vegetation is a good indicator of the effect of environmental variables on it. In the biplot figure (Fig. 2) obtained by the analysis of vegetation and environmental variables, the point locations represent individual species whereas arrows indicate change in environmental factor in a particular direction. Longer arrow was more closely correlated in ordination than short arrow. Besides species data environmental data were included on pH, EC and soil water content as soil variables and pH, EC and water table depth as water variables in the software CANOCO.

The CCA biplot of Lahore comprised of 78 species and six environmental variables. Among them water pH, soil EC, water content and water table showed a great influence upon species distribution. The majority of the species were distributed along the center of biplot. Although most of variables were strongly correlated but there was lack of particular role of any environmental variable in the distribution of species along two axis. Water pH seemed to perform some role in grouping of *Morus alba* and *Dactyloctenium aegyptium* as these species were more closely associated in Fig. 2. Whereas *Phalaris minor, Datura fastuosa, Trianthema triquetra, Oxalis corniculata* and *Polygonum plebejum* showed correlation with soil EC. Similarly water content was showing close correlation with axis 1 and *Rhynchosia minima* and *Ageratum houstonianum* were found associated with it. On the other hand soil pH defined no strong correlation in the species distribution. *Solanum nigrum* and *Cotula hemisphaerica* were more strongly influenced by water table as indicated by association of these species by water table arrow. Existence of species close to or past the head of the arrow will be strongly correlated; while those were at opposite end will be not as much strongly affected.

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