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PEDOLOGICAL AND FLORAL ASSESSMENT OF SHINGHAR VALLEY (DISTRICT ZHOB) THROUGH MULTIVARIATE TOOLS

A. Ayub, S. S. Ahmad*, S. Erum and A. Butt

Department of Environmental Sciences, Fatima Jinnah Women University, The Mall Rawalpindi Pakistan
*Corresponding author's e-mail: drsaeed@fjwu.edu.pk

ABSTRACT

The distribution of herbaceous plant species and effect of edaphic factors on species distribution was studied to build a correlation between the herbaceous species and environmental parameter through multivariate techniques. Three zones were formed on the basis of forest (*Pinus gerardiana*) density. Herbaceous vegetation was sampled, identified and classified through Two Way Indicator Species Analysis (TWINSPAN). Soil was analyzed for organic matter, electrical conductivity, pH, moisture content and heavy metals (lead, nickel, copper and zinc).Canonical Correspondence Analysis (CCA) was employed to correlate species diversity and edaphic factors, soil organic matter and zinc content was found to be most overruling edaphic factor in the distribution patterns of herbage. The study will be helpful in conservation and better management of native flora.

Key words: *Multivariate, Quantification, Pinus gerardiana, Edaphic factor, Shinghar*.

Abbreviations: TWINSPAN-Two Way Indicator Species Analysis. CCA-Canonical Correspondence Analysis. DCA-Detrended Correspondence Analysis.

INTRODUCTION

In the forest ecosystem, various ecological aspects of herbaceous layer are of great importance. These layers efficiently contribute to the most significant processes of ecosystem such as nutrient cycling and energy flow (Gilliam *et al*., 2007). Regionally, the mountainous vegetation protects the soil but unfortunately in many regions the vegetation is threatened by climatic and human activities (Urooj *et al*., 2015). Vegetationis considered as a significant factor for the maintenance of overall systems in mountains and for this reason requires a proper classification, documentation for record and quantification in order to form relation with multi-environmental variables (Khan *et al*., 2012).Vegetation is also known as theconsiderable aspect tocontrol the chemistry of soils (Klinger, 1996). Soil physicochemical characteristics arestrongly affected by the vegetation which in turn affects the floristic composition of vegetation (Eni *et al*., 2012).

Staticariate data are used in multidisciplinaryassessment and a variety of statistical methods have been used and proposed by researchers (Guisan, 1999).Canonical Correspondence Analysis was designed to identify the main variables in ecological data-sets and for investigating different effect of particular variables on different groups of species (Braak *et al*., 1995).(TerBraak, 1988) had developed statistical package of CCA for interrelating ecological parameters with species abundance/decline and it had been employed widely in different researches such as those of Arifa *et al*. (2014) and Kashian*et al*.(2003). Recent studies throughout the world show the application of CCA as the most applicable and demanding ordination tool (Bashir *et al*., 2016; Gulshad *et al*., 2016; Yousaf *et al*., 2016; Yüce and Gönülol, 2016; Ahmad *et al*., 2014; Ahmad *et al*., 2011).

Urooj *et al*. (2016) Ordinaly classified the vegetation of Mangla dam and employed different multivariate tools to determine the relationship between vegetation and different edaphic factors. Similarly, Gulshad *et al*. (2016) employed CCA to assess the differential response of vegetation present in Mughal Garden, Wah along the effective soil gradients present there. A different researchcarried along roadsides near district Abbottabad, involved the calculation of vegetation by multivariate technique such as CCA and Detrended Correspondence Analysis (Ahmad *et al*., 2009).Same methodology was applied by researcher for the analysis of soil and vegetation along the road side greenbelts of the city Rawalpindi (Shabbir *et al*., 2014).Al-Sheikh *et al*.(2005) carried a research in Egypt which applied CCA, DCA and TWINSPAN. Similar procedure was followed in Guilan province of Iran(Adel *et al*., 2014) and He *et al*.(2006), calculated the vegetation structure in china. Harvey (1996) reported the use of CCA at different spatial scales can offer useful ecological insights studied by bio-geographers.

The main objective of this research was to check the underlying environmental gradients associated with the vegetation variation by using the CANOCO toolsfor the processing of two different types of matrix sheets. One is the classified vegetation data obtained from TWINSPAIN and the second is the analyzed results of soil for environmental variables like pH, E.C, soil moisture content, organic matter and soil heavy metals (lead, nickel, copper and zinc).

MATERIALS AND METHODS

Research site: Shinghar valley is subsidiary core of Suleiman range. Main peak range is about 9273 ft. It is about 50 km from Zhob City. Shinghar, lies at 31^0–36' North and from 69^0–59'East.The valley has edible pine forest "Chilghoza" covers an area of about 1036 Hectares. A wide cover of medicinal herbs is also covered in the area.

Zonation of the research site: Zonation of the study area (Figure 1) was developed on the basis of forest density. Zone-I thick forest (60%), zone-II moderate forest (25%) and zone-III sparse forest (15%).

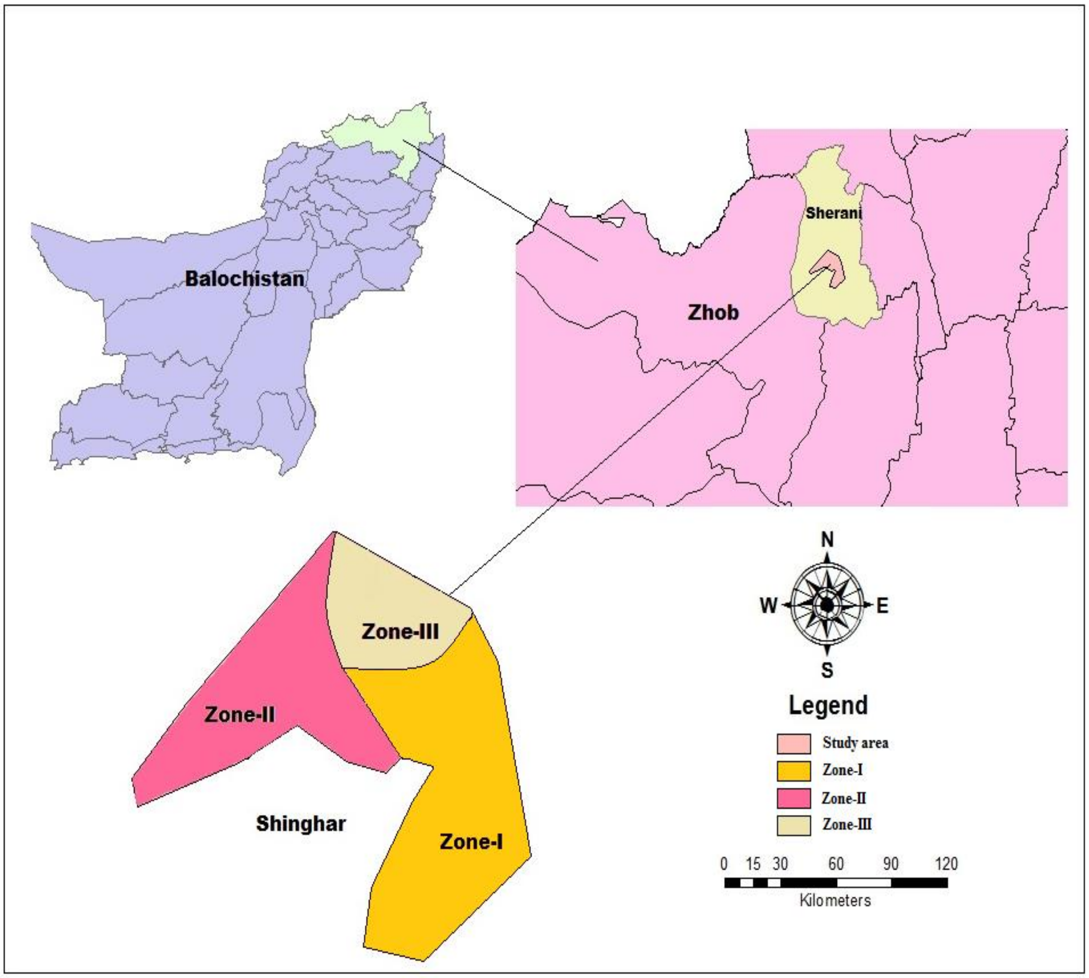

Figure 1: Study Area Map

Vegetation sampling: The floristic data was obtained by randomquadrate sampling. About 200 quadrate of size 1x1 m^2were taken. The visual cover estimation was carried out by DOMIN scale. Species were preserved and identified from literature.

Soil sampling and analysis: Soil samples were collected along each quadrate for analysis and record. Soil was analyzed for moisture content, E.C, organic matter, pH and heavy metals (Pb, Ni, Cu and Zn).Soil moisture content was analyzed by following Allen method (Allen *et al*., 1974).Soil organic matter was analyzed by following Nikolskii method (Nikolskii *et al*.,1963). Soil heavy metals were analyzed by following Rowel method (Rowel, 1996).

Canonical Correspondence Analysis: After laboratory analysis, matrix sheets were prepared in Microsoft excel and were run in CANOCO to obtain species scatter biplots, data attribute plots, species response curves (GAM), t-value biplots and pie symbol plot for all the three zones and showed significant results.

RESULTS

Canonical correspondence analysis was carried out to correlate environmental variables with the herbaceous species by obtaining different graphs and charts.

Species scatter plot: Species scatter plots were drawn separately for all zones and the results illustrated that organic matter and electrical conductivity had great influence on the propagation of plants species found in zone-I (Figure 2). More specifically, *Ephedra intermedia* and *Astragulus tribuloides* were greatly affected by the soil Organic Matter. Soil electrical conductivity strongly influenced *Withania coagulans*. However, soil moisture content slightly affected *Teucrium patulum* and *Thymus linearis*. Soil heavy metals like lead, nickel, copper and zinc influenced plants species to a level of their tolerance, While another soil parameter like pH had no greater influence except for *Sophora mollis* in zone-I. Rest of the species either individually or in group did not showed any relation with the environmental variables.

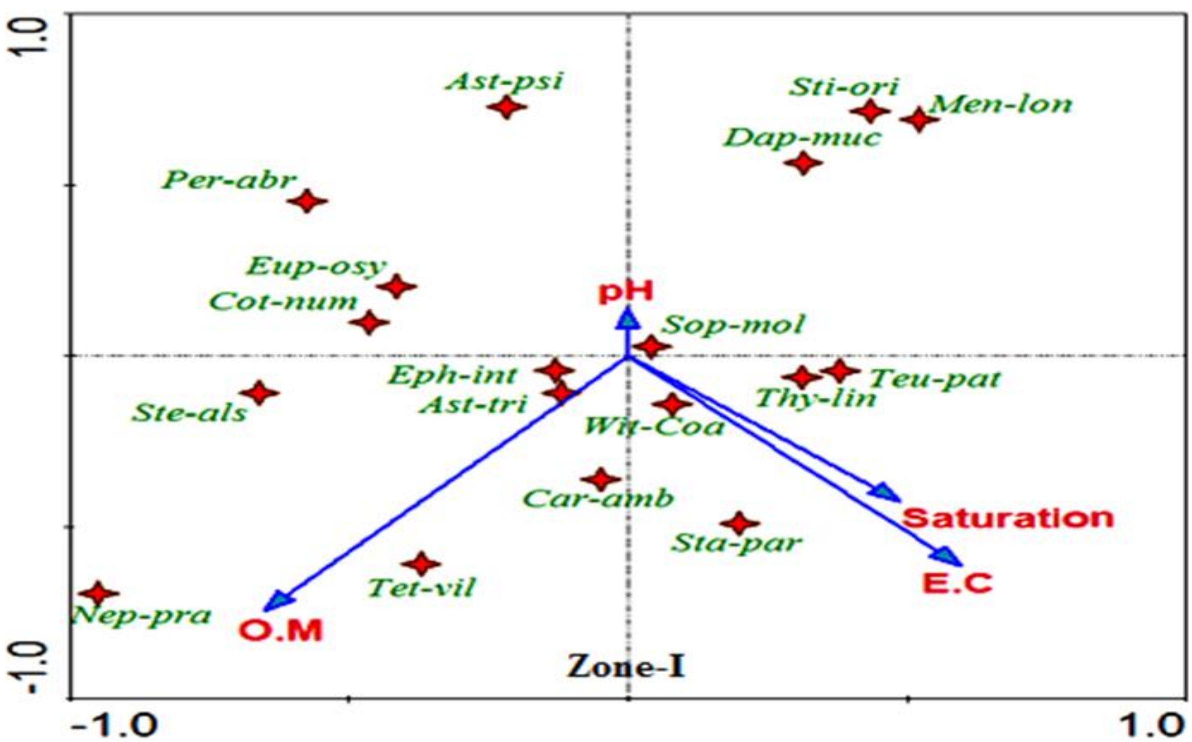

Figure 2: CCA plot of species and variables of Zone-I

T-value biplot: T-value biplots along with Van Dobben circles, elucidated that soil physicochemical parameters like organic matter, moisture content, copper (Cu) and zinc (Zn) significantly contributed in the species richness and distribution except electrical conductivity, lead (Pb) and nickel (Ni) (Figure 3). Species in all zones showed response toward soil analyzed for organic matter. In zone-Iplants species like *Cotoneasternum mularia*, *Ephedra intermedia*, *Nepetapra etervisa* and *Tetrapogon villosus* showed strong association toward organic matter. On the opposite side species like *Stipaorie ntalis*, *Teucrium patulum* and *Mentha longifolia* showed strong negative response and the rest of the species showed very less response towards organic matter of the soil occupyingzone-I. Zinccontent present in the soil of zone-II as compared to other heavy metals had positive influence on *Silenemoorcfroftiana*, *Haloxylon salicornicum* and *Ferulaoo poda* as confined in Van Dobben. *Stachysparvi flora*, *Chenopodium album* and *Zygophyllum simplex* confined in the blue circle represented their strong negative interaction with zinc. Most of the species in zone-III did not showed any or slight negative response.

Pie symbol plot: Pie symbol plots and species response curves for each variable were drawn which showed the same results. One of the important factors that play an important role in species growth and development is the soil organic matter. For Zone-III, four classes were divided from 21 distinct values(Figure 4, pie chart on the left side). Percentage average value of organic matter calculated was about 1.188 %. Class O.M-1(1.06- 1.1%), class O.M-2 (1.1-1.13 %), class O.M-3 (1.13-1.29%) and class O.M-4 (1.29-1.4 %). Results showed that class O.M-1 proved to be best for species richness. More over as depicted from the chart most of the species proved to favor their growth within the range of all classes except for some species. *Veronica agrestis* only favored to flourish in class O.M-1 whereas *Haloxylon salicornicum*, *Tetrapogon villosus* and *Mentha longifolia* preferred to grow in class O.M-4.

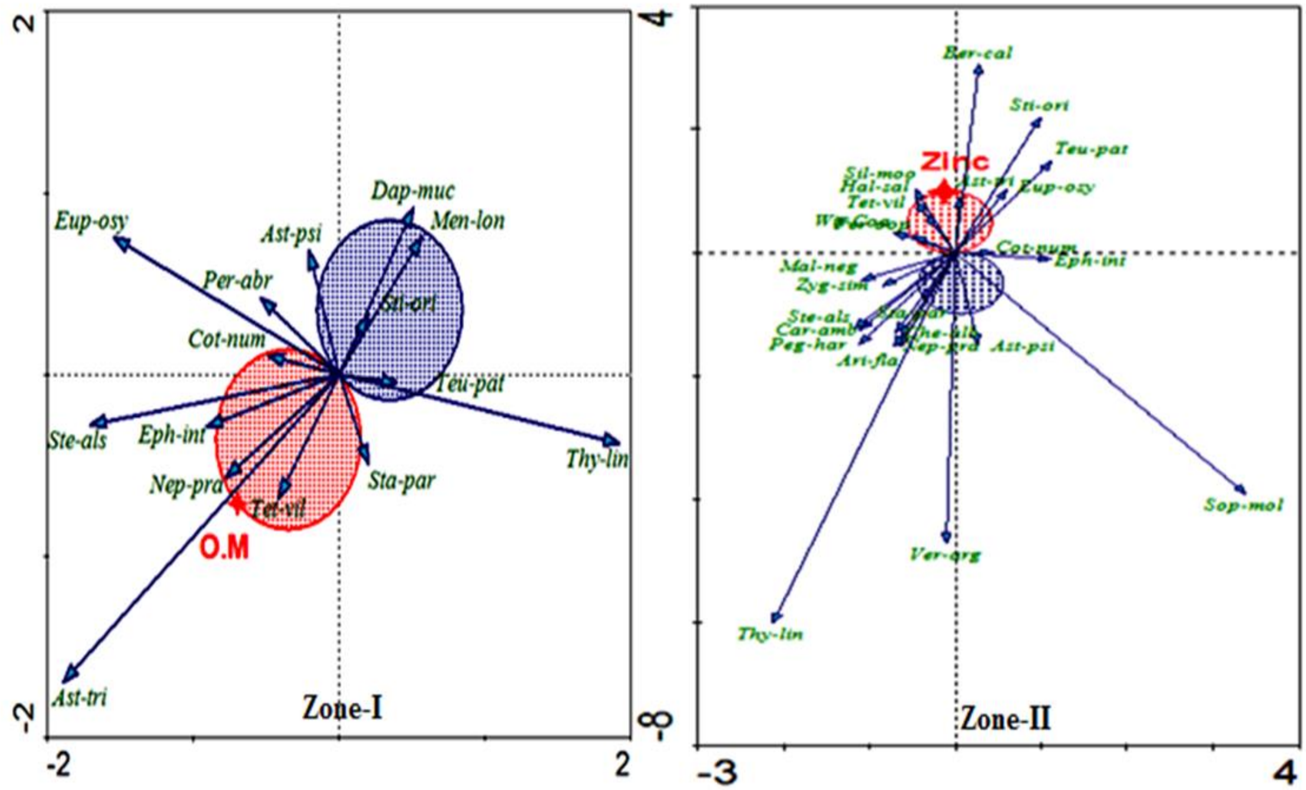

Figure 3: T-value biplot of O.M (Zone-I) and Zn (Zone-III)

Similarly, zinc is also an important nutrient for plants growth and reproduction but is required in low quantity. Excess amount of zinc content present in soil can cause toxicity. The required concentration of zinc for plants ranges between 15-20 mg/kg.Comparatively concentration of zinc content in zone-II (Figure 4, pie chart on the right side) soil ranged from 1-1.3 mg/kg. 4 distinct values were divided into 2 classes. Class zinc-1(1-1.1 mg/kg) and class zinc-2 (1.1-1.3 mg/kg). Most of the species were present in all classes and showed species richness and abundance but few species *Chenopodium album* and *Astragalus psilocentros* grow only under class zinc-1 whereas *Withania coagulans, Silenemoorcro ftiana*, *Haloxylon salicornicum* and *Tetrapogon villous* preferred to grow in class of zinc-2.

Generalized Additive Model: Specie response curve is a graphical representation and describes the relationship between a particular species with the environmental gradients that effect on its growth variations.In zone-I the most dominant species *Ephedra intermedia* showed the highest response towards the soil having organic matter in percentage of 1.3 to 1.4 %. Its upper quartile was at 40 and lower at 10. *Teucrium patulum* showed good growth response in less concentration of the organic matter in the percentage range of 0.8-0.9%. Other species showed great response in the less concentration of organic matter and showed to favor growth in the range of 0.9-1% and 1-1.3%. Most species of zone-I favored to grow in the optimum range of organic matter i.e. from 1 to 1.2 %. Other species did not showed any response towards organic matter content in soil of zone-I. Similarly GAM curve for zinc content showed that *Ephedra intermedia* formed highest Gaussian curve. Maximum response was shown by *Ephedra intermedia*in the range of high concentration of zinc from 1.4-1.5 mg/kg. The second highest response curve was shown by *Teucrium patulum*. Other species like *Sophoramollis* and *Cotoneaster nummularia* showed almost the same pattern of curve which indicated that both of the species responded well to zinc content with their optimum growth shown in the concentration range of 0.9-1.2 mg/kg (Figure 5).

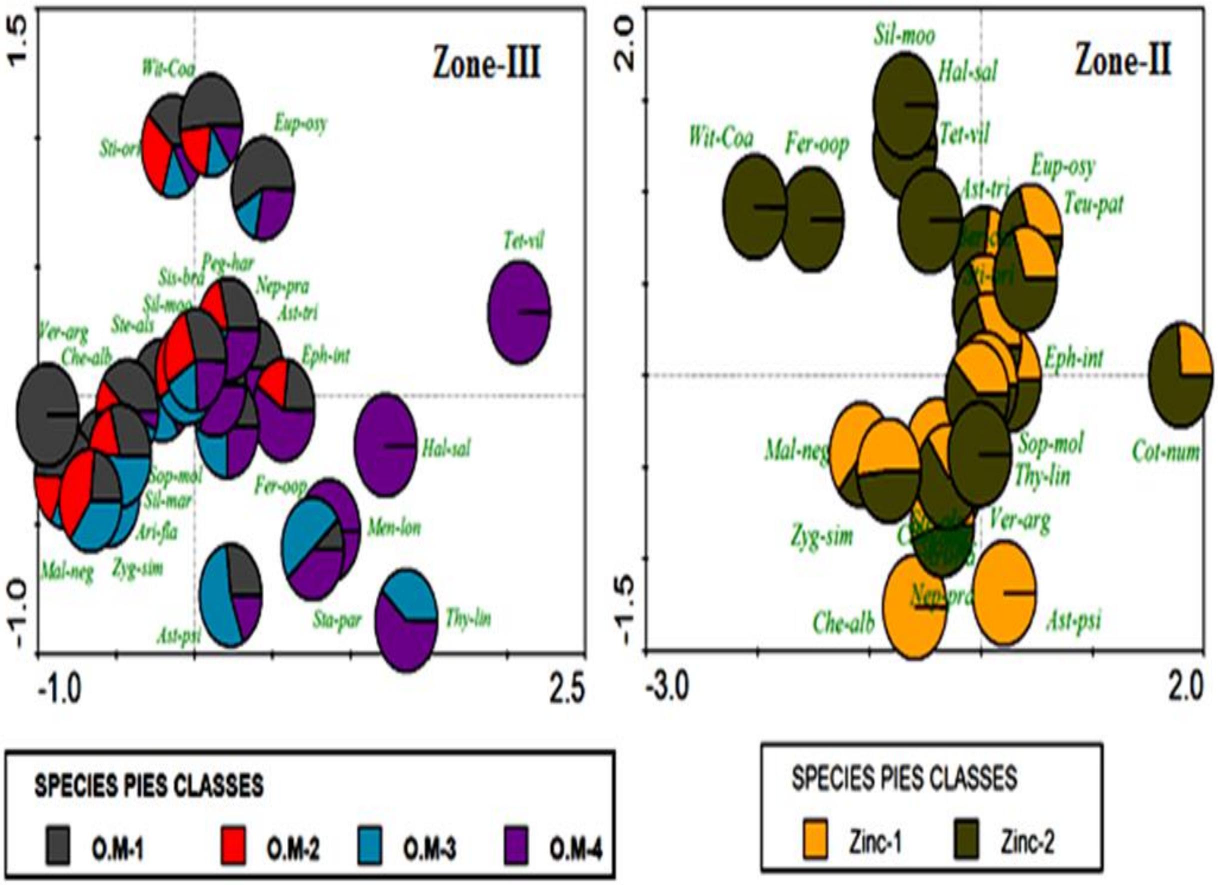

Figure 4:Pie chart of O.M (Zone-III) and Zinc (Zone-II)

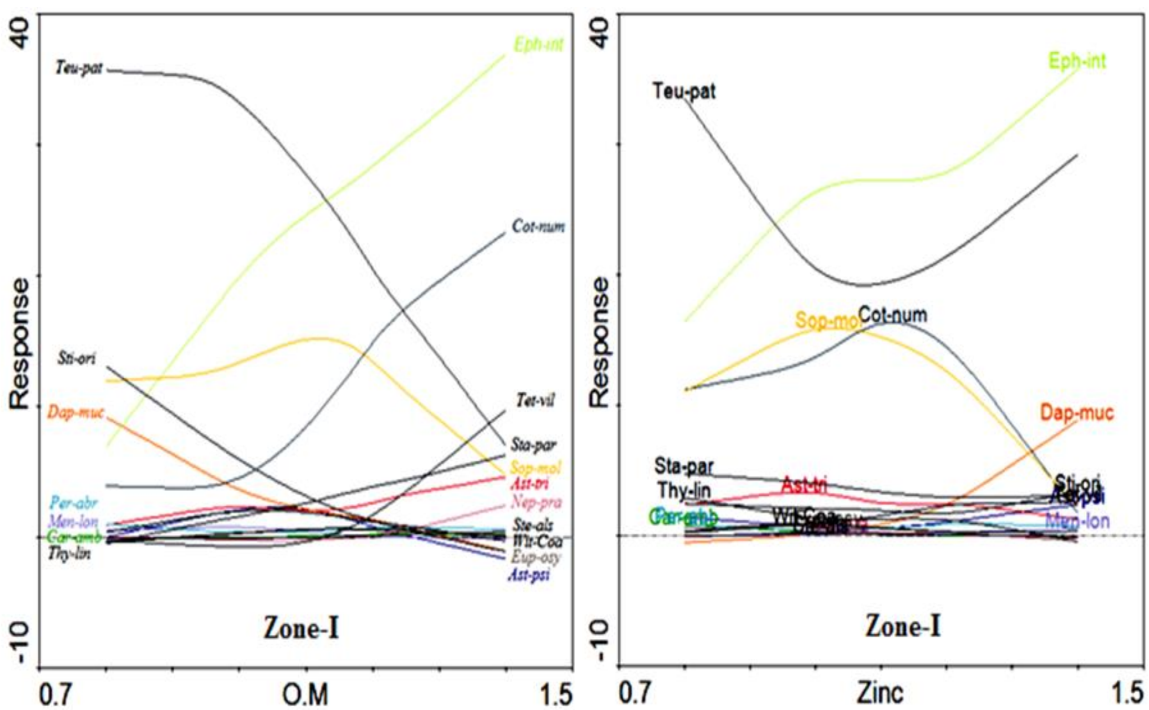

Figure 5: GAM OF O.M (Zone-I) and Zinc (Zone-I)

Data attribute plot: Data attribute plots were plotted to create relation between the most dominant specie *Ephedra intermedia* with the soil edaphic factors. In zone-II *Ephedra intermedia* was well distributed as clearly shown from the regularly distributed contour lines (Figure 6). All the values were positive which indicated that *Ephedra intermedia* had strong interaction with the soil organic matter, moisture content, electrical conductivity and pH of the soil. All soil parameters had close association with each other as shown by angles between the arrow head, which means that they have strong positive influence on the species which was clear from its dominancy over the rest species of the study area.

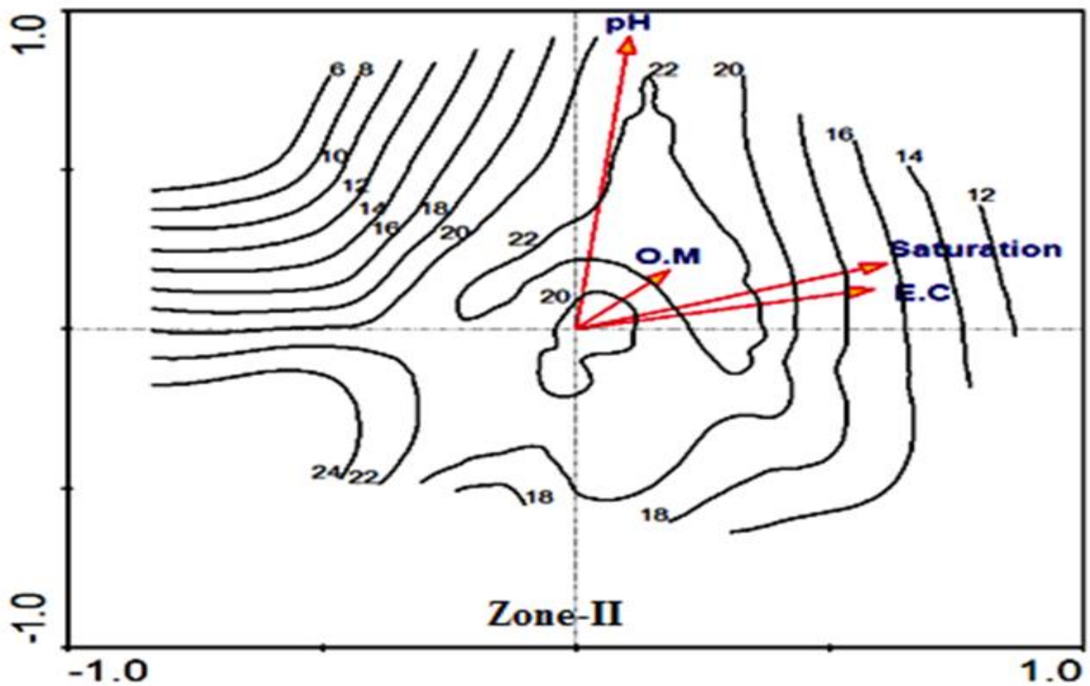

Figure 6: Data attribute plot of Zone –II.

DISCUSSION

In the present study, different graphs elucidate the association between species assemblage and the environmental gradients. The species scatter biplots were plotted with respect to environmental variables (electrical conductivity, organic matter, moisture content and pH) and soil heavy metals (lead, nickel, copper and zinc). Application of Van Dobben Circles revealed the correlation of species with each environmental variable. Based on multiple regressions between species abundance, environmental variables and heavy metals, the results revealed that soil electrical conductivity had not strong relationship as most of the species present in the three zones were showed in the negative response area. Similarly soil lead (Pb) and nickel (Ni) content did not showed positive significant relationship with the prevailing species of the study area. But other parameters of soil like organic matter content, pH, moisture content and heavy metals like copper and zinc contributed significantly towards species richness and abundance and very few species were indicated in the negative response area.Various studies that analyzed the effect of organic matter on plant growth also indicated that the plant species richness and abundance in soil is due the effect of organic matter and soil quality (Urooj *et al*.,2016;Yüce and Gönülol, 2016;LeszczyńskaandKwiatkowska-Malina, 2011; Yin *et al*., 2002). Gulshad *et al*. (2016) and Zare *et al*. (2011) also reported in their respective studies that pH, organic matter content, soil moisture content and heavy metals content make significant contributions in controlling the species richness, abundance and distribution.

The pH of the soil was mostly alkaline and the species of *Prosopis cineraria*, *Conyza bonariensis* recorded positive response for pHwhile the species of *Menthaspicata* and *Parthenium hysterophorus*, *Suaeda fruiticosa*, *Tarxacum officinale*, *Cenchrus agrimonioides*, *Convolulus arvensis* and *Cirsium arvense*, *Oxalis cornuculata* had recorded negative response towards the soil pH. Soil pH had very less impact on species of Zone-I and Zone- III and monotonic results were observed as the range of pH in forest was above 7. Similar response to soil pH by various species has been observed in the studies conducted by Gulshad *et al*. (2016) andAhmad *et al*.(2013).

Pie value plots were used to categorize each environmental variable into different classes by the different range. *Veronica agrestis* only favored to flourish in class O.M-1 whereas *Haloxylon salicornicum*, *Tetrapogon villosus* and *Mentha longifolia* preferred to grow in class O.M-4. While species *Chenopodium album* and *Astragalusp silocentros* grew only under class zinc-1 whereas *Withania coagulans, Silenemoor croftiana, Haloxylon salicornicum* and *Tetrapogon villous* preferred to grow in class of zinc-2. Relationship between the moisture and species was observed by using partial ordination in which class 3 had abundance of species. *Ranunculus muricatus* was dominant in EC while *Cannabis sativa* and *Cynodon dactylon* were lying in all four classes of pH and copper. *Viciafaba* and *Veronica persica* were abundant in EC while *Melilotus indica* was abundant in phosphorus, iron and zinc. *Veronica persica*, *Viciafaba* and *Ranunculus muricatus* were abundant in potassium and manganese pie chart. These results gave an indication of significance of soil O.M, zinc, soil moisture and EC for the growth and distribution of different species (Bashir *et al*., 2016;Yousaf *et al*., 2016; Ahmad, 2014).

Species response curves (GAM) were plotted against a specific variable to observe the response of species. The results depicted that within the three zones some species formed high bell shaped curves which indicated their abundance and their compatibility with the specified variable. Whereas, most of the species formed a straight line which indicated that they were in stress condition against the specified environmental variable. The species which were dominant in the study area showed bell shaped curves representing their significant relationship with the environmental gradients. The common species which showed high response in the all the zone of the study area were *Ephedra intermedia, Sophoramollis, Cotoneaster nummularia, Peganum harmala, Teucrium patulum, Thymus linearis, Tetrapogon villosus, Peganum harmala* and *Malva neglecta*. This interpretation is verified by the similar studies (Bashir *et al*., 2016; Yousaf *et al*., 2016; Urooj *et al*., 2015). Ejrnaes (2000) also employed Generalized Additive Model for studying the response of 146 species against pH as environmental gradient and 20% of the species resulted in formation of unimodal sigmoid curve.

Data attribute plot was drawn which revealed dominant species had significant affiliation with the environmental variables as shown by the positive values of contoured lines. Over all, dominant species of *Ephedra intermedia* had resulted in strong correlation with soil organic matter, moisture content, electrical conductivity and pH of the soil.Thus indicated that the species showed growth at wide range of every analyzed soil environmental variable.

Conclusion: This study merely reported the significance of herbaceous vegetation along the Shinghar valley. Soil's organic matter and Zinc were found to be affectingthe distribution of species. Role of soil's lead and nickel concentration was found insignificant in determining species abundance. Results provide a base line for the conservation, management and future research to promote and protect the forest ecosystem

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