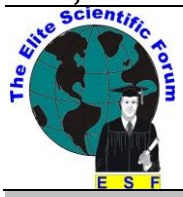
Pak. j. life soc. Sci. (2018), 16(1): 35-41 E-ISSN: 2221-7630; P-ISSN: 1727-4915



Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Ordinal Quantification of Weed Status at Khanpur Dam, Pakistan

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ARTICLE INFO
Received: Dec 09, 2017
Accepted: May 15, 2018

Keywords
Multivariate techniques
Ordination techniques
Weed status

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ABSTRACT

Weeds, spontaneously growing vegetation, are affected by environmental gradients. The present study was conducted along Khanpur dam, Pakistan with the objective to determine the weed status and subsequent effect of environmental variables. Environmental factors were also considered to record the data regarding occurrence of weed species in the study area. Different factors including pH, electrical conductivity, organic matter saturation, macronutrients and micronutrients were determined while weed species were determined using Canonical Correspondence Analysis. About 100 species in to four groups were collected along with the Dam and corresponding soil samples were also collected for the study of different nutrients. Environmental factors influenced the frequency of species in a clear way. The results showed that among all the groups, *Cynodon dactylon* and *Cannabis Sativa* were the most occurring species with the occurrence rate of about 70%. The *Salvia moorcroftiana* was the second most occurring weed specie in the area with the frequency of about 30% in all four groups. Among all environmental factors, iron was found most significant factor and its rate of effect was about 60% as compared to that of rest of the factors. The order of intensity of occurrence of species was Cynodon > Cannabis >Salvia > while soil nutrients were in the order of iron >zinc > phosphate.

INTRODUCTION

Growth of plants is found to be dependent upon soil characteristics of the particular area as soil provides them anchorage, medium for nutrient transport, moisture, organic matter and in return plants also exert their impacts upon the soil health and prevailing ecosystems. The study has focused on the status of weed herbaceous flora of Khanpur dam having moderate climate (Bashir et al., 2016) located at 33.7689º N and 72.2453º E (Khan et al., 2012). The dam was built to account for drinking purpose for twin cities of Islamabad and Rawalpindi and for irrigation purpose of Khyber Pakhtunkhwa (KP) (110 cusecs) and Punjab (87 cusecs) provinces, with storage capacity of 106,000-acre feet and 167 m height (Ejaz et al., 2012). Dam built on Haro River is fed by four tributaries i.e. Lora Haro, Stora Haro, Neelan and Kunhad (Khan et al., 2012).

The aim of the study was to use ordinal techniques for studying weed status and impact of soil parameters over growing weeds. Ordinal quantification employs disperse diagrams along 1 or 2 axis or uses points along axis (Khan et al., 2015). The ordinal quantification methods due to its immense importance are employed in phytosociology for vegetation or weed assessment. Weed plants are spontaneously growing vegetation that occur in specific time (Van der Maarel and Frankel, 2012). These weeds exist at specific habitat with specific character called as environmental factors. These factors are responsible in distribution of plants over time and space. These are also important in preventing soil from physic-chemical losses, and also affect soil structure and texture (Eni et al., 2012). proposed Two Way Indicator Species Analysis (TWINSPAN) for species classification and Detrended Correspondence Analysis (DCA) was proposed for clustering of closely associated species by Kallenge and Hooker (2018); while Canonical Correspondence Analysis (CCA) was formulated for scrutinizing the correlation between environmental parameters and species (Khan et al., 2015**).**

Several researches have already been conducted which quantified weed herbaceous flora and highlighted the impact of soil or environmental parameters over its status. Bashir et al., (2016) studied the herbaceous flora of Wah Cantonment using TWINSPAN and DCA and found *Cynodon dactylon* and *Cannabis sativa* as the overruling species. Gulshad et al., (2016) applied CCA and its techniques i.e. Van dobben circles and Partial ordination for studying correlation between soil gradients and vegetation of Mughal Garden Wah, Pakistan. Species of *Ziziphus nummularia, Adiantum capillus-veneris, Sisymbrium irio* and *Solanum nigrum* were found to be strongly affected by soil organic matter. The main purpose of this study was to observe the changes in the vegetation pattern and effect of different environmental factors on the occurrence of vegetation along the Dam of Khanpur, the hub of vegetation.

MATERIALS AND METHODS

Collection of herbaceous weed sample

Weed samples were collected during the month of April using Braun Blanquet approach by random sampling technique (Bashir et al., 2016; Ahmed, 2012). Total fifty quadrats of 1×1 were laid down and plant cover was recorded through visual estimation method (Kalleng and Hook, 2018).

Environmental data

Soil samples were collected randomly with herbaceous samples with the help of shovel in polythene bags; while water samples were collected in plastic bottles. Soil samples were collected from the depth of 10-15 cm.

Soil analysis

Soil was subjected to different tests in environmental labs of FJWU for determining various physic-chemical charecteristics viz. pH, EC, micronutrients (Cu^{2+}, Fe^{2+}, Mn^{2+}), macronutrients (Potassium, Phosphorous); while for determination of organic matter and saturation, the samples were sent to Soil Survey department, Rawalpindi, Pakistan.

Soil pH and EC: pH and EC of soil was determined by dissolving soil into water to attain 1:2 ratios. pH meter (Crison MM40+) with calibration of 4,7 and 9 buffer solutions was used for determining pH of particular soil sample. EC for particular soil sample was determined using Jenway 470 model and was noted in dS/m unit.

Soil micronutrients: Iron, copper and manganese were determined by meshing and sieving 1 g of dried soil and then digested to 12 ml aqua regia (9 ml HCL: 3 ml HNO_3). Then the samples were subjected to hot plate at 80º C for 2 hours followed by cooling and filtering the resultant solution. These filtered solutions were raised in volume to 50 ml by mixing it with distilled water. Then the extracted solution was passed through atomic absorption spectrophotometer for micronutrients determination (Glower and Hand., 1996).

Soil macronutrients: For macronutrients assessment, the concentrations of potassium and phosphorous (essential for effective plant growth) were determined.

Potassium determination: For K determination, 1 g of dried crushed soil was dissolved in 10 ml of ammonium acetate and solution was shaked for 5 minutes, then subjected to filtration. Each prepared soil solution was passed through atomic absorption spectrophotometer at 776 nm)

Phosphorous determination: A total of 1 g soil sample was extracted with deionized water and filtered. 0.5 ml of soil extract was transferred to disposable cuvette, containing 0.5ml of reaction mixture (200 mM 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid) HEPES, pH 7.0, 20 mM $MgCl_2$), both were mixed and incubated for 10 minutes. Prepared sample was then passed through atomic absorption spectrophotometer at 360 nm. (Campbell et al., 2015).

Ordinal quantification for data analysis

In the present study, ordinal assessment was used for classification of herbaceous data for delineating close associations amongst plant communities through indirect gradient analyses i.e. Two Way Indicator Species Analysis and Detrended Correspondence Analysis for delineating distribution trends. Associations between environmental data and herbaceous community were analyzed using CCA.

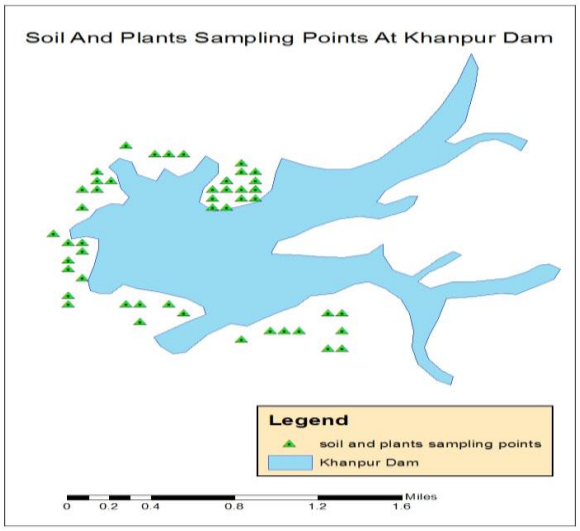

Fig. 1: Map of sampling points of weed flora and soil at Khanpur Dam.

1. TWINSPAN

In the present study, Two Way Indicator Species Analysis (TWINSPAN) was applied using PCORD 5.1 (Bashir et al., 2016) for classifying existing plant species along Khanpur Dam and for delineating major communities on the basis of relative frequencies and abundance.

2. DCA

Indirect gradient analysis technique i.e. Detrended Correspondence Analysis (DCA) was applied for determining ecological relationships i.e. species richness (Bashir et al., 2016). It was also employed to validate TWINSPAN results of clustering.

3. CCA

Direct gradient analysis technique i.e. Canonical Correspondence Analysis (CCA) and its sub techniques of Van dobben circles and partial ordination was applied to elucidate ecological associations between existing plant communities and soil. CCA and DCA analyses were applied using CANOCO 4.5 software program (Gulshad et al., 2016). Soil gradients including organic matter, pH, EC, macronutrients and micronutrients were considered for finding effects of soil parameters over plant growth.

RESULTS AND DISCUSSION

TWINSPAN

Dendrogram was divided into two groups i.e. one major group and one minor group. Major group A contains 2 sub-groups A-1a and A-2b (Figure 2a).

Group A-1 consisted of *Acacia modesta Wall*, *Amaranthus spinosus*, *Anagallis arvensis*, *Cyperus rotundis*, *Berberis lyceum Rolye*, *Fumaria indica (Haussk.)Pugsley*, *Tephrosia purpurea* and *Parthenium hysterophorus. Acacia modesta* Wall and *Amaranthus spinosus* were two most dominating species, for this reason this group was named as *Acacia-Amaranthus.*

Group A-2 was comprised of *Cassiaabsus*, *Malvastrum coromandelianum*, *Verbenatenuisecta var. alba*, *Cynodon dactylon*, *Euphorbia heliscopia* and *Salvia moorcroftiana Wall*. In this group *Euphorbia heliscopia* and Salvia *moorcroftiana* Wall were most dominating species. Therefore, this group was named as *Euphorbia-Salvia.*

Other group was minor group B and was further sub divided into B-1a and B-2b.

Group B-1a covered *Cannabis Sativa*, *Diclipterarox burghianaNees*, *Lycopericon esculentum Mill* and *Verbenatenuisecta var. alba*. *Cannabis Sativa* and *Dicliptera roxburghiana Nees* were dominating species group was termed *Cannabis-Dicliptera.*

Group-2b included *Cyperusrotundis, Malvasylvestris ,Dodonea viscosa* and *Xanthium strumarium. Malva sylvestris* and *Dodonea viscosa* were dominating. Therefore, the group was named *Malva-Dodonea.* (Figure 2b).

In last decade, lack of information on species diversity of Khanpur dam had diminished vegetation in study site. So, for proper conservation and management, wild species needs to be conserved. Keeping in view the importance of wild species, present study was conducted on the similar study design as proposed by Ahmad and Jabeen, 2009, Ahmad, 2011, 2012). TWINSPAN had previously been applied to study vegetation of Ayubia National Park, Margalla Hills National Park and Hanna Lake; and in all studies TWINSPAN divided vegetation communities into four groups. For the present study, *Cynodon dactylon* was the most dominant species followed by *Cannabis sativa* and *Malvastrum coromandelianum* at second and third places, respectively.

DCA

Detrended Correspondence Analysis (DCA) was carried out to find trends in clustering species of major groups in ordination space (Ahmad, 2013). The species were further classified to find out the distribution pattern and major plant communities prevailing in the study area. Species were represented by a red triangular point on each group and black color was assigned for representation of specie name. The distances between points on the graph represented the distribution of species.

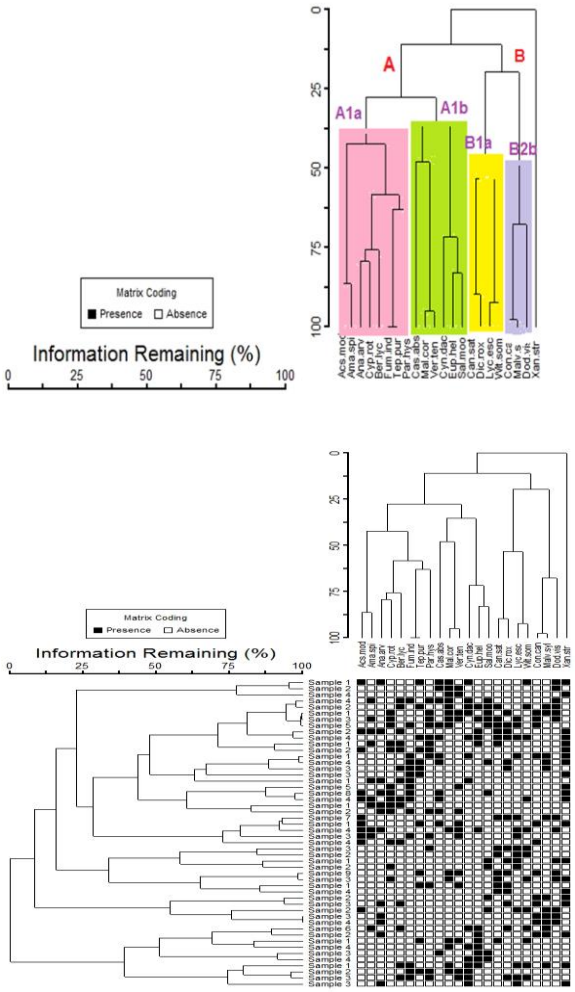

Fig. 2: (a,b) Two Way Cluster Analysis of Khanpur dam.

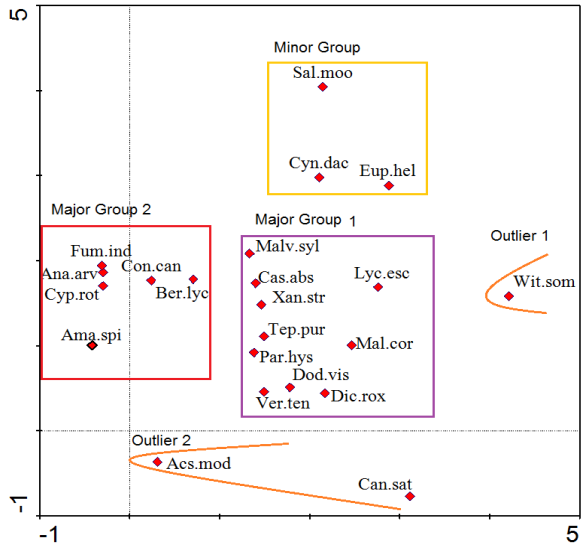

Fig. 3: DCA Scatter plot.

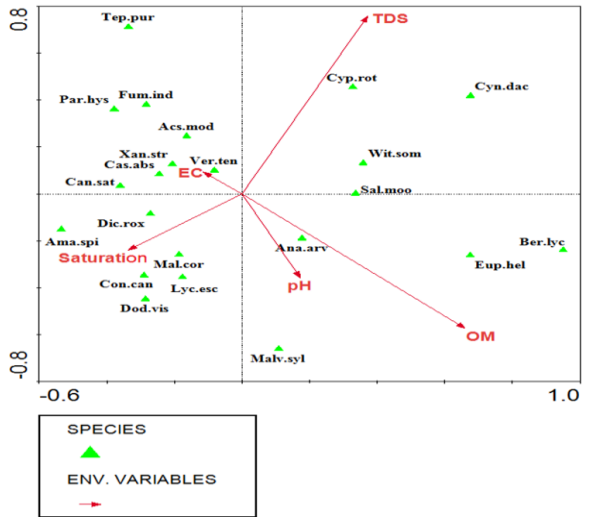

Fig. 4: CCA bi-plots.

DCA resulted into two major groups and one minor groups along with two outlier groups (Figure 3).

Major Group 1: This group comprised of following species: *Malva sylvestris*, *Cassia absus*, *Lycopericon esculentum Mill*, *Xanthium strumarium*, *Tephrosiapurpurea*, *Malvastrum coromandelianum*, *Parthenium hysterophorus*, *Dodoneaviscosa*, *Dicliptera roxburghiana*, *Verbena tenuisecta*.

Major Group 2: Following species included in this group: *Anagallisarvensis*, *Conyza Canadensis*, *Cyperusrotundis*, *Berberislycium rolye*, *Conyza canadensis*, *Fumariaindica.*

Minor Group: Minor group contained *Cynodondactylon* and *Euphorbia heliscopia* Species were classified in ordinate space using DCA. The DCA verified the grouping of plant communities by TWINSPAN. DCA grouped similarly occurring herbaceous species. DCA produced two major groups, one minor group and outliers. *Cannabis sativa* and *Malvastrum coromandelianum* appeared dominant in major group; while *Cynodon dactylon* appeared as dominant in minor group.

CCA

The arrowhead of iron was longer than others and was found to be affecting species of *Salvia moorcroftiana Wall.* Zinc was emerged as second most effecting factor on species and had reported slight effect over *Cannabis Sativa L.* EC, Cadmium, copper and manganese showed negligible effect. Potassium was affecting specie of *Parthenium hysterophorus L.* (Figure 4).

T Value bi-plots

T value bi-plots were constructed only for environmental parameters showing significant effect. EC, pH, Organic matter, TDS, cadmium, copper and manganese had no effect over plant growth.

i. The range of saturation in study area had no positive effect over plant growth while species of *Cynodondactylon*, *Euphorbia heliscopia* and *Berberislyceum rolye*had showed negative response towards saturation (Figure 5a).

ii. Species of *Anagallisarvensis L.* was found to be negatively correlated with iron as it was passed through blue circle. Species of *Euphorbia helioscopiaL.*was passing through red circle and was positively correlated, rest of the species were remained impassive against iron (Figure 5b).

iii. Phosphorous was found to be negatively correlated with *Cynodondactylon*. It was suppressing its growth. Other species remained impassive against Phosphorous (Figure 5c).

iv. Zinc was found to be negatively affecting the growth of *Anagallisarvensis L. as* it was passed through blue circle. Rest of the species were remained impassive against phosphorous (Figure 5d).

T value bi-plots were constructed to relate positive or negative effect of certain parameters over species abundance. In the present study, out of soil parameters electric conductivity (EC), pH, total dissolved solids (TDS), organic matter (OM), saturation, cadmium, micro and macronutrients; only saturation, Zinc, iron and phosphorous affected growth of some species. Species that were passed through red circles were positively correlated. Range of parameter was involved in species richness. While blue circle was representing negative correlation of certain parameter with species growth and the range of parameter was involved in suppressing growth of certain species.

T value bi-plots were applied to assess impact of altitude over species richness. Species that were positively correlated with altitude passed through red circle while those whose growth was suppressed by altitude were passed through blue circle (Urooj et al., 2016).

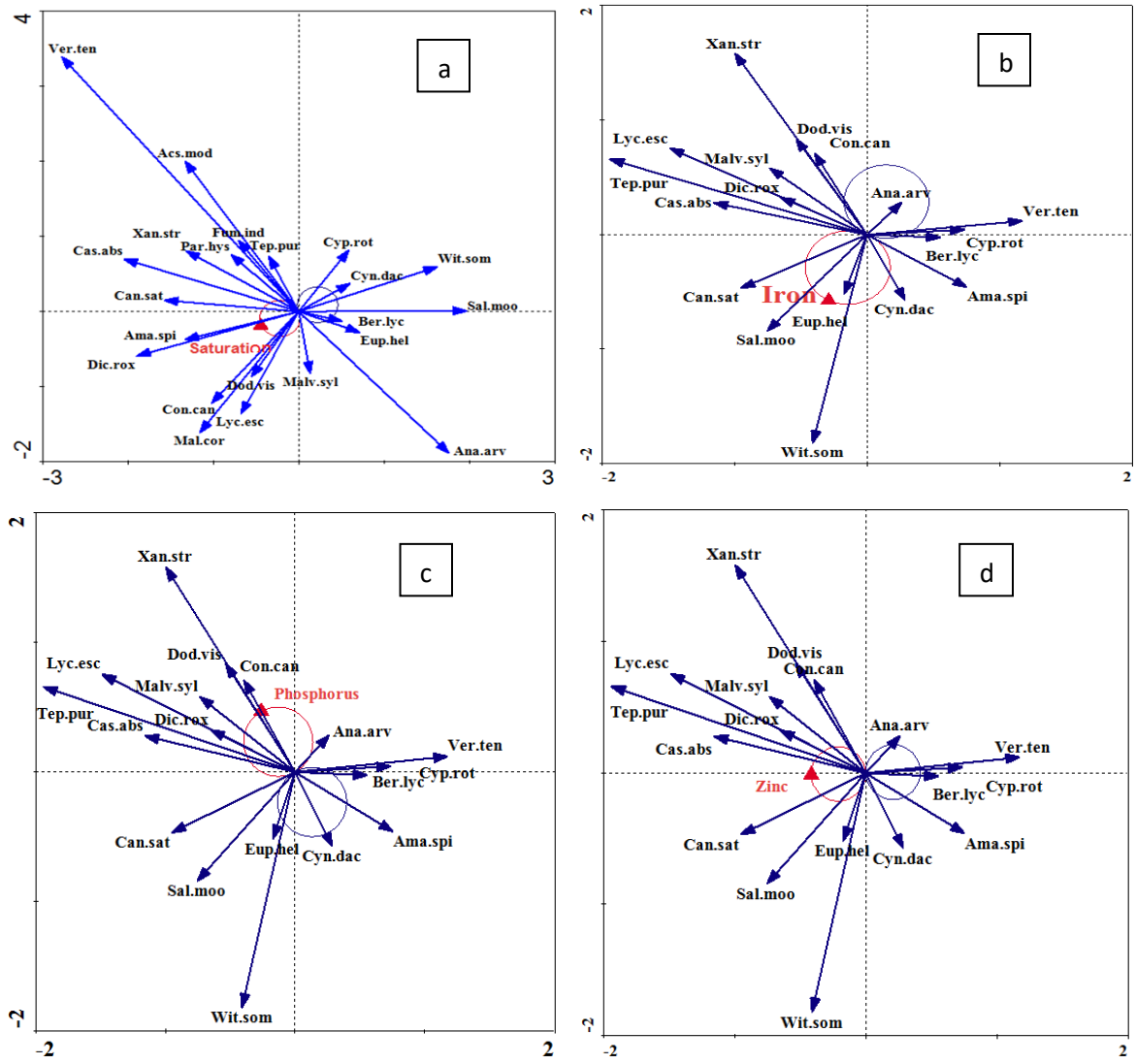

Fig. 5 T-value biplots (a-saturation), (b-iron), (c-phosphorous), (d-Zinc).

Partial ordination

Pie charts were also constructed for only significant environmental parameters.

i. Species were classified into four groups with lower quartile -0.8 and upper is 0.8. Pie-chart of saturation was ranged from 0.66 to 1.26. Average value for pie-chart of saturation was 0.9668 and its median was 0.96. Class 1 and 2 contained 13 members while 3 and 4 contained 12 members. Most of the species were present in class 1. Dominant species of *Cynodon dactylon* showed favorable growth in class 1 (Figure 6a).

ii. Iron concentration was determined in soil ranges from 15.6994 – 15.9641 ppm. Total 46 distinct values were noted. Calculated average was 15.78 ppm. All classes have 13 plant members found in soil. Found concentration range in tested soil proved to be the best range for species abundance in selected study area (Figure 6b).

iii. Phosphorus is essential macronutrient for plant growth. Study area soil samples found to have 22 distinct value of phosphorus concentration ranging from 2.1 to 4.4 ppm. Class 1 proved to be most favourable class for plant richness in area. Total 14 plants member were exiting in class 1 having concentration ranging from 2.1 – 2.6 ppm. Some species like *Euphorbia helioscopia, Amaranthus spinosus and Berberis lyceum* were found in class 1, 2 and 4 but not found in soil having phosphorus concentration ranging from 3.1 to 3.7 ppm (Figure 6c).

iv. Zinc is very important element necessary for plant growth. Soil samples of selected area had 47 distinct values for zinc as micronutrient in soil ranging from 0.3131ppm to 0.5501 ppm. Class 1and class 3 proved to be favourable class for plant richness in area. Total 14 plants member were exiting in class 1 having zinc concentration ranging from 0.3131 ppm to 0.3298

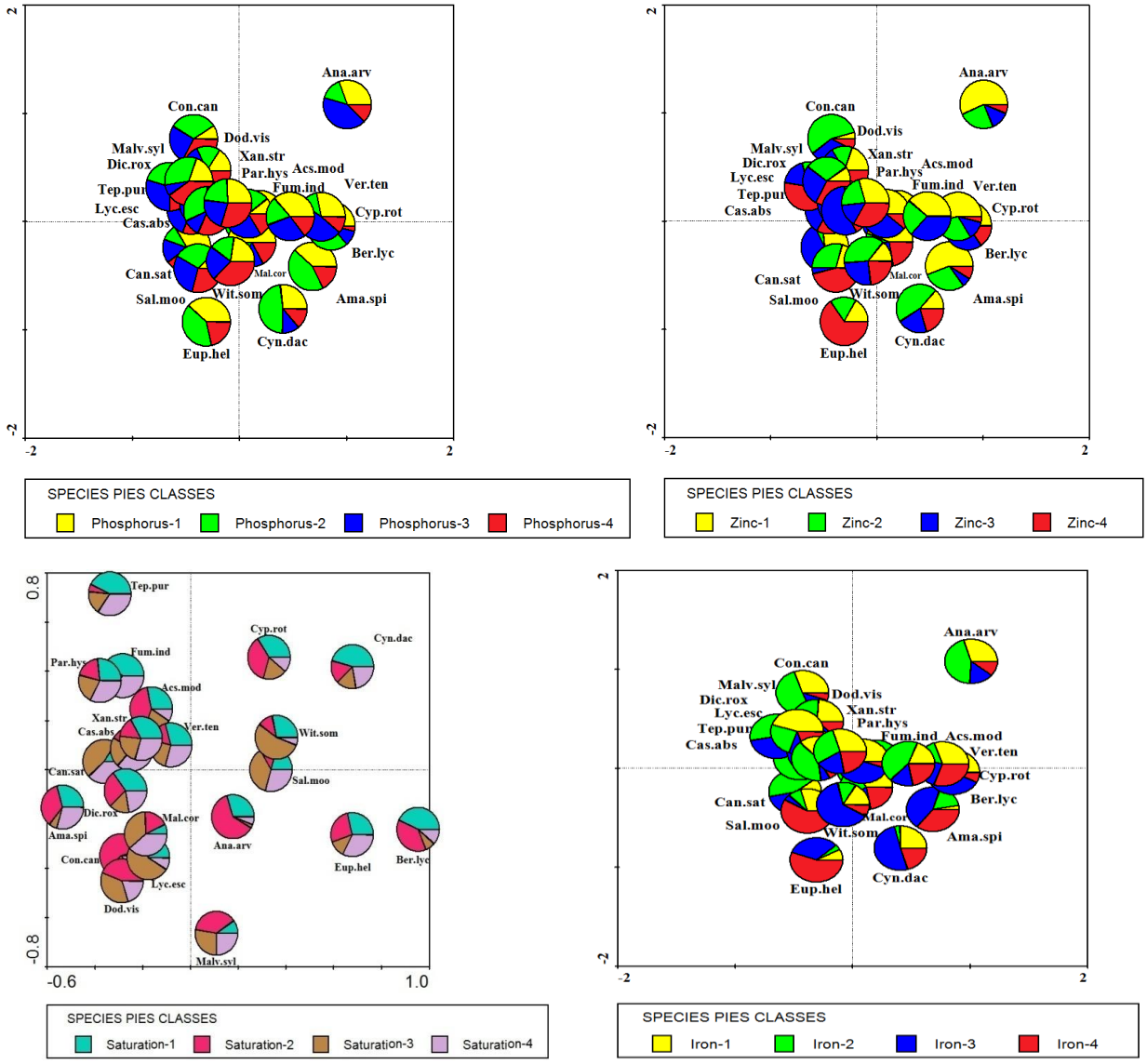

Fig. 6: Pie-chart of (a-saturation), (b-iron), (c-phosphorous), (d-Zinc).

ppm and 13 members were found in class 3 having zinc concentration ranging from 0.419 ppm to 0.4912 ppm (Figure 6d).

Partial ordination had estimated the probability of effect of environmental parameters in community structures at different range level for same variable (Dong and Smith, 2016). *Cynodon dactylon* was present in proportion of class of soil parameter favoring to species abundance.In conclusion, *Cynodon dactylon* was the most dominant species followed by *Cannabis sativa* and *Malvastrum coromandelianum* at second and third places, respectively. Due to rapid urbanization, medicinal weeds are declining. So, the management of area should take serious action. The study will help in conserving weed flora.

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