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ENVIRONMENTAL DIVERSIFICATION AND SPATIAL VARIATIONS IN RIPARIAN VEGETATION: A CASE STUDY OF KORANG RIVER, ISLAMABAD

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Abstract

The present study was conducted at Korang river, Islamabad to determine soil and vegetation associations and affiliations. Herbaceous flora and soil samples were collected randomly by using 1×1 square meters quadrate. For each plant in quadrate visual cover estimation was noted. Twenty one species belonging to 14 families were identified. CCA (Canonical Correspondence Analysis) was applied in order to find out the strength and relation between environment and plant species. The results exhibited that pH and copper strongly affected the abundance of *Cannabis sativa* while profusion of *Cynodon dactylon* was influenced by moisture content. CCA functioned on water quality parameters indicated that sulphate and TSS were the major holding factors promoting the growth of *Cannabis sativa*. T-value biplots were created for each environmental parameter to assess whether the relation was positive or negative with variables. GLM was also taken into account to value the relation between response and predictors in a way that *Cannabis sativa* tolerated adverse environmental conditions in the current study. Partial ordination was used that gave variation partitioning of plant species against every parameter. The survey of edaphic factors and vegetation structure along Korang river was helpful for not only improving and mending the present condition of river but also for planning and conservation of plant species diversity.

Introduction

Vegetation along water body is called "Riparian Vegetation". This vegetation plays an important role in ecology. That's why riparian zone plays a significant role in logging (Correll, 1991). Hill (1973) introduced the term Correspondence Analysis for the first time to ecologists. Canonical correlation was used to assess the environmental relationship with plants, thus called direct gradient analysis (Austin, 1968). CCA got entry in ecology in 1896 (Braak, 1986) which related species abundance data with environmental variables. CCA was executed with regression methodologies for hypothesis testing (Braak, 1986) and provided predictors of linear combination that led to the separation of best species niche. Independently CCA was a variant of PCA consisting instrumental variables (Braak, 1987).

Korang River was selected as study area which is located in Islamabad covering 906 Km² area. This area belongs to Potohar plateau having altitude range from 502 m to 609 m. Korang river flows from Margalla hills to Rawal dam so it is the outlet stream of the dam. The stream further joins Soan river. Fig. 1 shows overall study area.

The predominant assessment of the survey was to evaluate different parameters of total organic matter, extractable potassium, available phosphorus, heavy metals and total nitrogen content that could affect the relationship of soil and vegetation. Other objectives were to estimate variation between soil and plant communities along Korang river and to find out the correlation of environmental variables with species abundance/richness using CCA, to determine the response of species to environmental stresses i.e., in terms of presence and absence of particular species within the concerned vicinity and measurement of multiple edaphic factors that were influenced by soil in the study area.

Materials and Methods

Plants were collected during spring season when they were in flowering stage. Fifty quadrates were laid down randomly and size of each quadrate was 1×1 square meters, this method called as Braun-Blanquet approach. The cover value of plants was achieved by Domin cover scale (Kent & Coker, 1992). Composite soil samples were collected, and sent to the soil fertility survey and testing laboratory for tests. Soil was collected from the areas with any unusual feature like dumping of waste, grazing, change in soil color, fire outbreak, water outflow, and digging. Soil sampling started from 1-15 centimeters in depth. Plastic spatula was used for digging and polythene bags were used for the storage of soil that were marked with tags or codes. 250 gm soil was collected in each bag. Samples were sent to laboratory for testing of nitrogen content, potassium, available phosphorus, organic matter, pH, EC, zinc, iron, copper, and manganese. Fig. 2 is exhibiting the methodology of study in a flow chart.

Multivariate techniques for vegetation analysis: The biggest and contemporary advancement in ordination methods was introduction of Canonical Correspondence Analysis. Canonical correlation was used to assess plant-environment relationships, which was the first model of multivariate direct gradient analysis in the field of ecology (Austin, 1968). This method combined Correspondence Analysis with regression methodologies and provided for the testing of theory (Braak, 1986). Furthermore, there were three more techniques applied in CCA (t value biplot, GLM, partial ordination). T-value biplot also called Vann Dobben circles used for species score and environmental variables in low dimensional space, which made possible to determine the strength of affiliation between species and environment. Generalized linear model used was a statistical technique to relate response to linear combination of predictor variables. The current approach was quite attractive to provide a

general theoretical framework, simplified these models in statistical software, as a result the algorithm could be used to estimate, infer and assess model adequacy for all GLMs (Guisan & Zimmermann, 2000).Ecological communities respond to many factors, so CANOCO has the ability to factor out such influences and the resulting graph called variable partitioning or partial ordination. The analysis can be performed to both direct and indirect gradient analysis. Variance partitioning can be reported in the form of percentage and pie chart (Draper & Smith, 1981).

Results

CCA: The factors that were selected to reveal the association between environmental variables and species were organic matter, potassium, pH, zinc, phosphorus, electrical conductivity, iron, manganese and copper. The triangle shaped point showed different species while arrow head was indicating environmental variables. The edaphic variables with long arrows had more important influence on community variation and species distribution. The angle between an arrow and each axis was a reflection of its degree of correlation with that axis (Farrag, 2012). The species closest or nearest the arrow, were strongly influenced by the nearby environmental gradients while, the species far away from the arrow were less affected by the environmental factors. The distance between the points showed degree of similarity between different species within the same quadrat. If multiple species occupied the same point, it meant their abundance was same and affected by that particular gradient in a very same way, in that particular quadrat (Bruelheide & Udelhoven, 2005).

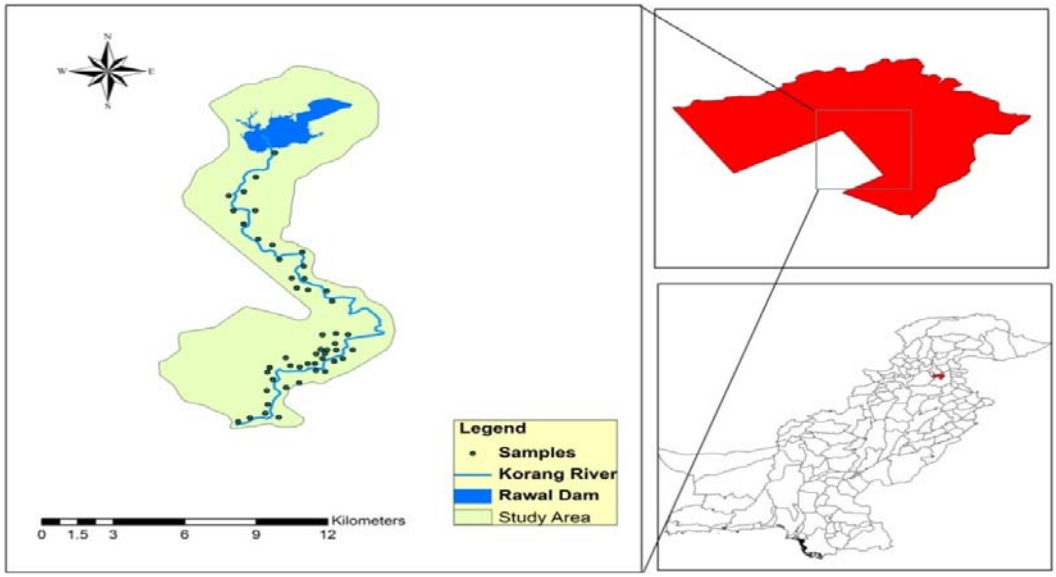

Fig. 1. Study area map.

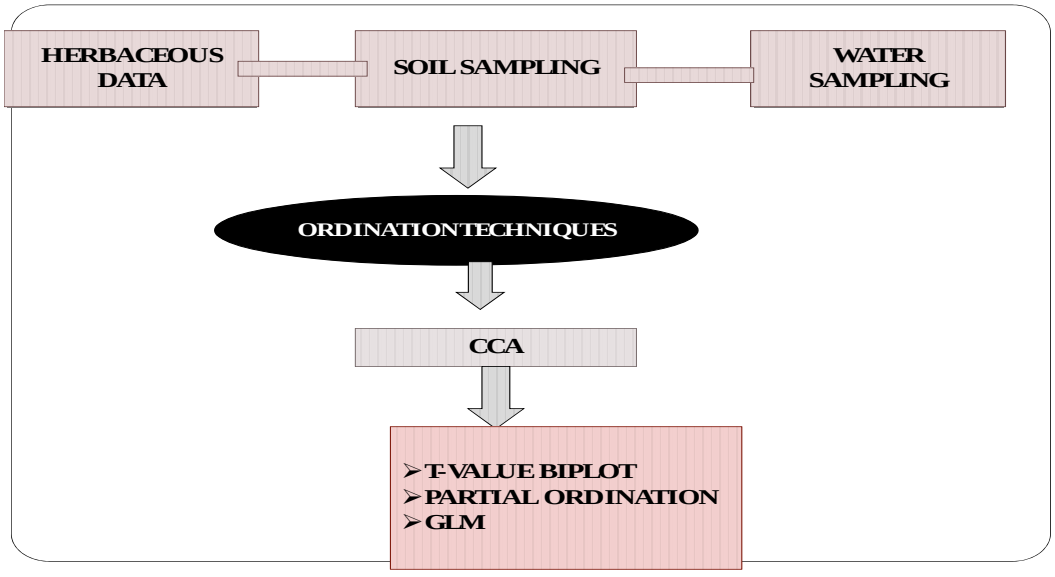

Fig. 2. Flow chart of methodology.

The arrow head of pH was longest than any other variable of CCA biplot. It showed remarkable effect on *Cannabis sativa* while copper and moisture content also contributed to the dominance and abundance of *Cannabis sativa*. The other species were also affected by moisture content like, *Cynodon dactylon* and *Galium aparine*. Zinc strongly affected *Euphorbia helioscopia* and *Malvastrumcoromandelianum*. Phosphorus strongly affected *Veronica persica*. Iron was commanding *Veronica* and *Capsella bursa pastoris*. Organic matter content had a low impact on *Coronopus didymus* (Fig. 3).

T-value biplot: From a T-value biplot, it could be inferred whether species reacted significantly to any particular environmental variable and if environmental variables responded significantly to the regression of any particular specie (Braak & Looman, 1994).

In the above figure, red circle was showing positive response while blue circle was showing negative response. Vann Dobben circle preset to hollow red circle with greater choice for higher or advanced values of explanatory variables and hollow blue circle having preference for lower values of the descriptive or explanatory variables.

Cynadon dactylon, Ajuga bracteosa, Xanthium strumarium, Cannabis sativa, Ranunculus muricatus and *Galium aparine* showed positive response, meant these species were having elevated level of abundance in the presence of moisture content, but *Cynadon dactylon*, and *Cannabis sativa* showed liking for higher values of explanatory variables and were much significant. *Coronopus didymus, Parthenium hysterophorus, Stellaria media, Melilotus indica* and *Euphorbia helioscopia* exhibited negative response in the presence of saturation, while *Malvastrum coromandelianum* and *Conyza canadensis* remained unaffected in the presence of moisture (Fig. 4).

The arrowhead of *Parthenium hysterophorus* was just crossing the red circle which showed that it had partiality for higher values of explanatory variables and positive regression. *Stellaria media, Melilotus indica, Coronopus didymus* and *Cannabis sativa* also showed positive response towards pH. The arrow head of *Conyza canadensis* was inside the blue circle so the species demonstrated preferences for lower values of explanatory variables and highly negative regression as compared to other species that were passing through the negative response circle, while *Cynodon dactylon, Euphorbia helioscopia* and *Malvastrum coromandelianum* also exhibited negative response towards pH (Fig. 5).

GLM (species response curve): The spatial analysis of species distribution in any area is a noteworthy part of conservation and planning. For this purpose, an extensive range of arithmetical, numerical and machine learning procedures were introduced in concurrence with RS and GIS (Tutz & Kauermann, 2003).

Upper quartile of *Cannabis sativa* was 80 and lower quartile was 10 while median was 47.5 and the curve for this species was tallest. It meant that the species could have survived both in the absence and presence of any environmental variable. Upper quartile of *Cynodon dactylon* was 30 while lower quartile and median were 0 while rest of the species came under stress and could not tolerate the lack and excess of pH, organic matter, saturation, electrical conductivity, potassium, phosphorus, iron, copper, manganese and zinc, presented in a form of response curve (Figs. 6 to 7).

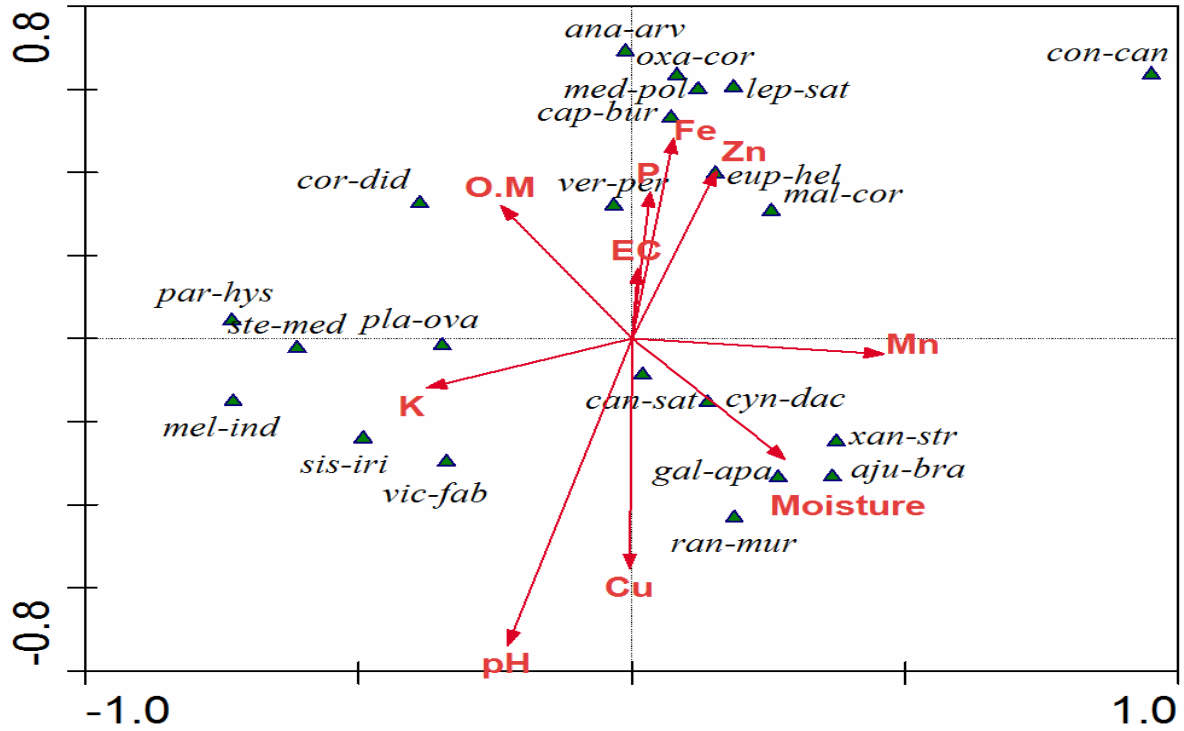

Fig. 3. CCA biplot for species and environmental variables.

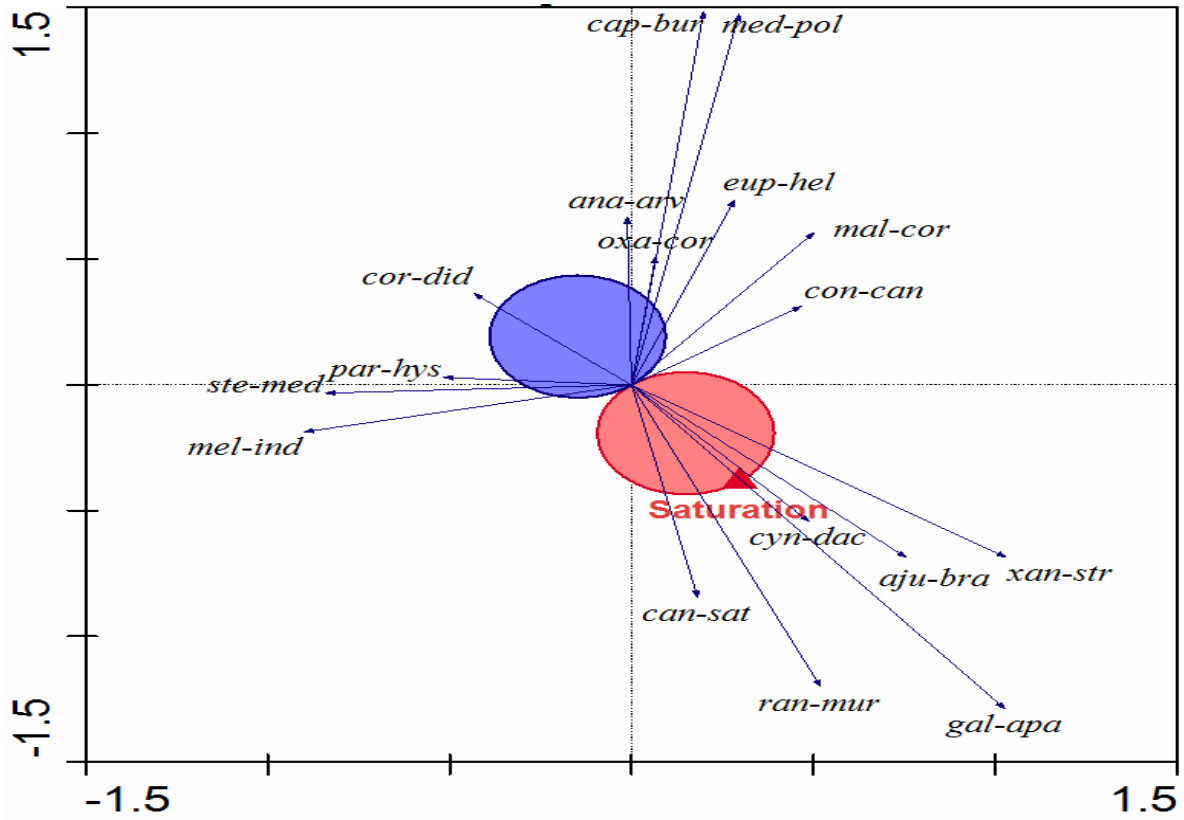

Fig. 4. T-value biplot of saturation content.

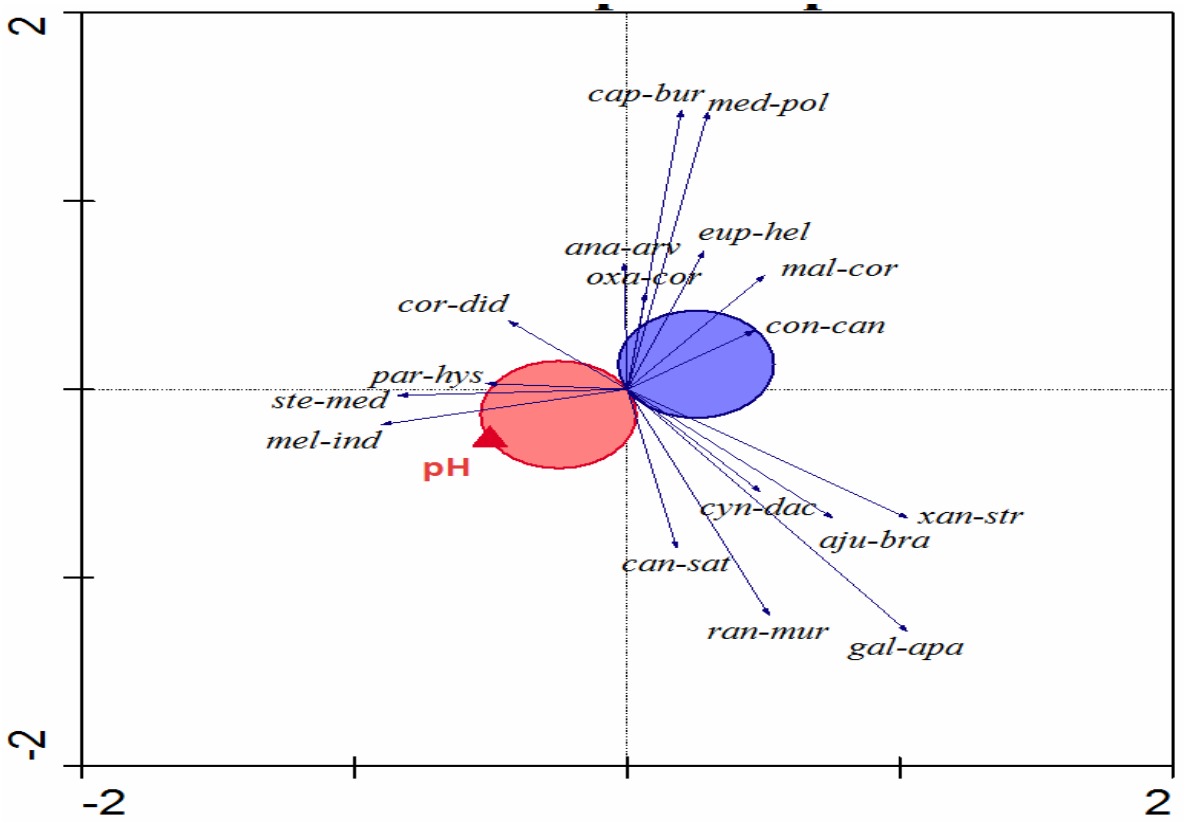

Fig. 5. T-value biplot of pH.

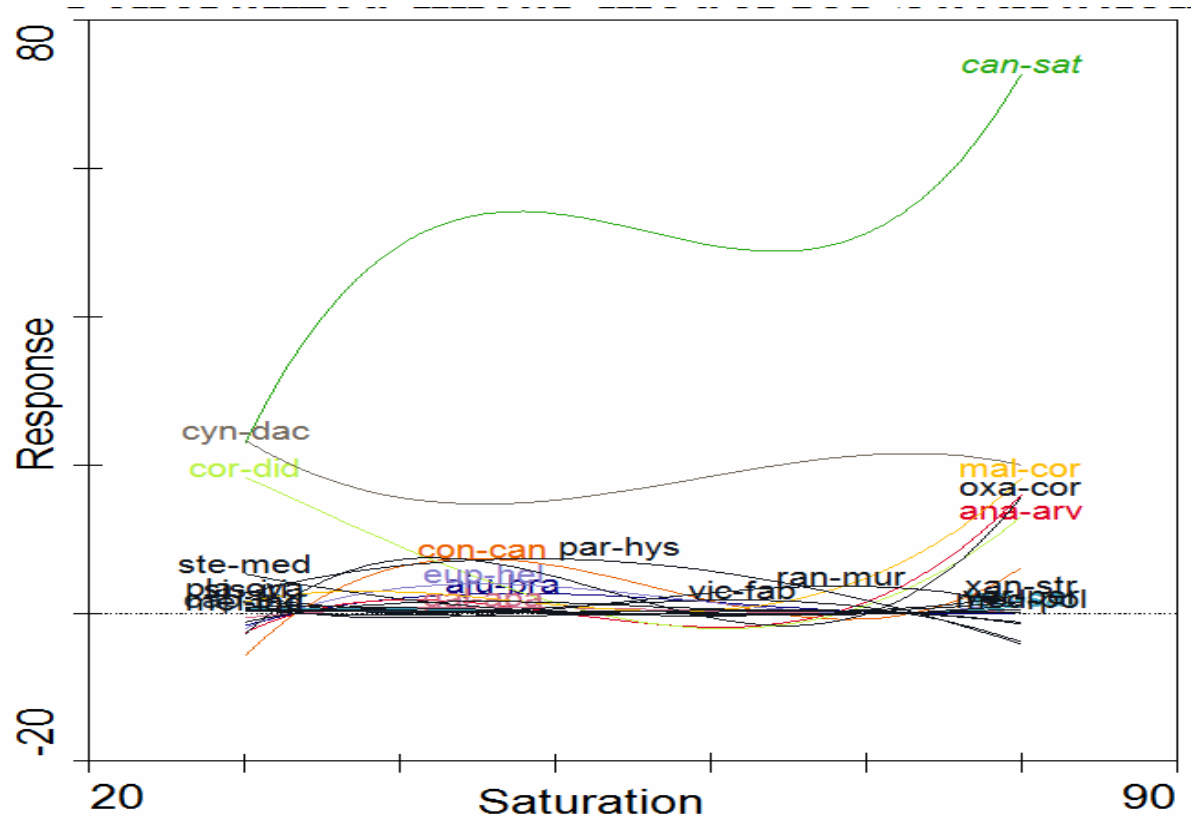

Fig. 6. Generalized linear model of saturation.

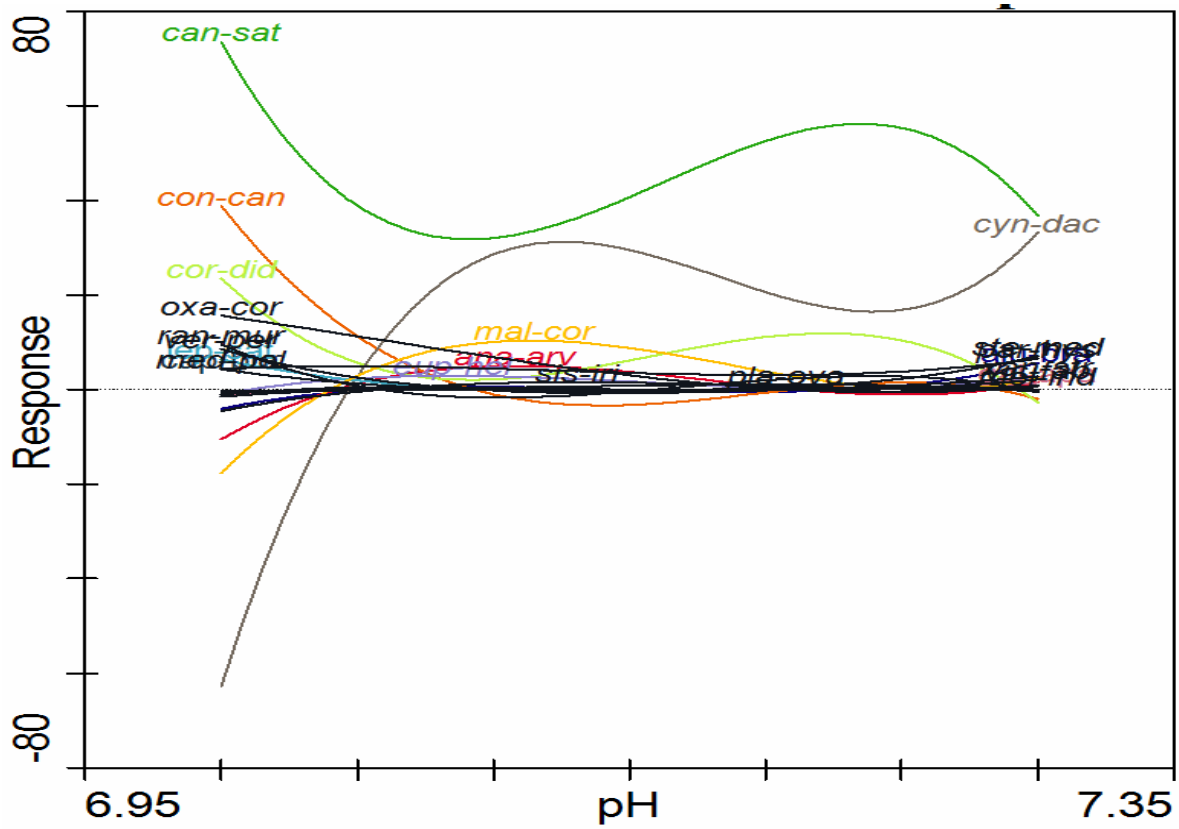

Fig. 7. Generalized linear model of pH.

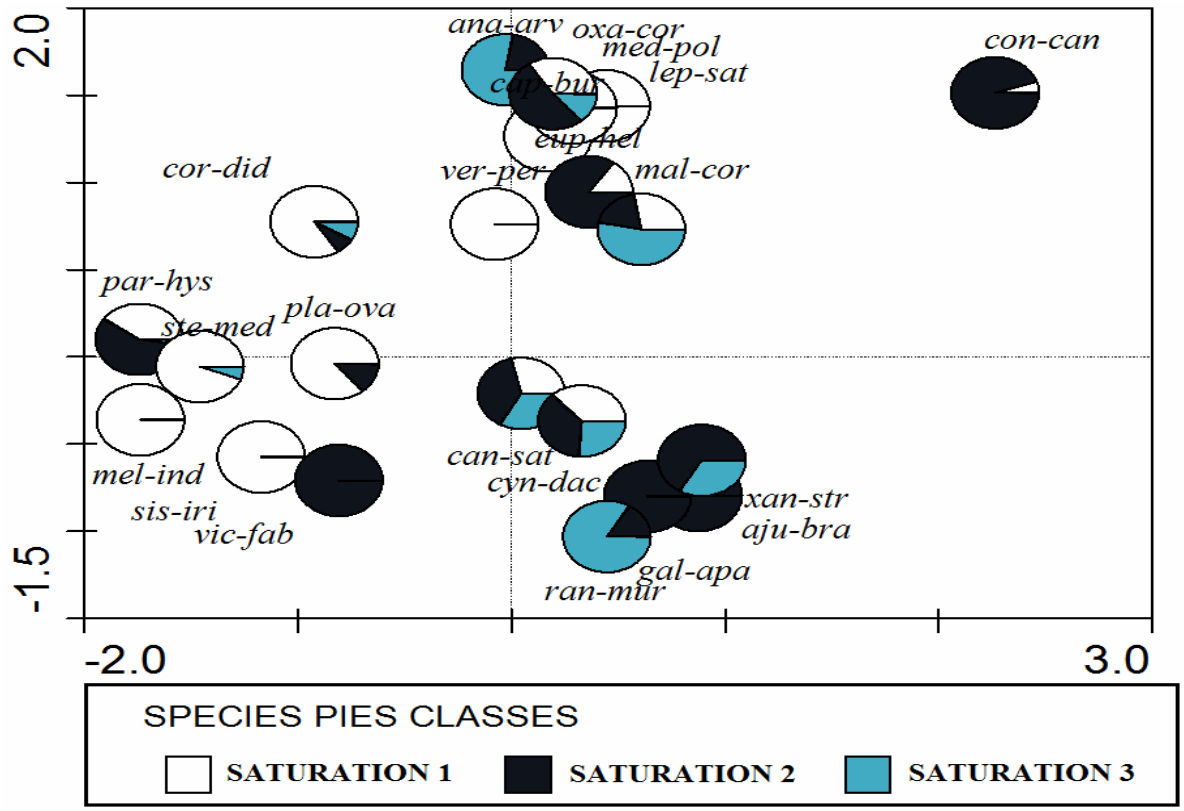

Fig. 8. Pie chart of saturation.

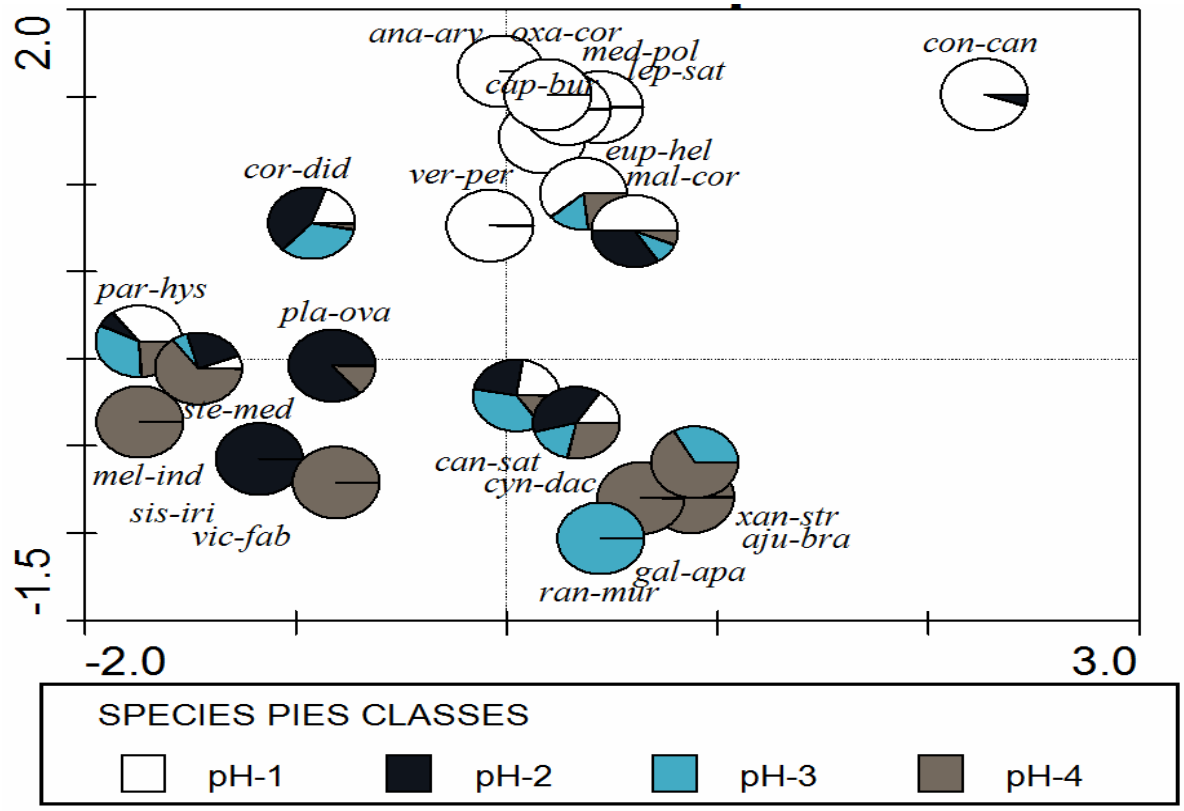

Fig. 9. Pie chart of pH.

The range of interval was 32 to 76, median was 45, Class I, II and III, comprised of 16, 11 and 18 members of plant species respectively (Fig. 8).

The interval or upper inclusive limit ranged 7.05 to 7.09, median was 7.22, Class I, II, III, IV consisted of 14, 14, 13 and 9 plant species respectively (Fig. 9).

Partial ordination (Pie Chart): Scatter plot is a set of bivariate. A visual picture showed the relationship between the two variables which helped or aided regression model or correlation coefficient. Scatter plot in the form of pie chart displayed moisture content, organic matter, electrical conductivity, pH, phosphorus, potassium, iron, manganese, zinc and copper of each sample. It is a circular chart which cuts into various slices, represents the data quantitatively (Draper & Smith, 1981).

Discussion

Multivariate technique Canonical Correspondence Analysis identified the correlation between species richness/ abundance and environment. The principle combined species ordination data with constrained regression by maximizing relation between environmental variables and axes of species ordination. The plant species implicated to have unimodal response as specified by ordination axes (Fewster *et al*., 2000).

T-value biplot is a figure or diagram which contains arrows for species and symbols for environmental gradients. It showed statistically significant pair wise relationships between vegetation and soil, or water. In biplot projection, t-values of regression coefficient that were achieved for multiple regressions with particular species acted as a variable of response and all environmental gradients as estimators. The present study showed *Cannabis sativa* and *Cynodon dactylon* had positive response with saturation and revealed preference for higher values of explanatory variables i.e. positive regression coefficient response with respect to environmental variables. Due to higher moisture content, *Cannabis sativa* and *Cynodon dactylon* were the most abundant species among all so a positive association had been observed with water content. According to T-value biplot, *Coronopus didymus* and *Cannabis sativa* demonstrated positive relationship with pH. The plant's growth depended on efficacy to take in and absorb nutrients at different concentrations in the solution of soil. Plants had ability to utilize nutrients in minute amount, while others needed great quantities of elements to assimilate enough for productivity. Plants grown along running water or lotic channels depended on a definite pH range of both water and soil. Enzymes of plants performed best under a precise pH range of soil surrounded its nutrient assimilating roots and nearby water was incorporated into the plant. Whether it was outside the ideal or perfect range, the enzymes could not operate correctly, and fitness of plant decreased. *Cynodon dactylon* and *Cannabis sativa* responded positively in the presence of moisture. Water has been essential for plants through which plants transport nutrients necessary for photosynthesis. In case of water shortage, plants may wilt. If a plant got too much water, roots could wilt. With copper, *Cannabis sativa* and *Cynodon dactylon* showed positive relationship i.e. their growth, scattering and abundance got affected by micronutrient. Plants differed by nearly all other organisms i.e. they used light in order to convert carbon dioxide and water into oxygen and rich energy carbohydrates. Growth of plants was reliant on photosynthesis which in turn was dependent on adequate provision of a number of chemical elements as well as metals like iron, copper and manganese that played an important role in metal and protein complexes necessary for regulating main processes of photosynthesis. There was a positive response of zinc with *Coronopus didymus* while negative with *Cannabis sativa*. Aquatic to semi-aquatic plant species like macrophytes which were large rooted aquatic plants, plant distribution differed in accordance to the availability of resources. The distribution of plant species also varied with chemical and biological contents of water sources and the way of delivery of elements and nutrients through hydrological processes such as rivers, lakes, wetlands and streams (Austin, 2007).

The spatial estimation and prediction of species scattering and distribution pattern played central role in ecosystem conservation planning. There was a wide variety of statistical techniques that were used with GIS and RS in combination. These statistical techniques often called regression analysis i.e. generalized linear model (GLM) and generalized additive model (GAM). Ecological models could be produced with the help of these statistical methods. Besides conservation, another advantage was that biotic data could be helpful for estimation of past environmental conditions, important in paleoecology. Fossil biostratigraphical data could be converted into quantitative records. A theory tested if species responded to environmental variables or gradients with a symmetric, unimodal response function. Dispersal, succession, competition, grazing pressure and fire need to be included. Biological processes in association with historical disturbances, species dispersion and dispersal barriers e.g. mountain ranges were also accountable. GLM incorporated interaction terms and cubic polynomials. It was concluded that the spatial allocation of individual species better shaped by GLM in comparison to CCA. The response of species against environmental gradients was a skewed figure and tails towards mesic central or middle portion of variables and modes with abrupt fall/decline towards extremes of gradient. Species limits towards the extremes were determined by physiological tolerances while internal limits were determined by opposition/competition (Austin, 1999). Upper quartile of *Cannabis sativa* was 80 and for *Cynodon dactylon* it was 30. Lower quartile for *Cannabis sativa* was 10 and 0 for *Cynodon dactylon*. Rest of the species came under stress and could not tolerate lack and excess of saturation content. For spatial modeling of species distribution, GLM needed presence and absence data (Nicholls, 1989, 1991; Rushton *et al*., 2004). Species responses were dependent on the nature of environmental predictors and associated ecological processes.

Partial ordination was used for elucidation of total diversity of species with respect to spatial variables so that sampling areas and ecological communities could be compared. The techniques based on impartial estimates of differences of species composition data set that was determined by explanatory variables. Significance of fractions of concerned plot maps of fixed values equivalent to fractions could be tested. Variation partitioning was applied to determine probability of series of estimators or predictors for explaining patterns in community structure. Partial ordination used in canonical analysis was biased. The technique tested whether the two fractions of variation were significantly dissimilar from each other. The assessment provided a pace for understanding the factors patterning plant species structure (Draper & Smith, 1981; Ahmad & Ehsan, 2012). Moisture pie chart had 3 classes while number of plant species was more in class III. So, *Ranunculus muricatus* was showing abundance. *Cannabis sativa* and *Cynodon dactylon* were lying in all four classes of pH and copper. *Viciafaba* and *Veronica persica* showed abundance with electrical conductivity. *Melilotu sindica* demonstrated abundance with phosphorus, iron and zinc. *Veronica persica*, *Viciafaba* and *Ranunculus muricatus* showed profusion with potassium and manganese.

Conclusion and Recommendations

In this study CCA was applied to assess soil and vegetation along Korang stream. Total twenty one species were identified in study area. CCA results exhibited that *Cannabis sativa* was strongly influenced by pH and copper and *Cynodon dactylon* i.e. the second most abundant species, affected by moisture content. CCA results of species and water data indicated that the abundance of *Cannabis sativa* was due to sulphate. The research could help to render the decision makers to improve the present condition of site by recovering water quality and conserving soil and plant species present along the stream.

- Effective river conservation must include protection and improvement of key physical and ecological processes that are driven by energy inputs. Different conservation programs should be organized in diverse fields of agriculture, forestry, water management, flora and fauna and capacity building. Plantation activities should be carried out to raise awareness among societies regarding importance of biodiversity. GIS can be used as an effective tool as it interprets, displays, manages and computes the vegetation, soil and hydrological data that can be further used as a standardized data by conservation organizations, research based institutions and scientists.
- River management should also involve students to conduct and execute research, groundwork and experimentation on environment and biodiversity in order to protect and maintain native flora. Projects on natural resources management should be carried out with the help of governmental, semi and non-governmental organizations. Nurseries of fast growing plant species should be established in order to meet fuel demands of local region. Water and soil resources should be used in a sustainable manner and not be exploited in a way that they enhance the aesthetic of local area. Ethno botanical research should be done so that plant resources can be valued and preserved.

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