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Phytosociological Synthesis as Inferred from Soil Analysis of Some Industrial Areas of the Punjab

Maria Ali, Tahira Ahmad and Audil Rashid
Department of Biological Sciences, Quaid-I-Azam University, Islamabad, Pakistan

Abstract: This study was done in few areas of the Punjab where vegetation analysis and evaluation of stand structure was carried out to establish plant communities. The stands were located both in control area and in the sites contaminated with industrial effluents. Data collected in the field using quadrats were subjected to two-way indicator species analysis (TWINSPAN) on the basis of which two major distinct groups were formed. (1) *Cynodon dactylon* group, the dominating species of the control area and (2) *Desmostachya bipinnata* group, the dominating species of the contaminated area indicating its tolerance and ability to withstand metal contaminants. Furthermore, the quadrat information was processed to determine the importance value of species and results of soil analysis were used for causal interpretation of prevailing plant communities. It appears that edaphic characteristics were not posing a detrimental threat to natural flora, however ground cover was on decline in various stands of contaminated sites.

Key words: Plant communities, plant diversity, species distribution, vegetation classification

INTRODUCTION

The phytosociological attributes of an area are well apprehended by a large number of factors. By giving the classification of an area, in terms of defining its vegetation somehow reflects the type of prevailing climatic conditions of that area. Sites that continuously receive polluted water definitely show a gradual change in composition of natural vegetation. The response of natural flora to deteriorating soil conditions is universal. The decline in number of certain plant species to a limit where only few or at times only one species survive reflects a survival mechanism. Such endemics are considered better adapted to existing situation.[1]

The study of vegetation structure has become important in the Punjab context. With the advent of canal irrigation, the vegetation of the Punjab plains has undergone dramatic changes. A large number of exotic species were introduced which acclimatized and became mixed with our indigenous vegetation. This led to the initiation of several successional trends that have been the subject of various vegetation scientists.[2] On the other hand the indiscriminate discharge of wastewater from factories in the water channels results in the creation of polluted sites. It has been reported that in Pakistan about 9000 million gallons of wastewater is being daily discharged into water bodies from industrial sector.[3]

A systematic study of the area shows a strong correlation between the vegetation type and various factors. Ground layer plant species and animals are considered as most sensitive indicators of acid deposition[4]. In this context, very few studies have been designed to highlight the effects of soil pollution on the vegetation structure and composition. Therefore, present study was planned to describe the overall vegetation structure near the industrial areas of the Punjab and to study the distribution pattern of dominant colonizers of contaminated sites and their causal interpretation. It was also kept in mind to find out any colonizers on contaminated sites that might have some heavy metal resistant mechanisms. Search for such plants was also one of the focal point of this study.

MATERIALS AND METHODS

Study Area: Based on the objectivity of the research work, utmost effort was made to select those areas that were near to the industries and received their effluent water and or otherwise it was kept in mind that the site must be close to any natural drain or water channel in that zone where industries have been established. As it was observed that most of the industries lack any treatment facilities, hence they discharge their waste directly in outside environment or to any nearby passing drain.

Few sites were selected in the Gujrat District present in Gujranwala Division where comparably very few industries are present. The site refers to as one of the prominent rice growing areas in Pakistan and in present

Corresponding Author: Maria Ali, Department of Biological Sciences, Quaid-I-Azam University, Islamabad, Pakistan
E-mail: smaria78@yahoo.com

study it served as reference area. The main sampling region lies in the Gujrat and Sheikhupura Districts present in the Gujranwala and Lahore Divisions respectively especially along the Degh Nullah, which receives a variety of industrial effluents. The area had undergone rapid industrialization.

Gujrat District lies between north latitude 32°-19′ to 33°-03′ and east longitudes 73°-31′ to 74°-28′[5]. The Sheikhupura District lies between north latitudes 31°-05′ to 32°-04′ and east longitudes 73°-15′ to 74°-41′[6]. The climate is hot and dry during summer and dry and moderately cold in winter. The climatic conditions of both the districts are more or less same throughout the year as both lie in the same environmental zone.

The vegetation sampling was conducted randomly to determine the density, frequency and cover values. Importance values were also calculated.[7] A FORTRAN based computer package TWINSPAN was used to analyze and classify the data. A dendrogram was built from the top down for the association analysis.

The soil samples were taken from the selected stands and soil properties were determined. The particle size analysis was carried out by Bouycous hydrometer method.[8] Organic matter content was determined by Tyurin's method.[9] Alkaline earth carbonates were determined by acid neutralization method.[10] Micro-Kjeldahl digestion assembly was used for the determination of total nitrogen. Concentration of Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K) and Heavy metals (Zn, Pb, Fe, Ni, Mn and Cr) in soil extracts were determined directly by atomic absorption spectrometer.[11] Concentration of phosphorus as phosphates was determined by molybdenum blue method using saturation extract.[12] Carbonates, bicarbonates and chlorides in the soil extract were determined by titration with dilute acid.[10] The gravimetric determination of sulphates was done that involves precipitation of barium sulphate.[13]

RESULTS

The soil texture of the studied sites to a great extent reflected the soil physical properties of both industrial and non-industrial zone. Mostly a loam type of soil was observed having variable fraction of sand and clay particles (Table 1). In general, the soil moisture contents of the contaminated sites ranged between (1.3-12.5%) which was less compared to reference sites (2.1-17.29%). Along soil moisture, another factor that promoted *Desmostachya bipinnata* in contaminated area is soil organic matter which was less in contaminated sites 0.004-3.33% compared to reference sites 0.34-3.99% (Table 1).

Table 1: Physical properties of the soils of reference and contaminated sites

Stand No	Moisture content %	Soil Texture	Organic Matter %
Reference site			
1	11.73	Sandy loam	1.4
2	17.29	Sandy clay loam	1.51
3	4.52	Clay loam	2.8
4	4.63	Sandy loam	2.18
5	16.86	Loamy sand	3.62
6	2.1	Sandy clay loam	3.99
7	15.7	Loam	1.34
Contaminated site			
8	1.83	Loam	3.24
9	3.52	Sandy loam	0.004
10	9.56	Sandy loam	2.33
11	12.5	Sandy loam	0.77
12	1.31	Loam	2.85
13	10.01	Loam	1.65
14	3.51	Loam	3.33
15	1.41	Sandy loam	2.38

The mean values and standard deviation for the chemical parameters of reference and contaminated sites are given in Table 2. Significant difference was found for soil nitrogen, phosphorus and calcium content between the two sites. The standard deviation and the mean values for heavy metals (Mn, Fe, Ni, Zn and Cr) are presented in Table 2 where zinc, manganese, total chromium and trivalent chromium showed significant differences. Amount of phosphorus in general is lacking in the area. Most of the sites in the contaminated region are devoid of phosphorus. As far as phytosociological results are concerned, a total of 69 species were recorded in this study. Dominant and co-dominant species were sorted according to maximum importance value (Table 3) in each stand. TWINSPAN classified the data into two major groups/communities, four sub-groups/communities and eight sub-divisions shown in Fig 1.

Most of the quadrats separated by TWINSPAN in the *Cynodon dactylon* group are from the stands of reference sites. Few samples from stands of contaminated region also got separated in this group due to the dominance and high importance value of *C. dactylon*. The division of groups into sub-groups is based on the presence or absence of one species or the other. Samples separated in the *Desmostachya bipinnata* group mostly belongs to the stands of contaminated sites. Therefore statistical analysis of vegetation proves that trend because *D. bipinnata* group formed by 24 quadrats, all of which belong to contaminated area comprises of only 22 species compared to 47 species that observed in *C. dactylon* group. Thus two different communities are established in two different study regions.

DISCUSSION

There is a close relationship between the vegetation of a particular area and its soil. Quality of a soil can be inferred from the vegetation it supports.[14] Detailed

Table 2: Mean±Standard deviation of chemical parameters and heavy metals in the soil samples of reference and contaminated sites

	Chemical Parameters									
Site	pH	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Na (ppm)	HCO_3 ($meqL^{-1}$)	Cl ($meqL^{-1}$)	SO_4 ($meqL^{-1}$)
Reference	7.8±0.21[a]	0.0158±0.03[a]	1.371±1.9[a]	35.859±19.8[a]	459.68±250.3[a]	44.852±16.6[a]	43.822±9.3[a]	3.071±749[a]	1.728±2.7[a]	0.701±0.7[a]
Contaminated	7.5±0.25[a]	0.174±0.04[b]	0.289±0.4[b]	29.678±11.8[a]	326.21±221.3[b]	33.362±19.6[a]	47.093±5.3[a]	3.35±0.4[a]	4.796±9.5[a]	0.559±0.3[a]

Heavy Metals						
Site	Zn (ppm)	Fe (ppm)	Ni (ppm)	Mn (ppm)	Total Cr (ppm)	Cr^{+3} (ppm)
Reference	0.005±0.008[a]	0.138±0.44[a]	0.043±0.03[a]	0.079±0.14[a]	0.001±0.002[a]	0.001±0.002[a]
Contaminated	0.001±0.003[b]	0.23±0.02[a]	0.066±0.06[a]	0.291±0.73[b]	0.0005±0.0009[b]	0.0005±0.0009[b]

Values with different letters within the column are significantly different.

Table 3: The average importance values of dominant species from reference and contaminated areas

Site	Species	Average importance value
Reference area	*Cynodon dactylon*	113.41
	Ranunculus muricatus	20.38
	Parthenium hysterophorus	15.25
	Eleusine aegyptica	14.77
	Cenchrus ciliaris	8.34
Contaminated area	*Cynodon dactylon*	80.33
	Desmostachya bipinnata	40.71
	Parthenium hysterophorus	9.42
	Brachiaria ramosa	5.62
	Suaeda fruticosa	5.28

studies have been carried out on the soil plant relationship in other countries but very little work has been carried out regarding the description of vegetation in Pakistan. The importance of present study emphasized the major differences between the contaminated and reference sites in relation to phytosociology and edaphic characteristics. Due to presence of large number of industries, the area is under stress of effluents. In the industrial region there are very few industries that have their treatment plants and most of the effluents from the industries enter directly into the open drains. The most important nullah in the Sheikhupura District is the Degh Nullah that marks drainage line and is extensively polluted due to direct entrance of effluents into the water system. The main Degh passes by Kalashah Kaku in Lahore District.

Heavy metals contaminated land is increasingly becoming an environmental, health, economic and planning issue in Pakistan.[15] Vegetation of an area is a prominent indicator of the deteriorating soil conditions and natural habitat and is quite sensitive to such an extent that any change in physical and chemical properties of soil due to agricultural exploitation or contaminant addition by effluents and waste disposal, can alter its structure and composition. Sites recently contaminated or polluted over a long period often show interesting vegetation development processes.[16] The pollutants affecting the natural distribution of plants in the contaminated sites was determined by carrying out phytosociological study of the area in comparison with the sites not under such influence.[17] The vegetation observed at two sites differs considerably, which could be attributed to the change in the soil properties. Species richness was found to be highest in association with high structural diversity and species turnover was strongest where environmental heterogeneity was high.[18]

The vegetation of the contaminated area is showing reduced number of species and vegetation cover as only few species could survive and are inhabitant to the area. Majority of the stands located in Sheikhupura District manifested a situation where grass species such as *C. dactylon, D. bipinnata* and *Brachiaria* sp. were recorded in terms of having highest importance value (Table 3). Interestingly the Sheikhupura District is regarded as hot regions of Punjab where temperature in summer may exceed more than 40°C. The two factors, climate and soil contamination become a hallmark of this District and have played a substantial role in composition and structure of vegetation. The vegetation structure and composition of Sheikhupura District is actually a representation of natural flora being influenced directly or indirectly by industrial effluent contamination. The results of the phytosociological study reveal that this influence has modified the vegetation composition more instead of structure, an indication that species composition is more susceptible to change in climatic and edaphic characteristics.[19]

Cynodon dactylon and D. bipinnata occurred as dominants in each community with fine textured soils. Chugtai also find these species in fine textured soils.[20] Sultana found *D. bipinnata* in fine textured saline soils.[21] Muftee[22] reported fairly high degree of salt resistance in *C. dactylon.* Regarding vegetation composition, the results showed some sort of similarity. This can be explained by the comparison of reference and contaminated sites (Table 3). The results obtained from phytosociological study derived from quadrat analysis elaborate a comprehensive detail based on which importance value (I.V.) of species was determined. The results of the same quadrats were subjected to TWINSPAN also. The objectivity behind the application of two methods was to find out whether groups formed through TWINSPAN reflect a natural synthesis and to what extent chronological sequence of importance value determined by quadrat analysis is in agreement with

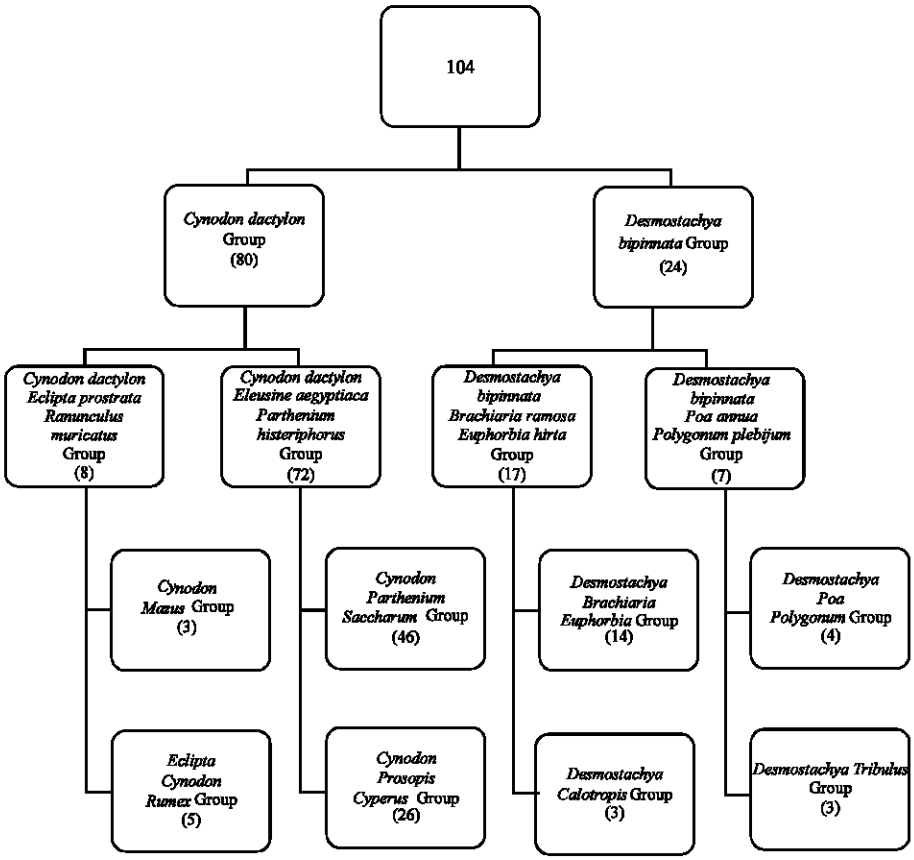

Fig. 1: Dendrogram showing the results through TWINSPAN

Total number of quadrats = 104
Total number of species = 69
Number of species in major group 1 = 47
Number of species in major group 2 = 22

groups of TWINSPAN. It was found that *C. dactylon* having highest importance value comprising a major group in TWINSPAN proving similarity in results of both the methods.

The average importance value of *C. dactylon* in reference area is 113.41 which is far greater 80.33 than the average importance value of *C. dactylon* in contaminated area (Table 3). This decline in *C. dactylon* in contaminated area is accompanied with striking increase of *D. bipinnata* constituting the average importance value 40.71 (Table 3). Hence a *Desmo*-replacing-*Cyno* trend is recognized in contaminated areas of Sheikhupura District. This successional drift has been confirmed through the results of vegetation analysis (Fig. 1).

Growing habit of *C. dactylon* is cluster formation containing large number of individual plants; the condition requires a lot of water for its growth. *C. dactylon* makes a complete cover on the ground, therefore, less evaporation from the soil surface takes place. On the other hand, *D. bipinnata* tends to grow in much smaller groups maintaining its individual identity. The scattered growth of *D. bipinnata* seems to be associated with soil moisture availability, which exists, in small pockets in soil. Usually grasses need lot of water to grow as their bulk is mainly a contribution of water. Hence, soil moisture in localized spots seems the prime reason of small group formation of *D. bipinnata*. Subsequent decrease in soil moisture caused decrease in *C. dactylon* number that in turn reduced the root density in soil, a prime reason for less organic matter content in soils of contaminated area. Normally soil processes are dynamic but at present the way soil features are persisting, it seems that contaminated sites of Sheikhupura District might show further dominance of *D. bipinnata* but complete absence of *C. dactylon* may not be achieved as occasional rainfall temporarily changes the moisture status of soil.[23] Phytosociology of large area showed that *Desmo*-dominance was particularly near the

drains. Another trend observed was the mixing of *Saccharum bengalense* with *D. bipinnata*, away from drains or where soil was least contaminated. Topography has played a vital role in the initiation of that trend. Land having even surface with maximum seepage through lateral movement of polluted water has reduced the mixing trend of *Saccharum* with *Desmostachya* while uneven topography promoted the trend. As far as essential nutrients are concerned, low phosphorus in contaminated areas signifies the role of nutrient poor soil in rehabilitation of vegetation status. Consequently re-growth of natural vegetation in soils without adequate phosphorus is too slow and depletes soil organic matter as well. Thus low amounts of phosphorus could be attributed to the return of low amount of organic matter. As whole the contaminated areas appeared to have more limitations for vegetation restoration.

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