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Relationship between Soil Characteristics and Vegetation Types in Damghan

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Abstract

Relationships between soil factors and vegetation types in playa of Damghan was investigated. Six vegetation types including *Artemisia.sieberi, Arundo. sp, Artemisia.sieberi-Peganum.harmala, Alhagi.cammelerom, Artemisia.sieberi-petropyron.sp, Tamarix.passerinoides-Halocnemum strobilaceum*. One bare land was recognized in the study area and the research was conducted within mentioned types. Canopy percentage of plant in different types was estimated based on randomized-systematic sampling method, within 1 m^2 quadrats. Along four transects 300 m each, 15 m^2 quadrats established for estimating cover percentage in each type. Soil sampling was performed from 0-15 and 15-50 Depths at the starting and end points of transect. Measured soil factors included EC, pH, texture, Ca^{2+}, Na^+, Mg^{2+}, $Co3^{2-}$, HCO_3^-, Cl^-, $CaSO_4$, $CaCO_3$. In order to find the relationship between soil factors and vegetation properties, multivariate analysis was used. The results showed that separation of understudy types was mainly related to soil characteristic including texture, Ec, Na^+, Mg^{2+}, Cl^-.

Keywords: Multivariate analysis; Iran; factor; Semnan; Quadrat; Axis; Ordination

1. Introduction

The investigating the relationship between different plants with biotic and abiotic component, which are in an ecosystem, is usually a part of the ecological studies. The results of these studie help to improve our knowledge of each plant community by environmental factors such soil, topography and climate. In fact, this factors cause the establishing of the different kind of plant species in different habitats (Jafari et al., 2003) Without an exhaustive understanding of saline land ecosystems, we cannot have a logical and correct use of these areas. Every kind of changes in the existent components of a natural ecosystem, especially plants and soil, finally leads to the gradual changes in whole of that. Therefore, the importance of separation and classification of plant communities in these ecosystem, their limitations as well as their relations with other components of ecosystems, become more clear (Hoveizeh, 1997). The arid areas of the worlds consist of broad saline regions where various halophyte communities establish on them (Breckle, 1986). As arid regions are usually characterized by minimal precipitation and frequent droughts (Mabbutt, 1977), thus availability of water is one of the primary factors controlling the distribution of species (Noy-meir, 1973; Yair and Danin, 1980). The most critical gradients in biotic factors may be related to water availability, including annual precipitation, soil properties, and topography (Parker, 1991). Correlation of soils and vegetation are important for most investigation of plant habitats.

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In the arid regions of the middle East, Jafari et al. (2003), Heshmati (2003), Hillel and Tadmor (1962), Kassas and Girgis (1965), olsvig-whittaker et al. (1983), stahr et al (1985) and AbdEl-Ghani (1997; 1998, 2000) worked in this direction. These investigations include large areas and therefore they reported striking gradients referring to soil conditions and vegetations. Different studies have revealed that although competition influences the growth and distribution of the plants, but soil characteristics are of high importance in distribution of salt land plants.

Several studies have provided qualitative assessments of the distribution of plant species and associations in relation to physiographic factors in different areas of the world (Moustafa and Zaghloul, 1996; Jafari et al., 2003; Danin, 1983; Batanouny, 1985; Migahid et al., 1959; Abd oEl-Ghani (1998, 1999, 2000), Heshmati, 2003; shaltout et al., 1995 and springule et al., 1997). The approach in some this study (Danin, 1983; Batanouny, 1985) was to provide subjective description of ecological conditions based on the field experience and interpretation of the author. Modern synecological research has preferred a more subjective methodology for use at the local and sometimes regional scale, seeking to reduce the complexity of a field data set either by classification and/or ordination of floristic data and then relating results to environmental data, or by deriving vegetation-habitat relationships from a single analysis of a combined floristic and environmental variable set (Ter Braak, 1987 c). These more objective approaches include some the mentioned above studies, e.g. springuel *et al*. 1997; Moustafa and Zaghloul; 1996 and Jafari *et al*., 2003. The main purpose of this research was to investigate the relationship between soil characteristics with plant species to determine the most important factors affecting the separation of vegetation types. Second aim was to identify the soil characteristics that are indicator of specific species. By knowing the relationship between soil and vegetation of a given area, it will be possible to apply these results for other similar regions and recommend the suitable guidance for management, reclamation and utilization of saline lands.

2. Materials and Methods

2.1. Study area

The study area is marginal lands of Damghan, approximately 100 km of Semnan, in north of Iran, between longitude 36° 09´ 26˝ to 36° 18´ 42˝and latitude of 54° 36´ 40˝ to 54° 49´ 02˝ with an area of 41200 ha (figure 1). Mean elevation of the region is 1180 m. mean slope of the region is 2 %. The mean average of annual precipitation is 127 mm, The maximum of annual temperature is recorded 42°c while the minimum temperature is -16°c. The soil temperature regime is thermic and the soil moisture regime is aridic.

Fig. 1. Study area

2.2. Data- collection

Based on field surveys, 6 dominant vegetation types were distinguished. Sampling was performed in the key area of each vegetation type using randomized-systematic method. Plot size was determined using minimal area method. Considering variation in vegetation and environmental variables fifteen 1 m^2 plots in each vegetation type with a distance of 50m from each other were established. Floristic list and canopy cover percentage were recorded. Soil samples were taken from 0-15 cm and 15-50 cm layers. Measured soil factors included pH (using pH meter), Ec (USING Ec meter), texture (determined by Bouy oucus hydrometer), Soluble calcium and magnesium (determined by titration with solution EDTA method), Soluble chlorine (determined by titration with $AgNO_3$), Soluble Carbonate and bicarbonate (determined by titration with H_2SO_4 using metilorange and phenolphthalein respectively), Soluble Sodium and Potassium (determined by flame photometry method), Gypsum (determined by Aceton method) and lime (determined by collin's Calcimeter).

2.3. Data analysis methods

Data matrix of environmental factors and vegetation types was made. The windows of PC-ORD (ver.3.3) (McCune and Mefford, 1997) were used for ordination of vegetation types in gradient of soil characteristics. Principal component analysis (PCA) was used to analyze the data. PCA is ordination technique that constructs the theoretical variable that minimizes the total residual sum of squares after fitting straight lines to species data. PCA does so by choosing the best values for the sites (Jafari *et al.*, 2003). To apply PCA, data standardization is necessary if we are analyzing variables that are measured in different units. Also, species with high variance, often the abundant ones, therefore dominate the PCA method, where as species with low variance, often the rare ones, have only minor influence on the method. These may be reasons to apply standardized PCA, in which all species receive equal weight (Jafari *et al*. 2003). Therefore, data were standardized by centered and standard deviation (Jongman, 1987). Eigenvalues for each principal component was compared to a broken- stick eigenvalue to determine if the captured variance summarized more information than expected by chance. Broken-Stick eigenvalus have been shown to be a robust method for selection of nontrivial components in PCA (Jackson, 1993).

3. Results

In order to find the most effective factors on the separation of vegetation types, PCA was used. Table 1 shows the ordination results of the PCA analysis. As it is shown in Table 1, PC 1 and PC 2 are accounted for 67.93% of vegetation variations that is caused by soil characteristics, which From 67.93% of variations, PC 1 and PC 2 include 43.02% and 24.90%, respectively. According to correlation coefficients between factors and components, the factors of PC 1 are sand in the first soil layer (0-15cm) and EC, Cl^-, Na^+ in the second layer (15-50 cm). PC_2 includes $Mg^{2+}$and clay at depth 0-15cm and only Mg^{2+} at depth 15-50cm (second layer). Therefore, PC 1 can be considered as an indicator of soil Salinity, texture and Nutrient characteristics of soil. In face, these factors are the most effective factors on the separation of plant types. Fig 2 represents the diagram of types distribution in relation to soil variables in PC 1 and PC 2.

According to the diagram and interpretation of the vegetation types spatial distribution, in addition to the soil characteristics (soil characteristics of each of the seven vegetation types are summarized in Table 2) we can refer to some points as follows:

1. Distance between the indicator points of vegetation types shows the degree of similarity and dissimilarity of soil characteristics.
2. Considering PC 1, all coefficients of the soil characteristics that were significant except for sand are positive.

Therefore, plant sites situated in positive direction of 1 axis have direct relationship with PC 1 factors. In the second principal component (PC 2), coefficients of all factors are negative.

3. The distance between indicator points of the vegetation types with axis is representative of the relationship power in explanation of variations.

Table 1. PCA applied to the correlation matrix of the environmental factors in the study area

AXIS	Eigenvalue	%of Variance	Cum.% of Var.	Broken-stick Eigenvalue
1	10.326	43.024	43.024	3.776
2	5.974	24.894	67.917	2.776
3	3.215	13.396	81.314	2.276
4	2.442	10.174	91.488	1.943
5	1.328	5.534	97.022	1.693
6	0.715	2.978	100	1.493

Factor loading in principal component analysis

factor	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6
Principal components						
PH1	-0.0647	0.2667	-0.3046	-0.3005	0.0889	0.0578
PH2	0.1631	0.18	-0.251	0.2565	0.3561	-0.0184
Ec 1	0.2693	-0.0195	0.2432	0.1411	0.0828	0.0423
Ec 2	0.2393	-0.1708	0.0504	-0.2484	0.1924	-0.1929
CO3 1	0.2045	0.2365	-0.1426	0.0437	-0.3485	-0.061
CO3 2	0.1389	0.3103	-0.0121	0.1104	-0.1268	-0.4931
HCo3 1	0.1354	0.3068	-0.0609	-0.1166	-0.1862	0.4686
HCo3 2	0.194	0.2013	-0.2926	-0.0435	0.2533	-0.076
Cl 1	0.2549	-0.1073	0.2507	0.1087	0.1442	0.0474
Cl 2	0.2742	-0.1071	0.1391	-0.1558	0.128	-0.128
Na 1	0.2752	0.0027	0.2245	0.1387	0.0764	-0.0432
Na 2	0.2692	-0.1235	0.0569	-0.2021	0.153	-0.1648
Ca 1	0.2207	0.1954	0.1887	-0.0714	-0.3032	-0.1675
Ca 2	-0.1912	-0.125	0.2567	-0.2534	-0.312	-0.2098
Mg 1	-0.0928	-0.3532	0.0182	0.1709	-0.2615	0.0611
Mg 2	0.1814	-0.3244	-0.0572	-0.0171	0.1164	0.0537
CaCO3 1	-0.076	0.2348	0.3650	0.2561	-0.0242	0.175
CaCO3 2	0.1371	0.1614	0.1774	0.4709	-0.0111	0.103
clay 1	0.1618	-0.2912	-0.1885	0.1822	-0.1438	0.0264
clay 2	0.2572	-0.1297	-0.1156	-0.1024	-0.1077	0.4301
silt 1	0.0966	0.2475	0.2615	-0.3576	-0.0124	0.0866
silt 2	0.1968	-0.0477	-0.3024	0.1506	-0.3673	-0.2844
sand 1	-0.2736	-0.0001	-0.1184	0.2371	0.1573	-0.1275
sand 2	-0.2595	0.1083	0.2105	0.003	0.2336	-0.1649

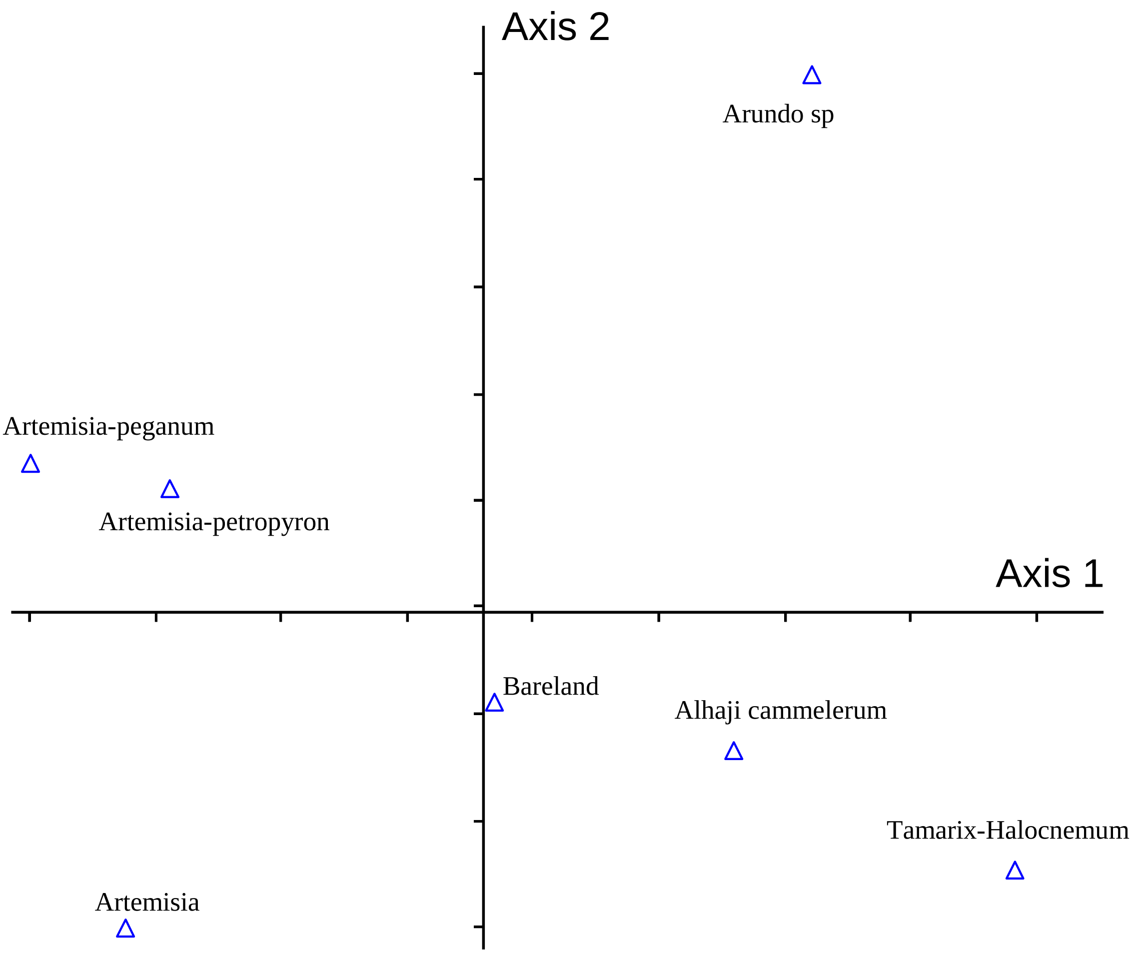

Fig. 2. PCA–ordination diagram of the vegetation types related to the environmental factors in the study area.

Whatever the length of vector loading that indicates the vegetation types is bigger and angle between vectors with axis is smaller, there is more correlation between vegetation types, with axis and relation power. As it shown in fig.1, the location of types in 4 quarters is different. This means that different types presence in different sites is affected by different environmental factors. *Aru*. type is equally affected by axis 1 and 2. This type is lied in fires quarter, so it has a direct relationship with heavy Texture, high acidity. Generally with attention to the position of this type in the first quarter, can say that environmental condition. In this type differ from each other.

In relation to two types of *Ar.Si-Pe.ha* and *Ar.Si-Pe*, this type showed noticeable positive correlation with sand (light texture), while EC, Cl^-, Na^+ have reverse relationship with this types.

As it is shown in Fig.2 *Al.Ca* and *Ta.-Ha* types are located in fourth quarter and equally affected by axis 1 and 2, So this types have a negative relationship with clay, Sand and Mg^{2+} while it has seen a positive relationship among this types and EC, Cl^-, Na^+.

BL and *Ar.si* has been located in negative side of Axis 1 and 2, therefore, it has a positive tendency to Mg^{2+}, Sand and Clay, while this type are reversely influenced by Cl^-, EC, Na^+.
Appendix: Units and abbreviations of the vegetation types and soil characteristics in the figures and tables.

4. Discussion and Conclusion

Soils of the study area are considered as saline soils, which might be the reason for low plant diversity in the area. It is because of that plants can absorb their necessary ions only when there is a constant ionic ratio among existing ions in the soil, otherwise roots will not be able to absorb soil ions and this causes a disturbance in plant growth and distribution. Low diversity of plant in the study area is an evidence for this material. In addition, high salinity is other reason that makes difficulty in the establishment and regeneration plants in saline lands. Only high adapted plants can grow under such conditions. *Halocnemum strobilaceum*, *Tamarix passerinoides* and *Artemisia sieberi* are examples of plants that grow in saline soils of the study area. Results demonstrate that there is a specific relationship between soil characteristics and the separation of the vegetation types. Soil Salinity and texture are the two main factors that cause separation of the types in the study area. This result are supported by the works of Flowers (1975); Kassas (1957); Ungar (1968); Caballero et al. (1994); Jafari (1989); Moghimi (1989); Maryam *et al*. (1995); Zahran *et al*. (1989); Jafari *et al*. (2003, 2004); Heshmati (2003), Monier *et al*. (2003). These researchers found that distribution of plants in a given region is a function of soil salinity. Abu-Ziada (1980) showed that there is a strong relationship between plant distribution pattern with soil salinity and moisture. In the current study, it was revealed that soil salinity and its variation are of the most important factors in the classification of vegetation. As noted earlier, soil texture was found as an effective variable on the vegetation types separation. This is due to texture influence on the amount of moisture (Monier *et al*., 2003) and available nutrient of soil (Jafari et al., 2004) that can influences on growth and distribution of plants. In addition, nutrients have been strongly correlated with vegetation (wales, 1975; Pregitzer and Barnes, 1982; Pregitzer et al., 1983).

PCA analysis indicates that *Ar.Si-Pe.ha* and *Ar.Si- Pet* types show a negative relationship with salinity nutrients of soil. These types are indicators of soil with low salinity and nutrients. By contrast, *Al.ca* and *Ta.pa – Ha.st* types are indicators of soil with higher salinity and nutrients.

Generally, each plant species has specific relations with environmental variables. These relations are because of habitat condition, plant ecological needs and tolerance range. Understanding the indicator of environmental factors of a given site leads us recommend adaptable species for reclamation and improvement of that site and similar sites.

Appendix A

Units and abbreviations of the vegetation types and environmental factors in the figures and tables.

Co_3^{2-}	*Carbonate (meq/ li)*
HCo_3^-	*Bicarbonate (meq/li)*
Mg^{2+}	*Magnesium (meq/li)*
Cl^-	*Chlorine (meq/li)*
Ca^+	*Calcium ion(meq/li)*
Na^+	*Sodium ion (meq/li)*
EC	*Electrical conductivity(ds/m)*

Table 2. Soil physical and chemical characteristic of study area (in different vegetation types)

Vegetation type	Depth (cm)	pH	EC	$CO3^{2-}$	$HCO3^{-}$	Cl^{-}	Na^{+}	Ca^{2+}	Mg^{2+}	$CaCO_3$	Clay (%)	Silt (%)	Sand (%)
Art	0 - 15	7.7	6.5	0.0	1.4	16.4	14.2	7.2	37.6	7.9	34.8	12.8	52.4
	15 - 50	7.4	9.1	0.0	1.0	12.0	7.6	19.2	22.4	7.5	20.8	32.8	46.4
Aru	0 - 15	8.0	92.6	0.4	2.4	79.0	197.1	26.0	4.0	12.9	26.8	30.8	42.4
	15 - 50	8.1	20.8	0.4	2.0	70.0	79.6	4.0	8.4	16.7	28.8	34.8	36.4
Art-Peg	0 - 15	8.0	4.1	0.0	2.0	2.6	2.1	14.4	17.6	12.1	20.8	32.8	46.4
	15 - 50	7.1	8.9	0.0	1.0	23.0	10.3	26.0	6.8	5.0	18.8	14.8	66.4
Art-Pet	0 - 15	8.1	2.1	0.0	1.9	2.5	1.3	3.8	14.8	9.2	27.3	19.8	52.9
	15 - 50	8.0	3.0	0.0	1.8	2.5	1.2	4.8	15.3	8.2	23.3	21.8	54.9
Al	0 - 15	7.7	108.1	0.0	1.6	145.6	215.0	16.2	16.1	8.9	29.8	27.8	42.4
	15 - 50	7.7	105.7	0.1	1.6	150.1	215.9	13.1	29.5	9.3	28.8	23.8	47.4
Ta- Ha	0 - 15	7.8	103.3	0.2	2.1	134.5	193.9	17.6	24.2	5.2	38.8	24.8	36.4
	15 - 50	7.7	101.9	0.0	1.7	146.5	220.8	7.6	38.8	8.3	56.8	36.8	6.4
BL	0 - 15	7.5	115.1	0.0	1.8	143.0	207.9	14.0	28.0	15.0	30.8	22.8	46.4
	15 - 50	7.6	18.9	0.0	1.0	67.0	52.4	12.0	22.0	17.1	28.8	20.8	50.4

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