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Halophyte species of desert areas and soil physicochemical properties (case study: eastern rangelands of Sabzevar city)

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ABSTRACT:

Rangeland ecosystems are a different type of habitat in saline ecosystems. Vegetation distribution on these lands depend on soil properties; therefore studying vegetation changes related to soil properties are necessary for management and restoration of saline rangelands. This study tries to identify main halophyte plant communities and their relationships with soil physical and chemical properties in eastern rangelands of Sabzevar province. In order to study vegetation and soil properties and after field study, six main types were determined in the study area considering observed differences in the communities. Sampling method was systematic–randomized method. Considering distribution patterns of species, the plots of 3×3 meter were selected to study the vegetation cover. Soil sampling includes five samples in each point, one from central plot and others from four corners of the plot. The results showed that the most important separation factors of *Halocnemum strobilaceum* from *Salsola* sp are the amount of salinity and sodium. Also, the amount of gypsum is one of the other factors to separate *H. strobilaceum* from other species. The most significant factors to separate *Alhagi camelorum* and *Artemisia sieberi* from others species are the maximum amounts of sand percentage and the minimum amounts of gypsum. *Prosopis farcta* by the maximum amounts of clay has the significant and noticeable difference with others spices. Finally, *Seidlitzia rosmarinus* has the minimum amount of clay and maximum amount of gypsum after *H. strobilaceum*, and this can be the cause of separation of this species from other species.

Keywords:
Saline Soil, Vegetation Communities, Soil Properties, Rangeland of Sabzevar

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INTRODUCTION

The regions of Iran with a variety of climates and soils are a main place for vegetating many species. The factors influencing the growth of this species and its application, could be costly and time consuming, while planning to prevent rangelands. To identify the factors influencing the establishment of native vegetation in the area and their survival is essential. The soil is affected by the vegetation that grows on it (Kilaneh and Vahabi, 2012). The soil in turn affects the nature of the vegetation. According to some studies, although the weather factors has the most important role in the development of plant growth, soil is the main factor influencing the distribution of plant communities (Jafari *et al.,* 2008). One of the major problems in natural resources, especially pasture lands are saline soils and salinization in non-saline soils (Jafari, 1994). It is estimated that 23% of land in the world are saline. Asia continent with about 310 million acres has the highest salinity after the Australia (Abadi, 2006). Saline soils in Iran are about 24 million hectares that is equivalent to 15% of the country's land (Abadi, 2006). The concept of salinity is the high concentration of mineral. It seriously changes root environment, osmotic potential of the soil solution and dissolved ions, alters the normal balance and inhibit plant growth (Ahmadi and Jolodar, 2002). In arid and semi-arid rangeland ecosystems, especially in saline soils, distribution of plant communities depends on the area dominated by environmental factors (Bravodela and Poggiale, 2005). Saline soils have fewer species and in some cases a single species that species distribution are dependent on soil physical and chemical gradient, biological activity (Adam, 1963; Lefor *et al.,*1987).

Halophyte are natural flora in saline soils and their life cycle is completed in saline lands (Flowers *et al.,* 1977). Growth and production of halophyte is changed by changing salinity (Ungar *et al.,* 1979). Understanding the relations between halophyte species and effective environmental factors on the establishment and distribution of salt has significant impact on the management of saline land ecosystems (Bravodela and Poggiale, 2005). Many studies have shown that there are interactions between vegetation and soil characteristics in non-saline lands (Jafari *et al.,*2002; Nia *et al.,* 2007). Due to expansion of saline and gypsum soils in Iran, conducted research on the effects of saline and gypsum soils on vegetation distribution is limited and sporadic. The most important factor in areas with high levels of soluble salts or exchangeable sodium or both are are soil salinity, texture and electrical conductivity and other factors have less impact (Ahmadi *et al.,* 2007).

Many studies have been conducted to investigate the interaction between soil and vegetation. Lu *et al.* (2006), compared the relation between soil factors and species distribution in the floor of shrubs and herbaceous plants. The result of direct gradient analysis showed that organic matter, soil moisture content and acidity are the most important factors that justify the distribution of species in each floor. Moghimi and Ansari (2004) said that the quality of the soil and humus habitat of *Prangos* in Kermanshah province is due to the high amount of carbon, nitrogen and organic matter. Toranjzar (2005) in investigation of the relation between soil properties and vegetation cover in the rangelands of Qom Vashnaveh found that soil factors have a significant impact on vegetation change; so that, in the studied types, organic matter, sand percentage and electrical conductivity had the highest correlation with plant species. Shokrollahi *et al.* (2012) investigated the effect of soil properties and soil factors on vegetation cover of Pelour summer rangeland and concluded that among the physiographic factors there were a strong relation between direction of slope and density of vegetation cover of the soil. Among the most important factors of soil on canopy cover were nitrogen, phosphorus, pH and litter. Also more important influencing factors on density of plant species were organic matter, phosphorus, pH and conductivity.

Kilaneh and Vahabi (2012) investigated the effect of soil properties on the distribution of vegetation in the central Zagros Rangelands and concluded that clay percentage, organic carbon, soil depth, percentage of lime, surface gravel percentage and bare soil percentage were the most important factors in separation of rangeland sites. Jafari *et al.* (2006) in Houz Soltan area of Qom found there is a special relation between plant species and soil diversity that role of salinity and texture is more effective than other factors.

One of the important plants in the management of salty land is revival of vegetation (Qadir and Oster, 2004). In this field, planting of halophytes species especially with native species are recommended (Lieth *et al.,*1999). For this purpose, it is recommended to study the physical and chemical properties of soil because they are an important role on establishment, growth and distribution of plant species in saline land. It can be used both in recognition of the potential of revival of saline lands and in the selection of suitable plant species. So, it is necessary to identify communities' halophytes and their relation to environment, especially soil properties across the different areas of country with saline soils.

The purpose of this study is to identify the communities of halophytes in the eastern pastures of Sabzevar city, Khorasan Razavi. Also, the physical and chemical properties of the soil for these plant communities and separation these plant communities were investigated and compared to study better management in this field.

MATERIALS AND METHODS

Geographical location

The case study area is located between 56° 46' E to 57° 38' E and 35° 46' N to 36° 19' N in the east of Sabzevar city. Figure 1 shows the location of the studied area in the city of Sabzevar, Khorasan Razavi province (Sabzevar *et al.,* 2014).

According to the statistics of Sabzevar meteorological station, the closest station to the study area, the annual average of precipitation is about 191 mm per year. Precipitation ranges in the seasonal distribution is0 mm in summer to about 70 mm in winter. The annual temperature range is about 28°C that varies this mean average from at least 9°C to at most 26°C (Sabzevar *et al.*, 2014). Regional climate according to Emberger method and coefficient obtained on it is cold and dry. According to Domarten method, drought index for mentioned area is 6.82 that is classified as dry climate (Sabzevar *et al.*, 2014). The most of this area is located in the watershed central desert of Iran. The largest seasonal river in the study area is Sabzevar Kal Shoor that passes from Sabzevar plain. Mainly Geological case study consists of deposits of Tertiary geology and present time that poly quaternary (conglomerates with low slope) are abundant in the region.

Sampling of vegetation and soil

Field data were collected at April 2014 and before the start of the grazing season referred to the study area. Since vegetation type is the main study on vegetation studies and pastures, so classification of vegetation types were the first stage of the study.

The land use map were used to segregate the pastures from other sources and the rangelands by using Kuchler and Zonneveld (1988) method to distinguish the dominance of vegetation types and the degree of dominance by one, two or three species and appearance. Relatively homogenous vegetation units were identified and coded. After initial recognition and naming of the types, with scrolling, areas were drawn for their approximate boundaries on the map 1:25,000. This method relies on the appearance of species in plant communities, a kind of study and identification of plant communities is based on physiognomic - floristic (Kuchler and Zonneveld, 1988). Boundaries are set to tip separation and are approximate. Because changing plant communities, has been a gradual transition from one society to another and can never be a definitive boundary

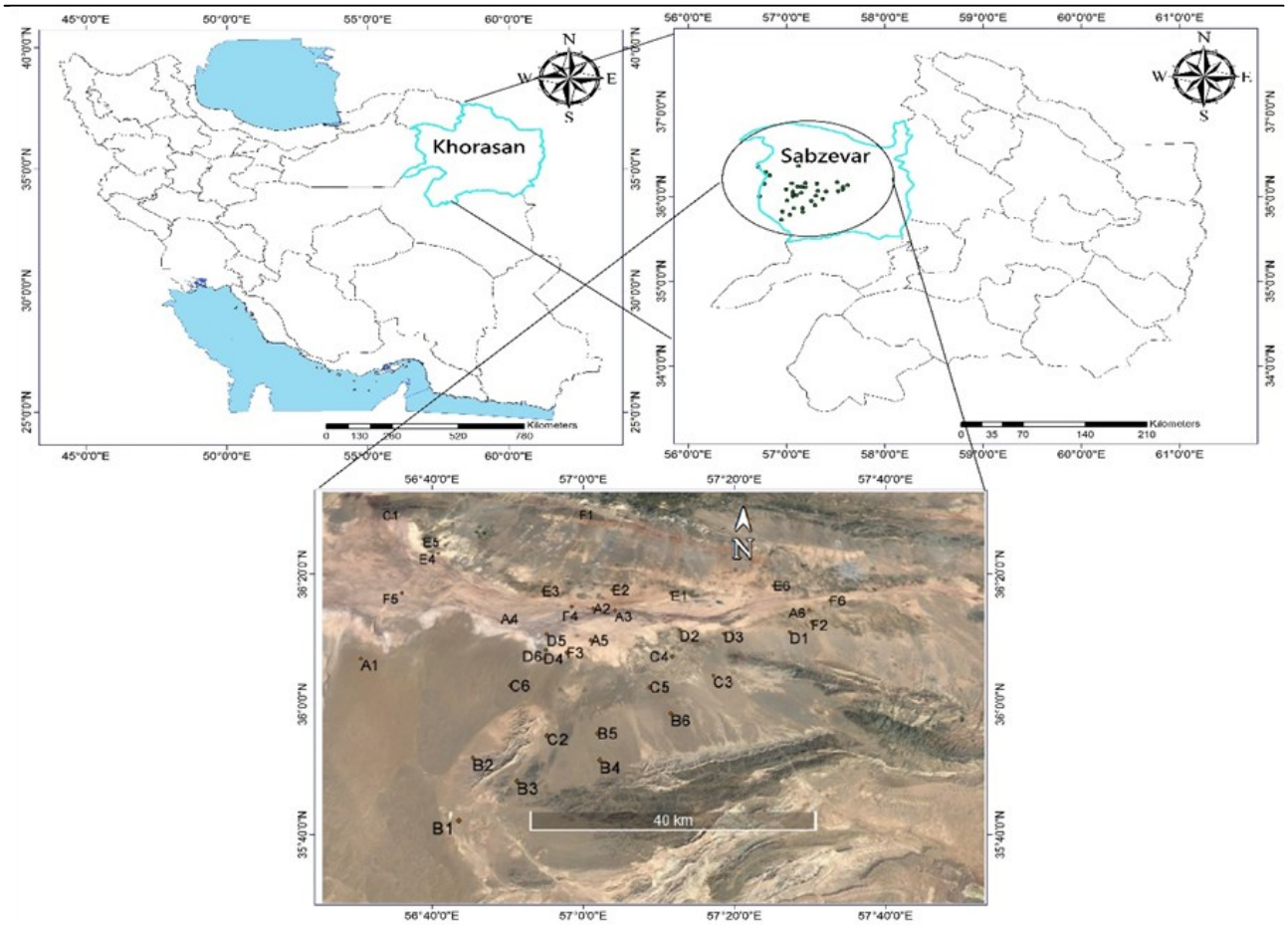

Figure 1. Location and sampling points of the study area in the Sabzevar-Khorasan Razavi

between two adjacent communities determined (ecotone area). But always between the two communities, there is a passage area which includes elements of both community (Kuchler and Zonneveld, 1988; Ardakani, 2004). Typing method was performed physiognomic - floristic and sampling was carried out in a systematic randomized types desired (Asri, 1995).

In the beginning, each sample type was divided into six sections (three in the northern half and three in the southern half), each sampling was performed in random to measure the vegetation and soil sampling. The method was to throw an object into one way. According to the type and distribution of species and the centrality of the falling object, a plot of 3 × 3 m was marked. Canopy and density of vegetation were calculated in each 9 m^2 by meter and ruler scales. After performing the measurement of vegetation, soil sampling was conducted. Soil sampling in each point included five data recorders. One of five data recorders was conducted from center of the plot, the other four data recorders were conducted from four sample plots at four directions with 90° and in four corners of the plot and then mixing them and supplying at a similar sample. To study the physicochemical properties of the soil, sampling from soil and vegetation was performed in six replications in each habitat of the species. Thus, 36 samples of soil (six samples and six replicates in each samples) were prepared. Samples were transferred to the laboratory in agricultural and natural resources research center at Sabzevar city for evaluation of desired indices. The physical properties (percentage of sand, silt and clay) and chemical properties (salinity, acidity, sodium, calcium, magnesium, and gypsum) were tested. The percentage of sand, silt and clay of soil texture was determined by

Hydrometer method and separation of particles with the use of Kalgan (sodium hexa meta phosphate) and a mixer. After preparing saturated mud and measuring acidity, extraction was performed by a vacuum pump and then the electrical conductivity of the content was measured by a conductivity meter. Also, the sum of calcium and magnesium dissolved in the saturated extraction was determined by Complexometry method and was reported in milliequivalents per liter as shown in Table 1.

Data analysis

To compare the soil physicochemical properties of the halophyte species of habitat area, after obtaining the test results of soil samples, the results were analyzed. Each plant species according to specific ecological characteristics choose soil with specific features. The soil characteristics within each habitat can be considered as the same and these characteristics between different habitats are considered as different. Thus, a randomized complete block design was used to analyze statistics. The physical and chemical changes of soil were assessed at six sites and six samples (each species as a sample). The determination of each sample was performed by six replications. The results of soil chemical and physical properties were analyzed using MSTAT-C statistical program. The means were compared by Duncan test.

RESULTS AND DISCUSSION

Results related to the classification of vegetation types

The region was investigated for knowing the properties of soil and to observe the differences in the region. These determined six vegetation type viz., *Halocnemum strobilaceum*, *Salsola* sp, *Prosopis farcta*, *Seidlitzia rosmarinus*, *Alhagi camelorum* and *Artemisia sieberi*. In the index type of *Halocnemum strobilaceum*, it is the high dominant species in the region which covers 18% and associated species are *Artemisia sieberi* and *Seidlitzia rosmarinus*. Each later species covers about 2% area.

Seidlitzia rosmarinus index type are included with an average coverage of 12% and associated species such as *H. strobilaceum* with the average of 5%, *Sophora alopecuroides* with 2%, *Salsola* with 2% and *Zygophyllum eurypterum* with 2%. *Salsola rigida* are included with an average coverage of 11% and associated species such as *Seidlitzia rosmarinus,* with an average of 3%, *Alhagi camelorum* with 3%- *Salsola* with 2% and *Prosopis farcta* with 2%. *Prosopis farcta* is associated with an average coverage of 24% with *Sophora alopecuroides* with an average of 7% and *Alhagi camelorum* with 5%. *Artemisia sieberi* with an average coverage of 14% and associated species such as *Zygophyllum eurypterum* with 5%, *Convolvulus arvensis* with 2%, *Sophora alopecuroides,* with 3%, *Peganum harmala* with 3%, *Astragalus* sp with 3%, *Acanthe phyllum bracteatum, Acantholimon* 3% and 3% of *Alhagi camelorum.* The latter index type was more on the agricultural land and are included with an average coverage of 21% and associated species such as *Prosopis farcta* with an average of 5% -

Table 1. Comparison of means of soil physical and chemical properties in the species habitat

Parameters	*Salsola* sp	*Halocnemum strobilaceum*	*Prosopis fracta*	*Seidlitzia rosmarinus*	*Alhagi camelorum*	*Artemisia sieberi*
Salinity (ds/m)	88.90^{a}	66.57^{ba}	14.40^{b}	12.97^{b}	1.37^{b}	1.35^{b}
Acidity (meq/l)	7.70^{a}	7.62^{a}	7.82^{a}	7.65^{a}	8.12^{a}	7.92^{a}
Sodium (meq/l)	1276^{a}	635.80^{ba}	150.10^{b}	130.10^{b}	18.05^{b}	9.14^{b}
Calcium (meq/l)	92^{ba}	111.20^{a}	32^{c}	52.33^{bc}	35.83^{bc}	$24/67^{c}$
Magnesium (meq/l)	61.33^{a}	61^{a}	21^{ba}	28^{ba}	14^{b}	11^{b}
Gypsum (meq/l)	7.95^{bc}	35.37^{a}	3.37^{c}	16.27^{b}	0^{c}	0^{c}
Sand (%)	44.75^{ba}	40.88^{ba}	36.82^{b}	44.75^{ba}	73.38^{a}	74.90^{a}
Silt (%)	46.97^{a}	43.45^{a}	45.42^{a}	37.60^{ba}	19.72^{b}	20.87^{b}
Clay(%)	8.30^{b}	10.62^{b}	17.77^{a}	4.15^{b}	6.97^{b}	4.23^{b}

*Alphabets in superscripts mean statistical difference

Table 2. ANOVA results for chemical and physical properties of the soil with species habitat

Treatment	Degrees of freedom	Sum squares	Mean square	F-value	P -value
EC	5	41855.77	8371.15	3.21*	0.0226
Acidity (meq/l)	5	1.14	0.22	1.79 Ns	0.1187
Sodium (meq/l)	5	7591504.72	1518300.94	5.84**	0.0011
Calcium (meq/l)	5	37759.67	7551.93	6.70**	0.0004
Magnesium (meq/l)	5	15126.14	3025.22	2.95*	0.0318
Gypsum (meq/l)	5	5576.95	1115.39	19.73**	0.0000
Sand (%)	5	8254.40	1650.88	4.40**	0.0001
Silt (%)	5	4563.08	912.61	2.98*	0.0302
Clay (%)	5	778.77	155.75	7.94**	0.0001

*means statistical difference

Sophora alopecuroides with 3%, *Salsola rigida* with7% Peganum *harmala* with 2% and *Convolvulus arvensis* with 6%.

Results related to differences between soil properties and vegetation types

Table 1 reveals the mean and standard error of the data obtained from the measurements of soil physical and chemical properties. Table 2 shows the results of the analysis of variance of the data obtained from the measurements of soil physical and chemical properties.

Based on the results presented in Table 2, six types of vegetation index in terms of characteristics were noticed. The table shows that among all the physical and chemical properties of soil, except acidity there are differences. The electrical conductivity, magnesium and silt has less difference (5%) and calcium, sodium, gypsum, sand and clay has more difference (5%) in vegetation types. Table 1 indicates significant difference between the study areas based on soil properties.

Salinity between *Salsola* sp and *H. strobilaceum* also between *H. strobilaceum* with the other species were not significant. whereas significant difference were between *Salsola* sp and other species.

Physical properties of soils (soil texture)

Sand

Analysis of variance for sand content showed significant differences among species in the level of one percent (p=0.0001, value<0.01). The differences are between the two species of the *Artemisia sieberi* and *Alhagi camelorum* with *Prosopis fracta*. The other species didn't showed significant difference with each other and also with the three species. The most of the sand is for two species of *Artemisia sieberi* (74.90%) and *Alhagi camelorum* (73.38%) and the lowest sand is for the *H. strobilaceum* (4.87%) and *Prosopis fracta* (36.82%).

Clay

The difference between the content of clay with target species is significant at one percent habitat, the same as the difference between the content of sand (p=0.0001, value<0.01). So with a confidence level higher than 99% there is a difference between the sand and clay habitats. The most clay content is for the *P. fracta* (17.77%) and the least content is for *S. rosmarinus* (4.15%). Comparison table shows the mean differences between the *P. fracta* with other species are significant but they are not significant between other species. Kilanah and Vahabi (2012) considered clay percentage as the most important factors in the separation of rangeland habitats that is similar to the results of these study.

Silt

The results of silt content showed that there are significant differences between the three species of *Salsola* sp, *P. fracta* and *H. Strobilaceum* with the two species *Artemisia sieberi* and *A. camelorum*. This difference is significant at the 5%level (p=0.0302, value<0.05). Thus, at 95% confidence level there is a

difference between silt habitats. As a result, the difference between silt and sand habitats are less likely than clay. The other comparisons of averages are not of significant difference. The most and the least silt content is for *A. camelorum* (19.72%) and *Salsola* sp (46.97%) respectively. Sperry and Hacke (2002) reported that soil is a very important factor in the separation of ecological groups and it is effective for the infiltration and retention of water and for the availability of water and nutrients for the plants. Their results are similar to this study.

Results related to differences in soil texture for six vegetation types are shown in Figure 2. Based on Figure 2 there are huge difference between *A. camelorum* and *Artemisia sieberi* with other species in terms of percentage of high sand and low silt percentage. Hence, these two species act as psammophytes and has a great desire to settle in the light texture.

Chemical characteristics of the soil

Electrical conductivity

Table 2 shows the ANOVA results at 5% significance. The main difference is between *Salsola* sp with the other species except *H. strobilaceum* and there is no significant difference between other species. The highest average of EC is for *Salsola* sp (88.90ds/m) and the lowest is for *Artemisia siberia* (1.35ds/m) and *Alhagi camelorum* (1.37ds/m). Ahmadi *et al.* (2007) introduced soil salinity as one of the effective factors in separating vegetation types in Eshtehard summer rangelands.

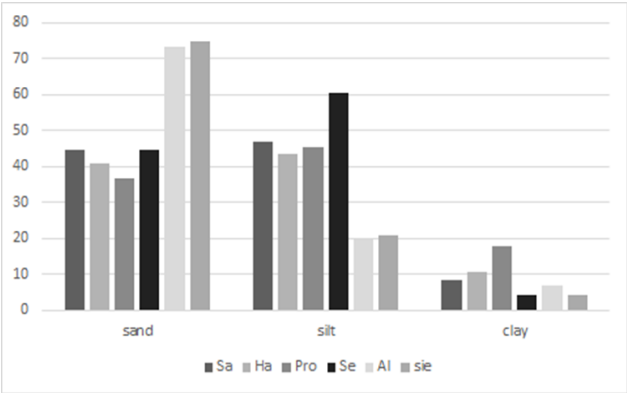

Figure 2. Components of soil texture in six vegetation types

Ghahreman *et al.* (2003) investigated the diversity of plant communities in Arak Mighan desert and found that two factors of salt and ground water depth are the most important edaphic factors in changes of area species diversity. Their result is consistent with a part of above result.

Acidity

The highest acidity is for a *A.camelorum* (8.12) and the least is for *H. strobilaceum* (7.62) and *S. rosmarinus* (7.65). The change of acidity between the species is low. According to the analysis of variance, the difference is not significant even at the level of five percent (p=0. 1187, value<0.05). Zulfaqari *et al.* (2010) concluded that the most important role of soil acidity is controlling the solubility of nutrients in the soils and it has that significant difference on distribution of the area of the plant species. Shokrollahi *et al.* (2012) considered texture and acidity as effective factors on the vegetation cover and electrical conductivity and pH as effective factors on the plant density. Their results are consistent with this study results about electrical conductivity and texture as well as acidity.

Sodium

Analysis of variance showed significant differences in the level of one percent (p=0. 0011, value<0.01) with a confidence level higher than 99%. The results of the means comparison for sodium is similar to the electrical conductivity.

Calcium

There found significant difference between calcium content of the studied species. These differences found to be the lowest for *H. strobilaceum*, *Salsola* sp, *S. rosmarinus, A. camelorum, P. fracta* and *Artemisia sieberi* subsequently. The difference between the calcium content of the species are significant in one percentage level with a confidence level higher than 99% (p=0.0004, value<0.01) Significant differences are between *H. strobilaceum* with other species except *Salsola* sp, *Salsola* sp with *P. fracta* and *A. sieberi* and finally two

species of *P. fracta and A. sieberi* with *S. rosmarinus* and *A. camelorum* are seen. The difference is not significant between the two species viz; *P. fracta* and *A. sieberi* and also *S. rosmarinus, A. camelorum* and *Salsola* sp.

Magnesium

Analysis of variance table for magnesium showed that there are significant differences in the level of five percent and with a confidence level of 95% between habitats of studied species (p=0.0318, value<0.01) The amount of magnesium exhibited differences less likely than sodium and calcium between habitats. Also, the mean comparison table shows that there is no significant difference between two species i.e. *S. rosmarinus* and *P. fracta* with other species. There is not a significant difference between *A. sieberi* with *A. camelorum* and also *H. strobilaceum* with *Salsola* sp. But there is significant difference between *H. strobilaceum* and *Salsola* with *A. sieberi* and *A. camelorum.* The highest magnesium content is for *H. strobilaceum* and *Salsola* sp and lowest is for *A. sieberi and A. camelorum.*

Gypsum

There is significant difference in gypsum content between species at one percentage level. According to sig value calculated between habitats, highest level of confidence is related to the amount of gypsum. The highest gypsum content is for *H. strobilaceum* habitats and the lowest is for *A. camelorum* habitat. There are significant differences between means in four species *A. camelorum*, *A. sieberi*, *P. fracta and Salsola* sp. Also, there is no significant difference between *Salsola* sp and *S. rosmarinus.* But there are significant differences between *H. strobilaceum* and *S. rosmarinus* with other species. Finally, the results of the different chemical properties of soil in six vegetation types are given in Figure 3.

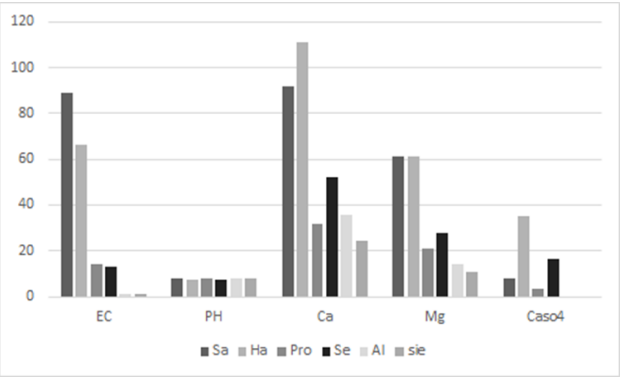

Figure 3. Results of soil chemical properties in six vegetation types studied

Figure 3 shows differences between *H. strobilaceum* and *Salsola* sp and other species in terms of salt, calcium, magnesium and gypsum. These two species represent more halophytic nature when compared to other species. Comparing the results with the results of other studies as well as comparing our results with each other about any vegetable can be found depending on the type of species (with different ecological characteristics), conditions in the study area (with different characteristics, climate, edaphic and topographic). In any special habitats, chemical and physical characteristics of a specific factor control and are important for the establishment of different plant species. In this study and other research, soil texture was a limiting factor in the some vegetation types and also chemical properties of soil are limiting factors. So sase studies are required in each region. The other difference between this study and other research of assessing the desert plants and halophytes are very different from other regions because of the geographic and climatic conditions and therefore show different results.

Saline soils are located in arid regions. These soils have a high concentration of soluble salts or exchangeable sodium or both (Jafari, 1994). Because of the presence of soluble salts, they have low fertility, and affects most plants (Jafari, 1994). The results of analysis of vegetation with soil physical and chemical factors showed that the presence of plant species and soil factors such as soil texture (clay content, silt and sand), salt, sodium, gypsum and calcium content, magnesium are closely related. The study in the saline soils of the

studied area showed that generally *Salsola* sp and *H. strobilaceum* are distinct because of their most salinity, followed by sodium, calcium and magnesium. But the most important factors in the breakdown are salinity and soil sodium. Also gypsum content is the factor of breakdown of *H. strobilaceum* between the other species. Also, it has the most significant influence over the other species in the habitat. So on the other hand, these two species choose the habitat with the most salinity and contaminants. Also soil texture cannot be responsible for the significant difference in the percentages of clay, silt and sand in these two species. Therefore, these two species from soil texture view can be established in the soils with different textures. Two species of the *A. camelorum* and *A. sieberi* among different species in all the measured parameters showed the lowest rate except in percentages of sand and acidity (no significant differences between species). With regard to the percentage of sand, they showed the most significant difference allocated to it. Comparison of averages showed that the most predominate factors that separate these two species are the high sand percentage content and the lowest gypsum content in these habitats. Generally, it can be said these two species in comparison with the other species choose habitats with less salinity and mineral and lighter texture. *S. rosmarinus* and *P. fracta* in comparison with the other species showed medium contents of the measured parameters (except the gypsum and clay percentage). *P. fracta* has the least gypsum content. *P. fracta*, *A. camelorum* and *A. sieberi* showed the most and significant difference in the clay content. Finally, *S. rosmarinus* has the lowest percentage of the clay, and the high percentage of the gypsum are after *H. strobilaceum.*

In general, it is necessary to have information about the characteristics of the soil in plant ecology. Because the soil is the primary factor that determines the type of vegetation within a region. Soil characteristics are very different in ecosystems and this differences cause vegetation changes. Consequently, the collection or distribution of herbivores and carnivorous animals are very diverse. On the other hand, if the characteristics of physical and chemical characteristics of soil in habitats are known to improve and expand the rangelands, adaptable species with local ecological conditions, especially soil conditions can be recommended.

CONCLUSION

Based on all the above research, we aimed to investigate the association between halophytes rangelands of Sabzevar East from the edaphic perspective of the social conditions. So, in the management of the pastures, comprehensive and accurate impression could be made. The outcome of the survey results can be found in pastures east of Sabzevar, in terms of restoration and modification of vegetation with native species in areas where salinity is high. *Salsola* sp and *H. strobilaceum* species can be found in any context of the soil. Also in areas where the soil is light, besides light texture, soil salinity level is too low, rangeland management according to multiple targets could be done with the two species viz: *A. camelorum* and *A. sieberi*. There are also two other types of properties listed above have the ability to deploy and modify in moderate condition rangeland. Finally, it can be said with regard to soil edaphic data in each habitat and vegetation type, the information regarding the vegetation in these areas, can be realized through the edaphic conditions without soil testing and soil sampling avoiding high costs. The information in the studied area could be used for the total area with similar climates desert rangelands.

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