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Research and Full Length Article:

Effect of Environmental Traits and Grazing Intensities on Plant Community Distribution (Case Study: Saral Rangelands, Iran)

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Abstract. Understanding ecological processes is a prerequisite for the management of rangelands; therefore, recognition of the relationship between environmental factors and vegetation is very important. The present research aims to investigate environmental and management factors affecting rangeland vegetation distribution in Saral rangelands of Kurdistan province, Iran, in 2017. Sampling was done in eight vegetation types along four 300 m transects. Fifteen 1m^2 plots established along each transect in 20 m distances. Ten soil samples along transects were taken according to the plants root depth in the average depth 0-50 cm in 10 profiles within each vegetation type. Various environmental factors such as topographic factors (slope, aspect, and elevation), soil physical properties (depths, soil texture, gravel, and saturation moisture) and various chemical factors such as acidity, electrical conductivity, lime, gypsum, nitrogen, phosphor, and potassium were measured and grazing intensity considered and measured as managerial factor. The collected data were subjected to Principal Component Analysis (PCA) and the important factors affecting plant community distribution were determined. According to the results, first and second components account for 39.29% and 26.28% of community distribution, respectively. The results showed that among various environmental and grazing factors affecting plant distribution, soil texture, soil depth, grazing intensity, elevation, potassium and gravel had the most significant effects on present plant community distribution in studied rangeland. Silt, gravel and grazing intensity play important roles in the spatial distribution of vegetation communities, respectively.

Key words: Topographic factors, Soil physicochemical properties, PCA, Grazing intensity

Introduction

One of the major challenges for rangeland managers is suitable strategies of rangeland development and improvement as well as increasing biodiversity and species richness (Hea *et al.*, 2007). Rangeland ecosystems in western Iran are characterized by high potential thanks to its proper climatic and soil conditions. The importance of such resources necessitates range researchers to identify and understand its real potential and contribution to produce wildlife and livestock forage and supply needs for the human community. This entails for acquiring ecological needs. Ecological capability based optimal management is the main tool for managing rangeland ecosystems (Jin-Tun, 2002).

One prerequisite of management is the knowledge of the status and general conditions of rangelands and to adopt approaches for its improvement (Moreno, 2006). Rangeland plant species grow and complete life cycle under many factors such as physiography, edaphic and human managerial factors. What seems important is to support plants association during growth and creating optimum conditions for their regeneration. Such knowledge is obtained by studying the environmental factors that affect their distribution. In arid and semi-arid areas, environmental factors have a great contribution to plant distribution. Homogeneous habitats with similar ecologic and floristic composition host similar ecological species groups, in turn, form ecological groups in the various regions. Such characteristics can be promising in habitat classification (Kashian *et al.*, 2003; Kooch *et al.*, 2008).

While evaluating environmental factors in the distribution of vegetation communities in Shahryar rangelands, Iran, Zare *et al.* (2011) classified vegetation communities and distribution of plant communities in relation to environmental factors applied PCA for the analysis of environmental factors as well vegetation changes. The results showed that the most important drivers of vegetation communities are soil texture, salinity, effective soil depth, available nitrogen, potassium, organic matter, lime and soil moisture content. While studying the effect of soil properties on the species richness in the southwest of Africa and Namibia, Medinski *et al*. (2010) concluded that edaphic factors including pH, EC, and soil infiltration have positive effects on plant community distribution. Manolaki and Papastergiadou (2013) studied the impact of environmental factors on the distribution of aquatic macrophytes along a Mediterranean lotic ecosystem. The Redundancy Analysis (RDA) and Canonical Variate Analysis (CVA) were used to determine the relationship between environmental factors and plant community. The results showed a strong seasonal signal with dissolved oxygen, nitrogen nutrients (nitrite, nitrate, and ammonium), pH and water temperature all significant discriminating variables. Yibing (2008) using Canonical Correspondence Analysis (CCA) and Principal Component Analysis (PCA) in China showed that soil physical and chemical properties such as nutrients, moisture, salinity and pH affect habitat homogeneity control vegetation distribution pattern. Zhang and Dong (2010) in order to restore vegetation in the loess plateau of China, which is sensitive to the erosion evaluated the relationship between environmental factors and vegetation diversity. Plant communities characterized with diverse composition, structure, and environments were analyzed by cluster analysis of not weighed pair group method with arithmetic mean (UPGMA). The CCA data analysis showed that the key factor in vegetation restoration is time of grazing followed by elevation, soil type, slope, and aspect in loess areas and had a determining role in the vegetation distribution. Ehsani *et al*., (2015) studied the effect of some environmental factors on plant distribution in Valuyeh rangeland, Mazandaran, Iran and reported that the most effective factors on vegetation distribution in both north and south aspects of Valuyeh area are elevation, slope, and soil stability, respectively. In a rangeland ecosystem, the result of what happens within the ecosystem emerges as physical appearance or physiographic characteristics. Asadian *et al*., (2017) used Principal Component Analysis (PCA) for evaluating relationships between environmental factors and plant communities in enclosure rangelands of Hamedan, Iran and found that there are correlations between the ecological units and the physic soil factors including stone and gravel (0.25), clay (-0.26), sand (0.28), silt (0.38) and slope (-0.36). Kipngetich Rotich *et al*., (2018) reported that vegetation cover of herbaceous plants was significantly higher under rotationally grazed areas compared to both continually grazed and not grazed areas with average values of 55, 37 and 27%, respectively in semi-arid grazing lands of Makueni County, Kenya.

Anthropogenic factors also have special effects on this evolvement and this denotes the necessity of management factors affecting human intervention and present research deals with the effect of grazing intensity as the cause of effective management factors. Saral rangelands in Kurdistan province, Iran have great potential to provide forage, medicinal plants and recreational needs fraught with diverse vegetation. Given its potential and rangeland management requirements, there is a need to recognize the interactions of vegetation communities and environmental factors. In absence of such knowledge, the proper decision making in Saral rangeland ecosystem sustainability will not be possible given the foregoing, to investigate the distribution of vegetation communities in relation identification of the most important factors. The aim of this study was to determine the effect of environmental traits and grazing intensities on plant community distribution in Saral rangelands Kurdistan province, Iran

Materials and Methods

Study area

The study area is Rangelands of Saral in the west of Iran that restricted by 50° 46' to 50° 47' E and 45° 35' 45° 36' N located in 17 km northwest of Divandareh city, northern Kurdistan (Fig. 1). This study area is selected because of its importance on supply forage for livestock grazing and natural landscape of it. It has an elevation 2150 ma.s.l. The average annual precipitation is 480 mm with maximum and minimum monthly precipitation in July and January, respectively and the average annual temperature 10° C. The relative humidity in Saral is 49% maximum relative humidity (Statistic period 1990 to 2005, Divandareh Weather Station). According to Emberger and DeMartin methods, climate was classified as semi-humid and hyper-cold semi-humid.

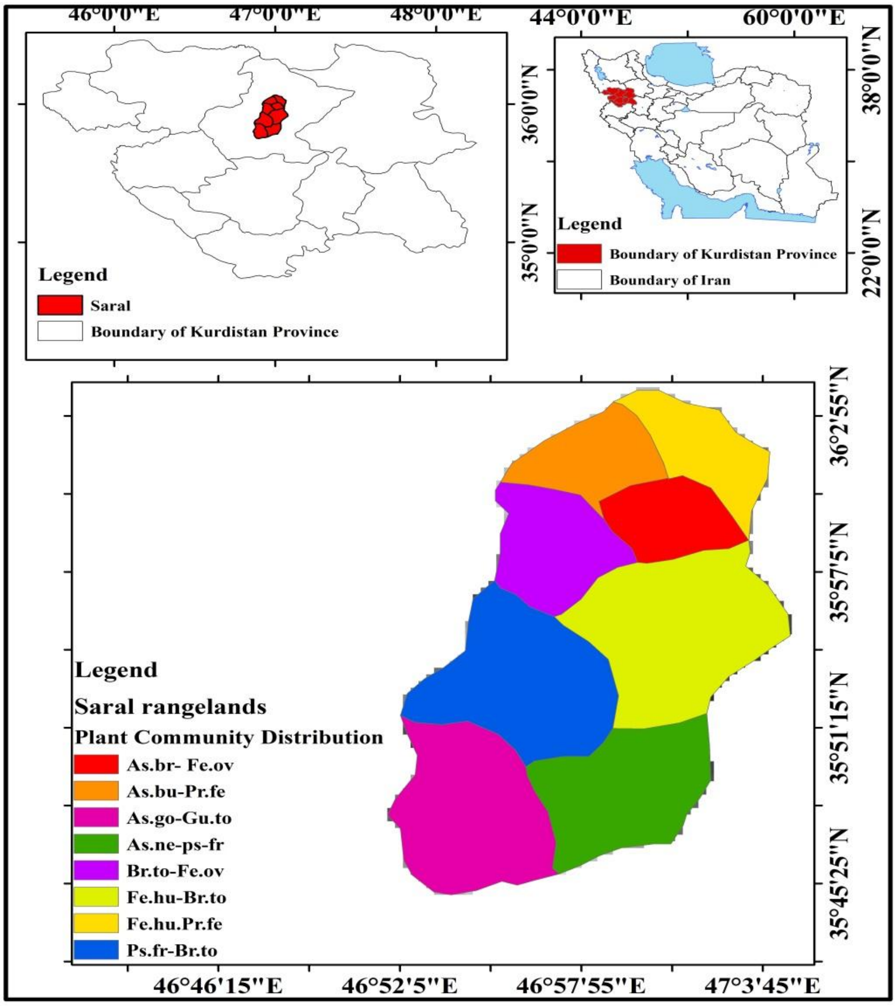

Fig. 1. The geographical position of the study area

Methodology

In this study, vegetation types were determined by field survey. Number and length of transects were assigned based on the composition and type of vegetation. At the next step, a randomized-systematic sampling method along transects was carried out for data collection. The first plot in each transect was sampled randomly and the rest were located systematically in 20 m intervals. Sampling was conducted within vegetation types to determine environmental and managerial factors within the plots.

Quadrat area was determined according to the type and distribution of plant community and the sample size was calculated by the minimum level of primary sampling and vegetation changes. In each vegetation type 60 plots (15 plots per transect) with 300 m transects were located along environmental gradients. Topographical variables were determined for different vegetation types. The average elevation with altimeter, slope percent with inclinometer and aspect within dominant vegetation in 8 geographic slope aspects for every plot were specified. Soil samples along transects were taken according to the plants rooting depth in the average depth 0-50 cm in 10 profiles within each vegetation type.

Considering that the management factor is a qualitative issue and there is not a quantitative index for it, different rangeland conditions were considered as the determinant factor of management.

In the laboratory, air-dried soil samples were passed through 2 mm sieve and sample weight and gravel percent were determined before soil weight measurement. We used particles< 2 mm to determine clay, silt and sand percent (Bouyoucos, 1962).

Soil texture was determined by soil texture triangle. Measurement of Electrical Conductivity (EC) and pH were made using electrical conductivity meter and pH meters, respectively. Soil depth was determined in the field. Soil lime was measured by calcimeter method in percentage and for measuring organic carbon, Walkley- Black (1934) method was used (Pansu and Gautheyrou, 2006). Potassium was measured by a flame photometer and Kjeldahl method was used to measure nitrogen (Bremner and Mulvaney, 1982). Grazing density was measured by rangeland condition for each vegetation type.

The matrix of plant vegetation types and environmental data were analyzed using principal component analysis (PCA) using PC-ORD software. The PCA determined plant community distribution and explain their correlation with environmental factors. This method reduces the matrix of correlations to a few important components having the most important factors affecting species composition,

Results

In the study area, 8 vegetation types in field survey based on physiognomic traits were identified: *Astragalus gossypinus- Gundelia tournefortii, Astragalus nervestipulius- Psathyrostachys fragilis, Astragalus bukanensis- Prangos ferulacea, Psathyrostachys fragilis- Bromus tomentellus, Astragalus brachystachys- Festuca rubra, Bromus tomentellus- Festuca rubra, Ferula haussknechtii- Prangus ferulacea, Ferula haussknechtii- Bromus tomentellus*.

Results of eigenvalues explained variance of PCA presented in Table 1. Given the PCA, eigenvalues are indicators of importance of variables in each copponents. The first and second components account for 39.29% and 26.28% of total variation for community distribution, respectively. In other words, the first and second components together accounted for 65.57% of the total variation.

According to Table (2), the first component included soil physical properties (clay, sand and soil depth) and (elevation) the second one included silt, potassium, gravel and grazing intensity.

Table 1. Eigenvalues, explained variance and cumulative variance for principal component analysis of Saral rangelands

Components	Eigenvalues	Explained Variance%	cumulative variance%	Broken-stick Eigenvalue
1	5.89	39.29	39.29	3.32
2	3.94	26.28	65.57	2.32
3	1.82	12.10	77.67	1.82
4	1.53	10.19	87.86	1.49
5	1.31	8.71	96.57	1.24

Table 2. The eigenvector of the variables in each component in the PCA

Environmental Factors	Axis 1	2	3	4	5
Sand	**0.36**	-0.23	0.07	0.05	0.11
Soil depth	**0.37**	-0.19	0.08	0.07	0.09
Clay	**-0.34**	-0.21	-0.17	0.01	-0.23
Elevation	**-0.39**	0.16	-0.08	0.00	0.03
Silt	0.13	**0.46**	0.09	-0.07	0.11
Grazing	0.12	**0.43**	-0.01	0.15	-0.11
K	-0.19	**-0.37**	0.14	0.32	0.17
Gravel	-0.14	**-0.45**	-0.03	0.13	0.08
Ec	-0.18	0.05	**0.58**	-0.06	0.25
Saturation%	-0.18	0.08	**-0.63**	0.09	-0.05
Lime	0.31	0.10	0.02	**0.39**	-0.33
Slope	0.19	-0.19	-0.19	**-0.58**	-0.13
Acidity	-0.31	0.20	0.03	-0.16	**0.40**
N	0.13	0.06	-0.32	0.45	**0.54**
Rainfall	0.26	-0.07	-0.24	-0.33	**0.47**

The bold and underlined values are the most important trait for each principle component axes

As it can be seen in Fig. 3 and ordination biplot in the first axis from left to right, soil depth and sand percent increase and elevation and clay percent decrease accordingly and for the second axis from bottom to up, potassium and gravel are reduced and at the same time, silt content and grazing intensity from the bottom-up increased and had a significant effect on vegetation type establishment.

There was a negative correlation between soil depth and elevation in the first component and positive correlation between grazing intensity and the silt in the second component. As mentioned earlier, the first component has the most important role in explaining the variance (39.29) followed by the second component variance about 26.28 among the factors explained. Eigenvalues from the third, fourth and fifth principal component axes accounted for 12.10, 10.19 and 8.71% of total variance percent, respectively (Table 1).

For analysis of this biplot, some points should be taken into account that the difference and spatial correlations between vegetation types on the graph suggest a relationship between these types, the more close, the more similar and vice versa. The graph is illustrated as vector and has positive and negative directions, so the distribution of community and vegetation types are explained with the vector direction and the vector size and the angle between the vectors and the types of plants, determining the degree of spatial correlation of vegetation types and is a component.

The vegetation types of *A. nervestipulius - P. fragilis* and *P. fragilis-B. tomentellus* are located in the first quadrant of coordinates influenced by the first axis i.e., in soils with more sand and depth soil, low clay content and low elevation.

The vegetation type of *A. bukanensis-P. ferulacea* are placed over the third quadrant and are affected by second axis representative characteristics, i.e. in low grazing intensity and low silt content and more gravel and potasium.

The vegetation type's *A. brachystachys-F. ovina, F. haussknechtii- B. tomentellus* and *B. tomentellus- F. ovina* and *F. haussknechtii- P. ferulacea* are placed over the forth quadrant and all types are affected by first axis representative characteristics, i.e. in shallow soils and low sandy and higher elevations coupled with higher clay content. *F. haussknechtii- P. ferulacea* is influenced by the second axis. This type of vegetation is growing in soils with high percentage of gravel and potassium and with lower grazing and silt content.

The vegetation type of *A. gossypinus-G. tournefortii* is located over the second quadrant influenced by the characteristics of the second axis, in soils with high silt and low potassium and gravel and intensive grazing.

As it can be seen in Table 2 and Fig. 2, the important factors determine the distribution of habitats and as different environmental gradients affect plant sites spatial distribution. In this study, the factors that influence the distribution of vegetation include soil texture, grazing intensity, soil depth, elevation, potassium and gravel.

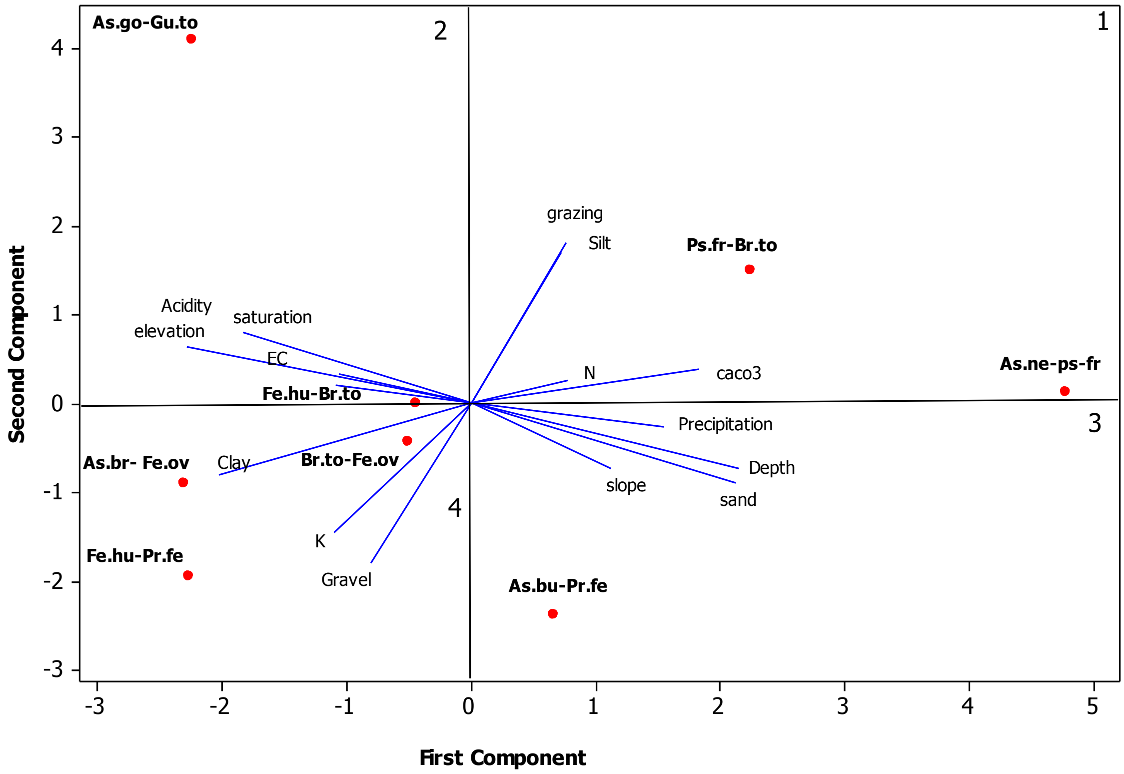

Fig. 2. Ordination biplot for the studied area using principal component analysis

As.go-Gu.to: *Astragalus gossypinus-Gundelia tournefortii*
As.bu-Pr.fe*: Astragalus bukanensis-Prangus ferulacea*
As.br- Fe.ov*: Astragalus brachystachys–Festuca ovina*
Br.to-Fe.ov*: Bromus tomentellus-Festuca ovina*
Fe.hu-Pr.fe*: Ferula haussknechtii-Prangus ferulacea*
Fe.hu-Br.to*: Ferula hausknekhtii-Bromus tomentellus*
As.ne-ps-fr: *Astragalus nervestipulius-Psathyrostachys fragilis*
Ps.fr-Br.to*: Psathyrostachys fragilis-Bromus tomentellus*

Discussion

As it can be seen among edaphic factors, soil physical variables affecting the distribution of vegetation communities in this study are of great importance than chemical ones and management and physiographic factors have the significant effect which is in line with results of research carried out by Munhoz *et al*. (2008). Zare *et al*. (2011) pointed out that one of the most effective factors on vegetation in multivariate analysis is soil textures that contradict with the current study. Yibing (2008) used cluster analysis and PCA in China, and considered soil chemical and physical characteristics like nutrients, moisture, salinity and pH as determinants of ecosystem's homogeneity and spatial distribution of plant communities. The results agree with findings of Jensen (1990) about slope influence on the distribution of shrubs and the strong correlation of soil and plant distribution. Soil texture is stable soil physical properties which affect other soil properties such as bulk density, moisture storage, structure, permeability, cation exchange capacity, saturation of soil moisture and organic matter (Jafari Haghighi, 2003). Fisher and Fuel (2004) stated that low altitudes are characterized with more species richness in Arizona that is attributed to higher temperature. Wang et al. (2012) studied the effects of environmental factors on the distribution of plant communities in Qinghai-Tibet Plateau and reported that the most important factor for distribution of plant communities was the soil depth. Asadian *et al.* (2017) showed that stone and gravel percent, Electrical Conductivity (EC), clay, organic carbon, canopy cover of grasses, total canopy cover, and pH are important factors in the distribution of plant community in Gonbad, Hamedan that these finding except gravel and clay content are inconsistent with our results.

The results show that the characteristics of habitat in *P. fragilis- B. tomentellus* and *A. gossypinus- G. tournefortii* are under heavy grazing and *F. haussknechtii - P. ferulacea* and *A. bukanensis- P. ferulacea* are characterized with light grazing and other types were subjected to an average degree of intensity. Grazing intensity affects the distribution of the plant community. With a higher grazing intensity, density and species composition of vegetation are affected and an increase in grazing intensity and plant species response against this condition, the composition can be observed in certain plants. Michelle *et al.* (2002) argued that the reduction of species diversity expresses itself adversely and stems from the human's operations. Zhang (2009) evaluating the influences of grazing intensity, soil variables and topographic features on the plant variety reported that the grazing intensity is able to alter vegetation composition and topographic characteristics could alter plant variety and the soil variables could alter permanently vegetation diversity and structure. Meligo (2006) pointed out the lightest grazing intensity as the main cause of reaching plant diversity to its peak. Grazing management is considered the most important of all grazing management decisions (Kipngetich Rotich *et al*., 2018). Findings of Zhao (2007) and Todd and Hoffman (2009) suggest that with increasing grazing intensity, one would be faced up against lower number of palatable species and vegetation cover while higher numbers and coverage of ephemerals support the notion provided that is consistent with these results.

Conclusion

Regarding the results of the research and this fact that grazing intensity factor affects the distribution of vegetation communities, it seems necessary to provide management solution and improvement of the rangeland according to the dominant plant species. It is necessary to manage grazing intensity in Saral rangelands and apply balanced grazing to reduce livestock trampling and improve the soil structure that is one of the effective factors on community distribution according to the results of this research. Soil physics are indirectly controlled by management principles such as grazing intensity and can be improved by proper distributing of livestock in the rangeland preventing the focus of livestock in specific areas. Importance of rangeland ecosystems in striking balance in earth requires that the awareness of the ecological characteristics helps proper management. As dominant species in the study area have low palatability associated with overgrazing, it is the indication of poor rangeland management. Even within those types with steep slopes, and effects of grazing, rangeland degradation is much more obvious, implying a lack of care on education and extension by the responsible institutions. Livestock grazing is found to be the only factors that can be undertaken by human control. The importance of grazing will be outstanding in the perspective of ecosystem management. Given the susceptibility of rangeland in mountain areas, especially in the early spring and late autumn, it is recommended that such rangelands should be subjected to optimum management in terms of introduction and removal of livestock and stocking rate.

The results showed that among various environmental and grazing factors affecting plant distribution, soil texture, soil depth, grazing intensity, elevation, potassium and gravel had the most significant effects on present plant community distribution in the studied rangeland. Silt, gravel and grazing intensity play important roles in the spatial distribution of vegetation communities, respectively.

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اثر خصوصیات محیطی و شدت چرا در پراکنش جوامع گیاهی(مطالعه موردی: مراتع سارال، ایران)

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چکیده. درک فرآیندهای اکولوژیکی لازمه مدیریت مراتع است، بنابراین، شناخت روابط عوامل محیطی و پوشش گیاهی برای مدیریت مراتع بسیار مهم و ضروری است. هدف از انجام این تحقیق، تعیین عوامل محیطی و مدیریتی تاثیرگذار بر توزیع جوامع گیاهی در مراتع سارال در استان کردستان (غرب ایران) در سال ۱۳۹۶ بوده است. نمونه‌برداری در ۸ تیپ گیاهی و در طول ۴ ترانسکت ۳۰۰ متری انجام شد و در طول هر ترانسکت، ۱۵ پلات ۱ مترمربعی به فاصله ۲۰ متر از هم قرار داده شد. در هر جامعه گیاهی، ۱۰ پروفیل خاک در توزیع یکسانی در داخل واحد نمونه‌برداری حفر شد که در عمق ۰-۵۰ سانتی‌متری با توجه به عمق ریشه دوانی گیاهان، نمونه خاک برداشت شد. عوامل محیطی متعدد همچون عوامل توپوگرافی (شیب، جهت و ارتفاع)، خصوصیات فیزیکی خاک (عمق، بافت خاک، سنگ و سنگریزه و رطوبت اشباع) و خصوصیات شیمیایی خاک مانند اسیدیته، هدایت الکتریکی، آهک، گچ، ازت، فسفر و پتاسیم اندازه‌گیری شد و شدت پراکنش نیز به عنوان عامل مدیریتی تاثیرگذار در نظر گرفته شد. پس از گردآوری داده‌ها، آنالیز مؤلفه‌های اصلی به منظور تعیین عوامل تاثیرگذار بر توزیع جوامع گیاهی استفاده شد. بر حسب نتایج آنالیز مولفه‌های اصلی، محور اول و دوم به ترتیب ۳۹/۲۹٪ و ۲۶/۲۸٪ تغییرات و توزیع جوامع گیاهی را تبیین کرده است. نتایج نشان داد که در میان عوامل محیطی متعدد و عامل مدیریتی، بافت خاک، عمق خاک، شدت چرا، ارتفاع از سطح دریا، پتاسیم و درصد سنگریزه بیشترین تأثیر را در توزیع جوامع گیاهی در این مراتع داشت. خصوصیات فیزیکی خاک و عامل مدیریتی به ترتیب شامل درصد سیلت و سنگریزه و شدت چرا نقش بسیار مهمی را در توزیع مکانی جوامع گیاهی در این مطالعه ایفا کردند.

کلمات کلیدی: عوامل توپوگرافیکی، خصوصیات فیزیکی خاک، خصوصیات شیمیایی خاک، تجزیه مولفه-های اصلی