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The relationship between elevation, soil properties and vegetation cover in the Shorb-Ol-Ain watershed of Yazd

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Abstract

Determination of the relationship between topography, vegetation and soils is essential factor in planning and management of arid areas. This study aimed to determine the relationship between the elevation, soil properties and vegetation cover in the Shorb-Ol-Ain watershed of Yazd. The purpose of this study was to identify the relationships between elevation, soil properties and vegetation cover in the watershed in order to protect soil and water and reclamation of watersheds. Eighteen land units were determined through overlaying maps of slope, aspect and elevation using the geographic information system as a basis for soil and vegetation sampling. In each land unit, samples were taken randomly in three reapplication using the vegetation plot and soil sampling to a depth of plants rooting and soil samples were tested to determine the percentage of gravel, sand, silt, clay, lime and Electrical Conductivity (EC), power of Hydrogen (pH), and organic matter content. The relationship between the elevation, vegetation and soil were analyzed using SPSS software and considering the obtained results, it was found that the elevation has an impact on the percentage of the vegetation cover. Among the studied soil factors, only there was a significant relationship between the elevation and percentage of gravel, EC and organic matter content. According to the results of this study, physiochemical properties of soil and percentage of the vegetation cover are partly under the influence of elevation So that at higher elevations because of more moisture and lower livestock grazing, the percentage of the vegetation cover was significantly higher than lower elevations. At higher elevations, the rock and gravel amount were also more than lower elevations. On the other hand, at lower elevations, soil organic matter and soil salinity is greater than the higher elevations due to the transmission of the material by runoff and their accumulation in the lower parts of the watershed.

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Introduction

In Yazd with arid and semi-arid climate, there is high restrictions for agricultural and biological measures. In this region there are some single mountains that make microclimate because of elevation changes. This microclimate can affect on soil and vegetation. Knowing this relation can help agriculture and natural resources manager for vegetation development, biological soil conservation and land planning.

Distribution pattern and abundance of species and plant communities in different areas, especially in arid areas often is related to three groups of environmental factors: the physical variables, soil chemical properties and human impacts (Enright *et al.,* 2005). There is a special relationship between environmental characteristics and vegetation in a region (Arshad *et al.,* 2008). Among environmental factors, parameters such as slope, aspect, elevation and other environmental factors have effects on soil physical and chemical parameters (Enright, *et al.,* 2005). Topography directly through changes and adjustments on environmental factors, and indirectly through its effect on soil formation has a major impact on plant communities. The knowledge of topography characteristics is necessary to manage these lands. Topography through effects on soil moisture and microclimate has a significant impact on the characteristics of the ecosystem and controls vegetation patterns (Clark, 1990).

There is a close relationship between some environmental factors, percentage of the vegetation cover and density of dominant species. Identification of these relationships plays an important role in preservation of vegetation, soil and water and in conservation, improvement and restoration of range lands (Shokrollahi *et al.,* 2012). Each land unit has a unique slope, aspect and elevation thus it has different conditions for the growth and development of plants (Moradi and Ahmadipour, 2006). Physical and chemical properties of the soil play a major role in creating change and diversity in rangelands, on the other hand rangelands play an important role in the development of the soil properties. The Separate investigation of the vegetation cover or physiographic features are not the systematic way to evaluate and classification of the habitat, but a simultaneous study of vegetative and environmental factors can have a more favorable result (Fisher and Fuel, 2004). In addition to the topography, the land use is also effective on soil characteristics. In general, changes in land use affect the soil quality and the physico-chemical properties of the soil, the physicochemical properties of soil play an important role in watershed erosion (Emami *et al.,* 2014). Spatial variability of soil characteristics is a function of environmental factors such as climate and landscape characteristics, including location, topography, slope, elevation, parent materials and native vegetation (Maleki *et al.,* 2013). The effects of topographic variables and soil physicochemical properties on the performance of effective parameters on the growth of Artemisia siberia in Nodooshan stepped rangelands was investigated using Redundancy Detrended Analysis method (RDA) showed that there is a significant relationship between the vegetative characteristics of *Artemisia sieberi,* soil variables and topography (Abdollahi and Naderi, 2013). Studies regarding the effects of various factors of climate, soil and topography on the vegetation cover of the central rangeland of Argentina have been carried out by Cantero *et al.* (2003), They showed that in addition to the above variables, the soil nutrient plays an important role in plant distribution. Xu *et al.,* 2008 using the field survey of vegetation, soil and topography variables in the valley of the Min Jiang River in China, concluded that elevation, vegetation cover, variety of good quality soils, the favorable topographical situation, radiation, runoff and soil erosion potential are directly related. Rossi *et al.,* 2014 carried out a study to explore the relationship between vegetation, soils and geomorphology in Italy. 168 kinds of relationships was discovered between different types of vegetation, soils and geomorphology and 1092 relationships were discovered between land cover variables and topography. Masoumi *et al.*, 2014 also showed topography affecting on landslides

occurrence by spatial multi criteria evaluation (SMCE) by GIS modeling in humid region. Determine the factors which control the presence and relative abundance of the plant species in arid and semi-arid areas is one of the main objectives of the research in such areas, because the quantitative analysis of the relationships can be useful in the management of the species in such regions (He *et al.,* 2007). The purpose of this study was to explore the relationship between elevation, soil and vegetation properties in an arid and semi-arid climate in single mountain microclimate in order to complete missing studies and predict the accurate and stable responses to maintain and protect soil and water resources.

Materials and methods

I. Study area

The Shorb-Ol-Ain watershed is located in the west, 20 kilometers away from Yazd city Fig. 1. The average elevation of the study area is 2223 meters and the yearly average precipitation is about 187.6 millimeter. It has an area of about 14.291 square kilometers and its perimeter is about 23.351 kilometers. The Shorb-Ol-Ain is a sub basin of the Khezrabad watershed. Khezrabad watershed includes 21 independent sub basins and one dependent subbasin that the Shorb-Ol-Ain is one of the independent subbasins. The Flow chart is shown in Fig. 2 & 3.

II. Methodology

In order to create the land units map, the maps of elevation, slope and aspect were prepared using the topographic and DEM maps. Then the mentioned maps were integrated and the final map, including 18 homogeneous land units were prepared. After that, using GPS the latitude, longitude, and elevation of the area was determined, the position in the region, the number and the range of land units were determined and finally vegetation and soil were sampled in each land unit. In order to soil sampling, 3 profiles were excavated in each land unit to the depth of the plant rooting zone.

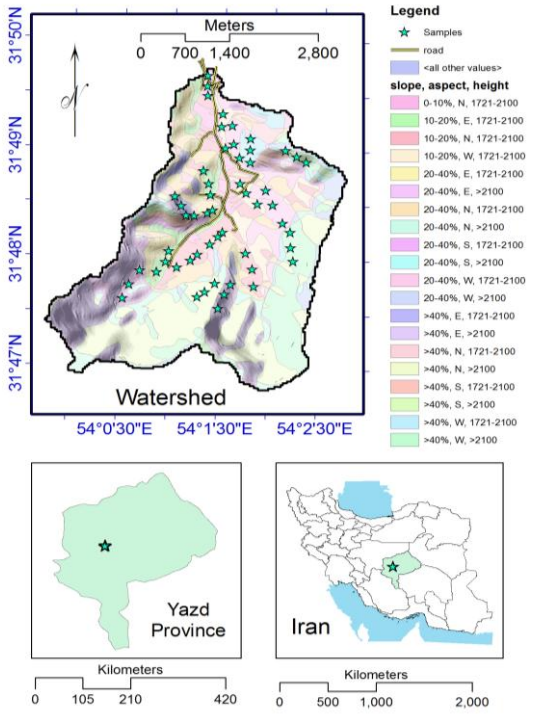

Fig. 1. Geographical location of the Shorb-Ol-Ain watershed in Yazd.

Fig. 2. Nature of study area, soil samples, vegetation and plot.

The standard amounts of soil were sampled from each profile in a way that reflect the different soil horizons, then samples were transported to the laboratory for analysis. About samples of the vegetation covers, the percentage of the vegetation cover, type of plants (shrub or bush) and the dominant species were determined in each land unit using the plot method. To determine the percentage of vegetation cover, three plots with an area of one square meter were located randomly in each land unit. Soil samples were transported to the laboratory and air dried. In the next step, the soil samples were crushed in a porcelain mortar and passed through a 2 mm sieve so the soil samples were prepared for testing.

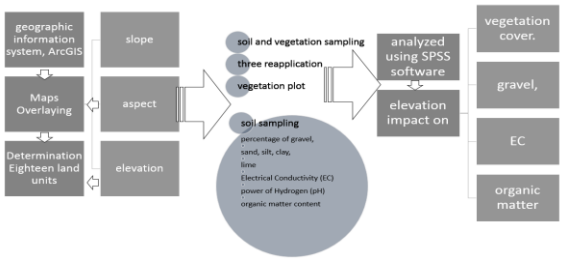

Fig. 3. Flow chart of the study.

Soil physical and chemical characteristics were measured, including percentage of gravel, soil texture by hydrometer method (Bouyoucos, 1962) as well as by a soil texture triangle (the percentage of sand, silt and clay), organic matter by the Walkley and Black method (Walkley and Black, 1934), soil acidity using a pH meter, lime with neutralization method using hydrochloric acid and titration method, and bulk density by the clod method (liquid paraffin). For statistical analysis, the SPSS software was used.

The Mann-Whitney U test was used to investigate the relationship between the various classes of elevation and the percentage of the vegetation cover, sand, silt, clay, gravel, Electrical Conductivity (EC), power Hidrojen (pH), Organic Matter (OM) and lime percentage and based on the results of the test, the impact was significant at the 95 percent level, but there was not a significant relationship between the various classes of elevation and sand, silt, clay, lime content and pH (Table 1).

Table 1. The results of Mann-Whitney U test for investigation of relationship between the various classes of elevation and the percentage of vegetation cover and soil properties.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Veg% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.006	Reject the null hypothesis.
2	The distribution of Stone% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.001	Reject the null hypothesis.
3	The distribution of Clay% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.216	Retain the null hypothesis.
4	The distribution of Silt% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.739	Retain the null hypothesis.
5	The distribution of Sand% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.924	Retain the null hypothesis.
6	The distribution of EC (ds/m) is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
7	The distribution of pH is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.137	Retain the null hypothesis.
8	The distribution of OM% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.015	Reject the null hypothesis.
9	The distribution of Lime% is the same across categories of H1_2.	Independent-Samples Mann-Whitney U Test	.574	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Results and discussion

The results showed that different elevation classes had a significant impact on the percentage of the vegetation cover and there is more vegetation cover in the higher elevations in comparison with the lower elevations Fig. 4. Sharafieh and Sagheb Talebi 2012 also showed that the plant species had developed with limitation in different elevations. Fakhimi Abarghoie

et al., 2011 in the study of Steppe grassland of Nodooshan, Yazd, confirmed the relationship between elevation and vegetation. Fisher and Fuel (2004) also have been introduced the elevation above the sea level as an effective factor in the plants diversity. Fattahi *et al.,* 2008 showed that elevation has a significant effect on the percentage of *Astragalus* and the most coverage of Astragalus was found in the elevation class of 2500-2300 meter. Zaremehrjardi *et al.,* 2008 in Dagh Fin of Bandar Abbas found that there is a difference between the percentage of vegetation cover and the different classes of elevation. They found that the percentage of the vegetation cover have been increased with increasing in the elevation. Heidari *et al.,* 2010 carried out a research in Dalab Protected area and founded that the elevation above the sea level had a significant impact on diversity of herbaceous species. Jazirehi and Ebrahim Rustaq 2003 emphasized on the important role of the elevation above the sea level as a limiting factor for distribution and diversity of plants in the Zagros forests.

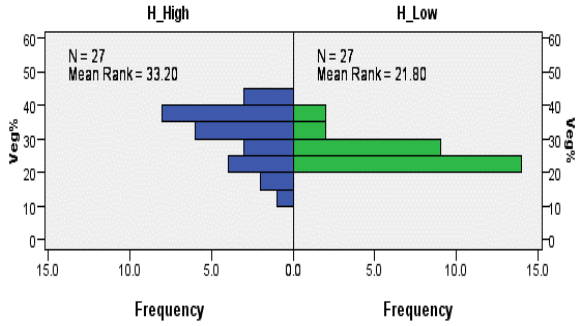

Fig. 4. Diagram of elevation and percentage of the vegetation cover in the watershed.

Khademolhosseini *et al.,* 2007 expressed that because of the effect of elevation on temperature and humidity, it is a controlling factor in the distribution of plant species. In the present study, it seems that because of the more grazing at lower elevation and difficult access to high elevations, the percentage of the vegetation cover at lower elevations is less than higher elevations.

The results showed that different classes of elevation have a significant impact on the percentage of stones and pebbles in the soil and at higher elevations, there are more stones and pebbles Fig. 5. It also showed that the different elevation classes has significant impact on soil EC and in lower elevations soil EC is greater than higher elevations Fig. 6, this is due to leaching of salts from higher elevations to lower elevations.

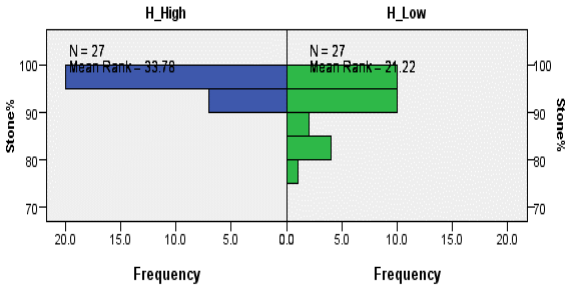

Fig. 5. Diagram of elevation classes and stone and gravel percent in the watershed.

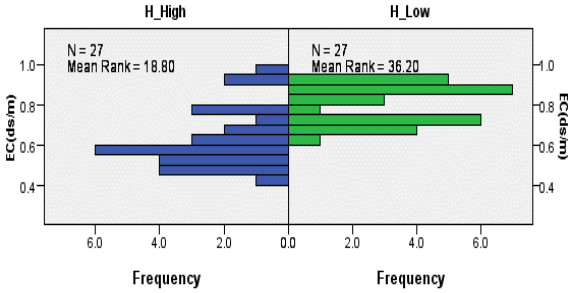

Fig. 6. Diagram of elevation and soil EC in the watershed.

The results showed that different elevation classes have a significant impact on soil organic matter content and it is greater in lower elevations Fig. 7. This observations shows the effect of topography properties on the soil evolution and then soil properties. Wu *et al.,* 2008 showed that soil organic matter and soil nutrients were significantly correlated with elevation. Jiang and Thelen, 2004 reported that there was a negative correlation between elevation and soil organic matter content. Soil organic matter decreases with increasing in elevation.

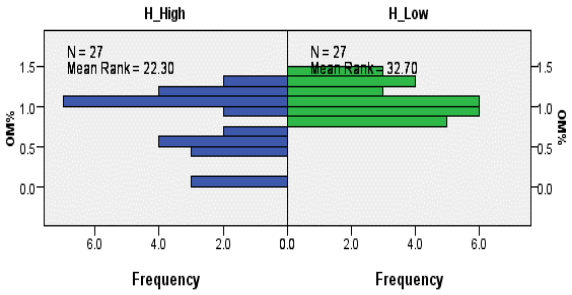

Fig. 7. Diagram of elevation and organic matter content in the watershed.

Babaloa *et al.,* 2007 by studying the relationship between soil properties and slope position in the jungles of North-West of Nigeria concluded that the soil in the valley is more fertile than the soils in the high elevations. Elevation is one of the affecting factor on changes in soil characteristics (Mokhtari Karchegani, 2012, Sharma *et al.,* 2009).

Due to differences in soil characteristics at different elevation classes, it can be said that the elevation above the sea level is one of the factors that affects the amount and type of precipitation, temperature, evaporation, solar radiation intensity. It has a significant effect on the soil formation and evolution, thus it can cause differences in the soil properties at different elevation classes.

Conclusions

The results of this research showed that in the higher elevations the percentage of vegetation, stone and gravel were significantly higher than lower elevations. This was due to the drought of the area and grazing. In the higher elevations, the humidity was greater and because of the difficult access, animals grazing was lower. Also, organic matter and salts is washed away by runoff from higher elevations and accumulated in the lower parts of the basin, so soil organic matter content and soil salinization at lower elevations was more than higher elevations.

To achieve the best results, it is recommended that entry and grazing of livestock has to be restricted to restore the vegetation cover and reduce further damage to the vegetation cover and soil. It is also recommended that comprehensive studies have been carried out in the field of biodiversity and herbaceous species, so a continuous monitoring of the status of plant species diversity as one of the main indicators of sustainable development is possible. The relationship between soil properties and the presence and absence of plants and the relationship between the vegetation cover and soil physicochemical properties must be examined. It is also recommended that another study carried out in the protected rangeland to reduce the role of factors such as grazing and human effects, thus the obtained results are more carefully.

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