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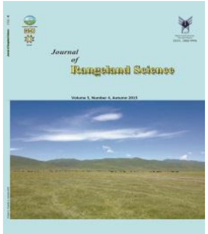

Research and Full Length Article:

Evaluation of Soil Quality Based on Minimum Data Set in Karvan Rangeland, Isfahan, Iran

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Abstract. Plant life and food production for human closely depend on fertile and healthy soil. Knowledge about qualitative properties of soil and its potential production can contribute us in the plantation, fertilization, utilization and land management. In addition, Rangelands cover a very large portion of the earth's surface and play an important role in food security and other ecosystem services. Therefore, the present study has been conducted in order to evaluate soil quality according to minimum data set in Karvan rangeland which is located in the west of Isfahan province, Iran. For this aim, three vegetation types including *Scariola orientalis-Astragalus gossypinus* (*Sc.or-As.go*), *Psathyrostachys fragile-Astragalus gossypinus* (*Psa.fr-As.go*) and *Cousinia bachtiarica-Astragalus gossypinus* (*Cu.ba-As.go*) were selected in the study area. Then, four transects were established by a random systematic sampling; bias was placed to the general and lateral slope at the each vegetation type. The soil samples were taken at the start and end of each transect from two different depths (0-20 and 20-75 cm). Soil samples were analyzed and the physicochemical factors such as texture (silt, clay and sand), pH, Nitrogen (N), Phosphorus (P), potassium (K), Organic Carbon (OC) and Organic Matter (OM) were measured. Then, Soil Quality (SQ) indices were calculated using Bajracharya formula. The results showed that soil of the study area had a poor quality and also, there was different soil qualities regarding three vegetation types. It was found that OC (or OM) and N had maximum limitations on soil of Karvan region and caused low SQ indices. Also, pH only without any limitations was put in the highest rank for SQ measuring.

Key words: Soil quality, Minimum data set, Vegetation and fertility, Karvan region

Introduction

Soil is one of the most important natural elements that ensure plant growth and provide more than 97% of the world's food requirements (Agheli Kohan and Sadeghi, 2004). Also, it plays an important role as a seed bed and provides all the requirements for plants (Raymod *et al.*, 1998). For example, the crop harvest was followed by the erosion and depletion in soil elements. This has led to the reduction of some important elements such as nitrogen (70%), potassium (90%) and phosphorous (100%) (Dreshcel *et al.*, 2001). Therefore, Soil management could change the dynamics of soil matter and seasonal and spatial distributions by changing the quality and quantity of plant residues, and the nutrient element in the soil (Kandeler *et al.*, 1999). Physical and chemical properties of soil and fertility are used to investigate the sustainable land potential (Lynn *et al.*, 2009). There is a difference concerning soil properties and elements (except P) between rangeland and cultivated lands (Zehtabian *et al.*, 2004) and some of the soil characteristics will be destroyed due to the land use changes for agricultural purposes (Ahmadi Ilakhchi *et al.*, 2002). For example, soil organic carbon reservoir has been influenced severity by changing the land use and land management (Lorenz *et al.*, 2008) or storage capacity of soil has been effectively related to some factors such as clay, silt and sand contents and porosity index (Rezaei, 2003) so that all soil properties affect soil productivity. However, rangelands have an important role in economy of society and culture (Rezaei *et al.*, 2006a). Thus, high quality range plant production needs appropriate soil and enough elements which are available for plants and there should be a balance among the elements in soil (Tandon, 1989). There are other methods to evaluate the ecosystem and soil such as landscape functional analysis (LFA) which needs some simple factors including soil cover, litter cover, cryptogam cover, shell brittle, erosion properties, sediment, micro-topography, quenched test and soil texture (Tongway and Hindley, 2004).

In all methods, adequate information may be necessary for quality assessments (Andrews *et al.*, 2002). Soil quality indexing is a new approach in spatial and temporal evaluation of land management system effects on soil capacity to function (Erkossa *et al.*, 2007). Soil Quality Indices (SQI) are regarded as a complex set of physicochemical soil factors; they are easily calculated and have the following features: being sensitive to land management changes, being simply measured, having continuity along the site and at all time, closely investigating and measuring, very cheap and adaptable for all ecosystems (Schoenholtza *et al.*, 2000). Soil quality (SQ) affects the rangeland **(**USDA, 2001) through plant production, reproduction, mortality, erosion, water production and water quality, wildlife habitat, carbon sequestration, vegetation changes, establishment and growth of invasive plants and rangeland health. Soil quality can be also defined for such issues as productivity, environmental quality or human health. SQ is a concept that is hidden amidst the statements of all soil scientists (SBSMNFR, 2008) and includes the assessment of soil properties and ability while surveying the relationship between their processes as a part of healthy ecosystem (Schoenholtza *et al.*, 2000). Nowadays, most researchers only use physical or chemical properties to evaluate the SQ; however, considering that most of soil potentials are related to chemical, physical and biological factors, a complex of all factors should be used to calculate the SQI (Barrios *et al.*, 2006). Rangeland re-vegetation success not only depends on climate, topography and management, but is strongly influenced by soil (Heady and Child, 1994). There are many different parameters and formulas to evaluate the SQ and soil potential (Andrews and Carroll, 2001) and due to budget allocation and lack of time, this is essential to use minimum data for conducting the investigations and evaluations in the research work. In recent study, Rezaei *et al.* (2006b) had used the minimum data set in order to evaluate SQ and soil potential. Although to evaluate the soil quality, N, P and K are mainly measured (Peterson *et al.*, 2002), all soil parameters are implicated on SQ and fertility. So, this research was conducted to evaluate the soil quality based on a formula presented by Bajracharya *et al.* (2006) using minimum data set in Karvan rangelands (west of Isfahan province, Iran).

Materials and Methods

Study area

Karvan region is located at 70 km of western Isfahan province, Iran (Fig. 1). The elevation of the area is 2080 m above sea level, mean annual rainfall is 250 mm and mean annual temperature is 14°C. Also, this area is located between the arid and semi-arid regions as ecotone zone and has both arid and semi-arid vegetation elements.

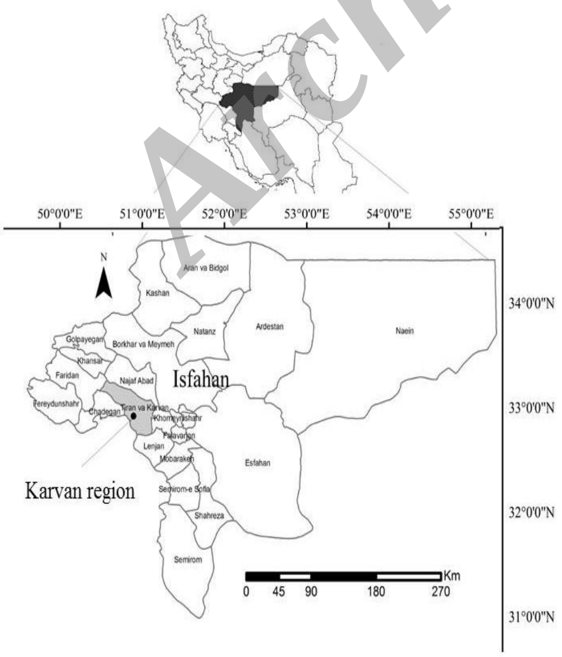

Fig. 1. Geographical location of Karvan rangeland (Western Isfahan, Iran)

Data Collection

First, in order to investigate the physicochemical properties of soil and samples after a preliminary field visit, three vegetation types were determined with Physiognomic - Floristic System. Three major vegetation types were detected including *Scariola orientalis-Astragalus gossypinus, Psathyrostachys fragile-Astragalus gossypinus* and *Cousinia bachtiarica-Astragalus gossypinus*. To achieve the desired aim, four transects (length of 200 m) were placed in each vegetation type with 100 m distance from each other and oblique to general and lateral slope of the studied region. Then, soil samples were taken at the beginning and end of each transect from two different depths (0-20 and 20-75 cm according to soil depth and bed rock). Finally, 24 profiles (8 profiles in each vegetation type) and 48 soil samples were taken. Then, physical and chemical properties of soil such as pH, Organic Carbon (OC), Organic Matter (OM), Nitrogen (N), Phosphorus (P), potassium (K), Sand, Silt and Clay were measured in soil laboratory of Natural Recourses Department of Tehran University.

Then, Soil quality values as proposed by Bajracharya *et al.* (2006) have been calculated using the following equation (Equation 1).

$$SQI = [(a \times RSTC) + (b \times RpH) + (c \times ROC) + (d \times RNPK)]$$

(Equation 1)

Where

R_{STC} = assigned ranking values for soil textural class,

R_{pH} = assigned ranking values for soil pH, R_{OC}=assigned ranking values for soil organic carbon,

R_N=assigned ranking values for nitrogen,

R_P=assigned ranking values phosphorus, R_K=assigned ranking values for potassium, and a=0.2, b=0.1, c=0.4 and d=0.3 are the weighted values corresponding to each parameter.

Also, based on NRC bulletin (1993), standard values classification was used to evaluate each soil factor (Table 1).

Table 1. Soil parameters and ranking values for evaluating them (NRC, 1993)

Parameters	Ranking Values				
	0.2	0.4	0.6	0.8	1
Soil pH	<4	4.1-4.9	5-5.9	6-6.4	6.5-7.5
Soil organic carbon (%)	<0.5	0.6-1	1.1-2	2.1-4	>4
Fertility (NPK)	Low	Mod Low	Moderate	Mod. High	High
Soil textural class	C, S	CL, SC, SiC	Si, LS	L, SiL, SL	SiCL, SC
SQI	V. poor	Poor	Fair	Good	Best

Abbreviation= SQI: Soil Quality Index, C:Clay, S:Sand, CL: Clay loam, SC: Sandy Clay, SiC: Silty Clay, Si: Silt, LS: Loamy sand, SiL: Silty loam, SL: Sandy loam, LS: Loamy Sand, SL: Sandy loam, SiCL: Silty clay loam and SCL: Sandy Clay loam

SQI was measured for the first and second depths of soil separately. Then, SQI for total soil profile (75 cm) was measured according to top and subsoil QIs as follows (Equation 2):

$$SQI = [(20 \times SQI) + (55 \times SQI)]/75 \quad \text{(Equation 2)}$$

Also, in order to determinate the difference between soil physicochemical properties and SQI in two different depths and among three vegetation types, the Kolmogorov-Smirnov test (KS-test) was used to identify the data normality and then, the One-way ANOVA test and the post hoc test were performed using the Duncan method for grouping treats by the means of SPSS software (17.0 version).

Results

The initial comparison of soil physicochemical properties of three vegetation types showed that there were significant differences ($p \leq 0.01$) between some factors such as OC, P, K and Clay percent that could affect SQ. Regarding gravel, sand and silt percent, there were no significant differences among three vegetation types at two depths of soil profile. But for OM, the highest value was obtained in *Scariola orientalis-Astragalus gossypinus* type ($p \leq 0.01$). ANOVA table shows that SQI was not significantly different ($p \leq 0.01$) at different depths of soil in the study area except first depth at 5% confidence (Table 2). Table 3, shows means comparisons between factors based on Duncan test. Also Table 4 show soil factors, ranking values and soil quality index

Table 2. Analysis of variance for SQI at different soil depths among vegetation types

Depth	S.O.V	df	SS	MS	Sig.	F
(0-20)	Between Groups	2	0.163	0.082	0.001^{*}	7.05^{*}
	Within Groups	21	0.090	0.004	-	-
	Total	23	0.253	-	-	-
(20-75)	Between Groups	2	0.049	0.25	0.021^{ns}	4.6^{ns}
	Within Groups	21	0.092	0.004	-	-
	Total	23	0.142	-	-	-

S.O.V: Sources of variation, df: Degrees of freedom, SS: Sum of Squares, MS: Mean-Squares, *: Significant at 1% confidence

Table 3. Mean values of important soil physicochemical properties and their difference at first and second depths of soil

Vegetation types	Depth	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	OC (%)	OM (%)	pH	N (Meq/L)	P (Meq/L)	K (Meq/L)	SQI
Scariola orientalis-Astragalus gossypinus	d_1 (0-20)	32.70^{ns}	22.75^{ns}	32.90^{ns}	34.40^{ns}	0.56^{a}	0.93^{ns}	7.87^{ns}	4.40^{ns}	16.80^{ab}	76.40^{a}	0.54^{a}
Psathyrostachys fragile-Astragalus gossypinus		33.00^{ns}	27.20^{ns}	42.40^{ns}	30.40^{ns}	0.45^{b}	0.72^{ns}	7.90^{ns}	4.20^{ns}	15.50^{b}	61.50^{b}	0.42^{b}
Cousinia bachtiarica-Astragalus gossypinus		34.60^{ns}	34.60^{ns}	32.10^{ns}	34.40^{ns}	0.55^{a}	0.94^{ns}	7.89^{ns}	4.60^{ns}	19.50^{a}	80.20^{a}	0.43^{b}
Scariola orientalis-Astragalus gossypinus	d_2 (20-75)	38.50^{ns}	38.50^{ns}	33.10^{ns}	38.60^{b}	0.54^{a}	0.90^{a}	7.88^{b}	4.60^{ns}	13.80^{ns}	60.50^{b}	0.40^{ns}
Psathyrostachys fragile-Astragalus gossypinus		47.50^{ns}	30.90^{ns}	36.90^{ns}	32.10^{a}	0.42^{b}	0.68^{b}	7.89^{b}	4.10^{ns}	16.30^{ns}	57.50^{b}	0.32^{ns}
Cousinia bachtiarica-Astragalus gossypinus		42.20^{ns}	42.20^{ns}	31.60^{ns}	31.10^{ab}	0.25^{b}	0.43^{c}	7.97^{a}	4.00^{ns}	17.00^{ns}	71.60^{a}	0.41^{ns}

Similar letters had no significant difference at first and second soil layers among three vegetation types ($p \leq 0.01$)

Table 4. Soil factors, ranking values and Soil Quality Index (SQI)

Vegetation Types	Parameters	Ranking Values				
		0.2	0.4	0.6	0.8	1
Scariola orientalis-Astragalus gossypinus	Soil pH	-	-	-	-	7.87
	Soil organic carbon(%)	-	0.55	-	-	-
	Fertility (NPK)	-	Mod Low	-	-	-
	Soil textural class	-	Clay loam	-	-	-
	SQI	-	-	<u>**Fair**</u>	-	-
Psathyrostachys fragile-Astragalus gossypinus	Soil pH	-	-	-	-	7.90
	Soil organic carbon(%)	0.41	-	-	-	-
	Fertility (NPK)	low	-	-	-	-
	Soil textural class	-	-	-	-	Silty clay loam
	SQI	-	<u>**Poor**</u>	-	-	-
Cousinia bachtiarica-Astragalus gossypinus	Soil pH	-	-	-	-	7.93
	Soil organic carbon (%)	0.40	-	-	-	-
	Fertility (NPK)	low	-	-	-	-
	Soil textural class	-	Clay loam	-	-	-
	SQI	-	<u>**Poor**</u>	-	-	-

Investigation of soil physicochemical properties in this region indicated that there is no restriction about some factors. For example, pH value belongs to high value ranking in all three vegetation types in the study area.

In general, soil properties in *Psa. fr- As. go* and *Co. ba-As. go* types had similarities that were much closer together in some cases such as fertility. Soil of *Sc. or-As. go* type was more nutritious than two other vegetation types. Soil texture in three vegetation types was mostly put in heavy texture ranking. For SQI, only *Scariola orientalis-Astragalus gossypinus* had fair ranking among three vegetation types and had shown a better condition (Table 3).

Discussion

Research and adequate information about SQ could contribute us in managing the land uses. Soil testing is the most accurate method for determining whether sufficient nutrient is present. SQ is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, sustain plant and animal productivity, maintain or enhance the quality of water and air and support human health and habitation (USDA, 2001). Numerous factors could affect SQ. Some proceedings such as range management can change the SQ although Steffens *et al.* (2011) reported that some factors including livestock grazing had no effects on the amount of OC (OM and SQ) in their study site. However, SQ parameters will be changed even without human interventions (SBSMNFR, 2008). Climate factor could affect SQ (Vallejo *et al.,* 2005) and will be most likely the most important factor. Also, some lateral factors could have less effect on SQ. Rezaee *et al.* (2006) found that geographic aspect had no effects on soil properties in the study area. The result of this study showed that there were moderate-low and low ranking values of soil fertility and then poor and fair SQ (Tables 4&3). This can be different not only around the world but also in different vegetation types (similar to this research). Present study indicates that SQI related to soil properties was not in good conditions among all vegetation types in which SQI was between 0.32 to 0.54 (Table 3). Awasthi (2004) reported that SQI had the highest and lowest values (0.69 and 0.17) in the undisturbed forest lands and Khet land in Mardi watershed of Middle Mountain, respectively. SQ specifies that there is a kind of fertilizer and tillage required in soil. But, it is noteworthy that the nutrient elements in plant and soil structure vary at different times of the year (Demirosoy *et al.,* 2010). Therefore, SQI should be measured and used over time based on our ability and perception (Dumanski and Pieri, 2000).

Jagadamma and Lal (2010) reported that there is OM available in heavy soil texture more than light texture; these factors can influence soil quality that is different with the present study. First vegetation type (*Scariola orientalis-Astragalus gossypinus*) had a lower clay percent but the highest OM percent. Also, He *et al.* (2009) indicated that the amount of OC was higher in clay texture in different soil depths. In present research, soil had a heavy texture in three vegetation types and soil components were relatively in equal Ratio. Other researchers reported that physical soil factors had more effects than chemical properties on soil potential, dry matter production and overall forage yield for animals (Rezaei *et al.,* 2006b). Zornoza *et al.* (2007) concluded that Organic Carbon (OC) had the most effects on SQ in the study area in Alicante province, Spain. However, in present study, physicochemical soil factors have been combined while influencing SQI. Also, because of the region location which was located in boundary of steppe and semi-steppe zone, some soil properties such as OC, OM and N percent were very low

(Table 3). SQI is increasingly proposed as an integrative indicator of environmental quality (NRC, 1993); therefore, soil status in this region is not in a good condition. But soil pH was good among three vegetation types in the study area**.** In general, the main reason for low SQ in the study area returns to climate. Due to location in the arid and semi-arid land, Karvan rangeland has low annual precipitation. As a result, rainfall and humidity affect plant vegetation and vegetation in turn influences soil physicochemical properties. SQI among three vegetation types had no significant difference at 1% confidence but *Sc.or-As.go* type had the highest SQI (0.52) as compared to the other vegetation types ($p \leq 0.05$). Similar to our result, Bajracharya *et al.* (2006) reported that SQI land uses were not distinctly different in a mid-hill watershed of Nepal.

Conclusion

The results of present study showed that soil quality was placed in the poor class based on minimum data set method using Bajracharya formula and NRC ranking. Chemical properties of soil such as OC and N content were the main reasons for low quality in this region although pH was in the best ranking. Soil texture approximately imposed no limitations on soil quality. Also, SQI in *Sc. or-As. go* type was better than two other vegetation types in the study area.

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ارزیابی کیفیت خاک در مراتع کرون (اصفهان، ایران) بر اساس مجموعه حداقل داده‌ها

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چکیده. حیات نباتات و تولید غذا برای بشر ارتباط تنگاتنگ با سلامت و حاصلخیزی خاک دارد. دانش در خصوص خصوصیات کیفی خاک و پتانسیل آن می‌تواند برای کشت گیاهان، کوددهی، بهره‌برداری و مدیریت زمین مؤثر باشد. از سویی مراتع، سطح وسیعی از زمین را پوشانده‌اند و نقش بسزایی در امنیت غذایی و سایر خدمات اکوسیستم دارند. بدین ترتیب این مطالعه به منظور بررسی کیفیت فیزیکوشیمیایی خاک بر اساس حداقل داده در مراتع کرون در غرب استان اصفهان انجام شد. ابتدا سه تیپ گیاهی شامل ***Scariola orientalis-Astragalus gossypinus (Sc. or-As. go)* ، *Psathyrostachys fragile-Astragalus gossypinus (Psa. fr-As. go)*** و ***Cousinia bachtiarica-Astragalus gossypinus (Cu. ba-As.go)*** در منطقه انتخاب شدند. سپس چهار ترانسکت ۲۰۰ متری با فاصله ۱۰۰ متر از همدیگر و اریب با شیب عمومی و جانبی منطقه در هر تیپ گیاهی قرار داده شد. از ابتدا و انتهای هر ترانسکت و از دو عمق مختلف (۲۰-۰ و ۷۵-۲۰ سانتی‌متر) نمونه‌برداری انجام شد. نمونه‌های خاک مورد آزمایش قرار گرفت و خصوصیات بافت (شن، سیلت و رس)، اسیدیته، نیتروژن، فسفر، پتاسیم، کربن آلی و ماده آلی اندازه‌گیری شد. شاخص کیفیت خاک با استفاده از فرمول Bajracharya محاسبه شد. نتایج نشان داد که شاخص کیفیت خاک در این منطقه در وضعیت فقیر قرار دارد. همچنین این شاخص بین سه تیپ گیاهی منطقه متفاوت بود. خصوصیات مقادیر ماده آلی و ازت بیشترین محدود و تأثیر بر کاهش شاخص کیفیت خاک در منطقه نشان داده شد. همچنین تنها اسیدیته خاک بدون هیچگونه محدودیتی برای محاسبه شاخص کیفیت خاک در بالاترین سطح رده‌بندی قرار گرفت.

کلمات کلیدی: کیفیت خاک، مجموعه حداقل داده، پوشش و حاصلخیزی، ناحیه کرون