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Investigation effects of rangeland exclosure on some soil properties in *Artemisia sieberi, Stipa hohenacheriana* and *Salsola rigida* habitats (case study: Roodshoor, Saveh, Iran)

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Abstract

The overgrazing and excessive utilization of rangelands has caused vegetation and soil degradation in many rangelands. The various methods are applicable for rangelands restoration. Among these methods, rangeland exclosure is an effective, easy and low-cost method. In this research the effects of 20 years of rangeland exclosure were studied on some soil properties of Roodshoor region, Saveh, Iran. Sampling in each area was conducted using a systematic randomized method. Two 100-m long transects were randomly located in within exclosure and outside the enclosure. Soil sampling was conducted in first, middle and end of each transect. In both grazing exclusion and control sites two, soil samples were taken from depths of 0–30 cm and 30–60 cm. The samples were passed through a two millimeter sieve before analyzing for organic matter, nitrogen (N) content using Kjeldal, the amount of available phosphorus (P) by P-Olsen, potassium (K), EC and pH, and soil texture (sand, clay and silt percent), using the hydrometer method. Lime amount was estimated using calcimetry. For comparison of the soil properties in the grazing exclosure treatment and control was used from Duncan's test with SPSSver.17 software. In general, the results of research were showed significant positive effects on soil properties after 20 years of grazing exclusion in Roodshoor rangelands. N%, P%, K%, O.M% and Ec (ds/m) in grazed exclusion sites at every three habitats Artemisia sieberi, Salsola rigida and Stipa hohenacheriana have increased compared with the grazed area. Soil pH in grazed exclosure sites was decreased. Moreover, grazed exclosure had little effect on soil lime and texture.

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Introduction

Rangelands, as the context for profound economical and social changes in Iranian Nomadic People's lives have undergone some stress during the past three decades due to excessive grazing (Zarekia, 2012). The degraded rangelands are characterized by a lack of vegetation cover, increased soil erosion, invasion of alien plant species and bush encroachment, primarily by Prosopis juliflora (Mwangi & Swallow, 2008).

The overgrazing and excessive utilization of rangelands has caused vegetation and soil degradation in many rangelands. Soil, one of the most important elements of rangeland ecosystems, is the source of food and moisture content for rangeland plants. Excessive grazing is one of the most significant factors causing rangeland degradation and typically, this degradation is effective on vegetation and soil. The various methods are applicable for rangelands restoration. Among these methods, rangeland exclosure is an effective, easy and low-cost method. Exclosure demonstrate the direct economic benefit of controlled use of these fenced-off rangelands for rotational or seasonal grazing, as well as for other income generating activities such as forage cutting, seed harvesting and bee keeping. Short and midterm exclosure aimed at rangeland restoration and palatable vegetation replacement play a significant role in management operations.

Rangeland exclosure by pastoralists is mainly driven by ecological, institutional and socio-economical incentives. A growing body of literature indicates that enclosing and thus privatizing formerly communal rangelands, may result in social conflicts and foster rangeland degradation rather than contribute to rehabilitation and productivity increases (Beyene, 2010). Grazing exclusion is particularly likely to increase C uptake where overgrazing has decreased biomass productivity, thereby decreasing the quantity and quality of the biomass that is returned to the soil (Pei *et al.*, 2008). Establishment of exclosures, denoting areas closed off from grazing for a specific period of time, is a well-known management tool to restore degraded rangeland ecosystems. Regeneration of the vegetation has positive effects on biodiversity (Abebe *et al.*, 2006) and soil fertility (Mekuria *et al.*, 2007); it reduces soil erosion (Descheemaecker *et al.*, 2006) and increases water availability (Hongo *et al.*, 1995). As a means to modify rangelands, exclosure is effective on improvement of rangelands and includes prevention of livestock entering the rangeland, which may be only true about domestic animals and is recommended with various periods depending on region’s ecologic situations and the severity of rangeland destruction or administrative goals. In addition to plant reinforcement, accomplishing exclosure operations results in obvious changes in soil and vegetation (Moghadam, 1998).

Increasing population pressure, land use changes, overgrazing, and droughts induced severe land degradation Rangeland rehabilitation in the Baringo Basin is fostered through the establishment of communally and privately managed enclosures. In the Njemps Flats range unit, six communal and six private 3- to 23-year old enclosures and unfenced control plots in the open rangeland were subjected to a chronosequence analysis (Hickley *et al.*, 2004). Reduced grazing pressure can increase species richness and the abundance of phytophagous insects and their parasitoids (Parfitta *et al.*, 2010 and Bugalho *et al.*, 2011), whereas intense grazing can reduce arthropod species diversity and abundance (Mills & Adl., 2011).

Vajat *et al,* (2012) were investigated effects of enclosure on vegetation dynamic of rangelands of guilan province, Iran. They were showed that the total annual production of plants species in the enclosure increased 2.5 times more than those of outside the enclosure and the production percentage of class I (palatable species) and III (non-palatable species) species markedly differed inside and outside the enclosure but this difference did not exist in class II (semi-palatable species). As to the species cover, abundance of class I and class II species was greater inside the enclosure and that of class III was greater outside the enclosure. Liu *et al,* (2012) studied influence of grazing exclusion on soil macro-invertebrate diversity in degraded sandy grassland of China. They expressed some faunal groups lived in specific habitats due to strong adaptation to different management practices. For example, the Thomisidae, Philodromidae, Salticidae, and Rhopalidae tended to live in habitats with tall vegetation. The Lygaeidae, Miridae, Teneberionidae, and Linyphiidae adapted to live in soil with low Soil organic arbon and nitrogen (ungrazed grassland). Chen *et al,* (2012) were studied effects of grazing exclusion on soil properties and on ecosystem carbon and nitrogen storage in a sandy rangeland of Inner Mongolia, Northern China. They were noted grazing exclusion for 12 years in an area of desertified sandy rangeland led to significantly greater biomass and soil C and N than in an adjacent CG part of the site in a semiarid ecosystem in northern China, indicating that the protected part of the site was recovering from the grazing disturbance. Hosseini *et al,* (2012) were studied the vegetation changes of natural rangelands in Inche Shorezar of Agh Ghala, North Golestan Province, Iran. They were stated total and annual cover was high inside and adjacent of exclosures. Su *et al*, (2005) were studied influences of continuous grazing and livestock exclusion on soil properties in degraded sandy grassland, Inner Mongolia, northern China. They were noted to control desertification and decrease its influence on the remaining ecosystem and downwind areas, Chinese managers have implemented several successful measures in parts of the Horqin sandy rangeland since the mid-1970s: fencing of sandy rangeland to exclude grazing; planting of indigenous trees, shrubs, and grasses to stabilize and restore the soil; and installing sand stabilizing structures, such as straw checkerboards.

The purpose of this study was to investigation the changes of soil properties in Roodshoor grazing exclosure and grazed control site during 20-years period in Saveh, Markazi province.

Material and methods

Study area

The Roodshoor rangelands (50° 53' -51° 03' N latitude; 35° 25'- 36° 43' E longitude) are one of the steppe regions of Iran. These rangelands located Markazi province, Iran. Based on Demartonn method the region climate is cold-dry desert with mean long-term rainfall of 201.9 mm. This region has an average altitude of 1125 m. The regional soil type is brown eroded and its ingredients are old alluvial deposits. The soil depth is more than one meter.

Methods

The Roodshoor grazing exclosure was established in 1986 for 20 years. In order to evaluate the effect of grazing exclusion on soil properties after 20 years of grazing enclosure, and a grazed control site was selected in the region in 2009. The exclosure and control sites were in close proximity and were located in the same homogeneous ecological units. Dominant grazing animal in the region is sheep. The dominant vegetation types in the region are *Artemisia sieberi*, *Stipa hohenacheriana* and *Salsola rigida*.

Initially appropriate areas were selected for sampling. Sampling in each area was conducted using a systematic randomized method. Four 300-m long transects were randomly located in each area (within exclosure and outside the enclosure).

Soil sampling was conducted in first, middle and end of each transect. In both grazing exclusion and control sites two, soil samples were taken from depths of 0–30 cm and 30–60 cm. The soil samples for each depth per site were analyzed in the laboratory of the department of Natural Resources, Tehran University, Iran.

The samples were passed through a two millimeter sieve before analyzing for organic matter (Walkley & Black, 1934), nitrogen (N) content using Kjeldal (Bremmer & Mulvaney, 1982), the amount of available phosphorus (P) by P-Olsen (Olsen & Sommers, 1982), potassium (K) (Boltz & Howel, 1978), EC and pH (Sparks, 1996), and soil texture (sand, clay and silt percent), using the hydrometer method (Gee & Bauder, 1982). Lime amount was estimated using calcimetry (Jafari Haghighi, 2003).

Data were tested for normality before statistical analysis using the Kolmogorov Smirnove test. For comparison of the soil properties in the grazing exclosure treatment and control was used from Duncan's test with $SPSS_{ver.17}$ software. Significance was assessed at 5% probability level unless otherwise noted.

Results

Table 1, 2 and 3 shows the mean values of soil properties in habitats of *Artemisia sieberi*, *Salsola rigida* and *Stipa hohenacheriana* in the grazing exclosure and grazed control treatments in the 0-30 and 30–60 cm depths. The results was showed that soil nitrogen (N%) in grazed exclusion sites at every three habitats *Artemisia sieberi*, *Salsola rigida* and *Stipa hohenacheriana* has increased in the 0-30 and 30–60 cm depths. Phosphorous content in exclusion sites at every three habitats to grow in the 0-30 and 30-60 cm layers of soil compared with control sites. Soil potassium amount in grazed exclusion treatment at the 0-30 layers has increase than no exclusion treatment. Organic matter at both soil layers of 0-30 and 30-60 cm increased in the grazing exclosure sites compared with control sites. Grazed exclosure little affect on soil lime and lime amount was relatively independent of the exclosure. Soil pH in grazed exclosure sites was reduced. Soil Ec in exclosure sites increase compared with the control. Soil texture in every habitat was Sandy clay. Analysis of variance shows that soil properties differed between both sites and soil depths.

Table 1. Means and standard errors of the soil properties in exclusion and control sites in Artemisia sieberi habitat.

Properties	***0-30 cm***		***30-60 cm***	
	Grazed control	Grazed exclusion	Grazed control	Grazed exclusion
N (%)	0.07 ± 0.001b	0.08 ± 0.001b	0.11 ± 0.001ab	0.18 ± 0.001a
P (ppm)	38 ± 2.01ab	28 ± 1.11c	40 ± 3.07ab	42 ± 2.3a
K (ppm)	15 ± 1.9 a	13 ± 2.0 bc	6 ± 0.9 d	12 ± 1.1 bc
O.M (%)	0.9 ± 0.01bc	1.2 ± 0.02b	1.9 ± 0.02a	1.2 ± 0.03b
Lime (%)	10 ± 0.9ab	8 ± 0.8c	11± 1.0 ab	12 ± 1.03a
pH	7.32 ± 0.8ab	7.42 ± 0.7ab	7.36 ± 0.9ab	7.46 ± 0.71ab
Ec (ds/m)	0.3 ± 0.01b	0.8 ± 1.1a	0.32 ± 0.01b	.08 ± 0.9a
Sand (%)	58 ± 5.0a	48 ± 4.1c	52 ± 2.09ab	51± 1.1 ab
Clay (%)	24 ± 2.1c	28 ± 1.0b	25 ± 2.1c	33 ± 3.01a
Silt (%)	17 ± 2.0ab	19.5 ± 1.1a	16 ± 0.9ab	15 ± 2.02ab
Soil texture	Sandy clay	Sandy clay	Sandy clay	Sandy clay

N: Nitrogen, P: Phosphorous, K: Potassium, O.M: Organic matter

Table 2. Means and standard errors of soil properties in exclusion and control sites in Salsola rigida habitat.

Properties	***0-30 cm***		***30-60 cm***	
	Grazed control	Grazed exclusion	Grazed control	Grazed exclusion
N (%)	0.08 ± 0.001b	0.18 ± 0.009a	0.06 a± 0.001b	0.08 ± 0.001b
P (ppm)	38 ± 3. 1abcd	36 ± 2.16bcd	42 ± 3.57abc	43 ± 2.13abc
K (ppm)	15 ± 0.9 b	17 ± 2.1 ab	7.5 ± 0.8 d	7.5 ± 0.8 d
O.M (%)	0.8 ± 0.01c	1.3 ± 0.02a	1.01 ± 0.02b	1.1 ± 0.01a
Lime (%)	25 ± 1.12a	8 ± 0.8b	11± 0.9 ab	10 ± 1.0ab
pH	7.47 ± 0.9ab	7.44 ± 0.6ab	7.65 ± 0.7a	7.55 ± 0.7ab
Ec (ds/m)	0.7 ± 0.01a	1.3 ± 0.01b	0.7 ± 0.08a	1.3 ± 0.02b
Sand (%)	48 ± 3.02a	52 ± 3.0c	52 ± 2.29ab	48 ± 2.21 ab
Clay (%)	27 ± 3.1ab	24 ± 2.0c	28 ± 3.1a	29 ± 3.05a
Silt (%)	17 ± 1.7ab	15 ± 0.6ab	15 ± 1.0ab	22 ± 1.02a
Soil texture	Sandy clay	Sandy clay	Sandy clay	Sandy clay

N: Nitrogen, P: Phosphorous, K: Potassium, O.M: Organic matter

Table 3. Means and standard errors of soil properties in exclusion and control sites in Stipa hohenacheriana habitat.

Properties	***0-30 cm***		***30-60 cm***	
	Grazed control	Grazed exclusion	Grazed control	Grazed exclusion
N (%)	0.1 ± 0.001a	0.11 ± 0.009a	0.062 a± 0.001b	0.063 ± 0.001b
P (ppm)	33 ± 3. 1cd	43 ± 2.16abc	44 ± 3.57abc	45 ± 2.13a
K (ppm)	14 ± 0.9 bc	19 ± 2.1 a	7.5 ± 0.8 d	10 ± 0.8 cd
O.M (%)	0.8 ± 0.01d	1.8 ± 0.02a	1.1 ± 0.02c	1.5 ± 0.01b
Lime (%)	9 ± 1.12ab	8 ± 0.8ab	9 ± 0.9 ab	12 ± 1.0b
pH	7.37 ± 0.9ab	7.32 ± 0.6ab	7.08 ± 0.7b	7.05 ± 0.7b
Ec (ds/m)	0.3 ± 0.01a	0.43 ± 0.01a	0.3 ± 0.01a	0.43 ± 0.01a
Sand (%)	52 ± 3.02a	50 ± 3.0a	50 ± 2.29a	52 ± 2.21 a
Clay (%)	27 ± 3.1a	27 ± 2.0a	27 ± 3.1a	28 ± 3.05a
Silt (%)	16 ± 1.7ab	18 ± 0.6ab	16 ± 1.0ab	22 ± 1.02a
Soil texture	Sandy clay	Sandy clay	Sandy clay	Sandy clay

N: Nitrogen, P: Phosphorous, K: Potassium, O.M: Organic matter

Discussion

Livestock grazing exclusion has a high potential to restore vegetation and soil and is an important alternative to stop further degradation and combat desertification in arid and semiarid regions (Jeddi & Chaieb, 2010). Many studies have shown that grazing exclusion enhanced plant cover and biomass and improved overall soil quality. The results this study were indicated that grazing exclusion has a positive and significant impact on soil properties in the area.

Soil nitrogen (N %) in grazed exclusion sites at every three habitats *Artemisia sieberi*, *Salsola rigida* and *Stipa hohenacheriana* has increased. Vegetation cover strongly influences soil nitrogen content. Soils having good plant cover, aerial biomass and high root biomass usually have more organic matter and nitrogen (Foth *et al.*, 1997). Therefore, in grazed exclusion sites, vegetation cover and root volume in soil result in an increase in nitrogen content compared with the grazed area. Heavy grazing results in a reduction of plant residues in soil which affects the supply of nitrogen and phosphorous (Fernandez-Lugo *et al.*, 2009). Aboveground and below-ground litter accumulated rapidly after grazing exclusion, and this in turn led to greater soil C and N storage (Chen *et al.*, 2012 and Steffens *et al.*, 2008). Hosseinzadeh *et al*, (2010) were noted areas which non-grazed by animals had higher soil nitrogen content due to their dense vegetation cover, particularly nitrogen stabilizing plants like legumes and large volumes of plant roots in their soils.

Grazing exclusion caused phosphorous content to grow in the 0-30 and 30-60 cm layers of soil compared with control sites. In every habitats increasing phosphorous at depths 30-60 cm most have been. This is likely due to that rangelands vegetation exploits phosphorous from lower depths so when vegetation cover and biomass are restored with grazing exclusion phosphorous accessed at deeper soil depths is brought to the surface and accumulates at the soil surface (Azarnivand & Zare Chahoki, 2011). Garcia *et al*, (2011) were stated in area with subtropical type climate ascertained that amount of phosphorus in ungrazed area was higher than the grazed area. The increase may have been due to the effect of climate conditions and soil fertility. Hosseinzadeh *et al*, (2010) were said high amount of soil phosphorus in reference area may be due to the dominant positive effects of vegetation remains and high volumes of plant’s organs. In general, soils containing more organic matter have more organic phosphorus content as well. More vegetation remains, significantly increases soil phosphorus in reference area. Since when humus decomposes, phosphorus gradually releases in the soil. In addition, El-Dewiny, (2006) expressed that causing the degradation of organic matter; large amounts of available phosphorus are released. Subsequently, the availability of Phosphorus of the enclosed area is greater than that of the area with higher grazing intensity.

Soil potassium amount in grazed exclusion treatment at the 0-30 layers has increase than no exclusion treatment. This is likely due to an increase in potassium transfer by plants to the upper soil layers accessed from deeper soil layers compared to the control as discussed above for phosphorous. The increase in potassium amount is also likely due to the increased vegetation and litter cover and improved soil properties in the exclusion treatment (Mofidi *et al.*, 2013). Hosseinzadeh *et al*, (2010) Grazing had negative effects on soil potassium content. Therefore, we go toward the critical area soil potassium decreases. Higher soil leaching rates caused in lower potassium content in grazed areas. The results of this research is disagrees with the results Zarekia *et al*, (2012). They were founded that the high amount of K was observed in higher grazing intensity. The increase in K may have been related to livestock's positive effect on accumulation of K via trampling and their excreta.

Organic matter at both soil layers of 0-30 and 30-60 cm increased in the grazing exclosure sites compared with control sites. The reason is that excessive grazing causes the removal of biomass and vegetation cover from rangeland ecosystems that reduce litter cover and consequently soil organic matter and nutrients content reduce. These results are in agreement with the findings of Mofidi *et al*, (2013), Teague *et al*, (2011) and Hosseinzadeh *et al*, (2010). Soil of exclosure sites have more dense grasses cover, more organic matter and available water, more plant roots and better aeration than grazed soils with less cover (Mesdaghi, 2007). Mekuria *et al*, (2007) were reported strong increases in soil fertility, biological activity, and C storage as a consequence of grazing exclusion. Steffens *et al*, (2008) indicated that heavy grazing due to excessive reduction of vegetative cover, and changes in plant growth form and animal trampling affect the amount of soil nutrients. This cause reduces organic matter of soil. Moreover, Mikola *et al*, (2001) expressed excessive grazing that degrades the vegetation has a negative effect on soil physical properties and soil fertility. Liu *et al*, (2012) suggested that grazing exclusion for at least 15 years might be necessary for the recovery of soil fauna. The vegetation height and the soil electrical conductivity, organic carbon, and total nitrogen determined the distribution and community structure of soil macro-invertebrates. Yousefian *et al*, (2011) were indicated organic carbon (OC%) and organic matter (OM%) in baseline in two depths of 0–15 and 15–30 cm in enclosure rangeland were more than no enclosure rangeland. Because, grazing decrease the plant cover and biomass. So, it leads to return just a little of OM% to soil. Moreover, Yong-Zhang *et al*, (2005) studied the effects of enclosure and grazing on soil characteristics in north of China. They concluded that grazing caused the decrease of plant cover and OM%. Soil OC% and OM% in baseline in the first depth were more than the second depth.

Grazed exclosure little affect on soil lime. Lime amount in the deeper layers of the soil is more. Zare Chahouki, (2001) showed that relation of lime with plants were direct and sometimes are indirect. He remarks that in some regions, equable amount of lime in soil leads to more species diversity because lime enhances the soil biological activities. However, if soil lime amount increases, hardpan will be made and nutritive materials will face the problem of being absorbed by plants.

The results showed soil pH in grazed exclosure sites was reduced. Exclosure usually increase vegetation cover, total biomass, litter cover and consequence organic matter of soils. So, pH soil increases. Verdoodt *et al*, (2010) were expressed rangeland enclosure fostered regeneration of annual and perennial grasses, and significantly increased grass cover and standing crop. Mofidi *et al*, (2013) showed Reduction of soil pH due to exclusion could result from high vegetation biomass or dense root system and high soil organic matter, due to more active microorganism metabolism in the rhizosphere (David *et al*., 2004), organic acids secretion from the roots and large amounts of CO released from roots and micro-organisms (Hinsinger *et al*., 2003), increased leaching, and decreases in carbonate calcium equivalent (CCE) percentage. With increasing organic matter content, more mineral and organic acids are produced with carbonic acid being the most abundant. Moreover, feces and urine of livestock will increase organic and mineral matter in soil. This also will increase soil pH, consequently. Somda *et al*, (1997) reported that urine pH of ruminants is about 8.4 to 8.6.

Soil Ec in exclosure sites increase compared with the control. The EC increase in the grazing exclusion sites could be due to increasing soil cation exchange capability. Exclosure increase vegetation cover, plants species diversity, biomass, standing crop, organic matter and consequence pH is decreased. The increase ratio of Ec in *Salsola rigida* habitat was more than two others habitats. The reason is that *Salsola rigida* absorb sodium (Na^+) of soil and save in its biomass. When the productions of it fall on ground, soil Ec increase. Ghorbanian and Jafari, (2007) the concentration of Na+ in *Salsola rigida* is greater than other elements. Mofidi *et al*, (2013) stated improvement in soil structure, a decrease in runoff, and increased water infiltration could cause a reduction in CCE in the surface soil depths due to dissolving by pH reduction. The increased CCE in deeper soil layers could be attributed to its dissolving from upper soil layers and accumulation deeper in the soil profile, with high amounts of CaCO3 in the parent material. On the contrary, Zarekia *et al*, (2012) were indicated continuous grazing in the rangeland has reduced the vegetation and litter cover and consequently soil moisture. Whereupon, soil temperature and evapotranspiration and subsequently, soil salinity and salt increase, which finally leads to an increase in electrical conductivity (Ec). Hosseinzadeh *et al*, (2010) were founded the higher electric conductance in the reference area (grazed exclosure) is due to their higher amounts of soil organic matters and vegetation cover as compared with two other treatments (non-exclosure). In other words, heavy grazing intensities decreases the vegetation cover which results in more soil erosion and leaching and electric conductance (EC) in critical area than key and reference areas.

Soil texture in every habitat was Sandy clay. This texture provides proper condition for plants growth. So, exclosure success increases.

In general, the results of research were showed significant positive effects on soil properties and after 20 years of grazing exclusion in Roodshoor rangelands. N%, P%, K%, O.M% and Ec (ds/m) in grazed exclusion sites at every three habitats *Artemisia sieberi*, *Salsola rigida* and *Stipa hohenacheriana* have increased compared with the grazed area. Soil pH in grazed exclosure sites was decreased. Moreover, grazed exclosure had little effect on soil lime and texture.

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