SOIL PROPERTY CHANGES UNDER DIFFERENT KINDS OF HERBIVORE GRAZING IN ARID RANGELANDS OF YAZD PROVINCE, IRAN

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Abstract. Due to the lack of forage and poor condition in arid rangelands, investigation of soil properties is essential and very important. Therefore, the purpose of this study was to compare wildlife, livestock and alternative grazing effects on physicochemical characteristics of the soil in arid rangelands of Kalmand-Bahadoran in Yazd province. Soil samples were taken in each plot (0-30 cm) and in each site by random systematic method. The results showed that the highest amount of silt and bulk density belonged to livestock grazing site ($p<0.01$). Statistical analysis indicated that calcium carbonate percentage in livestock grazing site (18.33%) was higher than it was in wildlife+livestock (14.85%) and deer (12.57%) grazing sites ($p<0.01$), respectively. Acidity and electrical conductivity levels in livestock and wildlife+livestock grazing areas were significantly higher than that was in deer grazing site ($p<0.01$). Wildlife+livestock grazing area had more organic matters content (0.28%) compared to other areas ($p<0.01$). P and K parameters were in the order of livestock > wildlife+livestock > wildlife grazing sites. So that the amount of phosphorus was 79, 71 and 62 and potassium was 101, 87 and 77 in terms of livestock, wildlife+livestock and wildlife grazing sites, respectively. Nitrogen was the highest in alternative grazing area (0.08%), wildlife grazing site was in the second level (0.06%), and the least amount of Nitrogen was related to livestock grazing region (0.03%) ($p<0.01$). It can be inferred that there is no negative effects by deer and wildlife+livestock grazing. Proper management strategies should be performed as a tool to reduce some negative impacts.
Keywords: *Kalmand-Bahadoran, livestock, physicochemical characteristics, range management, wildlife*

Introduction

Rangelands are one of the most important ecosystems in the world which supply forage for wildlife and livestock (MacNeil et al., 2008). Rangelands sustainability is affected by several factors interaction such as organisms (herbivores), climatic and edaphic parameters (Heidarian Aghakhani et al., 2010; Speed and Austrheim, 2017). So, managing herbivores and vegetation interactions shows how soil and water resources are managed (Afrah et al., 2010).Generally, different grazing regimes can effect soil physiochemical characteristics (Li et al., 2017). Grazing by wild and domestic ungulates causes soil deformation by trampling and soil compaction (Yong-Zhong et al., 2005; Zhao et al., 2007; Kumbasli et al., 2010), and if grazing pressure increases, it will lead to rangeland degradation (Sandhage-Hofmann et al., 2015). Livestock grazing is usually guided by human (Ruiz-Mirazo, 2011) but wildlife freely move in rangelands (Fynn, 2012). Therefore, Grazing by wild ungulates naturally differs from livestock grazing (Jackson and Bartolome, 2007). Depending on the number of stocking rate, ungulate type (wild or domestic) and grazing periods, grazing practices affect soil properties

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(Sanjari et al., 2008; Hossein Jafari et al., 2014), and with proper managed programs it may have positive effect on soil characteristics (Vavra, 2005).

Wildlife and livestock grazing has positive or negative effects on soil characteristics in rangeland ecosystems (McDowell et al., 2004; Steffens et al., 2008; Zarekia et al., 2012; Hossein Jafari et al., 2014; Matano et al., 2015). High grazing intensity leads to decreasing nutrient availability resulting in soil fertility reduction (Morgan, 1995; Hiernaux et al., 1999; Connolly et al., 2016).

Based on literature review there are a few studies about comparing the effect of livestock and wildlife grazing on soil characteristics in rangelands (Parissi et al., 2014; Hossein Jafari et al., 2014). Kalmand-Bahadoran as an arid rangeland is important for wildlife conservation and livestock grazing. According to lack of forage and poor condition in arid rangelands, investigating soil properties is essential and very important. Therefore, the purpose of this study was to compare wildlife, livestock and alternative grazing effects physicochemical properties of the soil in arid rangelands of Kalmand-Bahadoran in Yazd province. This study focused on this hypothesis that three grazing management regimes change soil characteristics, but not essentially negatively. The results can help to find critical thresholds of grazing pressure on Kalmand-Bahadoran rangeland.

Materials and methods

This study was carried out in Kalmand-Bahadoran Arid Rangeland, at 1400 to 3290 m above sea level with 100 mm average annual precipitation (at 31°00′ to 31°40′N and 54°15′ to 55°20′ E). This area is located near Mehriz in Yazd Province, Iran (Karimian, 1999; Consulting engineers of Iran, 2002).

Three sites were selected in Kalmand-Bahadoran Rangeland in order to comparing the effects of livestock, wildlife and wildlife+livestock alternative grazing on soil properties. Three regions were selected for soil sampling based on topographic maps and field investigation (Hossein Jafari et al., 2014). Two regions were in protected area and under wildlife (deer) and deer+sheep and goat alternative grazing. The other was outside the protected area, under livestock (sheepand goat) grazing.

Soil samples were taken from the top soil (0-30 cm) in each plot and each site. Soil sampling was conducted based on random systematic method. 15 random transects of 100 m were placed in three sites. Soil samples were systematically taken from the first and at the end of each transect (30 samples from each site). In the laboratory, bulk density (by cylinder method) and soil texture (by hydrometric method) were measured. Acidity and electrical conductivity were determined using pH meter and EC meter in saturated mud. To measure organic matters, Walkley-Block method was used. Moisture and Calcium carbonate were determined by Oven and titration method respectively. The contents of N, P and K were determined by atomic absorption spectrometry (Jafari Haghighi, 2003). Data analysis was performed by ANOVA test using SPSS Software.

Results

The results of comparing physical parameters demonstrate that there is a significant difference in silt percentage ($p<0.05$) and bulk density ($p<0.01$) in different areas. The highest amount of silt is observed in livestock site (11.45%), but there is no difference between deer (6.43%) and deer+livestock (5.84%) grazing areas. The highest bulk

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density belongs to livestock site (0.98 gr/cm^2). Wildlife+livestock grazing region is in the second level (0.75 gr/cm^2). Wildlife site has the least amount of bulk density (0.70 gr/cm^2) ($p<0.01$). There is no obvious difference among three regions in terms of sand, clay and moisture percentages (*Table 1*).

Table 1. *Comparing soil physical parameters among three regions under wildlife, livestock and wildlife+livestock alternative grazing using ANOVA test*

Soil texture parameters (%)	Study site	Average	Mean Square	df	F	Significant
Sand	Wildlife	79.873	20.291	89	1.109	0.389^{ns}
	Wildlife + Livestock	81.713				
	Livestock	76.580				
Silt	Wildlife	6.427 b	28.561	89	5.839	0.039*
	Wildlife + Livestock	5.840 b				
	Livestock	11.453 a				
Clay	Wildlife	13.700	2.403	89	0.389	0.694^{ns}
	Wildlife + Livestock	12.447				
	Livestock	11.967				
Moisture (%)	Wildlife	1.020	0.002	89	0.818	0.485^{ns}
	Wildlife + Livestock	1.040				
	Livestock	0.993				
Bulk density(gr/cm^2)	Wildlife	0.703 c	0.066	89	26.923	0.000**
	Wildlife + Livestock	0.750 b				
	Livestock	0.980 a				

(^{ns}: No significant), ($^{*}P<0.05$), ($^{**}P<0.01$)

The results show that there is a significant difference among three regions in terms of soil chemical parameters (*Table 2*). Statistical analysis indicates that calcium carbonate percentage in livestock site (18.33%) was higher than wildlife+livestock (14.85%) and deer (12.57%) grazing areas ($p<0.01$), respectively. According to *Table 2*, acidity and electrical conductivity are equal statistically in livestock and wildlife+livestock areas. These parameters are significantly higher than that was in deer site ($p<0.01$).

Wildlife+livestock grazing area has higher organic matters (0.28%) compared to other areas. There is no significant difference between livestock (0.21%) and deer (0.22%) grazing sites in terms of organic matters ($p<0.01$).

P and K parameters are in the order of livestock>wildlife+livestock>wildlife grazing sites. So that the amount of phosphorus is 79, 71 and 62 and potassium is 101, 87 and 77 in terms of livestock, wildlife+livestock and wildlife sites, respectively. Nitrogen parameter with 0.08% is the highest in wildlife+livestock alternative grazing area. Wildlife site was in the second level (0.06%), and the least amount of Nitrogen was related to livestock grazing region (0.03%) ($p<0.01$) (*Table 2*).

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Table 2. *Comparing soil chemical parameters among three regions under wildlife, livestock and wildlife+livestock alternative grazing using ANOVA test*

Soil texture parameters	Study site	Average	Mean Square	df	F	Significant
Calcium carbonate (%)	Wildlife	12.573 c	25.216	89	46.878	0.000**
	Wildlife + Livestock	14.850 b				
	Livestock	18.330 a				
Acidity	Wildlife	7.839 b	0.364	89	18.247	0.003**
	Wildlife + Livestock	8.360 a				
	Livestock	8.500 a				
Electrical conductivity (ds/m)	Wildlife	0.775 b	0.409	89	45.056	0.000**
	Wildlife + Livestock	1.350 a				
	Livestock	1.463 a				
Organic matters (%)	Wildlife	0.220 b	0.004	89	25.800	0.001**
	Wildlife + Livestock	0.280 a				
	Livestock	0.210 b				
N (%)	Wildlife	0.063 b	0.001	89	44.33	0.000**
	Wildlife + Livestock	0.077 a				
	Livestock	0.033 c				
P (mg/kg)	Wildlife	62.00 c	217.0	89	31.00	0.001**
	Wildlife + Livestock	71.00 b				
	Livestock	79.00 a				
K (mg/kg)	Wildlife	77.00 c	436.0	89	62.286	0.000**
	Wildlife + Livestock	87.00 b				
	Livestock	101 a				

(ns: No significant), (*P<0.05), (**P<0.01)

Discussion and conclusions

The results demonstrated that silt percentage increased significantly in livestock grazing area compared to other sites. Sand and clay percentages decreased in livestock site but it was not obvious statistically. The reason for these differences might be changes in soil natural structure. The protected area is near to the mountains which are susceptible to erosion. Ajorlou (2007) and Hossein Jafari et al. (2014) announced that the reason for soil texture changes is sand transition from surrounding areas. Huang et al. (2007), Du to Kumbasli et al. (2010) and Cournane et al. (2011) also found similar results in their studies. They confirmed that the main reason for changes in soil particle composition is soil wind erosion.

The results revealed that the highest and the least amount of bulk density was related to livestock and wildlife sites, respectively. Totally, livestock grazing behaviour is different from wildlife (Speed and Austrheim, 2017). Livestock prefer to graze more concentrate than wildlife, while deer like to graze far from each other. In addition, livestock is conducted by a manager and does not graze freely in rangelands (Speed and

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Austrheim, 2017). This cause livestock has more pressure on soil and increase bulk density. But deer grazing area had the least amount of bulk density. Hossein Jafari *et al.* (2014) confirmed this issue in their studies. Other researchers confirmed that higher bulk density is due to increasing soil compaction and animal trampling (Brevik et al., 2002; Binkley et al., 2003; Hamza and Anderson, 2005). Increasing soil calcium carbonate and acidity is also due to high pressure in livestock grazing area. Livestock make bottom carbonate layer closer to the surface by soil layers degradation and cause a significant increase in soil calcium carbonate and acidity (Dormaar, 1998; Hossein Jafari et al., 2014).

Electrical conductivity had also a significant reduction in wildlife grazing area. When deer graze halophyte species, does not let plants residue and matters return to the soil. Therefore, it causes a reduction in soil salinity. This result is similar to (Ajorlou et al., 2011 and Zarekia et al., 2012) studies.

According this study results, organic matter percentages were low in three areas. In arid regions, high distances between plants and lack of vegetation can cause decreasing organic matter (Hossein Jafari et al., 2014). The results indicated that soil organic matter content has a significant increase in wildlife+livestock alternative grazing site. In this area, returning organic matters to the soil is higher than other areas. It seems that vegetation type and density leading to some changes in soil organic matters. Other studies announced that reducing soil organic matters decrease microorganisms activity and organic matters breaking down less than usual (Xie and Witting, 2004; Jalilvand et al., 2007). Sandhage-Hofmann et al. (2015) announced that when plants residues like litter, leaf and stem fall return to the soil, fertility enhances. According to the results, there is a linear relationship between organic matter and nitrogen. In other word, increased organic matter increases the amount of nitrogen. Many researchers refer to this relationship in their studies (Pei et al., 2008; Hosseinzadeh et al., 2010; Kumbasli et al., 2010). They announced that the reason is vegetation removal by herbivores. Schuman et al. (1999) revealed that the main reason for none increasing soil organic carbon and nitrogen is non-breaking and mixing plant residues with the soil. The results of Li et al. (2017) research in alpine meadow showed that exclusion enhanced C and N storage in soil via promoting grasses root system and their growth.

The results indicated that soil phosphorous was affected by grazing and its amount in livestock grazing site was higher than the other sites. It seems that high grazing pressure increased soil phosphorus level. This result is similar to those of Jusoff (1988); Javadi et al. (2006); Kohandel et al. (2006); Zarekia et al. (2012) studies. According to moisture deficiency in all three grazing sites, increasing the amount of soil phosphorus in livestock grazing site can be due to livestock dung and trampling which enhances the move ability of the phosphorus in soil. Haynes and Williams (1993) indicated that 65% of phosphorus in diet consumed by cow returned to the soil. The results of Garcia et al. (2011) study did not follow our results. They revealed that phosphorus level in non-grazed area was higher than grazed area in a rangeland with subtropical climate. They said that the reason may have been due to climate conditions and soil fertility.

Based on the results, soil potassium was higher in livestock grazing area compared to other sites. This can be also due to more livestock trampling and their excreta. The results are similar to several studies who reported that K level raised significantly in the site with successive grazing (Javadi et al., 2006; Kohandel et al., 2006; Garcia et al., 2011; Zarekia et al., 2012). Haynes and Williams (1993) stated that increasing K in the site under cow grazing is more due to animal urine than animal dung.

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Soil parameters like bulk density, pH, EC, organic matters, Calcium carbonate, N, P and K were good indicators of grazing management. It can be inferred that there is no negative effects by deer and wildlife+livestock grazing. Livestock grazing cause soil changes more than two other grazing site. Proper management strategies should be performed as a tool to reduce some negative impacts.

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