Evaluation of Enclosure Effects on Soil Carbon Storage (Case Study: Rangeland of Shahtappeh-Chah Mahmood and Chiro in Semnan Province)

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Abstract. Livestock grazing is one of the most important kinds of land usage that has a high potential to decrease or increase carbon storage in rangeland ecosystem. This research was investigated the effects of enclosure on soil carbon storage in a rangeland with dominant plants of *Artemisia aucheri*. Hence, two rangelands of enclosure (Shahtappeh-Chah Mahmood) and no enclosure (Chiro) were chosen in Semnan province, Iran. For soil sampling, 20 plots of 1x1 m^2 along with two vertical transects with 100 m length were used in each region. Then, two profiles were dug in 0-15 and 15-30 cm depths in soil of baseline and inter-path of plants in each plot. Data were collected for pH, EC, $CaCO_3$, saturation moisture, soil texture, organic carbon (OC%) and s organic matter (OM%), Soil bulk density and Soil carbon storage and the mean was compared by t-test. The results showed that there was a significant difference ($P<0.05$) between OC% and OM% of baseline in enclosure and no enclosure rangeland. Soil OC% and OM% in baseline in the first depth was more than the second depth in two study areas. There was a significant difference ($P<0.05$) between soil OC% and OM% in baseline and inter-path of plants in two depths of enclosure and no enclosure rangelands. Soil bulk density (gr/ha) in baseline and inter-path of plants in 15-30 cm was more than 0-15 cm. In enclosure and no enclosure rangelands, grazing had no significant effects on soil organic carbon storage of baseline in each depth. So, the total carbon in 0-30 cm in each region was 47.46 and 40.85 ton/ha, respectively. There was a significant difference between carbon storage of baseline and inter-path of plants ($P<0.05$) in two depths in enclosure and control rangelands. It was concluded that higher carbon sequestration occurs in the soil, the soil biological and mechanical activities can increase.

Key words: Enclosure, Carbon storage, *Artemisia aucheri*, Rangeland ecosystem, Semnan.

Introduction

Climate changes made by increasing temperature because green house gases that have a direct effect on life and health. Green house gases are effective on carbon and soil physical and chemical characteristics by changing aerial and underground biomass so that this event leads to decrease soil fertility, quality and quantity of reversal biomass (Lal, 2004). Green house gases are HCO, CO_2, CH_4, N_2O, CFC_5 and the other suspense particles in atmosphere that CO_2 is one of them (Andrew and Gregory, 2006). So that, the global effort had been done to decrease these gases caused by fossil fuel despite the communities involved in harmful changes of climate. Because politicians only propose some plans to decrease green house gases while they don't pay attention to the other factors caused by human activities (Fischlin *et al* 2007, McAlpine *et al.*, 2010, Piekle *et al.*, 2009, and Pielke, 2005). Therefore, economical activities (using fossil fuel) destroy forest and rangeland to improve agriculture that is increasing day to day. So, it's necessary to purify carbon. Decreasing of carbon by artificial method is expensive. Because of that, carbon sequestration by plant and soil is the best way (Karegar *et al.*, 2010). Industrial countries have a long-term plan to decrease CO_2 construction and carbon storage by forest and rangeland (Bordbar, & Mortazavi Jahromi, 2006). Rangeland ecosystem is one of the most important carbon reservoirs that have a high potential for carbon sequestration because 40% of world dry land is rangelands (Steffensa *et al.*, 2008) that contain one third of carbon storage above and underground (Derner and Schuman, 2007). In addition, rangelands sequester 500 milliard ton carbons yearly. Soil is one of the important carbon reservoirs in rangeland ecosystem and soil carbon sequestration is an important part of carbon sequestration in welter ecosystem that has a high effect on CO_2. So, little changes in soil carbon construction by changing land uses cause many changes in CO_2 construction (Steffensa *et al.*, 2008). For example, erosion, soil impact and run off decrease organic carbon of the soil and destroy the soil construction (Lal, 2004). Live stock grazing is one of the most important and usual land using in rangeland that has high potential for carbon storage changes by affecting the aerial and underground biomass (Chambers, and Brown, 1983), microclimate, available water and nutrient (Kielland & Bryant, 1998; Shariff *et al.*, 1994) and quality and quantity of entrance carbon to ecosystem by changes in species composition and plant community diversity (Scurlock *et al.*, 2002). Young-zhang *et al*. (2005) in their research evaluated the effect of enclosure and grazing on soil characteristics in north of China, showed that grazing leads to decrease that cover and soil organic carbon. Azarnivand *et al*. (2009) investigated the effect of livestock grazing on carbon sequestration and nitrogen reserve in rangeland with *Artemisia sieberi* in Semnan province. They showed that grazing has a significant effect on soil carbon storage in Ghoosheh, but there was no significant relation between grazing and carbon storage in Peighambaran. The effect of grazing is irregular (Reeder and Schuman, 2002). For example, some researchers showed increasing (Reeder *et al* 2004; Schuman *et al.*, 1999) and other researchers showed the decrease (Ardo and Olsson, 2003; Mahmoodi Taleghani *et al.*, 2007; Yong-Zhong *et al.*, 2005) of soil carbon and nitrogen storage. The results of 34 separate researches about the effect of grazing on carbon and nitrogen storage in grazing and enclosure in the world showed the increasing (60%) and decreasing (40%) of carbon storage in enclosure rangeland (Shrestha, and Stahla, 2008). Iran's rangeland with 86.7 million ha is the widest land (around 54%) that more than 70% of these rangelands are situated in arid and semi-arid area. Arid area (because of less moisture) decomposes the plant with lower speed. So, these lands are important in carbon sequestration (Briske *et al* 1996, Jafari Haghighi, 2003). Among the plants of this region, *Artemisia aucheri* is useful for environment to prevent soil erosion and also provide herbage for livestock and wild life. So it is necessary to investigate the effective management factors for carbon sequestration such as enclosure on *Artemisia aucheri*. Because it can keep the quality and quantity of soil and also it can be one of the best ways to overcome the air pollution and climate changing to reach the sustainable development Varamesh *et al.*, 2010). So, the aim of this study was investigation of the effects of enclosure on soil carbon sequestration in Shahtappeh-Chahmahmood and Chiro in Semnan province.

Materials and Methods

In this research, *Artemisia aucheri* has been chosen as dominant species in two rangelands of Shah tappeh-Chah Mahmood and Chiro in Semnan province (Fig. 1). The enclosure rangeland was Shahtappeh-Chah Mahmood and no enclosure was Chiro. The enclosure rangeland was about 10200 ha with maximum 2797m and minimum 1500 m altitude located in 35 km of Northwest of Damghan, Iran. The maximum temperature of 30.47°C was in August and minimum temperature of -11.42°C was in January and February. The climate was semiarid. All the topographic characteristics (slope, aspect height), soil, raining rate and climate were similar in two study areas (Anonymous, 2004).

Soil sampling was done by random–systematic method (Derner *et al.,* 1997; Mesdaghi, 2003) and 20 plots of 1x1 m^2 along with two vertical transects with 100 m length had been used in each region in a way that 4 transects and 80 plots were located in two study areas. The number of plots was obtained by statistical method (Naghipoor Borj *et al.,* 2008) (formula 1) and the size of plots by minimal area method (Mueller & Ellenberg 1974).

$N=p^2s^2/t^2x^2(1+2/n)$ (Formula 1)

Where:

N= is minimum number of sampling
t=is obtained by t student Table.
x= is the average of primary sampling.
p= is error P values that is between -0.1 and +0.1.
S^2= is variance
n= is the number of primary sampling.

In order to study the soil physical (bulk density, texture and saturation moisture%) and chemical (organic carbon, $CaCO_3$, pH and EC) characteristics, sampling was done in two depths of 0–15, 15–30 cm (according to soil depth) in baseline and inter–path of plant. Soil organic carbon changes were little in depths more than 30 cm (Jafari Haghighi, 2003). So, this study was done in 0-15 and 15-30 cm. Soil carbon sequestration was calculated by formula 2.

$Cc= 10000 \times c(\%) \times Bd \times e$ (Formula 2)

Where:
Cc= is the weight of carbon sequestration in m^2.
c(%) = is the carbon% in each depth.
Bd= is soil bulk density (cm^3) in each depth (Foroozeh et al 2008)
e= is the soil depth (cm).

Soil organic carbon and bulk density are multiplied by depth of soil and the total carbon sequestration is obtained (Zarrin kafsh, 1993). T–test had been used to compare the means of treatments using SPSS software.

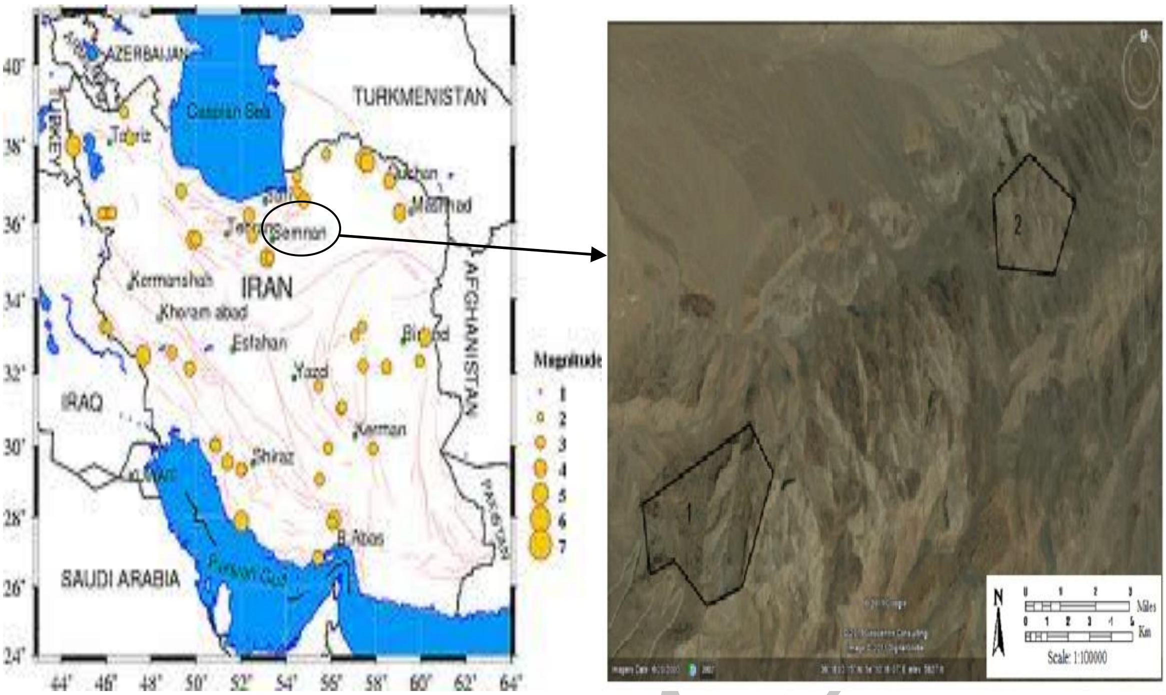

Fig. 1. The study area in Semnan province (1: Enclosure rangeland, 2: No enclosure rangeland)

Results

Investigation of soil characteristics in enclosure and no enclosure rangelands

The results showed that pH in two study areas was alkali and the EC in enclosure rangeland was 207 mmhos and in control was 186 mmhos. $CaCO_3$ in enclosure rangeland was 60.33 and in no enclosure were 66.08. Percentage of saturation moisture in enclosure rangeland was 17.23 and in no enclosure were 18.26. Soil texture in two study areas was sand-loam.

Table 1. Physical and chemical characteristic (0–30 cm) in enclosure and no enclosure rangeland

Rangeland	Soil characteristics				
	pH	EC (mmhos)	$CaCO_3$	Saturation moisture (%)	Texture
Enclosure	8.38	207.79	60.33	17.23	Sand-loam
No enclosure	8.29	186.21	66.08	18.26	Sand-loam

Comparison of OC% and OM% of baseline in enclosure and no enclosure rangelands

The analysis showed that there was significant difference ($P<0.05$) for soil organic carbon (OC%) and soil organic matter (OM%) of baseline in both depths between enclosure and no enclosure rangelands. Also, in two rangelands, OC% and OM% of baseline in 0–15 cm were more than 15–30 cm (Figs. 2 and 3).

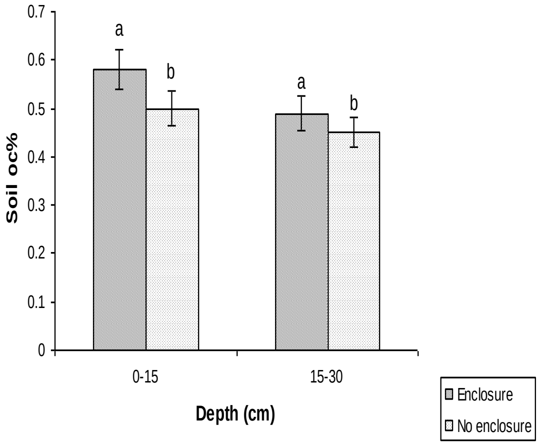

Fig. 2. Comparison of OC% baseline in 0–15 cm and 15–30 cm in enclosure rangeland

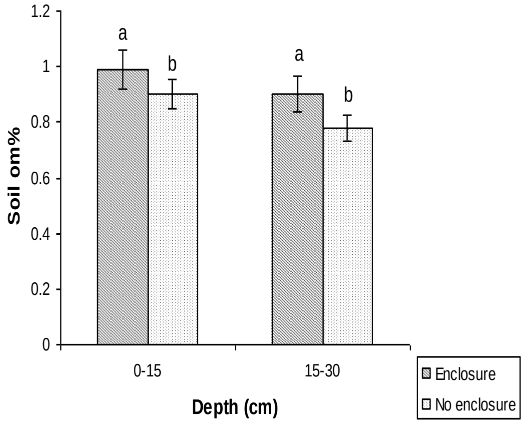

Fig. 3. Comparison of OM% baseline in 0–15 cm and 15–30 cm in enclosure rangeland

Comparison of OC% and OM% in baseline and inter-path of plant in enclosure rangeland

There was a significant difference (on 5% level) between soil OC% and OM% in baseline and inter-path of plants in two depths (0-15 and 15–30 cm). Also, soil OC% and OM% in baseline and inter-path of plants in the first depth was more than the second depth (Figs. 4 and 5).

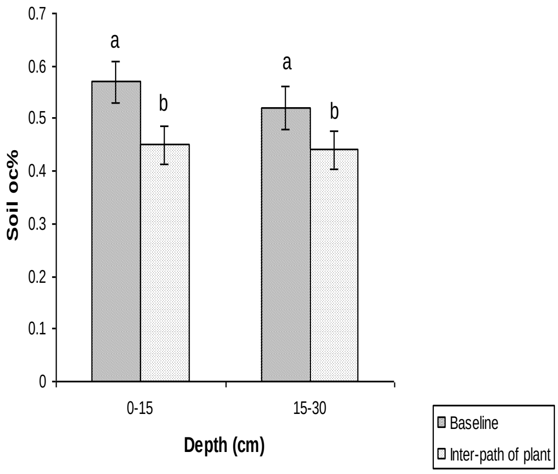

Fig. 4. Comparison of soil OC% in baseline and inter–path of plants in two depths in enclosure rangeland

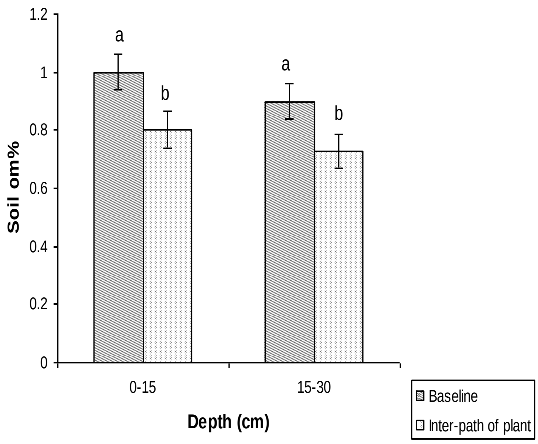

Fig. 5. Comparison of soil OM% in baseline and inter-path of plants in two depths in enclosure rangeland

Soil OC% and OM% in baseline and inter–path of plants in no enclosure rangeland

The result in no enclosure rangeland was similar to the enclosure rangeland. There was a significant difference ($P<0.05$) between soil OC% and OM% in baseline and inter-path of plants in two depths (0-15 and 15–30 cm). Also, soil OC% and OM% in baseline and inter–path of plants in the first depth was more than the second depth (Figs. 6 and 7).

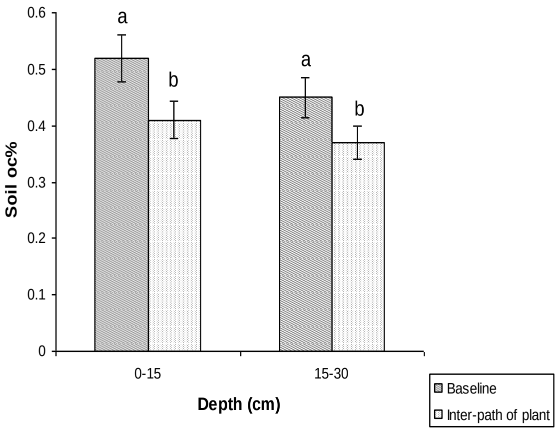

Fig. 6. Comparison of soil OC% in baseline and inter–path of plants in two depths in no enclosure rangeland

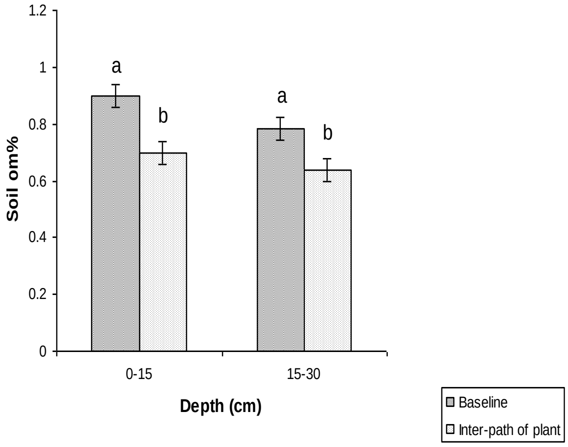

Fig. 7. Comparison of soil OM% in baseline and inter–path of plants in two depths in no enclosure rangeland

Soil bulk density changes in baseline and inter–path of plants

Soil bulk density (gr/cm^3) in baseline and inter-path of plants in the second depth was more than the first depth (Table 2).

Soil carbon storage changes in baseline and inter–path of plants

Comparison of soil carbon storage in base line in enclosure and no enclosure rangelands the results showed that grazing didn't have an effect on the soil carbon storage of baseline in 0–15 and 15–30 cm (Table 3).

Soil carbon storage in the first depth in enclosure rangeland was 24.84 ton/ha and in no enclosure rangeland was 21.84 ton/ha. Also, in the second depth, the soil carbon storage in enclosure rangeland was 23.3 ton/ha and in no enclosure rangeland was 19.01 ton/ha.

The result of T-test in enclosure and no enclosure rangelands showed that the *Artemisia aucheri* had a significant effect on soil carbon storage. Therefore, there was a significant difference between carbon storage of baseline and inter-path of plants ($P<0.05$) in each depth in two study areas.

Table 2. Soil bulk density in baseline and inter-path of plants in enclosure and no enclosure rangelands

Depth (cm)	Study area	Soil bulk density (gr/cm^3)	
		Enclosure	No enclosure
0-15	Baseline	1.59	1.61
	Inter-path of plant	1.56	1.54
15-30	Baseline	1.65	1.62
	Inter-path of plant	1.65	1.63

Table 3. Comparison of soil carbon storage in base line in enclosure and no enclosure rangelands

Depth (cm)	Treatment	Average	Std. division	df	t
0-15	Enclosure	24.16	10.37	38	-0.8ns
	No enclosure	21.84	7.74		
15-30	Enclosure	23.3	9.5	38	-1.6ns
	No enclosure	19.01	7.22		

ns=no significant

Table 4. Comparison of soil carbon storage in baseline and inter-path of plants in enclosure and no enclosure rangelands

Rangeland	Depth (cm)	Study area	Average	Std. division	df	t
Enclosure	0-15	Baseline	24.16	10.37	38	1.55*
		Inter-path of plant	19.89	6.54		
	15-30	Baseline	23.3	9.5	38	2.11*
		Inter-path of plant	17.84	6.57		
No enclosure	0-15	Baseline	21.84	7.74	38	2.22*
		Inter-path of plant	17.53	3.83		
	15-30	Baseline	19.01	7.22	38	1.99*
		Inter-path of plant	16.5	8.57		

*Significant on 5% level

Conclusion

This research showed that soil OC% and OM% in baseline in two depths of 0–15 and 15–30 cm in enclosure rangeland were more than no enclosure rangeland. Because grazing decreases the plant coverage and biomass. So, it leads to return just a little of OM% to soil. 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 coverage and OM%. Soil OC% and OM% in baseline in the first depth were more than the second depth. This conclusion was similar to the result obtained by Varamesh *et al*. (2010), Wezel *et al*. (2000), Yimer *et al*. (2006) and Zheng *et al*. (2008). Shrubs are as phytomass accumulation that produce the died organs above the soil. So, it is clear that soil of baseline in the first depth has more mineral and nutrient materials. Thus, soil OC% and OM% increase in baseline. The results showed that soil bulk density (gr/cm^3) in baseline and inter-path of plants in the second depth was more than the first depth. Since pores of soil are decreased by increasing the depth. So, the bulk density increases. Mahmoodi Taleghani *et al*. (2007) and Varamesh *et al*. (2010) in their researches showed that there was a direct relationship between depth and bulk density and the bulk density increases by increasing the depth of soil. This research indicated that grazing had no significant effect on carbon storage in baseline in two depths because of impalpable effects of grazing on root biomass as entrance carbon reservoir (Naghipoor Borj, *et al* 2008). In this way, Henderson *et al*. (2004) investigated the soil carbon reaction to the enclosure. They showed that the carbon of plants and litter in the enclosure rangeland are more than no enclosure rangeland, but there was no significant relationship between soil carbon and enclosure (Azarnivand *et al.* 2009). *Artemisia aucheri* had a significant effect on carbon storage. It means that there was a significant difference between soil carbon storage in baseline and inter-path of plants ($P<0.05$) in two depths in enclosure and no enclosure rangelands. The presence of various species has some high effects on carbon sequestration in two depths. Because the aerial organs fall above ground and biological activities are increased. Then, carbon transfers to the root and finally goes to the soil. Jafari *et al*. (2008) showed the similar conclusion. Their results showed that the soil carbon sequestration in two rangelands was decreased by increasing the depth of soil. Because OC% and OM% in 0–15 cm were more than 15–30 cm, carbon sequestration in the first depth was more than the second depth. This result was similar to the result of Rice (2000) research. He indicated that carbon sequestration in the arid rangeland has an indirect relationship with the depth of soil. This study showed that the enclosure had no effect on the soil carbon sequestration. Azarnivand *et al*. (2009) in their research showed the similar conclusion. They explained that enclosure had no phenomenal effect on the soil carbon sequestration in one of their study areas because of impalpable effects of grazing on the root biomass as entrance carbon reservoir (Azarnivand *et al.,* 2009). Jafari *et al*. (2008) had a similar idea. It was concluded that higher carbon sequestration occurs in the soil, the soil biological and mechanical activities can increase the soil carbon sequestration that leads to improve water and soil quality, decrease the erosion and also increase the water reservation and nutrient materials for producing more products as the advantages of carbon sequestration.

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