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Soil carbon capacity in a grassy rangeland ecosystem in North-western Iran: Implication for conservation

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Carbon dioxide is one of the most important greenhouse gases in the atmosphere. Ranges and based on carbon sequestration and soil conservation have a key role and known as dominant species in the region. In Iran, overgrazing of rangelands, during the process of soil erosion is happening that this fact resulted to decrease soil carbon. In the present study, comparative assessment of carbon sequestration capacity in the rangeland with different grazing intensity was investigated. Systematic random transect sampling with square plots was established in the region. After grinding the dried samples, organic carbon by electric furnace combustion method were measured and multiplied to the conversion ratio of organic carbon in plant biomass, carbon sequestration by total weight in both plant and finally the base case was calculated per hectare of range. Total organic carbon stock in the ecosystem, in plant biomass and soil in site 1 (low Stocking grazing) and site 2 (high Stocking grazing) was 7/5 and 4/7 ton/ha, respectively. The results of the study showed that rangelands have a major role in mitigating the effects of elevated atmospheric carbon dioxide levels on global climate change. Also, the results indicated that management practices, such as grazing, and improved plant species will be concluded to increase soil organic carbon storage in the study area.

Key words: Carbon sequestration, rangeland, soil carbon capacity.

INTRODUCTION

Human activity has adversely affected global C and N cycles, and contributed to an alteration of climate that will generate discernible feedbacks to all organisms and ecosystems on earth. In recent decades, extensive work has been conducted toward improving our understanding of global C reserves and quantifying the pools and fluxes that constitute the cycles. Since the amount of C stored in soil organic matter is approximately twice that in the atmosphere (Schimel, 1995), the accumulation of C in the terrestrial biosphere could partially offset the effect of anthropogenic carbon dioxide (CO_2) emissions at the atmospheric CO_2 level (Houghton et al., 1999).

Reducing emissions from electrical power generation is one of the most important steps than can be taken in an overall GHG mitigation effort. Electricity production contributes approximately 25% of the total of direct man-made GHG emissions today (NAS, 2010). On March 27, 2012, the U.S. Environmental Protection Agency (EPA) proposed a new rule that would limit emissions to no more than 1,000 pounds of carbon dioxide (CO_2) per megawatt-hour of production from new fossil-fuel power plants with a capacity of 25 megawatts or larger. EPA proposed the rule under Section 111 of the Clean Air Act. According to EPA, new natural gas fired combined-cycle

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power plants should be able to meet the proposed standards without additional cost. However, new coal-fired plants would only be able to meet the standards by installing carbon capture and sequestration (CCS) technology (Peter et al., 2012).

Carbon capture and storage (CCS) is one of a host of technical Rangelands are one of the most widely distributed landscapes in the world. Found at the more arid end of the earth's climates, approximately 30% of the ice-free global land surface can be considered rangeland (FAO, 2009), although estimates vary widely depending on the particular definition used (Lund, 2007). In turn, rangelands are thought to have as much as 30% of terrestrial carbon stocks (FAO, 2009). Because range-land vegetation mediates and constrains the carbon flux from the atmosphere into soils and plants, three major non-exclusive carbon management principles can be identified when rangeland ecological dynamics are considered. First, in rangeland ecosystems carbon flux into plants and soils is low, highly spatially and temporally variable, strongly influenced by stochastic events like weather, and largely outside the control of management. Second, in some rangeland environments, because of limited and slow plant growth, and significant storage of carbon in mineral form close to the surface, management that causes soil loss can significantly increase carbon flux to the atmosphere. Finally, carbon flows and pool sizes may be less variable and more amenable to enhancement through management at the less arid end of the rangeland climate gradient. These principles largely determine the outcome of carbon sequestration strategies in rangelands, and must be considered in assessing the ability to mitigate climate change through rangeland management (Booker et al., 2012).

It has been estimated that grazing lands contribute about 15% of U.S. soil carbon sequestration potential (Lal et al., 2003). U.S. rangeland livestock producers, generally operating with low and variable financial returns, continue to express considerable interest in diversifying income streams to include payments related to carbon sequestration (Diaz et al., 2009). Land management and conservation organizations also seek to promote management for increased carbon sequestration on private and public rangelands (Audubon California, 2012). As the U.S. failed to ratify the Kyoto treaty, the voluntary markets for trading carbon credits have thus far been the main thrust of initiatives for incentivizing management for carbon sequestration domestically. Rangelands have been defined as a type of vegetation, a land use, or what is left when other types are excluded. Definitions of rangeland that include specific uses, usually livestock grazing are not a good basis for stable descriptions of extent or processes.

In the past few decades, it has become clear that the C storage in grasslands has been significantly affected by changes in land-use and various ecosystem management strategies (Lugo and Brown, 1993; Post and Kwon, 2000; Jones and Donnelly, 2004; Billings, 2006; Elmore and Asner, 2006; Liao et al., 2006).

Schlesinger (1990) compiled data on long-term rates of soil organic carbon accumulation in Holocene age soils. He found a slow rate of carbon increase in soil even after thousands of years. Such as he indicates that faster rates of change over short time periods are possible as a result of changes in environmental conditions. Various land-uses result in very rapid declines in soil organic matter (Jenny, 1941; Davidson and Ackerman, 1993; Mann, 1986; Schlesinger, 1985; Post and Mann, 1990).

To assess soil C sequestration in rangelands one must deal with the variability in soils and vegetation at multiple spatial scales ranging from plant community interspaces (Derner et al., 1997) to the landscape. In rangeland ecosystems where environmental conditions support plant growth sufficient for plant competition and other biotic interactions to play a major role in vegetation development, grazing management that leads to increased soil carbon storage by plants, and increased woody and perennial vegetation with extensive root systems, can positively influence carbon sequestration, in scenarios similar to those of other mesic ecosystems. In fact, most information documenting carbon response to grazing is from less arid rangelands (Gilmanov et al., 2010; Conant and Paustian, 2002) and the highest estimates of potential rangeland carbon sequestration (Conant and Paustian, 2002; Ogle et al., 2004; Morgan et al., 2010).

Shifang et al. (2008) study vegetation and soil properties after enclosure and why in the desert steppe Alxa to conclude which was grazing enclosure compared with 2 and 6 year caused a significant decrease in soil organic carbon Nitrogen.

Semi-steppe region is the richest country in the direction of the dominant plant species Artemisia aucheri are the plant has an important role in carbon sequestration. Therefore, to study carbon sequestration capacity in the rangeland with different grazing intensity was investigated.

MATERIALS AND METHODS

Study areas in present study selected in areas with different grazing intensity (low and high intensity) located on rangeland around khoy city (44° 28´ Longitude and 38° 56´ Latitude) of west Azerbaijan Province (Figure 1). Characteristics of the study area are shown in Table 1. Average annual rainfall in the study area is 265/4 mm and average annual temperature is 12/9°C). The lowest and the highest amount of rainfall in the month of May is 125/8 mm. Texture of surface soil of both site was loam-sandy Dominate.

Sample size was obtained 1 m^2 by minimal areas (Derner et al., 1997). It was 1 m^2 in the long term enclosure in both sites. Sample volume was calculated 30 plots per site using statistical method (Bruce et al., 1999). Dominated Species (*Artemisia aucheri)* were selected in order to obtain the aboveground biomass by way of clipping method (Allen-Dias, 1996). Also all roots with diameter (Arzani et al., 2007). Along subsurface biomass were clipped about 200 g from each section including aerial and subsurface biomasses were collected in order to determine the carbon and moisture percentage. Ignition method was used to obtain the convention

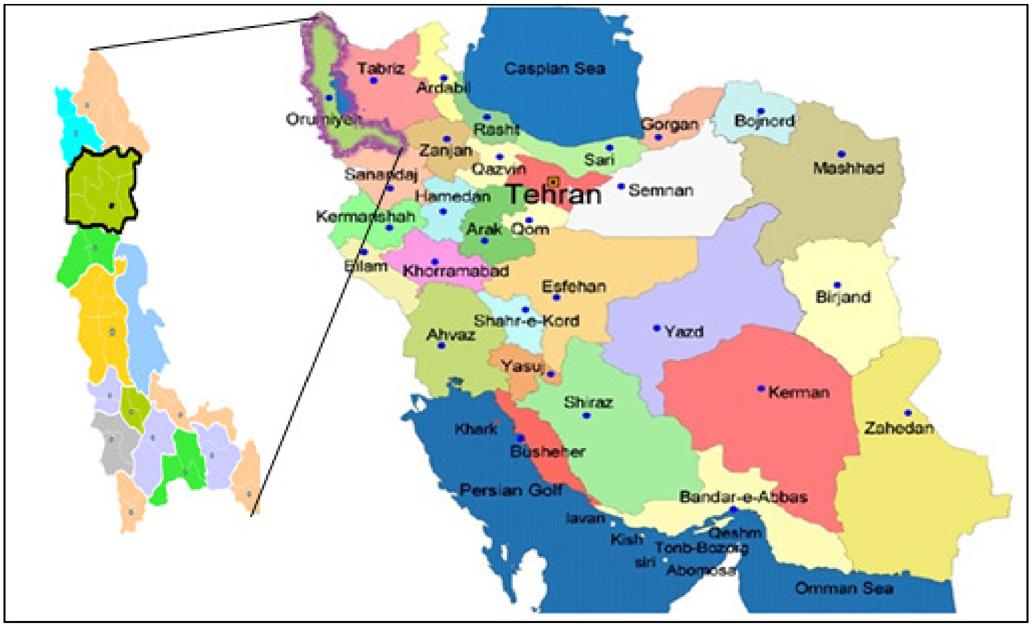

Figure 1. Location of the study area.

Table 1. Characteristics of the study area.

Site	The dominant type of vegetation	Range condition (based on four factor method)	Grazing intensity	Mean canopy area (percent)	The average slope (percent)
1	*Artemisia aucheri*	Average	Low	30	30
2	*A. aucheri*	Weak	High	20	25

factor of carbon sequestration of biomass (Scurlock et al., 2002). The biomasses of species were corrected as "Belowground biomass samples were ground after oven-dried at 40°C for 24 h because some parts of water (moisture) were present in plant material (bulk and chemically bound water) and data are correct. Then, 15 samples were provided from each biomass. Samples were burned by Furnace about 6 h in 600°C (Andrew and Gregory, 2006). Obtained ash, after exiting from oven was setup in desiccators to coot and then it was weighted. The rate of organic carbon (OC) for each biomass was calculated by ash weight, primary weight, and ratio of organic carbon to organic material (OM) (Equation 1). Conversion factor for each organ was calculated by primary weight percentage and percentage of the organic carbon.

$$OC = 0/45 \times OM \quad (1)$$

Soil bulk density measurements are required to calculate a carbon amount from studies that report only carbon or organic matter concentrations (Equation 2).

$$Sc = 100 \times OC \times Bd \times D \quad (2)$$

S.C = organic carbon (ton/ha), O.C = organic carbon (%), Bd = soil bulk density (g/cm^3), and D = study depth (m).

The analysis of data was done by SPSS version 16. In order to investigate and compare the carbon sequestration between different parts of the carbon sequestration places, one-way analysis of variance (ANOVA) was employed. For the purpose of comparison between the carbon sequestrations rate of corresponding biomasses, independent sample t-test and between aboveground biomass and subsurface biomasses for each site, paired t-test were employed.

RESULTS

Vegetation

The average percentage of treatment in site 1 (low Stocking grazing) was 35%, also the average percentage of vegetation in the treatment was calculated as 30% for site 2 (high Stocking grazing).

Aboveground and subsurface biomasses

The average carbon stocks in site1 (low Stocking grazing) regarding biomass sector, aboveground and subsurface biomasses was calculated as 1/18 and 1/15 ton/ha, respectively. Also, the average carbon stocks in site 2 (low Stocking grazing) regarding biomass sector, aboveground and subsurface biomasses was calculated as 0/57 and 0/27 ton/ha, respectively. The results show

Table 2. The amount carbon stock of study area.

	Treatment	Sites	Mean (ton/ha)	Standard error
Carbon stock	Aboveground biomass	Site1	1/18	0/3
		Site2	0/57	0/8
	subsurface biomass	Site1	1/15	0/04
		Site2	0/27	0/2
	Biomass total	Site1	1/17	0/05
		Site2	0/42	0/2
	Soil (0-15 cm)	Site1	15/74	0/06
		Site2	11/36	0/12
	Soil (15-30 cm)	Site1	33/59	0/03
		Site2	24/94	0/03
	Soil total	Site1	24/66	0/06
		Site2	18/15	0/08

Table 3. Comparison of the carbon stock between Aerial, Subsurface biomass and soil of study areas.

Treatment	$t_{statistic}$	df	Sig. (2-tailed)
Aboveground biomass	-2/796	29	0/009
Subsurface biomass	-3/970	29	0/001
Soil	-1/582	29	0/12

Table 4. Estimated Total organic carbon stocks per hectare in study sites

Treatment	Sites	Carbon mean (ton/ha)	Sd
Total ecosystem	1	7/5	12/45
	2	4/7	8/89

that the average total carbon stock in site 1 (low Stocking grazing) of biomass sector is further than site 2 (high Stocking grazing) (Table 2). The results of t-test showed that there are significant differences between biomass carbon stocks (Table 3).

Soil

The rate of average soil carbon stocks in site 1 (low Stocking grazing) in different depths (0 to 15 cm and 15 to 30 cm) calculated 33/59 and 15/74 ton/ha, respectively, also total carbon stock of soil is equal to 24/66 ton/ha (Table 2).

The rate of average soil carbon stocks in site 2 (high Stocking grazing) in different depths (0-15 and 15-30 cm) calculated as 11/36 and 24/94 ton/ha, respectively; also total carbon stock of soil is equal to 18/15 ton/ha (Table 2). The result of t-test showed that there is no significant difference between the two areas of soil carbon stocks (Table 3).

Whole ecosystem

Total organic carbon stocks in the ecosystem including plant biomass and soil in site 1 (low Stocking grazing) and site 2 (high Stocking grazing) were calculated as 7/5 and 4/7 ton/ha, respectively (Table 4).

DISCUSSION

Rangeland carbon sequestration research over the past decay has addressed the effects of management practices on soil carbon dynamics. Management practices such as grazing, nitrogen inputs via fertilization and dibber of nitrogen fixing legumes into rangelands, burning, woody plant encroachment, and restoration of degraded rangelands have been shown to influence soil carbon sequestration.

Carbon and nitrogen storage will decline in the heavily grazed grasslands (Cui et al., 2005; Elmore and Asner, 2006; Han et al., 2008; Steffens et al., 2008). In contrast, some studies have reported that soil carbon storage is higher in heavy grazing sites, mainly because of increased root production in the surface soil that accompanies changes in species composition (Frank et al., 1995; Reeder and Schuman, 2002; Liebig et al., 2006). Soil erosion and deposition can also play an important role in spatial distribution of soil organic carbon. Over long time periods, soil erosion and deposition are responsible for many of the landscape-level differences incarbon sequestration potential. Much of the soil organic C in rangelands is concentrated near the soil surface (Weaver et al., 1935; Gill et al., 1999) where it is more susceptible to loss or redistribution by wind and water. Therefore, sampling points should be spatially distributed based on the relative proportion of erosional and depositional surfaces.

The results showed that the total amount of carbon stock in biomass in site 1 (low Stocking grazing) is smaller than site 2 (high Stocking grazing) (1/17 and 0/42 ton/ha).

The results of other researchers studied proved that crops are most important and most sensitive parts of a range ecosystem that is not directly affected. The combination of livestock grazing on rangeland vegetation, net primary production, compared to root crops and pasture had great influence on the nutrient cycle (Milchunas and Lauenroth, 1993). The highest proportion of carbon sequestration in soil has been allocated to the study site and sake soil carbon in the ecosystem which is the largest carbon storage tank (Abdi et al., 2008; Schuman et al., 1999; Yong zhong, 2007).

The total amount of soil carbon stock in site 1 (low intensity gazing) and site 2 (high Stocking grazing) were calculated as 24/66 and 18/15 ton/ha, respectively. This fact shows that soil organic carbon of low stocking grazing rangeland is more. This indicates a direct role in the reduction because of its indirect role in reducing carbon in vegetation and soil erosion (Su-Young and Zhao, 2003). The results of the study proved that carbon storage declined in the heavily grazed grasslands, and soil acted as a C source. Declines in soil C and N storage under long-term heavy grazing have been reported previously (Cui et al., 2005; Elmore and Asner, 2006; Han et al., 2008; Steffens et al., 2008); Henderson (2004) reported that as a general rule, carbon in the soil is more than carbon in the root biomass (Aradottir et al., 2000).

Total organic carbon stocks in the study area including in biomass and soil parts in site 1 (low Stocking grazing) and site 2 (high Stocking grazing) calculated 7/5 and 4/7 ton/ha, respectively. Zhiming et al. (2012) stated that rangeland ecosystems cover about 50% of land. Also, he demonstrated that soil carbon and nitrogen storage in grassland ecosystem increasingly influenced by better grazing management.

Levels of grazing intensity and frequency of rotation as an effective management tools in rangeland ecosystems will affect carbon storage positively (Bruce et al., 1999). The estimates of soil C storage and rates of carbon sequestration for rangelands are being used by scientists and policymakers to estimate the potential of rangelands to help mitigate the elevated atmospheric levels of carbon dioxide (CO_2). Considerable interest is being generated in terrestrial carbon storage and marketing of stored carbon is being initiated to be used by industry that is emitting CO_2 into the atmosphere. Continued research, data synthesis and modeling will help to further refine estimates of terrestrial carbon storage in rangelands.

The results demonstrated rangeland ecosystem has a potential to enhance carbon sequestration and reduce the problems of climate change. Management practices such as reduction in grazing intensity can increase carbon sequestration potential which resulted in increasing capacity of rangeland carbon sequestration.

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