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Full Length Research Paper

Potential of carbon sequestration in rangelands of central Alborz (Iran)

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Carbon sequestration by rangelands is one of effective strategies, for preventing of climate change. The rangelands of Central Alborz (Iran) are important because of high diversity in plants species. In order to estimate the potential of carbon sequestration in these rangelands, two sites including Kabodno and Peymalat were selected. The carbon sequestration in plant biomass and soil was calculated by Ash and Walkley-Black method, respectively. The results showed that the carbon sequestration on plant biomass is almost double in the Kabodno site than Peymalat site. While the soil carbon sequestration on the Peymalat site is more than Kabodno site. Statistically, there is significant difference ($P_{value}<0.05$) between tow regions with a view to comparison of soil carbon sequestration in 0-15 cm soil depth was observed that statistical difference between two regions are significant ($P_{value}<0.05$), but these differences in depth of 15-30 are not clear. The distribution of the carbon in each item of studied factors showed that soil, aerial phytomass, subsurface phytomass and litter had the highest to the lowest shares of the carbon sequestration in two sites, respectively.

Key words*:* Carbon sequestration, Climate Change, Rangelands, Central Alborz, Kabodno, Peymalat, Iran.

INTRODUCTION

Since the Industrial Revolution is begun, the amount of atmospheric carbon dioxide and other greenhouse gases in earth's atmosphere are strongly increased (Lal, 2004). In the meantime, concentration changes of carbon dioxide from 280 ppm to 367 ppm have been remarkably impressed during 1750 to 1999 AD. Many of the environmental impacts are caused by increased carbon dioxide which is not entirely clear, but main reason for increasing earth's temperature can be considered for this reason (USGS, 2003). Changing in the earth's temperature, many agricultural systems, and all ecosystems are subject to change and ultimately cause to reduce biodiversity, increasing vast of deserts will reduce forests area (Purkhabaz & Purkhabaz, 2002). Therefore, preventing of temperature changes seems imperatively to reduce the carbon dioxide of atmosphere. Although there are different ways to reduce of this gas, biological methods of the carbon sequestration by vegetation and under soil also (CBO, 2007) are simplest, cheapest and the most practical solution ways (William, 2002). Major plant communities in terrestrial ecosystems, include forest communities 28%, rangeland communities 47%, and cropland 15% (Heady, 1975), performs these role as well which rangelands, as one of the widest earth 's dynamic ecosystem, are consequentially considered (Cook & Stubbendieck, 1986). Rangelands contain more than one third of carbon stocks in terrestrial biosphere that although the amount of carbon sequestration in unit area is slight, considering the high vast, these land features are great for carbon sequestration (UNDP, 2000).Despite significant differences in total carbon in rangelands, but the relative distribution of organic carbon is almost constant in rangeland ecosystems (Schuman et al, 2002). In the rangeland ecosystems, the most stocks of organic carbon in soil organic matter are located. Researches, therefore, were introduced that soils are main reservoir of organic carbon in rangeland ecosystem (Aradottir et al, 2000). Iran's rangelands with more than 86 million hectares vast includes 54% of the vital areas of the country and it has a major role in sustainable development (Eskandari et al, 2008) that if it going to proper management, then these areas could sequestrate one billion tons the organic carbon which is equal the worth 20 million tons of oil (UNDP, 2000). Despite the fact that north rangelands of Iran are less in area (three million hectares), focusing on the heights of Alborz mountains, it contains rich plant covers and genetic resources. Hence, it is considered to study the carbon sequestration. Regarding that, study aimed to assess the amount of carbon sequestration in central Alborz rangelands (as in the case of two rangeland sites, including Peymalat and Kabodno sites).

MATERIAL AND METHODS

Study Area Features

This study has conducted in central part of Alborz is called Baladeh that covers total surface is equal to 1300 square kilometers (Fig. 1). Two rangeland sites including Rangeland's Kabodno and Rangeland's Peymalat with details in Table 1 was selected.

On the basis of surveying in two sites, it can be argued that both sites have the rich-dominated flora of grasses which are affected by climate, soil, and topographic circumstances. The Floristic lists on two regions are given in Table 2 and 3 (DNRMI, 2003).

Research Methods

In order to study of vegetation parameters, first of all the area was monitored. Randomly-systematic method was used to obtain sampling from field. Three transects with length 100 m (one transect perpendicularly to the slope and two transects to horizontally slope) were established in each site and along line of each transect, 10 plots were employed to record field data. In order to estimate above-ground biomass, including plant's aerial organs and litter, clipping- weighing method was used. Hence, 25 plants stocks of each species include old and young plants were clipped from 1 cm from soil surface (Mesdaghi, 2004). One soil profile was dug in the direction of each tuft so that all roots with 1 diameter along subsurface phytomass were clipped (Zobeyri, 2000). Soil sampling was carried out from 0-30 cm depth (0-15 and 15-30 cm) (Gao et al, 2007) using random-systematic method concerning to three transects. Totally, soil's samples, 30 from each site, were collected and in order to determine bulk density and percent carbon, they were transferred to the laboratory.

Laboratory and Statistical Analyses

In laboratory, Ash method was used in order to determining of conversion ratio on biomass carbon sequestration (Macdicken, 1997). The aerial, subsurface phytomass and litter species were floured after drying in oven (its model: D-63450 Honou) under 40 degrees Celsius within 15 hours. Then, 10 samples, 2-gram, were provided from each biomass (Birdsey, 2000). Samples were burned by oven (its model: 170B .12 &5 L) about 5 hours in 600 degrees Celsius (Birdsey, 2000). Obtained ash, after exiting from oven, set up in desiccators (its model: GL- Q240) to cool 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) [Relationship No. 1: OC = 0.54 OM] (Birdsey, 2000).

Conversion factor for each organ was calculated by primary weight percentage and percentage of the organic carbon. In order to estimating soil carbon sequestration, the soil samples were primarily dried in the free space and it is then sieved using 2-mm sieve in the library. Measuring of inorganic carbon was done using Walkley-Black method (Nelson & Sommers, 1982) and so in order to calculate percentage of total carbon, bulk density was obtained Hunk method (Macdicken, 1997).

Considering research's objective, variables can be used including mineral layer depth, carbon density and soil bulk density was determined. In order to determining carbon sequestration with scale grams per square meter, formula 2 was used (Zahedi, 2002). [Formula 2: $Cc=1000 \times C\ (\%) \times Bd \times e$].

In this equation, "Cc" is amount of carbon sequestration in unit area (m^2), "C" is percent of carbon density in a certain depth of soil, "Bd" is the soil bulk density according to gram per cubic centimeter and "e" is soil depth according to centimeter.

The collected data was processed in Excel 2003. The analysis of data was done by SPSS V.17. In this study, In order to investigate and compare the amount of biomass and carbon sequestration on plant biomass and soil in two studied sites, independent t-test was used.

RESULTS

Features and Comparison of Soil Surface and Vegetation Cover

An abstracted result of soil surface and vegetation cover's percentage from average of plots' estimation in two sites was given in Table 4. Regarding it, the cover and litter percentages in the Kabodno site and bare soil and grit percentage in the Peymalat is higher.

However, comparing results of measured parameters showed that there is statistical difference between three factors, bare soil, cover and grit at 95 levels in two sites, while this difference between litters is not observed.

Above and Below- Ground Biomass

The results of estimating and comparing amount of plant biomass showed that aerial phytomass, subsurface phytomass, and litter in Kabodno site are more than Peymalat site.

Despite significant difference of amount aerial phytomass and subsurface phytomass in 95% level in two sites, it is not observable between amounts of litter in the two sites (Fig. 2).

Figure 1: Location of the study area in Iran regional map

Table1: Study area features

Specifications & Site	Rangeland's Kabodno	Rangeland's Peymalat
Longitude	51˚ 15´ to 51˚ 20´	52˚ 3´ to 52˚ 4´
Latitude	36˚ 4´ to 36˚ 7´	36˚ 8´ to 36˚ 10´
Rangeland's area (He)	780	303
Grazing capacity (A.U/3M)	1660	920
Range condition	Good	Moderate
Annual rainfall (MM)	398	293
Altitude from free sea level (M)	2980	2800
Temperature Maximum (C˚)	30	18.4
Temperature Minimum (C˚)	-15	-4.8
Texture soil	Clay- Sandy	Clay- Sandy
General slope (P)	40	35

Determination and Comparison of the Conversion Factor to Organic Carbon

Table 5 describe a brief results from determination the coefficients into average conversion factor of plant species to organic carbon in the two rangelands. It also shows that the conversion factor of aerial, subsurface phytomass and litter in Kabodno site is more than Peymalat site and significant difference in 95% level, that litter was related amount highest in the carbon sequestration. The organic carbon of plant biomass is calculated by equation No.1 individually.

Determination and Comparison of Carbon Sequestration in Phytomass and Litter

The results of estimating of total carbon sequestration which obtained from conversion ratio of plant organs generalized to organic carbon in plant biomass in the two study areas, have given in Figure 3. Results confirms that the total amount of carbon sequestration in aerial, subsurface phytomass and litter in Kabodno rangeland than in Peymalat rangeland has increased, that the aerial phytomass is allocated carbon per unit area.

Determination and Comparison of the Amount's Soil Carbon Sequestration

The soil carbon sequestration in 0-15 cm depth in the Peymalat site is more than Kabodno site (Table 6) and the mean's value results indicate significant differences in 95% level, while this difference are not observed in depth of 15-30 cm in two rangelands. It, however, is observed between 0-15 and 15-30 depth in each site. Wholly, the results showed that the total amount of soil carbon sequestration in Peymalat rangeland is more than Kabodno rangeland.

Total Carbon Distribution in the Study Areas

From total amount of carbon sequestration in Kabodno site, portion of carbon in aerial phytomass is 403.34 g/m² (8.31%), it is 357.06 g/m² (7.36%), 68.88 g/m² (1.42%), and 4023 g/m² (82.91%) for carbon in subsurface phytomass, litter, and organic carbon in soil, respectively. Also from total amount of carbon sequestration in Peymalat range, the portion of carbon in aerial phytomass is 203.19 g/m² (3.94%). It also is 162.69 g/m² (3.15%), 54.04 g/m² (1.05%), and 4744 g/m² (91.86%) for carbon in subsurface phytomass, litter, and organic carbon in soil, for Peymalat site, respectively. Therefore, the soil and litter have the highest and lowest share of the total carbon sequestration in the study (Figures 4 and 5).

DISCUSSION AND CONCLUSION

Table2: Floristic list of the study area (Rangeland's Kabodno)

Species	Family	Form life
Festuca ovina L	Poaceae	Perennial grass
Festuca spectabilis Jan	Poaceae	Annual grass
Bromus tomentellus Boiss	Poaceae	Perennial grass
Agropyron desertrum (Fisch) Schultes	Poaceae	Perennial grass
Agropyron pectiniforme Roemer	Poaceae	Perennial grass
Hordeum fragile Boiss	Poaceae	Perennial grass
Poa bulbosa L	Poaceae	Perennial grass
Lolium persicum Boiss &Hohen	Poaceae	Perennial grass
Stipa caragana Trin	Poaceae	Perennial grass
Dactylis glomerata L	Poaceae	Perennial grass
Achillea santolina Wilh C.Koch	Compositeae	Perennial forb
Senecio vulgaris L	Compositeae	Perennial forb
Stachys byzanthina C.koch	Labiateae	Perennial forb
Artemisia sieberi Besser	Compositeae	Shrub
Onobrychis cornuta (L) Desv	Papilionaceae	Shrub
Thymus persicus (Ronniger ex Rec)jalas	Labiateae	Shrub
Medicago sativa L	Papilionaceae	Perennial forb
Echinops rubustus Bunge	Compositeae	Perennial Forb
Salvia staminea Montbr & Auch	Labiateae	Annual forb
Galium verum L	Rubiaceae	Perennial Forb
Granium persicum Schonbeck- Temesy	Poaceae	Perennial grass
Ferulla macrocolea Boiss	Umbelliferae	Perennial Forb
Acanthophyllum glandulosum Bung	Caryophyllaceae	Shrub

Table3: Floristic list of the study area (Rangeland's Peymalat)

Species	Family	Form life
Festuca ovina L	Poaceae	Perennial grass
Festuca maritime L	Poaceae	Perennial grass
Bromus tomentellus Boiss	Poaceae	Perennial grass
Bromus tectrum L	Poaceae	Annual grass
Bromus briziformis Fisch& C.Mey	Poaceae	Annual grass
Agropyron trichophorum (link) *Melica persica* Kunth	Poaceae	Perennial grass
Poa bulbosa L	Poaceae	Perennial grass
Achillea santolina Wilh C.Koch	Poaceae	Perennial grass
Achillea filipendola Lam	Compositeae	Perennial forb
Senecio vulgaris L	Compositeae	Perennial forb
Plantago ovata Forssk	Compositeae	Perennial forb
Dianthus persicus Hausskn	Plantaginaceae	Perennial forb
Stachys byzanthina C.koch	Canyophilaceae	Perennial forb
Stachys inflate Benth	Labiateae	Perennial forb
Artemisia aucheri Boiss	Labiateae	Perennial forb
Onobrychis cornuta (L) Desv	Compositeae	Shrub
Thymus trauvetteri Klokov	Papilionaceae	Shrub
Thymus kotschyanus Boiss & Hohen	Labiateae	Shrub
Medicago sativa L	Labiateae	Shrub
Echinops rubustus Bunge	Papilionaceae	Perennial forb
Centaurea iberica Trev. Ex Spreng	Compositeae	Perennial Forb
Tragopogon kotschi Boiss	Compositeae	Perennial Forb
Marrubium astracanicum Jacq	Compositeae	Perennial Forb
Phlomis persica Boiss	Labiateae	Perennial forb
Galium verum L	Labiateae	Perennial Forb
	Rubiaceae	Perennial Forb

Researchers have shown that grazers are one of the most effective factors upon ground cover (Alizadeh et al, 2010; Su et al, 2003). Thus, a higher stocking rate in the Peymalat site was caused to decrease the percent of live vegetation cover and litter and increase the bare soil while this ratio in Kabodno site was vice versa to other site.(stocking rates were 0.57 and 0.33 per hectare in Kabodno and Peymalat sites, respectively). Overgrazing in the Peymalat range was decreased the plant biomass per unit area than to Kabodno site. Su et al (2003) also

Table4: The features and comparison of soil and ground cover

Site	Bare ground (%)	Vegetation cover (%)	Litter (%)	Grit (%)
Kabodno	5.3	85.2	6	3.5
Peymalat	14	76	4	6

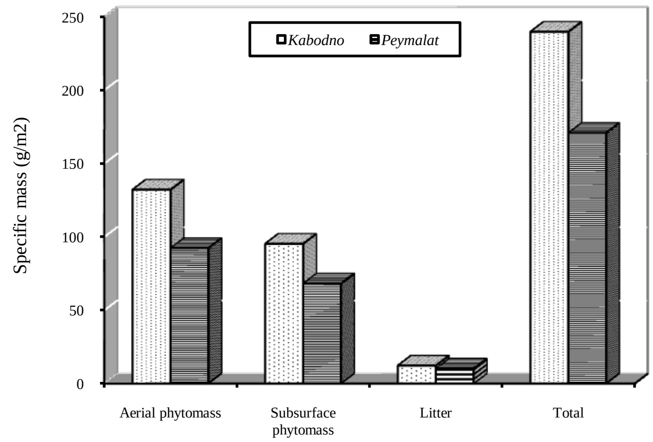

Figure 2: The amount of biomass in two areas

Table5: The amount's average and comparison of conversion factor of phytomass and litter to the organic carbon in the two areas (G)

Site	Kabodno		Peymalat		Sig.(2-tailed)
	Mean ± S. D	F	Mean ± S. D	df	
Aerial phytomass	0.07 a± 0.305	0.42	0.05 b±0. 219	18	0.01*
subsurface phytomass	0.02 a±0.374	0.73	0.03 b±0.238	18	0.00*
Litter	0.03 a± 0.560	16.64	0.01a± 0. 526	18	0.01*

Note: Uncommon alphabet in each row and * symbol presents that there is difference between them (p-value< 0.05)

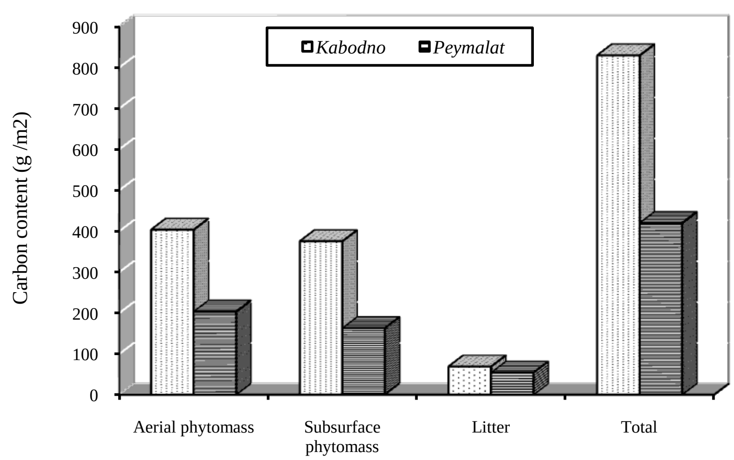

Figure 3: The amount of carbon sequestration on phytomass and litter in two areas.

believe that grazing livestock is one of the main effective factors on vegetation cover. Reducing litter in the Peymalat range is caused by higher stocking rate and movement of livestock in rangeland. It also causes physical crush in this site. Consequently, litter decomposition is also less than other site that Reeder & Schuman (2002) have pointed out similar results. The carbon sequestration in plants is carried by the various organs during the process of photosynthesis, so that is said whatever plants are woody; then wooden organ will

Table6: The amounts soil carbon sequestration in the two areas

Site	Soil depth (cm)	Density carbon (%)	Bulk density (gr/cm³)	Mean's carbon sequestration ± S.D (kg/m²)	Sig.(2-tailed)
Kabodno	0-15	2/211	1.189	3.943 ± 0.30	0.00*
Peymalat	0-15	3.131	1.155	5.424 ± 0.36	
Kabodno	15-30	1.812	1.322	3.593 ± 0.36	0.18
Peymalat	15-30	1.613	1.401	3.389 ± 0.29	

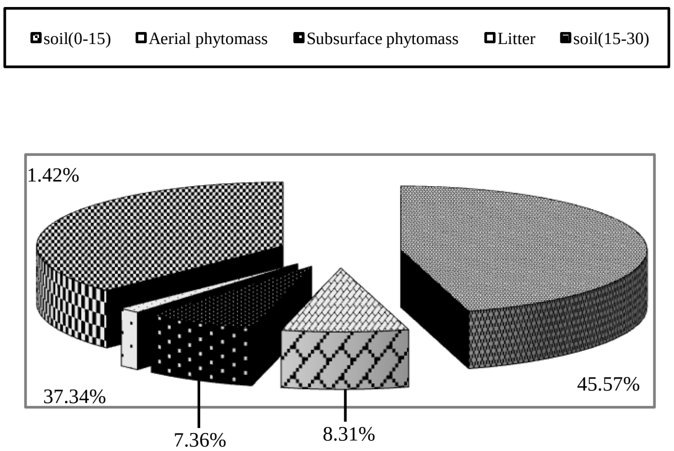

Figure 4: The distribution of carbon sequestration in rangeland's Kabodno

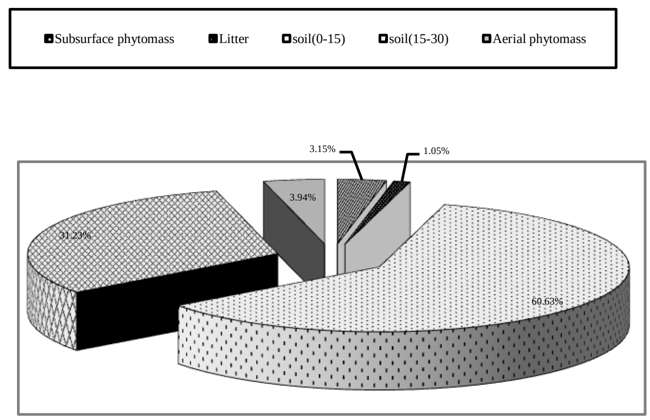

Figure 5: The distribution of carbon sequestration in rangeland's Peymalat

has higher carbon sequestration rates (UNDP, 2000). This study also showed that litter has the highest amount of carbon reservation, and totally plant species in Kabodno rangeland have more carbon sequestration than Peymalat rangeland. Although the most species in each site is grasses, decreasing of humidity in Peymalat site is caused to make the organs of grasses to firm and woody condition. Hence, this site has less carbon sequestration than the other site. Finer (1996) have reported same results in their study. Comparison results of total amount of the carbon sequestration on plant biomass from conversion ratio in two sites showed that the Kabodno site has almost double amount of the carbon sequestration than the Peymalat site. It is because of higher stocking rate in Peymalat rangeland which overgrazing reduces the rate of alive vegetation and decreases the photosynthetic organs as well as difference in plant community composition and environmental conditions are different in rainfall, temperature and so on in two sites. Schuman et al (2002) also pointed out to such same cases. This study showed that a part of main carbon sequestration has occurred in soil's these two sites that Aradottir et al (2000) have reported same consequence. The amount of carbon sequestration in the first depth (0-15 cm) of soil in the Peymalat site was more than Kabodno site and it was too observed significant statistical difference between them. These results are caused by the high density of litter in first depth of soil; more movement of livestock in Peymalat rangeland, and following the faster decomposing of litter with soil. This process is ongoing with less speed in Kabodno site. Frank et al (1995) achieved such outcomes. Finally, the distribution of carbon in the two site showed that differences in the amount of carbon sequestration in each of the studied parameters in both site; the distribution of carbon is stabled in each site that it fits with results of Schuman et al (2002). The main part of carbon sequestration has been on soil, then aerial phytomass and subsurface phytomass and ultimately to the least's amount on litter in two sites. So we can confidently state that soils are considered the main sink of organic carbon in the rangeland ecosystems. Thus, erosion process is causing loss of the soil carbon (McCarty & Ritchie, 2000) and any biological and mechanical activities can be caused the soil degradation which vegetation is definitely a positive step of soil treatment and sequestrate the carbon in soil (Izaurralde et al, 2007).

Increasing of the carbon sequestration can be balanced by increasing of the plants biomasses and productions which it is improving soil fertility, increasing soil water holding capacity and preventing water and wind erosions. So that the rangelands of central Alborz in Iran (with mean carbon sequestration nearly 5000 g/m²) can also optimize utilization and extract enough forage in these area. Consequently, the carbon sequestration can be considered an important factor in environment as sustainable development’s indicator.

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