Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 2, p. 244-250, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Estimation of carbon sequestration and micronutrient in oak high forest soils

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Article published on August 09, 2014

Key words: Carbon Sequestration, Micronutrient, Oak High Forest, Ilam Province.

Abstract

The main challenge of modern world, especially in arid and semi- arid regions, is climate warming due to green house gases. With regard to the role of forests in decreasing green house gases (by means of carbon sequestration), this study was done about oak high forests in Dalab region of Ilam province. 30 soil samples (combined sample) were collected from canopy and under canopy in order to measure carbon sequestration from two depths 0- 15 and 15- 30 cm as random- transect. Also, some of most important features of soil, including acidity, bulk density, and EC (Electrical conductivity), organic carbon, total nitrogen, absorbable phosphorous and exchangeable potassium, were measured in laboratory. Results showed that the value of carbon sequestration in 0-15 cm layer (46.18 ton/ ha) is significantly more than 15-30 cm layer (40.5 ton/ ha) whereas its value had not so difference in under and out of canopies. Pearson correlation results suggested a significant and positive difference among organic carbon, EC, nitrogen and potassium with soils carbon sequestration and negative relationship with soil acidity. With regard to so many benefits of carbon sequestration and also Iran membership in the Climatic Changes Convention, it is necessary that by means of managing, conserving and recovering forests to make a positive step toward reducing the density of atmospheric carbon, consequently reducing global warming.

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Introduction

Forest ecosystems represent a major sink for atmospheric C (Schimel *et al*, 2001) and Mediterranean and temperate forests play an important role in global C cycling and in C sequestration (Dixon *et al*, 1994; Peng *et al*, 2008). On the other hand, elevated CO_2 could increase forest growth; according to Norby *et al.* (2005), the net primary production of forests increased significantly due to elevated CO_2 in the atmosphere.

Nowadays, increasing greenhouse gases, in subsequent, global warming has so many negative effects on marine and dry ecosystems and become one of main challenges of sustainable development. Utilizing natural resources and increasing forest level through afforestation in almost countries is considered as one of effective procedures to reduce greenhouse gases also considered and regarded in various global environmental associations (Paul *et al*., 2002). Due to producing oil and its products, Iran has a major share to produce pollutants indirectly, e.g. CO_2 in global scale. Today, carbon refinement by artificial method, like filtering, needs a huge cost. As USA estimated 100- 300 $ per ton of carbon (Cannel, 2003).

Carbon sequestrated in forest ecosystem is main fraction of global carbon, as its vegetation would form about 82- 86% carbon above soil forest soils contains about 70- 30% of organic carbon available is soil (Wang *et al*., 2012). Therefore, forest ecosystem affect on the absorption of atmospheric CO_2, also provide proper conditions to rotate carbon and its conservation in soil (Lal, 2005). In order to reduce atmospheric CO_2 and make a balance in greenhouse gases content, carbon must be absorbed and sequestrated in various forms. Carbon sequestration means to change atmospheric CO_2 as carbonic organic combination by plants and its capturing for a determined period (Loal, 2004). By growing trees in forest and by passing time, carbon would be conserved in phloem tissues and organic matters, in soil. The capability of carbon sequestration is different based on plant variety, location and management method. Singh *et al.* (2013) stated that the soil carbon of an ecosystem is determined by the quality and quantity of biomass additions and its loss through decomposition. The role of carbon accumulation or loss from soil is determined by the quantity of recyclable biomass-carbon, temperature, rainfall, soil moisture content and disturbances.

Chen *et al.,* (2012) have assessed the effect of arable pasture in 7, 12 and 25 years periods on the conservation of organic carbon in damaged sandy semi- arid regions in china and concluded that arable pasture resulted in soil's carbon sequestration. Turner & Lamber (2000) observed lowest value of surface organic carbon in the soil covered by pinions compared to neighboring old tree coverage of Eucalyptus. They concluded that the value of conserved organic carbon value in different depths of soil showed difference daring 20- years' stabilization of tree coverage in the considered region. Shaabaniyan *et al* (2010), by studying and comparing diversity of broad- leaf varieties (European ash and acacia) and softwood species (cypress and red cedar) in Dooshan region of Sanandaj province of Iran concluded that highest value of organic carbon is observed in broad-leaf afforestation. The importance and role of forests in recovering a significant share of compressed materials by humans has illustrated the necessity of studies in the context of absorbing contaminants, including CO_2 more than ever.

During recent decades, studies of the carbon sequestration of forest ecosystems have became more actual, mainly in connection with the global increase of CO_2 in the atmosphere. But the potential of Persian oak for C sequestration in soils is poorly studied. With regard to the importance of carbon sequestration in global level, various researches have been performed in recent years in the context of carbon sequestration in forest regions, afforestation masses and urban forests in various regions. But, unfortunately, scarce research has been done in Iran. Therefore this research was done with the purpose of estimating the

value of sequestrated carbon in oak high forests and understanding the importance of these forests in regard to air filtration, absorption of atmospheric CO_2 and preventing soil erosion.

Materials and methods

Study Area

This research was done on a section of Zagros forests located in 8 km eastern Ilam County, in a forest region called Dalab that is considered as one of protected regions in Ilam province, Iran. Considered region is located in 46° 22' 15" to 46 ° 25' 27" eastern longitude and 33° 41' 01" to 33 ° 43' 13" northern latitude on cold semi- arid. Average annual temperature and precipitation were 16.9 ° C and 525 mm, respectively.

Methodology

In considered forest region, 10 trees were selected by random transact method and mixed soil samples in under and out of canopies were removed from both 0-15 cm and 15- 30 cm depth. Totally 30 soil samples were removed from 0-15 and 15-30 cm depth from under and out of canopy. Soil samples were dried in ambient temperature for 24 hours, after powdering, screened from 2 mm sieve and the following features in laboratory, soil texture by Hydrometric method, EC in saturated mud essence by using electronically EC meter, soil acidity by using saturated mud through electronically PH meter, bulk density by column method, soil organic material by means of Walky Block method, absorbable potassium by using Acetate Ammonia by using Flame photometer system, absorbable phosphorous by Olsson method and spectrophotometer and exchangeable potassium by using Acetate Ammonia. Finally, the rate of carbon sequestration obtained in soil samples by using the following formula:

$$Cc\ (kg/\ m2) = 10000*C\ (\%)*BD*e$$

Where C: the extent of carbon density (%), BD: bulk density (g/cm3), e: thickness of soil layer (cm) and Cc: extent or rate of carbon sequestration (kg/m2).

Statistical methods

Finally, after entering data by SPSS software and considering the normality of frequency distribution of variables by Kolmogrov-smirnov. ANOVA (one-way variance analysis) was used to compare considered features also Duncan test to compare multiple means.

Results

Carbon sequestration Means in Oak High forest

With regard to table 1 results, values of carbon sequestration in two situations (under and out of canopy) and depth 0-15 cm is more than 15- 30 cm. also, con-sequestrated carbon value out of canopy in both depths is more than its value under canopy. Table 2 shows the mean value of soil's carbon sequestration (± standard deviation) in oak high forest in considered depths. As observed in this table, totally it could be said that sequestrated carbon mean in the 30 cm above soil surface is 58.8 ton/ ha.

Comparison the Extent of carbon sequestration in surface unit

The results of variance analysis (ANOVA) showed that carbon sequestration is different significantly in considered mass (table 3). Based on results of Duncan test grouping, carbon sequestration value out of canopy in 0-15 cm depth is highest (47.98 ton/ ha), And is least (39.91 ton/ ha) under canopy in depth 15-30 cm. Also, whole samples were classified in two different groups (table 4).

Table 1. Statistical summary for carbon sequestration values in soil depths.

Depth of soil (cm)	Position	Organic carbon (%)	Carbon sequestration (ton / ha)
0-15	Under canopy	3.73	44.35
	Out of canopy	3.45	47.98
15-30	Under canopy	2.67	39.81
	Out of canopy	2.56	41.09

Table 2. Average of carbon sequestration (± SD) in oak high forest.

Depth of soil (cm)	Organic carbon (%)	Carbon sequestration (ton/ha)
0-15	3.64	45.56 (±4.83)
15-30	2.63	40.24 (±4.09)
0-30	6.27	85.8 (±4.68)

Table 3. The results of variance analysis in related to carbon sequestration in sub-canopy and outside canopy.

Source of variation	sum of squares	df	Mean-square	F	Sig
between groups Variances	256.308	3	85.436	4.273	0.014*
Within-group variance	519.836	26	19.994		
Total variance	776.14	29			

*Significant at 5% level

Table 4. Duncan's test for carbon sequestration comparison between two depth soil.

	Significant at 95%	
Samples	**1**	**2**
Out of canopy - Depth 15-0	47.98a	
Under canopy - Depth 15-0	44.37a	
Out of canopy - Depth 30-15		41.09b
Under canopy - Depth 30-15		39.91b
Significant level	0.152	0.960

Comparing carbon sequestration under and out of canopy

The results of comparing mean values by Duncan method in relation to soil carbon sequestration showed that there is on signification difference between under and out of canopy level 95%. In both depths the value of carbon sequestration out of canopy is more than under canopy (Fig 1). But the value of carbon sequestration in both considered depth has a signification difference at 95% level (Fig 2).

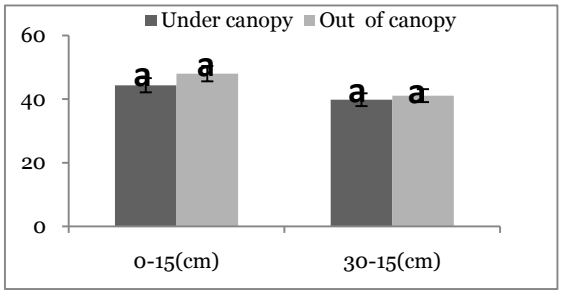

Fig. 1. Comparison of carbon sequestration under and out of canopy of trees.

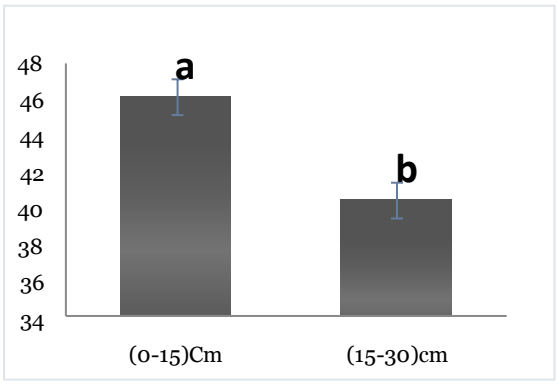

Fig. 2. Comparing carbon sequestration in the both depth.

Mean of some measured characteristics of soil

In table 5, means of some measured characteristics of soil in considered region are presented. The results show that values of under canopy have been more that out of canopy (table 5). Pearson correlation test results showed a positive significant relationship among organic carbon, total nitrogen and EC (Significant at 1% level) and exchangeable potassium (Significant at 5% level) with carbon sequestration. It was not observed a relationship between carbon sequestration and absorptive phosphorous (table 6).

Table 5. Mean of some characteristics of soil.

	Under canopy		Out of canopy	
Characteristics	0-15	15-30	0-15	15-30
Organic carbon (%)	3.73	2.67	3.45	2.56
Total nitrogen (%)	0.32	0.23	0.30	0.22
Phosphorus	154.68	105.09	111.39	93.94
Exchangeable potassium	532	361	528	220
Acidity	7.20	7.56	6.81	7.31
Electrical conductivity	0.76	0.53	0.99	0.49
Bulk density	0.79	0.99	0.93	1.07

Table 6. Pearson correlation coefficient (correlation between soil parameters and soil carbon sequestration).

Soil parameters	OC (%)	EC	PH	N (%)	P	K
Correlation coefficient	0.609**	0.484**	-0.523**	0.464**	0.099	0.422*
sig	0.000	0.007	0.030	0.000	0.604	0.020
N	30	30	30	30	30	30

** Significant at 1% level, *Significant at 5% level

Discussion

Absorbing carbon by forest soils and reducing green house gases is a procedure to prevent global warming. Results of this research showed that cased to sequestrate significant values of carbon in soil. Carbon sequestrated in oak high forest was about 86.62 ton/ ha. These values in 0-15 and 15-30 cm depth were 46.17 (53.30%) 40.45 (46.70%) ton/ha, respectively. As observed carbon sequestration value in present research and other Schuman *et al.,* (2002). Owliaiee *et al.,* (2009) in first layer is significantly more than second layer, it reason is high accumulation of foliage and organic matter on soil surface, subsequently, increasing organic carbon that has a direct relationship with carbon sequestration.

In this research, the value of carbon sequestration out of canopy is more that under canopy, its reason is scarcity of annual plant coverage percentage under canopy in relation to out of canopy, region gradient and presence of animals that caused to transfer foliage and plant organs far away from tree. These results have similarities to results obtained from Schuman *et al*., report in 1999, but it is in contrary to Alizadeh *et al*., (2011) results performed on.

Also, results of Pearson correlation test showed a positive significant relationship among organic carbon, total nitrogen and EC (probability level 99%) and exchangeable potassium (95%) and carbon sequestration in soil. It was not observed any relationship between carbon sequestration and absorptive phosphorous. It is apparent that soil PH changes caused changes in nitrogen absorption, microorganism's activity and feeds taking by trees, also the value of soil carbon. Acidity and nitrogen are most important indices effective on the organic carbon in this regard.

Some researchers have referred to relationship between carbon and nitrogen (Pussince, 2002), carbon and acidity (Skullberg, 1991) also carbon and soil texture (parrot *et al*., 1987), Skullberg *et al.,* (1991) by studding PH changes in various soil layers concluded that PH would have a significant relationship with organic carbon. Another result was to consider acidity and soil EC. The means of both variables showed a significant difference under and out of canopy in 0-15 cm depth. Totally in could be said that due to less bleaching there is better conditions under canopy. Bulk density increased by increasing soil depth, its main reason is the reduction of carbon by soil depth or weight of upper layers. Also, soil density in out of canopy is more than under canopy.

Refining atmospheric carbon by means of artificial methods burdens a huge cost, as estimated about 100- 300$ in U.S.A (Canel, 2003). If mean cost per ton computed 200$. The economic value of carbon sequestration in oak high forest is 17324$.

Finally it could be said that present research indicated that through the least treatment and protection, western oak high forest have a great effect on carbon content in soil, therefore, soil erosion resulted in carbon loss. With regard to this fact that soil erosion is one of main concerns of these forests, every biological and mechanical practice preventing soil and vegetation degradation, undoubtedly, is a positive step toward managing carbon sequestration. In general, carbon sequestration may be regarded as an added-value besides other values and benefits of

forest ecosystem, also as an index to assess the sustainability of natural resources.

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