Downloaded from www.jusres.com

ISSN No. 2455-5800
Journal of Scientific Research in Allied Sciences
Original Research Article

STATUS OF SEQUESTERED ORGANIC CARBON IN THE SOILS UNDER DIFFERENT LAND USES IN CENTRAL REGION OF HARYANA, INDIA

M. K. Gupta*, Vijendra P. Panwar and Manoj Kumar

**Scientist – F & Head (Retd.)*
Forest Soil & Land Reclamation Division
Forest Research Institute, P.O. New Forest, Dehra Dun (Uttarakhand)

Article history:
Submitted on: March 2017
Accepted on: April 2017
Email: info@jusres.com

ABSTRACT

A study was undertaken in Central Haryana comprising Jhajjar, Karnal, Panipat, Sonipat and Rohtak districts to estimate SOC stock under different forests covers available there as well as in other different land uses *viz.* block plantations, horticulture, agroforestry and agriculture. In central region of Haryana, Maximum SOC stock was under forests (37.17 t ha^{-1}) followed by plantation (27.04 t ha^{-1}), horticulture (26.28 t ha^{-1}), agroforestry (26.08 t ha^{-1}) and the least SOC stock was under agriculture land use (20.39 t ha^{-1}). Subset for $\alpha = 0.05$ indicate that forest stands separately (a), plantation, horticulture and agroforestry were statistically at par therefore, grouped together (b) while agriculture stand separately (c). SOC stock under forests was 37.46 %, 41.44 %, 42.52 % and 82.30 % higher as compared to plantation, horticulture, agroforestry and agriculture land use respectively. Total organic carbon stocks in the soils under forests in five districts comprising the central region of Haryana had 1.07 million tons. Out of these, Karnal district has the maximum SOC stock (409720.40 t) followed by Sonipat (258668.85 t), Panipat (156488.42 t), Rohtak (139336.02 t) and the least SOC stock was in Jhajjar district (10.5910.59). Total SOC stocks under horticulture in five districts comprising the Central region of Haryana had 191303.85 tons. Out of these, Karnal district has the maximum SOC stock (63833.64 t) followed by Sonipat (41243.02 t), Jhajjar (38109.40 t), Panipat (24653.47 t), and the least SOC stock was in Rohtak district (23464.32 t). Organic carbon stock in the soils under Bhindawas Wildlife Sanctuary was 12481.86 tons and in Khaparwas Wildlif Sanctuary was 2313.96 ton. Total

Downloaded from www.jusres.com

organic carbon stock in the soils in wildlife sanctuaries situated in central region of Haryana, was 14795.82 tons.

KEYWORDS: Soil organic Carbon, Carbon Sequestration, Land Uses, Forests, Plantations, Agriculture, Horticulture

INTRODUCTION

Carbon enters the soil as roots, litter, harvest residues, and animal manure. It is stored primarily as soil organic matter. However, in many areas, agricultural and other land use activities have upset the natural balance in the soil carbon cycle, contributing to an alarming increase in carbon release [1,2]. Absorbing CO_2 from atmosphere and moving into the physiological system and biomass of the plants, and finally in to the soil is a practical way of removing large volume of the major green house gas (CO_2) from the atmosphere in to the biological system. Thus, the carbon is sequestered in to the plants and then from the plants to the animals. Eventually, after the death of animals, the detritus decomposed in to the soil organic carbon by microbial activities. This sequestered carbon finally act as Sinks in the forest land [3]. Today, afforestation is considered an option to reduce the concentration of atmospheric carbon dioxide by increasing carbon sequestration in tree biomass and soils [4,5,6]. The reductions in concentration of CO_2 in the atmosphere can be achieved either by reducing the demand for energy or by altering the way the energy is used, or by increasing the rates of removal of CO_2 from the atmosphere through growth of terrestrial biomass (*e.g.* forests). According to Winjum *et al*., [7] the most promising management practices for CO_2 mitigation are reforestation in the temperate latitudes, and agroforestry and natural reforestation in the tropics. The 1997 Kyoto Protocol to the climate convention recognizes that drawing CO_2 from the air into the biomass is the suitable and low cost practical way for mitigation of the gas from the atmosphere.

Deforestation, burning of biomass, cultivation on soil, also enhances mineralization of SOC and release of CO_2 in to the atmosphere. Thus land use history has a strong impact on SOC pool. The soil carbon sequestration is a truly win-win strategy. It restores degraded soils, enhances biomass production, purifies surface and ground waters, and reduces the rate of enrichment of atmospheric CO_2 by offsetting emissions due to fossil fuel [8]. Land use and land cover change and agricultural practices contribute about 20% of the global annual emission of carbon dioxide [9].

More accurate estimates of global or continental CO_2 emission from land use/ cover change can only be obtained from extrapolation of reliable local estimates [10]. No systematic

Downloaded from www.jusres.com

study was undertaken to estimate the SOC stock in forests and other land uses by following uniform methodology for field and laboratory work in Haryana state**.** Present study was undertaken in Central Haryana comprising Jhajjar, Karnal, Panipat, Sonipat and Rohtak districts to estimate SOC stock under different forests covers available there as well as in other different land uses *viz.* block plantations, horticulture, agroforestry and agriculture as per the IPCC guidelines.

MATERIALS AND METHODS

The most prudent approach to study SOC, however, would be on a unit area basis for a specified depth interval which requires information on the spatial distribution of soil types, SOC and bulk density of soils. It would thus provide a better understanding of the terrestrial reservoir of SOC far beyond the general objectives of C sequestration in soils and the detrimental effects of global warming [11]. Topsoil is very sensitive to human disturbance under the changing climate. Estimates of topsoil soil organic carbon (SOC) pool may be crucial for understanding soil carbon dynamics under human land uses and soil potential of mitigating the increasing atmospheric CO_2 by soil C sequestration [12]. SOC is concentrated in the upper 12 inches of the soil. Thus it is readily depleted by anthropogenic (human-induced) disturbances such as land-use changes and cultivation [13,14]. The soil organic carbon stock therefore, was estimated up to the depth of 30 cm in this study.

Study was conducted in central region of Haryana comprising Jhajjar, Karnal, Panipat, Sonipat and Rohtak districts in five land uses *viz.* forests, plantations, horticulture, agriculture and agroforestry. Under forests land use, Soil Organic Carbon stock was estimated in available forest covers *i.e.* miscellaneous forests. Under plantation land use SOC stock was estimated in eucalyptus, shisham and *Ailanthus* block plantations. Under horticulture land use SOC was estimated in guava, mango, aonla, kinnu and ber orchards, which was available in this district. SOC was also estimated under agroforestry *viz*. polpar – wheat, poplar – sarsoo, eucalyptus – wheat and wheat - shisham models. In total 1,029 soil samples from all the land uses were collected. Soil samples were collected for organic carbon estimation, bulk density and coarse fragment estimation from different forest covers, horticulture, plantations and agroforestry. In each district, three ranges were selected and in each forest range, three blocks were selected randomly. Therefore, statistically, two stage sampling was done in which first stage unit *i.e.* forest range have been selected and second stage unit *i.e.* sampling sites randomly selected in three blocks of each range. At each sampling site, an area of about ½ km were covered and collect five soil samples from this

Downloaded from www.jusres.com

area for soil organic carbon estimation and two separate samples were collected for bulk density and coarse fragment estimation. It was ensured that sampling points typically represent the study area. Over all, one hundred and forty seven numbers of sampling sites (one thousand and twenty nine soil samples) were selected in all land uses in northern Haryana. Variation in the number of samples was due to difference in area available under particular land uses. Details of the sites from where soil samples were collected in different ranges and numbers of sample collected are presented in Table 1 and sampling points are depicted in Fig. 1.

Latitude, Longitude and altitude of each sampling site were recorded by GPS. Forest floor litter of an area of 0.5m x 0.5 m, at each sampling point was removed and a pit of 30 cm wide, 30 cm deep and 50 cm in length was dug out. Soil from 0 to 30 cm depth, from three sides of the pit, scraped with the help of Kurpee and this soil mixed thoroughly. Kept the soil in a polythene bag and tightly closed with thread with proper labeling. In the laboratory, samples were air dried and after drying the samples, grind it and sieve it through 100 mesh sieve (2 mm sieve). This sieved sample used for soil organic carbon estimation. Soil organic carbon was estimated by standard method [15].

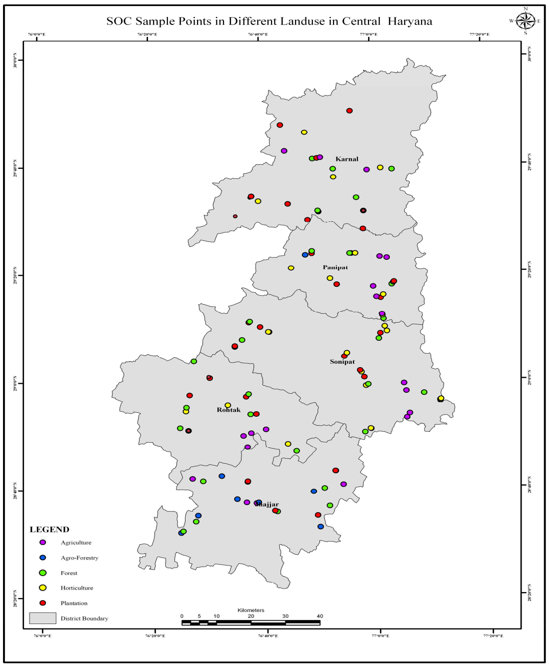
Amount of coarse fragments were estimated in each sample collected from different forests and deducted from the soil weight to get an accurate soil weight per ha basis and soil organic carbon estimation. BD is a very important soil parameter and is necessary to convert organic carbon (OC) content per unit area [16]. Bulk density of every site was estimated by standard core method [17]. All the methods used in this study are in accordance to [18] Ravindranath, and Ostwald.

Table 1. Details of the sites under all land uses in Central Haryana

Sl. No.	Vegetation Cover	Altitude (m)	Area Covered (Forest Ranges)	No. of samples Collected
Forest Land Use				
1	Miscellaneous	192 - 250	Matanhail, Jhajjar, Bahadurgarh Range of Jhajjar; Indri, Asandh, Karnal Range of Karnal; Panipat, Samalakha Range of Panipat; Rohtak, Maham Range of Rohtak; Gohana, Sonipat, Rai Range of Sonipat	266
Plantation Land Use			**Location Covered**	
1.	Eucalyptus	191 - 260	Dujana, Bakrabad, Badli, Majra Rohan, Nilokehri, Rangruti Khera, Nainaldrain, Balla, Munjra, Shekpura and Gharuanda, Naualtha, Madlauda, Sodhapur, Sampla, Titoli, Bohar, Madina and Lahli, Sonipat,	196

Downloaded from www.jusres.com

			Pubheta, Gohana, Kathura, Balgarh, Bichpuri, Bawana, Khar Khanda	
2.	Shisham	208 - 228	Asaudah, Samalakha and Bapauli, Makrolikalan, Gannaur	35
3.	**Ailanthus**	202	Sikanderpur	7
Horticulture land use				
1.	Mango	224 - 244	Sambholi, Munak, Shekpura and Gharaunda, Panipat, Samalakha	42
2.	Ber	204 - 280	Bahadurgarh, Jundla, Madina, Gannaur	28
3.	Guava	195 -230	Naugan, Khatibas, Siwana, Dhaur Road, Rangruti Khera, Bhraman majra, Adaiyna and Samalakha, Smaila and Singhpura, Samalakha, Dubheta, Gannaur, Sonipat, Kathura, Balgarh	112
4.	Aonla	199 - 210	Makroli Kala, Balgarh	14
5.	Kinnu	208	Gohana	7
Agroforestry Land use				
1.	Sarsoo - Poplar	246	Mynak	7
2.	Wheat - Eucalyptus	208 - 236	Dujan, Nilokheri, Gharaunda, Madlauda, Titoli	35
3.	Wheat - Shisham	197 - 242	Mathanhail, Sasrauli, Subana, Bakrabad, Badali, Asaudah, Duliana, Jhajjar East, RangrutiKhera, Jundla, Smaila, Makroli Kalan, Madim, Kalanaur and Bohar	105
Agriculture Land use				
1.	Agriculture	187 - 265	Chhuchhukwas, Gwalisen, Jhajjar and Gunda, Nising, Karnal, Manjura, Majri, Samalakha, Nimbari, Umerkheri, Baland, Rohtak, Sopda, Nathupur, Sabasi, Rai, Sonipat	175
			Total Samples Collected	**1029**



JUSRES, 2017

Downloaded from www.jusres.com

Fig. 1 Sampling points in central Haryana

The data for SOC stock was calculated by using the following equation as suggested by IPCC Good Practice Guidance for LULUCF [19]:

Equation for SOC:

$$SOC = \sum_{Horizon=1}^{Horizon=n} SOC_{horizon} = \sum_{Horizon=1}^{Horizon=n} ([SOC] * \text{Bulk density} * \text{depth} * (1 - C\ frag) * 10)_{horizon}$$

Where,

SOC = Representative soil organic carbon content for the forest type and soil of interest, tones C ha.$^{-1}$

$SOC_{horizon}$ = Soil organic carbon content for a constituent soil horizon, tones C ha $^{-1}$

[SOC] = Concentration of SOC in a given soil mass obtained from analysis, g C (kg soil)$^{-1}$

Bulk density = Soil mass per sample volume, tones soil m^{-3} (equivalent to Mg m^{-3})

Depth = Horizon depth or thickness of soil layer, m

C Fragment = % volume of coarse fragments / 100, dimensionless

RESULTS & DISCUSSION

Soil organic carbon stock under different land uses in northern region of Haryana was estimated and results are presented in Table 2. Under forest land use, mainly miscellaneous forests were there. organic carbon stock in the soils under miscellaneous forest was 37.16 t ha^{-1}. Under plantation land use, mainly eucalyptus, *Ailanthus* and shisham plantations were there. Organic carbon stock in the soils under eucalyptus was maximum (28.13 t ha^{-1}) followed by shisham (22.02 t ha^{-1}) and the least was under *Ailanthus* (21.60 t ha^{-1}). Statistically SOC stocks under different plantations were not different. Soils under eucalyptus plantation were having 27.74 % and 30.23 % higher organic carbon stock as compared to shisham and *Ailanthus* plantations respectively. SOC stock under *Ailanthus* plantation was marginally (1.94 %) higher as compared to shisham plantations. SOC stock under shisham plantation was 22.77 t/ha in Haryana has also been reported by Gupta and Pandey [20].

Under horticulture land use mainly ber, aonla, guava, mango and kinnu orchards were available in northern region of Haryana. Maximum SOC stock was observed under mango orchards (31.31 t ha^{-1}) followed by ber (25.50.63 t ha^{-1}), guava (25.08 t ha^{-1}), aonla (24.82 t ha^{-1}) and the least SOC stock was under kinnu orchards (21.38 t ha^{-1}). Soils under mango orchards was having 22.78 %, 24.84 %, 26.15 % and 46.45 % higher organic carbon stock as compared to ber, guava, aonla and kinnu orchards while SOC stock under ber orchards was

Downloaded from www.jusres.com

marginally higher 1.67 % and 2.74 % in comparison to guava and aonla orchards. Organic carbon stock in the soils under guava was marginally higher (1.05 %) as compared to aonla but 17.31 % higher in comparison to kinnu orchards. SOC stock under aonla was 16.09 % higher as compared to kinuu orchards. SOC stocks under different orchards were statistically non significant differences. 40.62 t/ha SOC stock under mango orchards, 25.78 t/ha in Sugarcane – poplar agroforestry model in Hardwar district of Uttarakhand was reported by Gupta [21].

In agroforestry land uses maximum SOC stock was observed under sarsoo – poplar model (28.80 t ha^{-1}), followed by eucalyptus - wheat (28.70 t ha^{-1}) and the least SOC stock was under Shisham - wheat (24.85 t ha^{-1}). SOC stocks under different agroforestry model were not statistically significant. Mitigation potential of sarsoo – poplar and wheat – eucalyptus were marginally higher as compared to wheat - shisham model. SOC stock under poplar – sarsoo model was marginally higher as compared to wheat – eucalyptus (0.35 %) while it was 15.9 % higher as compared to wheat – Shisham model respectively. SOC stock under wheat - eucalyptus model was higher (15.49 %) as compared to wheat – Shisham model.

Table 2. Soil Organic Carbon Stock under different Land uses in Central Region of Haryana (up to 30 cm)

Sl. No.	Vegetation Cover	SOC Stock (t ha^{-1})	SD	Mitigation Potential (Land use wise)	S E
Forest Land Use					
1	Miscellaneous	37.17	± 19.9154	--	1.44
Plantation Land Use					
1.	Eucalyptus	28.13	± 15.3073	1.30	1.29
2.	Shisham	22.02	± 8.7022	1.02	1.74
3.	*Ailanthus*	21.60	± 8.0167	1.00	3.58
Horticulture land use					
1.	Mango	31.31	± 17.6793	1.46	3.22
2.	Ber	25.50	± 10.1645	1.19	2.27
3.	Guava	25.08	± 9.4518	1.17	1.05
4.	Aonla	24.82	± 9.4461	1.16	2.98
5.	Kinnu	21.38	± 4.6683	1.00	2.08
Agroforestry Land use					
1.	Sarsoo - Poplar	28.80	± 2.9146	1.16	1.30
2.	Wheat - Eucalyptus	28.70	± 7.6552	1.15	1.39
3.	Wheat - Shisham	24.85	± 9.3566	1.00	1.08
Over all					
1.	Forests	37.17[a]	± 19.9154	1.82	1.44

Downloaded from www.jusres.com

2.	Plantation	27.04[b]	± 14.5115	1.33	1.11
3.	Horticulture	26.28[b]	± 11.7855	1.29	0.97
4.	Agroforestry	26.08[b]	± 8.8656	1.28	0.84
5.	Agriculture	20.39[c]	± 8.1097	1.00	0.72

Same alphabets represent statistically at par group

When SOC stock under different land uses were tested by one - way ANOVA, it was found that SOC stock under all land uses were significantly different (Variance ratio, F = 30.125; p = < 0.05) (Table 3). SOC stock under forests was statistically significantly different with the SOC stock under plantation, agroforestry, agriculture and horticulture. SOC stock under plantation was statistically significantly different from the SOC stock under agriculture (Table 3).

Table 3. Statistically significant mean differences on the basis of CD (LSD)

Sl No.	Vegetation	Mean Difference	P value
1	Forest Vs Plantation	10.1248*	0.000
2	Forest Vs Horticulture	10.8820*	0.000
3	Forest Vs Agroforestry	11.0807*	0.000
4	Forest Vs Agriculture	16.7730*	0.000
6	Horticulture Vs Agriculture	5.8910*	0.001
8	Plantation Vs Agriculture	6.6482*	0.000
9	Agroforestry Vs Agriculture	5.6923*	0.002

* *Mean difference is significant at the 0.05 level*

Share of SOC stock occupied by different land uses in northern region was worked out and depicted in Fig.2. Maximum share was occupied by forest (27.14 %) followed by plantation (19.74 %), horticulture (19.19 %), agroforestry (19.04 %) and the minimum share was occupied by agriculture (14.89 %).

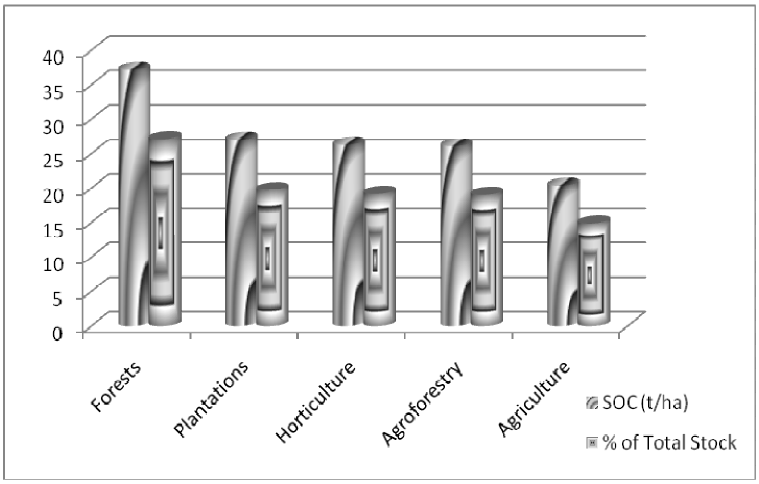


Fig. 2 Percent share of SOC stock occupied by different land uses in northern region

Downloaded from www.jusres.com

Over all, in central region of Haryana, Maximum SOC stock was under forests (37.17 t ha^{-1}) followed by plantation (27.04 t ha^{-1}), horticulture (26.28 t ha^{-1}), agroforestry (26.08 t ha^{-1}) and the least SOC stock was under agriculture land use (20.39 t ha^{-1}). Subset for α = 0.05 indicate that forest stands separately (a), plantation, horticulture and agroforestry were statistically at par therefore, grouped together (b) while agriculture stand separately (c) (Table 2). Mitigation potential indicated that soils under forests can sequester nearly double organic carbon as compared to agriculture land use. SOC stock under forests was 37.46 %, 41.44 %, 42.52 % and 82.30 % higher as compared to plantation, horticulture, agroforestry and agriculture land use respectively. Organic carbon stock in the soils under plantation was marginally higher as compared to horticulture (2.89 %) and agroforestry (3.68 %) while it was 32.61 % higher as compared to agriculture land use. SOC stock under horticulture land use was marginally higher as compared to agroforestry land uses (0.77 %) while it was 28.89 % higher as compared to agriculture land use. SOC stock under agroforestry was 27.91 % higher as compared to agriculture land use. Higher organic carbon stock in the forests may be due to better canopy coverage which provide higher litter fall. Changes in land use and vegetation cover affect various soil properties, including the soil organic carbon (SOC) pool and the transfer of atmospheric CO_2 to terrestrial landscapes. In natural or quasi-natural conditions a reduction in biomass increases the risk of erosion, and can reduce the stored soil organic matter content [22]. The annual litter input under the forest was more than twice that of the cropland, and the fine root biomass was significantly higher in the forest. We conclude that the higher litter input and fine root biomass may partly contribute to the greater SOC in the forest [23]. Among all other land uses, plantation land uses have better SOC stock. Plantation can improve the soil fertility and carbon store in the soils as they provide better crown over the ground which support the better soil environment. Afforestation and forest management can increase carbon stocks and account for emission reduction according to the Kyoto Protocol. Site management has important effects on the accumulation of soil carbon after afforestation. Soil disturbance can enhance soil carbon losses, with whole ploughing causing the most and disking the least loss of soil carbon. Soil carbon decreases with the increase of harvesting intensity and the retention of harvest residue can significantly enhance the accumulation of carbon in the soil [24]. Land-use changes such as those which result from afforestation and management of fast-growing tree species, have an immediate effect on the regional rate of C sequestration by incorporating carbon dioxide (CO_2) in plant biomass [25]. Shi and Cui [26] conducted a study in China and their results indicated that afforestation could

Downloaded from www.jusres.com

accumulate soil carbon with the accumulation rate of 42.05, 30.07 and 73.94 g C $m^{-2}yr^{-1}$ in 0-20, 20-40 and 0-40 cm soil depths. Five years after afforestation, plantations began to accumulate soil carbon rapidly, and plantations with the age of 10-20 years old had the highest soil carbon accumulation rate. Afforestation on former cropland and wasteland had higher accumulation rates of soil carbon than on former grassland. Soil carbon accumulated rapidly in broadleaved and mixed plantations, and the accumulation rate in broadleaved was higher than that in coniferous plantations

Agriculture land use had the lowest SOC stock in this region; it may be because of the continuous ploughing of the complete field which facilitates the CO_2 emission. Therefore, reduced tillage and no tillage practices are considered better techniques for reducing the CO_2 emission from agriculture fields. As much as 75% of the antecedent SOC pool can be lost following conversion of natural ecosystems to agroecosystems in tropical regions due to intensive tillage practices that increase decomposition and litter removal [27]. Conversion of natural to agricultural ecosystems causes depletion of the SOC pool by as much as 60% in soils of temperate regions and 75% or more in cultivated soils of the tropics. Some soils have lost as much as 20 to 80 tons C/ha, mostly emitted into the atmosphere. Severe depletion of the SOC pool degrades soil quality, reduces biomass productivity, and adversely impacts water quality Lal, [28]. Soil organic carbon is concentrated in the upper 12 inches of the soil. So it is readily depleted by anthropogenic disturbances such as land use changes and cultivation. The greatest changes in carbon storage result from the conversion of forests to cultivated land typically leading to loss of soil carbon sequestration potential [29].

Area under total forests in central region of Haryana spread over in the five district is 27702 ha [30]. Total organic carbon stocks in the soils under forests in five districts comprising the central region of Haryana had 1.07 million tons (Table 4). Out of these, Karnal district has the maximum SOC stock (409720.40 t, which is 37.99 per cent of total stock of forest in C R of Haryana) followed by Sonipat (258668.85 t which is 23.99 per cent of total stock of forest in C R of Haryana), Panipat (156488.42 t which is 14.51 per cent of total stock of forest in C R of Haryana), Rohtak (139336.02 t which is 12.92 per cent of total stock of forest in C R of Haryana) and the least SOC stock was in Jhajjar district (10.5910.59 t which is 10.59 per cent of total stock of forest in C R of Haryana). It is because of the area under forests in these districts which had followed the similar trend. The total SOC stock in central region *i.e.* 1.07 m t is equivalent to 3.95 m t of CO_2 sequestered in these soils. The build-up of each tons of soil organic matter removes 3.667 tons of CO_2 from the atmosphere

Downloaded from www.jusres.com

[31]. Enhancement of forest area and increasing the SOC stocks in these soils is a very important tool of removing CO_2 from the atmosphere. Accumulation of carbon in vegetation and soil can be accelerated by conserving our natural resources.

Table 4. District wise SOC Stock under Forest in Central Region of Haryana (up to 30 cm)

Sl. No.	**District**	**Area (ha)**	**SOC Pool (tons)**	**Per cent of total stock in Forest in C R of Haryana**
1	Karnal	7565	409720.40	37.99
2	Panipat	4103	156488.42	14.51
3	Sonipat	7359	258668.85	23.99
4	Rohtak	4594	139336.02	12.92
5	Jhajjar	4081	114186.38	10.59
	Total in Central region of Haryana	**27,702**	**10,78,400.070 or 1.07 million tons**	**100.00**

Total SOC stocks under horticulture in five districts comprising the Central region of Haryana had 191303.85 tons (Table 5). Out of these, Karnal district has the maximum SOC stock (63833.64 t which is 33.37 per cent of total stock of horticulture land use in C R of Haryana) followed by Sonipat (41243.02 t which is 21.56 per cent of total stock of horticulture land use in C R of Haryana), Jhajjar (38109.40 t which is 19.52 per cent of total stock of horticulture land use in C R of Haryana), Panipat (24653.47 t which is 12.89 per cent

Table 5 District wise SOC stock under Horticulture land uses Central Region of Haryana (up to 30 cm)

Sl. No.	**District**	**Area (ha)**	**SOC Pool (tons)**	**Per cent of total stock in Horticulture in N R of Haryana**
1	Karnal	2158	63833.64	33.37
2	Panipat	851	24653.47	12.89
3	Sonipat	1547	41243.02	21.56
4	Rohtak	1111	23464.32	12.26
5	Jhajjar	1670	38109.40	19.92
	Total in Central region of Haryana	**7,337**	**1,91,303.85**	**100.00**

of total stock of horticulture land use in C R of Haryana), and the least SOC stock was in Rohtak district (23464.32 t which is 12.26 per cent of total stock of horticulture land use in C

Downloaded from www.jusres.com

R of Haryana). It also may because of the area under horticulture land use in these districts which had followed the similar trend. The total SOC stock in central region *i.e.* 191303.95 t is equivalent to 7,01,511.20 t of CO_2 sequestered in these soils of horticulture land use. It evident from the data that Karnal is the most prominent district in central region of Haryana as far as SOC stock and horticulture land use is concern.

In central region of Haryana, Bhindawas Wildlife Sanctuary is located in Rohtak and Khaparwas Wildlif Sanctuary is located in Jhajjar. SOC stock under both wildlife sanctuaries in central region of Haryana was also estimated that date presented in Table 6. Maximum organic carbon stock was in the soils under Bhindawas Wildlife Sanctuary (12481.86 tons) followed by Khaparwas Wildlif Sanctuary (2313.96 tons). Total organic carbon stock in the soils in wildlife sanctuaries situated in central region of Haryana, was 14795.82 tons and it is equivalent to 54256.27 tons of CO_2 sequestered in these soils.

Table 6. SOC stock under different Wild life Sanctuary in Central Region in Haryana (up to 30 cm)

Sl. No.	Name	Area (ha)	SOC Stock (tons)	Per cent of total SOC Stock in C R in Haryana
Under Wildlife Sanctuaries				
1	Bhindawas Wildlife Sanctuary, Rohtak	411.53	12481.86	84.36
2	Khaparwas Wildlif Sanctuary, Jhajjar	82.70	2313.96	15.64
	Total	**494.23**	**14795.82**	**100.00**
	Equivalent to CO_2 Sequestered		***54256.27 t***	

Changes in the size of the SOC pool have implications for soil productivity and for atmospheric concentrations of CO_2, an important 'greenhouse gas'. Review of recent findings from long-term research sites to determine the impact of cropping practices on SOC reserves it concluded that: (1) the loss of SOC upon conversion of soils to arable agriculture has abated; (2) significant gains in SOC (typically about 3 Mg C ha^{-1} or less within a decade) can be achieved in some soils by adoption of improved practices, like intensification of cropping systems, reduction in tillage intensity, improved crop nutrition, organic amendments, and reversion to perennial vegetation [32]. Since every land-use change causes a disturbance of the long-termed adjusted balance of soil organic matter (SOM) supply and mineralization, self-restoration also leads to alterations in the SOM dynamics [33].

Downloaded from www.jusres.com

ACKNOWLEDGEMENTS

Authors are thankful to Dr. (Mrs.) Bindu Jain, Director, Medico Edge Publications for helping in publication expenses of this paper

REFERENCES

[1] Schlesinger, W.H. (1999). Carbon sequestration in soils. Nature, 284:2095-2096.

[2] Schlesinger, W.H. and Lichter, J. (2001). Limited carbon storage in soils and litter o fexperimental forest plots under increased atmospheric CO_2. *Nature* 411:466-469.

[3] Ramachandran, A., S. Jayakumar, R.M. Haroon, A. Bhaskaran and D.I. Arockiasamy (2007). Carbon sequestration: estimation of carbon stock in natural forests using geospatial technology in the Eastern Ghats of Tamil Nadu, India. *Current Science* 92 (3): 323-331.

[4] IPCC (2000). Special report on land use, land-use change, and forestry. In: R.T. Watson, I.R. Noble, B. Bolin, N.H. Ravindranath, D.J. Verardo, D.J. Dokken (eds.). Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, Cambridge, UK. p. 377.

[5] Paul, K.I., Polglase, P.J., Nyakuengama, J.G., Khanna, P.K. (2002). Change in soil carbon following afforestation. *For. Ecol. Management.* 168: 241- 257.

[6] Turner, J., Lambert, M.J. and Johnson, D.W. (2005). Experience with patterns of soil carbon resulting from forest plantation establishment in eastern Australia. *For. Ecol. Management.* 220: 259-269

[7] Winjum, J. K., Dixon, R. K. and Schroeder, P. E. (1992) *Water, Air, Soil Pollut*., 64: 213–228

8] Lal, R. (2004). Soil carbon sequestration to mitigate climate change. *Geoderma* 123: 1 - 22

[9] IPCC (2001). Climate change: the scientific basis. Intergovernment Panel on Climate Change. Cambridge (UK): Cambridge Univ. Press

[10] Cairns, M., Barker, J., Shea, R. and Haggerty, P. (1996). *Interciencia*, 21: 216– 223.

[11] Eswaran H, Van DB, Reich, P. (1993). Organic carbon in soils of the world. *Soil Sci Soc Am J* 57:192-194.

[12] Song, G., Li, L., Pan, G. , Zhang, Q. (2005). Topsoil organic carbon storage of China and its loss by cultivation. *Biogeochemistry* 74 (1): 47-62

[13] Post, W. M., Emanuel, W. R., Zinke, P. J. and Stangenberger, A. G. (1982).

Downloaded from www.jusres.com

Soil carbon pools and world life zones. *Nature* 298: 156–159

[14] Tian, H., J.M. Melillo and D.W. Kicklighter (2002). Regional carbon dynamics in monsoon Asia and implications for the global carbon cycle. *Global and Planetary Change* 37: 201-217

[15] Walkley, A. and Black, I. A. (1934). An Examination of Degtjareff Method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method. *Soil Sci.* 37: 29-37

[16] Sakin, E. (2012). Organic carbon organic matter and bulk density relationships in arid-semi arid soils in Southeast Anatolia region. *African Journal of Biotechnology* 11 (6): 1373-1377

[17] Wilde, S.A., Voigt, G.K. and Iyer, J.G. (1964). Soil and Plant Analysis for Tree Culture. Oxford Publishing House, Calcutta, India

[18] Ravindranath, N.H. and Ostwald, M. (2008). Carbon Inventory Methods: Handbook for Greenhouse Gas Inventory, Carbon Mitigation and Round wood Production Projects. Springer Publishers

[19] IPCC (2003). Good Practice Guidance for Land Use, Land Use Change and Forestry. Published by the Institute for Global Environmental Strategies (IGES) for the IPCC. Publishers Institute for Global Environmental Strategies, Japan

[20] Gupta, M. K. and Pandey, Rajiv (2008). Soil organic carbon stock under different plantations in some districts of Uttarakhand and Haryana. *Indian J. For.* 31 (3): 48 – 53

[21] Gupta, M. K. (2011). Soil organic Carbon stock under different land uses in Hardwar districts of Uttarakhand. *Indian For.* 137 (1): 105 – 112

[22] Sinoga Ruiz, J.D , Pariente, S., Diaz, A.R and Martinez Murillo, J.F. (2012). Variability of relationships between soil organic carbon and some soil properties in Mediterranean rangelands under different climatic conditions (South of Spain). *Catena* (94): 17-25

[23] Chang, R., Fu, B., Liu, G. , Wang, S., Yao, X. (2012). The effects of afforestation on soil organic and inorganic carbon: A case study of the Loess Plateau of China. *Catena* (95): 145-152

[24] Shi, J., Cui, L.-L., Tian, Z. (2010). Impact of site management on changes in soil carbon after afforestation: A review *Forestry Studies in China* 12 (3): 158-165

Downloaded from www.jusres.com

[25] Jandl, R., Lindner, M., Vesterdal, L., Bauwens, B., Baritz, R., Hagedorn, F., Johnson, D.W. , Minkkinen, K., Byrne, K.A. (2007). How strongly can forest management influence soil carbon sequestration. *Geoderma* 137 (3-4): 253-268

[26] Shi, J., Cui, L. (2010). Soil carbon change and its affecting factors following afforestation in China. *Landscape and Urban Planning*. 98 (2): 75-85

[27] Lal, R., (2005). Soil carbon sequestration in natural and managed tropical forest ecosystems. *J. Sust. For.* 21, 1–30

[28] Lal, R. (2004) Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science* 304: 1623 - 1627

[29] Rai S. C. and Sharma Purnima (2004). Carbon flux and land use/cover change in a Himalayan watershed. *Current Science* 86 (12): 1594 - 1596

[30] Anon., (2013). Forest Department, Government of Haryana.

[31] Bowen, G. D. and Rovira, A. D. (1999). The rhizosphere and its management to improve plant growth. *Adv. Agron*. 66: 1–102.

[32] Janzen, H.H., Campbell, C.A., Izaurralde, R.C., Ellert, B.H., Juma, N., McGill, W.B., Zentner, R.P. (1998). Management effects on soil C storage on the Canadian prairies. *Soil and Tillage Research* 47 (3-4): 181-195

[33] Kalinina, Olga, Sergey V Goryachkin, Nina A Karavaeva, Dmitriy Lyuri and Luise Giani (2010). Dynamics of carbon pools in post-agrogenic sandy soils of southern taiga of Russia. *Carbon Balance and Management* 5:1.