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Carbon stock in biomass and litter in different plantation of Tropical Forest Research Institute, Jabalpur

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ABSTRACT

In the present study quadrats were laid out for tropical forest tree species, raised in the campus of Tropical Forest Research Institute, Jabalpur during late '80s and early '90s, herbs and litter covering the plantations to estimate the carbon stock in biomass and litter. Tectona grandis was found to be the most abundant species with 159 individuals, followed by Albizia procera (69), Eucalyptus (35) and Dalbergia sisso (31). The average GBH is found to be 63.73 cm and the total above ground biomass (AGB) and the total below ground biomass (BGB) are found to be 50763.24 kg and 12690.81 kg, respectively. The total carbon is found to be 31727.03 kg. The carbon stock in these tree quadrats is 31.72 tonnes sequestering at the rate of 75.54 tonnes C per hectare of the plantation area.

INTRODUCTION

Carbon sequestration implies transfer of atmospheric CO_2 into other long-lived global pools including oceanic, pedologic, biotic and geological strata to reduce the net rate of increase in atmospheric CO_2. Biotic C sequestration techniques are natural and cost-effective processes, they have numerous ancillary benefits, are immediately applicable but have finite sink capacity. Engineering techniques like CO_2 injection in deep ocean, geological strata, old coal mines and oil wells, and saline aquifers along with mineral carbonation of CO_2 constitute abiotic techniques have a large potential of thousands of Petagram. However, these are expensive, have leakage risks. The main source of extra CO_2 which is being released into the atmosphere are fossil fuel burning, biomass burning, soil erosion, cultivation, deforestation, wetland conversion, etc. The observed climate changes like the sea-level rise of 15–23 cm during the twentieth century (IPCC 2007), the increase in global temperature has been 0.15°C per decade since 1975 (IPCC 2007) also affecting crop products (Bhardwaj and Panwar 2003), the notable shifts in ecosystems (Greene and Pershing 2007) and frequency and intensity of occurrence of wild fires (Running 2006; Westerling et al. 2006) are being caused due to anthropogenic activities which release CO_2 into the atmosphere. Consequently, the concentration of atmospheric GHGs and their radiative forcing have progressively increased with increase in human population, but especially so since the onset of industrial revolution around 1850. There are three strategies of lowering CO_2 emissions to mitigate climate change (Schrag 2007): (i) reducing the global energy use, (ii) developing low

or no-carbon fuel, and (iii) sequestering CO_2 from point sources or atmosphere through natural and engineering techniques. Studies of Indian forests as part of the national forest carbon balance show that forests are a major sink for atmospheric carbon (Ravindranath et al. 1997; Haripriya 2000; Chhabra and Dadhwal 2004; Manhas et al. 2006; Gupta 2009; Kaul et al. 2009). India State of Forest Report (2013) also explains forest and trees outside forest cover as 78.92 m ha (24.01% of total geographical area of the country), which is 0.63 m ha or 0.20% more in comparison to India State of Forest Report (2011).

Vast forest areas in India as well as its different provincial states accumulated a large amount of carbon as CO_2 from the atmosphere and play an important role for sequestering carbon in the regional, national and world scenarios. Terrestrial (plant and soil) carbon was estimated at 2000 ± 500 Pg, which represented 25% of global carbon stocks (Jana et al 2009).

Study Area

Tropical Forest Research institute (TFRI) is located in Jabalpur city of Madhya Pradesh at N 23º06´065´´ latitude and E 79º59´344´´ longitude. During late '80s and early '90s a number of plantations of tropical forest tree species were raised in the institute campus and in the surrounding areas. After this period few plantations were also raised as part of research experiments.

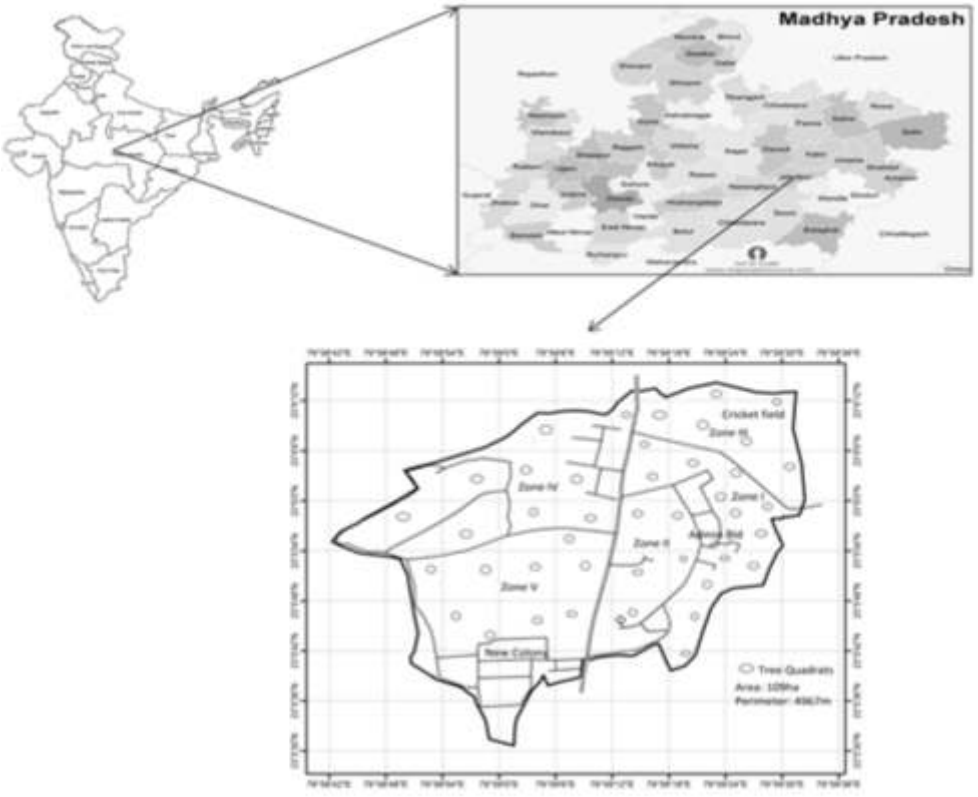

Fig 1. Map of Tropical Forest Research Institute showing the five plantation zones along with the forty-two tree quadrats

The main planted tree species are viz. *Albizia procera*, *Albizia lebbek*, *Tectona grandis*, *Dalbergia sissoo*, *Azadirachta indica*, *Eucalyptus hybrid*, *Gmelina arborea*, *Pongamia pinnata*, *Acacia nilotica*, *Santalum album* etc. The main objectives of this study were to quantify the carbon stock in the trees and ground vegetation present in the campus by non destructive method and to assess the carbon present thereby quantifying the contribution of TFRI Jabalpur in reducing CO_2 from the atmosphere.

MATERIALS AND METHODS

Vegetation survey and Laying out the quadrats

The trees planted on regular gap were surveyed by 'Quadrat Method' and scattered trees by stratified random sampling method. All the trees in TFRI campus were considered for study by calculating the area under plantation multiplied by density of trees. In plantations, quadrats of 10 m x 10 m size for trees, 3 m x 3 m for shrubs and 1m x 1m for herbs were laid out. Three quadrats of size 0.5m x 0.5m for litter in each tree quadrat were also laid out. Each tree in the selected quadrat was tagged by aluminium foil and given a unique identification number. The trees were marked at 1.37 m from the ground in the direction from which diameter of tree was measured.

Growth characteristics of trees

Height and girth of selected trees was measured September-November 2015. Height of the trees was measured by Ravi's altimeter and diameter (girth) by Gaytor Eye Tree Calliper.

In this paper we have used the allometric equations developed by Tropical Forest Research Institute Jabalpur. Above ground biomass (AGB) in the trees was quantified by non-destructive method using following allometric equation against GBH :

$y = 0.007 x2 + 1.898 x - 32.69$ where,

y = AGB (kg)

x = GBH (cm)

The below ground biomass (BGB) of experimental trees was calculated using 0.25x times above ground biomass as per norm of Intergovernmental Panel on Climate Change (IPCC 1996). The carbon content was considered half of the total dry biomass of trees.

Measuring carbon in herbaceous biomass

For measuring the carbon content of herbaceous biomass quadrats of 1m X 1m dimension were laid out. Three such quadrats were laid out in each quadrat for trees i.e. a total of 126 quadrats for herbaceous biomass were laid out. The herbs present in these quadrats were uprooted and taken to the lab where its fresh weight is recorded. The weight of the oven dried samples is later noted. Half of the dry weight is considered its carbon content.

Measuring carbon in litter

For collection of litter, pits of 0.5 m X 0.5 m X 6 inches were dug out. Three such pits were dug in each tree quadrat. A total of 126 litter pits were dug. The litter which falls in these quadrats was collected on quarterly basis. Half of the oven dried weight of the collected litter from each pit is considered its carbon content.

RESULTS AND DISCUSSION

A total of 42 quadrats for trees of the dimension 10 m X 10 m, were laid out. A total of 436 trees, having 30 cm or above GBH, were recorded in the selected quadrats (Table 1). A total 26 tree species were found in the selected, sites.

Table 1. Table showing the number of individuals in different girth classes along with the predominant species found in these girth classes

Girth class (cm)	No. of Individuals	Predominant species
30-50	162	*T. grandis, A. procera, D. sissoo*
50-100	234	*T. grandis, Eucalyptus sp., P. emblica*
100-150	30	*Eucalyptus sp., T. arjuna, M. Azedarach*
150-200	5	*A. procera, B. monosperma*
200-250	3	*P. pinnata, A. procera*
250-300	2	*T. arjuna*

Tectona grandis was found to be the most abundant species with 159 individuals, followed by *Albizia procera* (69), Eucalyptus (35) and Dalbergia sisso (31). The average GBH is found to be 63.73 cm and the Total above ground biomass (AGB) and the total below ground biomass (BGB) are found to be 50763.24 kg and 12690.81 kg respectively. The total carbon is found to be 31727.03 kg (Table 2).

Table 2. Table showing the ABG, BGB, total Biomass and total Carbon in the quadrats.

Parameter	Value
Total above ground biomas (kg	50763.24
Total below ground biomass (kg)	12690.81
Total Biomass (kg)	63454.05
Total Carbon (kg)	31727.03
Carbon in tonnes	31.72
Rate of sequestration tonnes/ha	75.54

The carbon stock in these tree quadrats is 31.72 tonnes sequestering at the rate of 75.54 tonnes C per hectare of the plantation area Table 2, Table 3 shows the area of the five zones along with the number of contained tree quadrats and the litter and herbaceous biomass. Three litter quadrats of size 0.5 m X 0.5 m X 6 inches were dug out in each of the 42 tree quadrats i.e. a total of 126 litter quadrats were dug out. Average dry weight of the litter varied from 1.66 to 2.97 t ha^{-1}, herbaceous biomass from 0.18 to 0.22 t ha^{-1} (Table 3). The results of the study will help manage tree plantations and natural vegetation sustainably in TFRI campus. Carbon stock and annual sequestration in different pools will generate the database for further research on climate change studies.

Table 3. Table showing the five zones, their number of quadrats contained and the herbaceous and litter biomass in t ha^{-1}

Zones	Area (approx in ha)	No. of tree quadrats	Litter biomass (t ha^{-1})	No. of litter pits	Herbaceous biomass (t ha^{-1})	No. of herbaceous quadrats
1	22.68	13	2.97	39	0.19	39
2	14.58	5	1.66	15	0.22	15
3	12.96	6	2.03	18	0.20	18
4	24.3	9	2.24	27	0.18	27
5	32.38	9	2.18	27	0.22	27

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