ISSN: 1394-7990
Malaysian Journal of Soil Science Vol. 22: 93-99 (2018) Malaysian Society of Soil Science

Carbon Stock Estimation of Trees in the Virachilai Ayyanar Sacred Grove in Pudukottai District, Tamil Nadu, India

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ABSTRACT

World carbon emission has been increasing due to the daily anthropogenic advances of human beings. Carbon dioxide concentration in the atmosphere has seen an increasing trend every year. Plants in the forests are effective in sequestering and storing carbon below ground and above ground by their photosynthesis process. Trees absorb atmospheric carbon, assimilate and store this carbon as rich organic compounds. Trees in the forests are contributing towards reducing atmospheric carbon. The present study estimated the amount of carbon that is sequestered by trees in Virachilai Ayyanar sacred grove in Pudukottai district of Tamil Nadu. The carbon stock in the various species ranged from 0.001 tons to 6.41 tons per hectare.

Keywords: **Carbon sequestration, above ground biomass, below ground biomass, bio-volume.**

INTRODUCTION

The emission of carbon in the world has been increased due to day by day. Omit S Santhropogenic activities, mainly industrialisation. The emission of green house gases through anthropogenic activities including deforestation, soil cultivation, draining of wet lands, land use change, forest fires and fossil fuel consumption has led to global warming. The destruction and degradation of vegetation by human activities results in the emission of carbon into the ecosystem. Carbon dioxide is the major green house gas that contributes to global warming (Hangarge *et al.* 2012). The concentration of carbon dioxide in the atmosphere has been increasing every year. Future atmospheric concentration of carbon dioxide is estimated to double and push global temperature approximately by 1.5 to 4.0 °C (Atwell *et al.* 1999). Forests are the major terrestrial sink for carbon in the world. They are also a potential source of biomass. This biomass can provide food, fuel-wood, and wood for other domestic and industrial uses (Ravindranath *et al.*1997). Forests are known to be a major sink and cost-effective option for the mitigation of global warming and climate change. Globally, forests store large amounts of carbon sequestered from the atmosphere and retained in living and dead biomass and soil. The forest ecosystem is one of the most important reservoirs of atmospheric carbon (Shrestha and Singh 2007).

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The carbon stock in forest vegetation is dependant on various factors such as plant species, geographical location and significantly, land use and deforestation (Shrestha and Singh 2007). Carbon sequestration is a process in which the atmospheric carbon is captured and stored in the biosphere. Globally 80% of carbon is stored in above ground biomass and 40% of carbon below ground biomass (Kirschbaum *et al.*1996). To quantify the sequestered carbon in the forest ecosystem, carbon pools under various forest types should be assessed. The objective of this paper is to estimate the sequestration of tree species of the sacred grove by calculating the above ground and below ground biomass and carbon storage.

MATERIALS AND METHODS

Study Area

The study was conducted in Virachilai Ayyanar sacred grove covers an area of about 7.3 hectares in Pudukkottai district and about 25 km away from Pudukkottai town. This grove is maintained by the local community of the adjacent village who are known for their strong religious, spiritual, and traditional beliefs and practices.

Pudukkottai district covers an area of 4,663 square kilometers and has a coast line of 39 km. It is located between 78.25' and 79.15' of the East longitude and between 9.50 and 10.40' of the North latitude. Various types of soils are found in this region. The floristic vegetation of the sacred grove is a typical inland tropical dry evergreen forest.

Field Methods

A 1-hectare plot was identified in the grove and subdivided into 50 x 25 m sub plots to study the vegetation. In each plot, all living species equal to or more than 20 cm girth at breast height (GBH) were identified (($\geq$20cm gbh) and their girth and height were measured. The plant specimens were collected and identified taxonomically using the publications of Gamble and Fisher (1915-1935), Henry *et al.* (1989) and Mathews (1981; 1991; 1993).

Biomass Estimation

Above ground biomass and below ground biomass, litter, dead plant matter and soil organic matter are the major carbon pools of an ecosystem (FAO 2005; IPCC 2006). The above ground biomass and below ground biomass of the sacred grove was estimated by carbon percentage and by measuring tree height, diameter at breast height (DBH) and wood density. The carbon concentration of different parts is rarely measured directly, but generally assumed to be 50% of the dry weight(Losi *et al*.2003; Jana *et al*. 2009; Chavan and Rasal 2011).

Estimation of Above Ground Biomass

The biomass of a tree is the sum of biomass of its trunk, branches, leaves, flowers, fruits and roots. For an accurate measurement of biomass, the trees would have to be felled. To avoid destruction, the standing woody biomass has been estimated by allometric equation based on diameter and height. The height was measured through shadow method. The GBH of the trees was calculated by multiplying biomass volume and wood density (Ravindranath and Ostwald 2008).

The volume of trees was calculated based on diameter and height. The wood density value of tree species was obtained from www.worldagroforestry.org.
The aboveground biomass was calculated using the following formula

AGB (kg) =Tree bio volume (TBV) (m3) x wood density (kg/m3)
TBV = 0.4 x (D)2 x H

Where D=GBH/3.14, Diameter (meter) calculated from GBH, and H = Height (meter).
Wood density data from Global Wood Density database was used.

The standard average density of 0.6 gm/cm is applied whenever the density value is not available for a tree species (Potadar Vishnu and Satish Pati 2016).

Estimation of Below Ground Biomass
The below ground biomass includes the biomass of all live roots c < 2 cm(Chavan and Rasal 2011). The below ground biomass is calculated by multiplying above ground biomass by 0.26 (Chave *et al.* 200) Ravindranath and Ostwald, (2008). Belowground biomass (BGB) kg/tree or ton/tree = above ground biomass (AGB) kg/tree or ton/tree x 0.26

Total Biomass
Total biomass is the sum of the above and below ground biomass
Total Biomass (TB) = above ground biomass + below ground biomass

Carbon Estimation
Generally, for any plant species, the total biomass x 50% is considered as carbon storage (Brown and Lugo 1982; Cannell *et al.*1995; Dixon 1994; Ravindranath *et al.* 1997; Richter *et al*.1995)

i.e. Carbon Storage = Biomass x 50%
or Carbon Storage = Biomass/2

RESULTS AND DISCUSSION

Carbon sequestration depends upon the size of trees, type of forest and age of trees (Terakunpisut *et al*. 2007). Thirty-five tree species were recorded from Virachilai Ayyanar sacred grove in total. The density of woody species (≥20gbh) was 398. Based on the density, *Albizia amara* (82 trees ha^{-1}) is the dominant species followed by Commiphora caudata (58 trees ha^{-1}) and Euphorbia antiquorrum (47 trees ha^{-1}).

Table 1 shows the total number of individual species. It also indicates the average GBH in cm and average tree height in m. There were 82 trees of the dominant species Albizia amara which sequestrated 6.41 tons of carbon per hectare. The next dominant species Commiphora caudata sequestrated 2.77 tons of carbon. There were only 5 trees of the species Tamarindus indica but it sequestrated more carbon than Commiphora caudata (2.92 tons).

A study of the data on the biomass accumulation (above ground and below ground) shows an increasing trend with GBH and height classes. The volume and subsequently, biomass was found to be related to diameter at breast height (DBH)

TABLE 1
Carbon storage in Virachilai Ayyanar sacred grove

Sl. No	Tree Species	No. of Individuals (ha^{-1})	Average GBH (cm) (ha^{-1})	Average height (m) (ha^{-1})	Average biomass (t/individual)			Carbon storage = Biomass /2 (t)	Carbon storage (t/species)
					Above ground bio mass	Below ground bio mass	Total Bio mass		
1	*Acacia nilotica*	2	47	5	0.03	0.01	0.03	0.02	0.03
2	*Albizia amara*	82	79	7	0.12	0.03	0.16	0.08	6.41
3	*Atalantia monophylla*	8	45	4	0.02	0.01	0.02	0.01	0.10
4	*Azadirachta indica*	1	127	9.5	0.43	0.11	0.54	0.27	0.27
5	*Bauhinia racemosa*	5	46	4.4	0.03	0.01	0.03	0.02	0.08
6	*Benkara malabarica*	12	34	3.5	0.01	0.00	0.01	0.01	0.07
7	*Carissa spinarum*	1	34	3.5	0.01	0.00	0.01	0.01	0.01
8	*Cissus quadrangularis*	1	27	5	0.01	0.00	0.01	0.01	0.01
9	*Commiphora caudata*	58	72	6	0.08	0.02	0.10	0.05	2.77
10	*Derris ovalifolia*	1	71	6	0.07	0.02	0.09	0.05	0.05
11	*Derris scandens*	31	35	8	0.02	0.01	0.03	0.02	0.47
12	*Dichrostachys cinerea*	2	62	5	0.05	0.01	0.06	0.03	0.06
13	*Diospyros ebenum*	1	52	5	0.04	0.01	0.05	0.02	0.02
14	*Diospyros ferrea*	1	40	4	0.02	0.00	0.02	0.01	0.01
15	*Diospyros montana*	5	62	5	0.05	0.01	0.07	0.03	0.17
16	*Drypetes sepiaria*	7	46	4.2	0.02	0.01	0.03	0.01	0.10
17	*Euphorbia antiquorrum*	47	38	3.5	0.01	0.00	0.02	0.01	0.36
18	*Ficus benghalensis*	2	198	12	0.74	0.19	0.94	0.47	0.94
19	*Gmelina asiatica*	3	46	4.3	0.02	0.01	0.03	0.01	0.04
20	*Grewia rhombifolia*	4	42	4.5	0.02	0.01	0.03	0.01	0.06
21	*Haldina cordifolia*	39	39	3.5	0.01	0.00	0.02	0.01	0.32
22	*Holoptelea integrifolia*	4	46	4	0.02	0.01	0.03	0.01	0.05
23	*Ixora pavetta*	3	65	5.5	0.06	0.01	0.07	0.04	0.11
24	*Manilkara hexandra*	35	38	3.5	0.01	0.00	0.02	0.01	0.27
25	*Mimosa intsia*	5	32	4	0.01	0.00	0.01	0.01	0.03
26	*Morinda pubescens*	1	47	4.4	0.02	0.01	0.03	0.01	0.01
27	*Pamburus missionis*	4	36	4	0.01	0.00	0.02	0.01	0.03
28	*Pleiospermium alatum*	1	35	3.2	0.01	0.00	0.01	0.01	0.01
29	*Reissantia indica*	2	26	3.5	0.01	0.00	0.01	0.00	0.01
30	*Salvadora persica*	1	127	11	0.43	0.11	0.54	0.27	0.27
31	*Strychnosnux-vomica*	7	44	4.2	0.02	0.01	0.02	0.01	0.09
32	*Tamarindus indica*	5	153	13	0.93	0.24	1.17	0.58	2.92
33	*Tricalyps aspaherocarpa*	2	24	3.5	0.00	0.00	0.01	0.00	0.01
34	*Ziziphus nimmularia*	1	36	3	0.01	0.00	0.02	0.01	0.01
35	*Ziziphus oenoplia*	2	45	4.2	0.03	0.01	0.03	0.02	0.03
		386/ ha.							16.19 tons /ha.

and height (H), FSI (1996). The biomass accumulation and carbon sequestration show an increasing trend with age of the trees. Our findings are comparable to the results of Mani and Parthasarathy (2007) in five inland sites of tropical dry evergreen forests located in Pudukottai district of Tamil Nadu State, Forest Survey of India (2002-2008), Chavan and Rasal (2011) and Hangarge *et al*. (2012).

CONCLUSION

Forests play a significant role in reducing the level of atmospheric carbon dioxide. The present study shows that trees act as a major carbon dioxide sink capturing carbon from the atmosphere and functioning as a sink, with the carbon been stored in the form of fixed biomass during the growth process. Virachilai Ayyanar is a sacred grove which has a thick vegetation that has high carbon sequestration potential. Therefore it can contribute to reducing the concentration of carbon dioxide in the atmosphere. However, this grove is gradually shrinking due to anthropogenic activities like agriculture, urbanisation and grazing activities. Thus measures need to be initiated to preserve the grove area and to maximise carbon sequestration.

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