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CARBON SEQUESTRATION AND BUDGETING IN PLANTATIONS OF FAST GROWING TREES

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ABSTRACT

The study was carried out to estimate the net carbon gain from afforested plantation of five different fast growing species *viz*., *Tectona grandis*, *Gmelina arborea, Dalbergia sissoo*, *Bambusa vulgaris* var. *vulgaris* and *Swietenia macrophylla* in the waste lands located at Energy Plantation Projects India Public. Ltd. (EPPI) Nattarasan Kottai Village, Sivagangai District in Tamil Nadu. The observations on the biometric, biomass and biomass carbon were recorded in native vegetation and afforested plantation. The carbon content of targeted species revealed that all the species recorded above 41 per cent carbon content and average highest carbon content was recorded by *Dalbergia sissoo* (43.37 %). Among five afforested tree species, *Dalbergia sissoo* contributed more biomass (14970.82 kg ha^{-1}) and biomass carbon (6593.55 kg ha^{-1}), followed by *Bambusa vulgaris* var. *vulgaris* (4078.87 kg ha^{-1}). The overall observation of the study helps to conclude that, *Dalbergia sissoo* showed high performance in term of growth, biomass accumulation, carbon sequestration and carbon storage followed by *Bambusa vulgaris* var. *vulgaris* under waste land condition with the minimal input of water. The study also explained that *Gmelina arborea* and *Tectona grandis* had shown poor performance under waste land condition.

Keywords: Carbon sequestration, afforested plantation, biomass, Co_2

INTRODUCTION

Carbon sequestration phenomenon is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time. Plants store carbon for as long as they live, in terms of the live biomass. Once they die, the biomass becomes a part of the food chain and enters the soil as soil carbon. If the biomass is incinerated, the carbon is re-emitted into atmosphere. Most terrestrial carbon storage is in tree trunks, branches, foliage, and roots which is often called biomass. Terrestrial vegetation and soil represents important sources and sinks of atmospheric carbon (Watson *et al*., 2000), with land use change accounting for 24% of net annual anthropogenic emission of GHGs to the atmosphere (Prentice *et al*., 2001). Trees act as a sink for CO_2 by fixing carbon during photosynthesis and storing excess carbon as biomass.

The utilization of world carbon stock is started since 3,00,000 years, when our ancestors learnt to use control fire. As the result of heavier anthropogenic utilization of carbon stock, now CO_2 is responsible for 60% of extra green house effect. As the result, the earth's atmospheric temperature increasing, consequently the climate is changing and causing damages to mankind in all possible directions. One of the most viable mitigating options is that trees acts as a carbon sink by absorbing CO_2 in air and lock carbon in wood for substantial period of time. Especially, the hardwoods which are predominant in tropical countries like India, can able to hold as much as 48% of carbon in the form of cellulose in wood. Thus trees are acting as an environmental scavenger to consume excess CO_2 in the atmosphere and capable of stabilizing changing environmental conditions. Forest ecosystem plays important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere (Vashum and Jay Kumar, 2012).But Indian forests are undergoing greater anthropogenic pressure and about one tenth of removed forest is replaced. India contains about 175 million ha of waste lands which are suitable and potential for growing trees and the real gap is to find out the potential tree species which are not only fast growing but also having high CO_2 sequestration capacity.

Description of study site

The project was carried out in the Energy Plantation Projects India Public. Ltd. (EPPI) plantation area located at Nattarasankottai Village, Sivagangai District in Tamil Nadu. The area supports shrubby grassland type of vegetation. This area was treated as wasteland and lying fallow for years together. The present study aims to assess the carbon sequestration potential through afforestation of waste land in Sivagangai district of Tamil Nadu using five fast growing tree species. Before afforestation, the existing carbon or base line carbon in the waste land was estimated to explore the quantum of carbon capture potential of the selected tree species over the existing carbon in the natural vegetation of the experimental area. This study elucidates the net carbon benefits through afforestation in wasteland and also gives ample scope about the prospects of converting wastelands in the country into carbon forests in future. Having this as background, the present study was carried out to estimate carbon in the existing natural vegetation as well as in the afforestation area.

MATERIALS AND METHODS:

Afforestation and carbon estimation in plantation

To assess the carbon sequestration potential through afforestation of waste land, the study site for the experimental trail was selected at Chozhavandhan village which is a part of Energy Plantation Public Limited, India (EPPI) located at Natarasan Kottai, Sivagangai district in Tamil Nadu. The study site selected for the experimental trail is a typical wasteland, which is deficient in organic matter with no cropping history for past 20 years The ten acres of native vegetation present in waste land had been cleared and it was planted with five fast growing species namely *Tectona grandis, Gmelina arborea, Dalbergia sissoo, Bambusa vulgaris* var.*vulgaris* and *Swietenia macrophylla*. The observation was recorded for various parameters at three month interval.

Above ground biomass estimation (AGB)

The above ground biomass estimation was done by destructive sampling method (plate 2). The trees were felled at ground level using a mechanical chain saw (Poulan / Pro, USA). After recording the total height and GBH of the felled trees, the above ground portions were separated into wood, branches and leaves. Fresh weights of all the above ground tree components were recorded immediately after felling using appropriate spring scales.

A small sample (500 gram) of wood, branches and leaves were immediately transported to the laboratory in double sealed polythene bags. The collected samples were dried at 80o C till constant weight was obtained. The oven dry weight of the whole sample was calculated using the formula given below by Lasco *et al.,* (2005).

From the oven dried weight carbon content in the tree biomass was ananlysed through appropriate laboratory technique.

$$\textbf{ODW (t)} = \frac{TFW - \{TFW*(SFW-SODW)\}}{SFW}$$

Where,

ODW = Total oven dry weight

TFW = Total fresh weight

SFW = Sample fresh weight

SODW = Sample oven dry weight

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Below ground biomass estimation (BGB)

To estimate the below ground biomass, pits were excavated by removing soils around the tree and complete recovery of roots were done at 1 m distance from tree base. The roots were carefully separated and weight was recorded immediately using appropriate spring scales. Representative sample (500 g) of roots was immediately transferred to the laboratory in double sealed polythene bags. The collected samples were dried at 80 o C till constant weight was obtained. The oven dry weight of the whole sample was calculated using the formula given below (Lasco *et al.,* 2005).

$$\textbf{ODW (t)} = \frac{TFW - \{TFW*(SFW-SODW)\}}{SFW}$$

Where,

ODW = Total oven dry weight

TFW = Total fresh weight

SFW = Sample fresh weight

SODW = Sample oven dry weight

Carbon estimation in biomass of native vegetation

The plant samples of various fractionated biomass viz., stem, branches, leaves and roots of trees, shrubs, herbs, grass, litter and necromass were collected, air dried and oven dried (plate 3). The oven dried biomass samples were grounded separately in Willey Mill. The carbon concentration in each biomass sample of native vegetation was determined as per the procedure given by Allen *et al.,* (1986).

Ash content estimation

Porcelain crucibles were washed with 6 N hydrochloric acid and distilled water and dried in an oven at 65°C for one hour. Less than one gram of powdered sample was taken in pre-weight crucibles. The crucibles were taken inside the cool furnace. After adjustment of the furnace at 550°C, heating was increased slowly and after reaching at 550°C, ignition was continued for1 hour. Then the crucibles were cooled slowly keeping them inside the furnace. After complete cooling, the crucible with ash was weighed and the percentage of ash was calculated as per the procedure given by Allen *et al.*, (1986) with the following formula.

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$$\textbf{Ash \%} = \frac{(W3 - W1)}{(W2 - W1)} \times 100$$

Where,

W1 = Weight of crucibles

W2 = Weight of oven dried powdered samples + crucibles

W3 = weight of ash + crucibles.

Carbon estimation in biomass

Carbon per cent in above ground biomass, below ground biomass, litter and dead organic matters was estimated as followed by Dhruw *et al.* (2009), using following formula given below.

Carbon % = 100% - {Ash % + Molecular weight of O_2 (53.3 %) in $C_6H_{12}O_6$}

The carbon stock in above ground biomass and below ground biomass was computed by using following formula given below:

Carbon (MT) = Biomass (MT) x Carbon per cent

Percentage of organic carbon using the above procedure was done for all samples of fractionated biomass viz., leaf, stem, branch and root. Similarly, it was done for all vegetational components viz., trees, shrubs and herbs. Using the carbon percent value, the above ground organic biomass carbon (t ha-1), below ground organic biomass carbon (t ha-1) and total organic biomass carbon (t/ha) were calculated on individuals species basis and also per hectare basis.

The total biomass carbon was calculated by using the following formula.

i) AGB carbon (t C ha^{-1}) = Components of above ground biomass (t ha^{-1}) x Carbon content (%)

ii) BGB carbon (t C ha^{-1}) = Components of below ground biomass (t ha^{-1}) x Carbon content (%)

iii) Total biomass carbon stock (t C ha^{-1}) = AGB carbon + BGB carbon

RESULTS AND DISCUSSION

Carbon content (per cent)

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Carbon content per cent in fractionated biomass components viz., leaf, branch, stem and root of *Tectona grandis, Gmelina arborea, Dalbergia sissoo, Bambusa vulgaris* var.*vulgaris* and *Swietenia macrophylla* were estimated and result were presented below.The result revealed that, there was a significant difference in carbon content percent in biomass components of different tree species. The average highest carbon content per cent was recorded in stem (44.55 %) followed by branches (42.12 %), roots (41.93 %) and the lowest average carbon content per cent was recorded in leaf (39.42 %) based on the mean carbon content of the selected tree species (Table 1). *Dalbergia sissoo* recorded highest average carbon content of 43.05 per cent followed by *Tectona grandis* (42.41%) and the lowest was observed in *Gmelina arborea* (40.76%).

Table. 1 Carbon content (%) in different components of tree species

Sl.no	Treatment	Leaf C	Branch C	Stem C	Root C	Mean C
1	***Tectona grandis***	40.27	42.57	44.56	42.23	42.41
2	***Gmelina arborea***	41.77	36.06	43.04	42.19	41.06
3	***Dalbergia sissoo***	39.53	44.66	45.75	42.24	43.37
4	***Bambusa vulgaris var.vulgaris***	37.04	43.06	44.49	39.44	41.01
5	***Swietenia macrophylla***	38.48	44.23	44.90	43.56	42.79
	Mean	39.42	42.12	44.55	41.93	42.00

Biomass content (kg ha^{-1})

The biomass in different component like leaf, branch, stem and root of the experimental tree species was estimated on kilogram per hectare basis and was given in Table 2. Significant difference in biomass content was observed within the tree components. The stem part accounted more average biomass of 1928.82 kg ha-1 when compared to all other tree component viz., root (1016.76 kgha^{-1}), branch (975.68 kg ha^{-1}), leaf (651.33 kg ha $^{-1}$). Based on the total biomass in trees *Dalbergia sissoo* (11162.54 kg ha^{-1}) accounted the highest total biomass followed by *Bambusa vulgaris* var. *vulgaris* (6693.60 kg ha^{-1}) and the lowest biomass carbon was observed in *Tectona grandis* (1129.62 kg ha^{-1}).

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Table.2 Above and below ground biomass (Kg ha^{-1}) of tree specie

Sl.No.	Treatment	Leaf	Stem	Branch	Root	Total
1.	*Tectona grandis*	642.31	618.32	439.51	812.78	2512.92
2.	*Gmelina arborea*	432.21	1642.38	962.17	811.47	3848.23
3.	*Dalbergia sissoo*	2275.21	5739.62	3825.95	3129.45	14970.23
4.	*Bambusa vulgaris* var. *vulgaris*	1246.5	4265.14	2386.21	2543.01	10440.86
5.	*Swietenia macrophylla*	847.2	1986.25	942.01	1148.65	4924.11

Biomass carbon content (per ha basis)

Biomass carbon on per hectare basis was given in Table 3. Among the targeted species Dalbergia sissoo recorded highest total biomass carbon content value of 4805.47 kg ha $^{-1}$ followed by *Bambusa vulgaris* var.*vulgaris* (2745.05 kg ha $^{-1}$) and the lowest biomass was registered in Tectona grandis (479.07 kg ha $^{-1}$).

Table 3. Biomass carbon (kg ha^{-1}) of tree species

Sl.No.	Treatment	Leaf C	Stem C	Branch C	Root C	Total C
1.	*Tectona grandis*	119.79	120.79	54.36	180.13	479.07
2.	*Gmelina arborea*	75.78	185	159.94	163.74	592.72
3.	*Dalbergia sissoo*	555.96	203.63	131.6	979.96	6593.55
4.	*Bambusa vulgaris* var. *vulgaris*	370.23	125	592.67	575.43	2745.05
5.	*Swietenia macrophylla*	143.05	612.54	79.07	213.52	1036.79

The study revealed that among the trees, *Dalbergia sissoo* (14970.82 kg ha^{-1}) accounted the highest total biomass followed by *Bambusa vulgaris* var.*vulgaris* (9611.58 kg ha^{-1}) and *Dalbergia sissoo* recorded the highest total biomass carbon content value of 6593.55 kg ha^{-1} followed by *Bambusa vulgaris* var. *vulgaris* (4078.87 kg ha^{-1}).Among the trees the maximum carbon content was observed in *Dalbergia sissoo* (43.37%) and in general, the two tree species *Dalbergia sissoo* and *Bambusa vulgaris* var. *vulgaris* showed better performance than the other three species.

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