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Carbon sequestration potential of different tree species in Allahabad, Uttar Pradesh

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ABSTRACT

The present study investigates above ground biomass and below ground biomass carbon sequestration potential of selected 12 tree species of SHIATS campus, Allahabad city viz *Dalbergia sissoo, Acacia nilotica, Azadirachta indica, Leuceana leucocephala, Aegle marmolos, Cassia fistula, Albizia lebbeck ,Bauhainia variagata, Ficus religiosa, Madhuca indica, Tectona grandis* and *Terminalia arjuna*. Non-destructive research approach was applied. The above ground biomass and below ground organic carbon have been estimated. *A lebbeck* was found to be dominant and sequestered 158.20 tons of carbon followed by *D sissoo* (151.84 tons). The species *F religiosa* had the lowest carbon sequestration potential (19.25 tons). The research can be useful for estimating carbon sequestration capacity of the tree species in Allahabad city for the purpose of obtaining carbon finance and assessing the contribution carbon sequestration in the tree species.

Keywords: Carbon sequestration; potential; biomass, tree species

INTRODUCTION

Trees are carbon reservoirs on earth. In nature forest ecosystem acts as a reservoir of carbon. Trees store huge quantities of carbon and regulate the carbon cycle by exchange of CO_2 from the atmosphere. Forest ecosystem is one of the most important carbon sinks of the terrestrial ecosystem. It uptakes the carbon dioxide by the process of photosynthesis and stores the carbon in the plant tissues, forest litter and soil. Thus forest ecosystem plays an important role in the global carbon cycle by sequestering a substantial amount of carbon dioxide from the atmosphere (Vashum and Jayakumar 2012). Carbon sequestration is a mechanism for the removal of carbon from the atmosphere by storing it in the biosphere (Chavan and Rasal 2012). In the global carbon cycle biomass is an important building block, especially carbon sequestration and is used to help to quantify pools and changes of green house gases from the terrestrial biosphere to the atmosphere associated

with land use and land cover changes (Cairns et al 2003). As more photosynthesis occurs more CO_2 is converted into biomass reducing carbon in the atmosphere and sequestering it in plant tissue above and below ground resulting in growth of different parts. Carbon sequestration is a mechanism for the removal of carbon from the atmosphere by storing it in the biosphere. Carbon in the system moves between the four major reservoirs: fossil and geological formations, the atmosphere, the oceans and terrestrial ecosystems including forest (Melillo et al 1993). Transfers between these reservoirs occur mainly as carbon dioxide (CO_2) evolved in processes such as fuel combustion, chemical dissolution, diffusion, photosynthesis, respiration and decomposition, wild fires and burning of biomass and furnaces. Forests play a significant role in the global carbon cycle through dynamic exchange of CO_2 with the atmosphere. The management of such terrestrial forest carbon stocks can deliver a significant component to international climate change abatement strategies (Read and Lawrence 2003). Forest ecosystems play a leading role in global terrestrial carbon cycle owing to their huge carbon pool and high productivity. Several studies so far suggested that forest action can effectively provide roughly 30 per cent of the total global effort needed in all sectors to meet climate mitigation strategies. With an increasing concern for global climate changes resulting from more and more anthropogenic greenhouse gases, protecting carbon stocks in the existing forests and getting the new carbon stocks through afforestation and reforestation have become the important measures to enhance the carbon sequestration capacity in the terrestrial ecosystems and mitigate the increasing carbon dioxide concentration in the atmosphere (Lal 2005).

Biomass is an essential aspect of studies of carbon cycle. There are two methods to calculate forest biomass; one is direct method and the other is indirect method (Salazar et al 2010). Direct methods also known as destructive methods involve felling trees to determine biomass. Indirect means of estimation of stand biomass are based on allometric equations using measurable parameters.

In this paper the estimation of the biomass and carbon sequestration rates for the selected trees species were carried out with diameter and breast height in SHIATS campus to investigate the extent to which the school can rely on carbon sequestration by trees species located in the campus.

MATERIAL and METHODS

Study area

The study area was located in Uttar Pradesh, India. Allahabad is located in the southern part of the state at 25°27’ N latitude 81°84’ E longitude. Allahabad possesses tropical to subtropical climate with extreme summer and winter. The

temperature falls to as low as 5°C in winter while in summer it reaches above 45°C. Hot sizzling winds are quite common during summer and sporadic spell of frost occurs during winter.

Sampling technique: Quadrate method was used in the study and quadrates of 40 x 40 m were made.

Measurement of height: To estimate biomass from selective tree species it is not advisable to cut them. The biomass can be measured by mathematical models by measuring diameter at breast height (DBH) directly and the girth at DBH (Chavan and Rasal 2010).

Above ground biomass (AGB) of trees: AGB included all living biomass above the soil. The aboveground biomass (AGB) was calculated by multiplying volume of biomass and wood density and the volume was calculated using volume equations given by Forest Survey of India 2013 report (Table 2).

Below ground biomass (BGB) of trees: The BGB included all biomass of live roots excluding fine roots having diameter <2 mm.

$$BGB = AGB \times (15/100) \text{ (tons)}$$

Total biomass: Total biomass is the sum of the above and below ground biomass (Sheikh et al 2011).

Total biomass (TB)= Above ground biomass + below ground biomass

Carbon estimation: Generally for any plant species 50 per cent of its biomass is considered as carbon (Pearson et al 2005).

Carbon storage= Biomass x 50% or biomass/2

RESULTS and DISCUSSION

The field data of the tree species studied from the quadrate method are tabulated in Table 1.The results reveal that *Azadirachta indica* trees were found to be dominant having the 91 trees and *Aegle marmelos* tree species having 4 trees.

Table 3 shows that maximum organic carbon was present in *A lebbeck* (158.20 tons) followed by *D sisso* (151.84 tons) and the minimum was recorded in *F religiosa* (12.55 tons).

The Table 3 also reveals that the 12 species with the total of 375 trees were recorded in the campus. *A indica* was dorminant in the campus having the total number of 91 tree species and sequestered 107.54 tons of carbon. The major carbon sequestrating species were *A lebbeck* (158.20 tons) followed by *D sissoo* (151.84 tons), *Tectona grandis* (113.51 tons) and *A indica* (107.54 tons). The *F religiosa* had the lowest carbon sequestration potential (12.55 tons).

Table 1. Field data of trees studied from the quadrate method in SHIATS campus

Species	Quadrant				Total
	1	2	3	4	
Dalbergia sissoo	10	6	15	7	38
Acacia nilotica	11	13	15	21	60
Azadirachta indica	13	19	22	37	91
Leuceana leucocephala	14	7	5	11	37
Aegle marmelos	-	-	3	1	4
Cassia fistula	2	8	5	2	17
Albizia lebbeck	11	6	5	11	33
Bauhinia variegata	-	1	4	8	13
Ficus religiosa	2	4	1	3	10
Madhuca indica	1	-	5	6	12
Tectona grandis	7	6	12	15	40
Terminalia arjuna	3	5	8	4	20

Table 2. Wood densities of selected tree species

Species	Wood density (g/cm^3)	Species	Wood density (g/cm^3)
Dalbergia sissoo	0.531	*Albizia lebbeck*	0.676
Acacia nilotica	0.610	*Bauhinia variegata*	0.619
Azadirachta indica	0.632	*Ficus religiosa*	0.354
Leuceana leucocephala	0.423	*Madhuca indica*	0.568
Aegle marmelos	0.738	*Tectona grandis*	0.455
Cassia fistula	0.529	*Terminalia arjuna*	0.467

CONCLUSION

From the research it was observed that *A lebbeck* species was found to be dominant that sequestered 158.20 tons of carbon followed by *D sissoo* (151.84 tons). The species *F religiosa* had the lowest carbon sequestration potential (19.25 tons). The research can be useful for estimating carbon sequestration capacity of the tree species in Allahabad city for the purpose of obtaining carbon finance and assessing the contribution carbon sequestration in the tree species. Current issues related to mitigating the global warming problem through forestry will include forest protection; the management of forests for carbon for joint products ie the management of forests to generate both carbon and timber as products.

Table 3. Mean value for above and below ground biomass with total organic carbon (tons/tree)

Species	# trees	Average organic carbon (tons/individual)			Total organic carbon (tons/tree)
		AGB	BGB	Total	
Dalbergia sissoo	38	6.41	0.96	7.37	151.84
Acacia nilotica	60	2.30	0.35	2.65	86.52
Azadirachta indica	91	1.70	0.25	1.95	107.54
Leuceana leucocephala	37	3.30	0.50	3.80	71.27
Aegle marmelos	4	6.56	0.98	7.54	19.25
Cassia fistula	17	3.73	0.56	4.29	37.56
Albizia lebbeck	33	7.84	1.18	9.02	158.20
Bauhinia variegata	13	2.50	0.37	2.90	19.54
Ficus religiosa	10	3.39	0.51	3.90	12.55
Madhuca indica	12	6.84	1.03	7.90	46.84
Tectona grandis	40	5.34	0.80	6.14	113.51
Terminalia arjuna	20	2.50	0.37	2.85	24.84
Total	375	-	-	-	846.46

AGB= Above ground biomass, BGB= Below ground biomass

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