Assessment of Tree Carbon Sequestration of Vimala College Campus, Thrissur, Kerala, India

I.J. Kaveri and M. Jayalakshmi

Abstract

Carbon exchanges between the land and the atmosphere are significant in the case of global warming. Trees with high carbon sequestration potential thus play a major role in capturing the CO_2 which is considered as contributor of global warming. The present study is an attempt to identify and document the carbon sequestration potential of trees in Vimala College (Autonomous) Campus and to analyze their efficiency in sequestering carbon. In this study, 40kinds of species from 20 families were identified in the campus through field survey. The amount of CO_2 in standing woody biomass of selected trees was calculated using non-destructive method. *Bambusa vulgaris* are found to have the highest Carbon sequestration potential whereas *Callistemon citrinus* is found to have lowest CO_2 sequestration potential. The study also put forward the sequestration model for urban areas and urban campuses.

Index Terms: Carbon dioxide (CO_2), Carbon sequestration, Non-destructive method, Total dryweight, Total green weight, Urban areas, Weight of carbon.

1. INTRODUCTION

Climate change features a crucial role in altering the world, causing extreme weather events like tropical storms, wildfires, severe droughts, and heat waves, etc. It's important to know how carbon and other greenhouse gases affect the environment because they're the promoters for heating and global climate change. In 2019, it was discovered that 21 of the 30 most polluted cities in the world were in India, as part of a worldwide survey (Regan, 2020). There are three strategies of lowering CO_2 emissions to resist 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. Among a number of approaches, tree planting is one of the most successful and well-known method in the world (Geist and Lambin, 2002; Zhenga, 2013). When the concentration of CO_2 within the air around a plant leaf rises, it is often absorbed more quickly, increasing the speed of photosynthesis. In response to growing concerns about global climate change which is treated because the main contribution by the emission of carbon to the atmosphere, considerable interest has been drawn to extend the speed of carbon sequestration.

Carbon sequestration may be a mechanism of removing carbon from the atmosphere by storing it within the biosphere (Chavan and Rasal, 2012). A stock that is taking-up carbon is called a "sink" and one that is releasing carbon is known as a "source." Trees function as the vital sinks for atmospheric carbon i.e. carbon dioxide, since 50% of their standing biomass is carbon itself (Ravindranath et al., 1997). Sequestered carbon is then accumulated in the form of biomass, deadwood, and litter in the soils and release of carbon from natural ecosystems results from natural processes (respiration and oxidation) as well as deliberate or unintended results of human activities (i.e. harvesting, fires, deforestation). According to Lal et al., (2003) terrestrial carbon sequestration is often termed as win–win or no-regrets strategy due to improved soil and water quality, restoration of degraded ecosystems, increased crop yield etc. In India, studies were done on the Indian forests and examined the strata and forest area changes of the state or region and revealed that the forests act as sink for atmospheric carbon (Ravindranath et al., 1997; Haripriya, 2000; Chhabra and Dadhwal, 2004; Manhas et al., 2006; Gupta, 2009; Kaul et al., 2009). Some of the studies estimated that carbon

IJ Kaveri currently pursued master's degree program in Botany from Vimala College, Thrissur, Kerala, India. E-mail: kaveriij24@gmail.com
M Jayalakshmi is currently working as Assistant Professor in Botany in Vimala College, Thrissur, Kerala, India. E-mail: jayavilas10@gmail.com

sequestration potential depends on various factors like location, climate, management activities done there etc. (Negi and Chauhan, 2002; Negi et al., 2003; Singh, 2003).

Despite the uncertainty surrounding Carbon offsets, especially land-use offsets, over 150 bilateral Carbon offset schemes are established so far. Approximately 30 programs are focused on forestry practices and land use alternatives that are intended to conserve and/or sequester C, or to substitute greenwood products for products derived from fossil fuels. By recent years, the awareness among people had raised and thus various studies had also been continuing in various urban environments such as industrial areas, college campuses, polluted cities, roadsides and even in certain rural villages too. However, a complete and recent analysis of carbon sequestration of Vimala College campus has not yet been performed which could be performed similarly in other campuses too. Therefore, the main objective of this study is to evaluate the carbon sequestration potential of selected plant species and to propose a sequestration model for the urban areas.

2. STUDY AREA

The study area, Vimala College Campus is a part of Thrissur Corporation and is located at Ramavarmapuram, Thrissur District, Kerala (Figure 1. The geographical location of Vimala College lies between 10.553215385472264 latitude and 76.22682776972341 longitudes of Thrissur district, according to the Survey of India Toposheet No. 58 B and 49 N. The campus has a total area of 26 acres. The average annual rainfall ranges between 2310.1 and 3955.3 mm in the district with mean annual rainfall of 3198.133 mm. The average annual maximum temperature is 32.30⁰C and minimum temperature 23.3⁰C. The humidity is higher during monsoon months from June to October and is around 93% during morning hours and 76% during evening hours (Department of mining and geology, 2016).

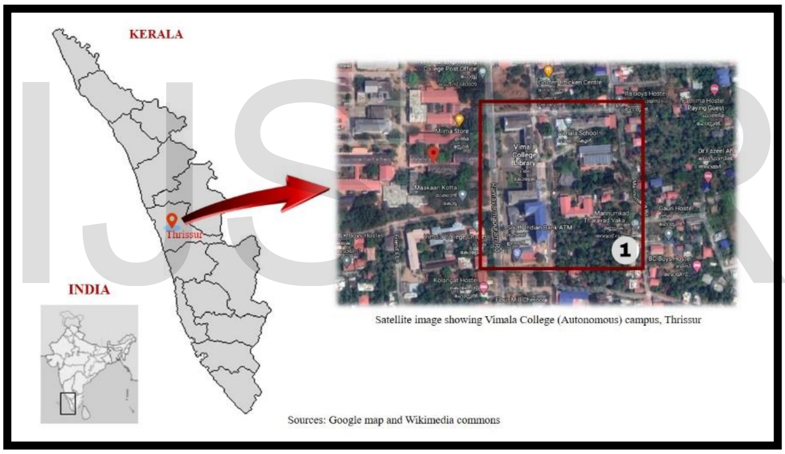

Figure 1. Study area

3. Materials and Methods

3.1. Field Survey of Trees in the Campus

Frequent visits were done for data collection and the species were identified using standard floras (Hooker, 1872; Manilal and Sivarajan, 1982). Each tree in campus was identified to the species level, including its scientific name and family. The trees were counted using the census system, which involved direct counting. The survey process was conducted during the months February – March 2021.

3.2. Measurement of Tree Height and Diameter at Breast Height (DBH)

The height and diameter of tree species were taken by direct measurement method using measuring tapes. Diameter at Breast Height (DBH) is measured using a measuring tape by wrapping it around the circumference of tree. While measuring the DBH, special concerns were taken on cases of split trunks and trees on slopes.

IJ Kaveri currently pursued master's degree program in Botany from Vimala College, Thrissur, Kerala, India. E-mail: kaveriij24@gmail.com
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When the trunk is at an angle or is on a slope, the trunk is measured at right angles to the trunk along the centre of the trunk axis, so the height is the average of the shortest and the longest sides of the trunk. When the trunk branches or splits less than 4.5 feet from the ground, the smallest circumference below the lowest branch is measured and if the tree has a branch or a bump at 4.5 feet, diameter slightly below or above the branch/bump is measured. Measuring of Bamboo species were done by wrapping the whole culm and measuring the diameter at breast height.

3.3. Determination of the weight of carbon dioxide sequestered in the tree

In order to estimate the weight of Carbon dioxide sequestrated in the tree, the total green weight and dry weight of the tree is calculated by non-destructive method. From this the weight of carbon in the tree is calculated and this gives the values for calculating the weight of carbon dioxide sequestrated by the tree.

3.3.1. Determination of the total green weight of the tree:

The green weight is the weight of the tree when it is alive. Calculating the green weight of the above-ground weight is as follows (Saucier *et al.*,1986):

$W_{above\text{-}ground}$ = Above-ground weight in pounds

$W_{above\text{-}ground} = 0.25\ D^2 H$ (for trees with D<11)

$W_{above\text{-}ground} = 0.15\ D^2 H$ (for trees with D>11)

Where, D = Diameter of the trunk in inches

H = Height of the tree in feet

The root system weight is about 20% of the above-ground weight. Therefore, to determine the total green weight of the tree, multiply the above-ground weight by 1.2:

$$W_{total\ green\ weight} = 1.2 \times W_{above\text{-}ground}$$

3.3.2. Determination of the dry weight of the tree:

The average tree is 72.5% dry matter and 27.5% moisture (DeWald *et al.*, 2005). Therefore, to determine the dry weight of the tree, multiply the total green weight of the tree by 72.5%.

$$W_{dry\ weight} = 0.725 \times W_{total\ green\ weight}$$

3.3.3. Determination of the weight of carbon in the tree: The average carbon content is generally 50% of the tree's dry weight total volume (Saucier *et al.*,1986). Therefore, for determining the weight of carbon in the tree, multiply the dry weight of the tree by 50%.

$$W_{carbon} = 0.5 \times W_{dry\ weight}$$

3.3.4. Determination of the weight of carbon dioxide sequestered in the tree:

The weight of CO_2 in trees is determined by the ratio of CO_2 to C is 44/12 = 3.67. Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.67 (Saucier *et al.*,1986).

$$W_{carbon\text{-}dioxide} = 3.67 \times W_{carbon}$$

4. Results and Discussion

Frequent field survey formulated the overall trees within the campus encountered a total of 146 from 62 kinds of species and 40 of the species from 20 families were selected. The selected species include 18 exotic species and 22 native species. This study was carried out in the months February to March which is considered as cool and salubrious in February and hot summer season in March (Department of Mining and Geology, 2016). Since it was during the starting of hot summer season, the unavailability of flowers from trees made the identification of species with leaf and bark characters. The most occurred on in the campus is *Polyalthia longifolia.* The genus Bambusa from family Poaceae (Graminae) is considered as grass family and according to floras they were considered as shrubs but according to Indian Forest Act, 1927 bamboo is considered as tree. So, for this study, the genus Bambusa is incorporated and measured as culm. Thus, the CO_2 sequestration potential of selected species were calculated from their height and DBH (Table 1, Graph 1). The tree species which showed the maximum diameter is *Bambusa vulgaris* with 514 inches, *Bambusa tuldoides* with 345 inches, *Acacia sinuata* with 108.9 inches and *Murraya paniculata* with 120 inches. *Manilkara sapota* with 8 inches and *Annona squamosa* with 9.5 inches showed the minimum diameter values. The tree species which showed the maximum heights are *B. tuldoides* with 60.69 feet, *Bambusa vulgaris* and *Ficus religiosa* with 52.49 feet. Some trees of the species like *Aegle*

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M Jayalakshmi is currently working as Assistant Professor in Botany in Vimala College, Thrissur, Kerala, India. E-mail: jayavilas10@gmail.com

marmelos, *Bambusa tuldoides*, *Caesalpinia coriaria*, *Cassia fistula* etc. showed minimum heights. The final calculation of Carbon sequestration showed the maximum value in *B. vulgaris* with 3320851.007 lbs Carbon/year, *B. tuldoides* with 1729823.958 lbs Carbon/year and *A. sinuata* with 65203.997 lbs Carbon/year (Graph 2). The least amount of Carbon sequestration was shown in *Callistemon citrinus* with 570.239 lbs Carbon/year and *Simarouba glauca* with 689.690 lbs Carbon/year. On the basis of this study, it is noticed that the greater the breadth and height of the tree, the greater the value of total green weight of the tree, dry weight of the tree, weight of carbon in the tree and weight of carbon dioxide sequestered in the tree. So even the heights are low, the diameter in a greater amount have the capability to give a good value.

Table 1. List of CO_2 sequestration potential of selected trees in vimala college campus

No.	Binomial Name	Family	Diameter (in inches)	Height (in feet)	CO_2 sequestrated
1	*Acacia sinuata*	Fabaceae	43.5	19.68	8917.645
			108.9	22.96	65203.997
2	*Aegle marmelos*	Rutaceae	20.5	32.80	3300.867
			70	16.40	19243.608
			22.7	36.08	4452.099
3	*Annona squamosa*	Annonaceae	9.5	19.685	709.051
4	*Artocarpus heterophyllus*	Moraceae	52.2	44.2913	28900.543
5	*Artocarpus incisus*	Moraceae	68	39.37	43594.311
6	*Azadirachta indica*	Meliaceae	31	19.68	4528.924
			32	19.68	4825.825
7	*Bambusa tuldoides*	Poaceae	220	19.68	228095.667
			93	16.40	33966.932
			345	60.69	1729823.958
8	*Bambusa vulgaris*	Poaceae	120	39.37	135760.830
			514	52.49	3320851.007
9	*Bauhinia variegata*	Fabaceae	43.5	39.37	17839.821
10	*Caesalpinia coriaria*	Fabaceae	37	16.40	5376.428
11	*Callistemon citrinus*	Myrtaceae	11	19.68	570.239
			88	22.96	42577.857
12	*Cassia fistula*	Fabaceae	22.5	16.40	1988.178
			24.8	29.52	4347.7673
13	*Castanospermum australe*	Fabaceae	10.8	26.246	1221.816
14	*Casuarina equisetifolia*	Casuarinaceae	33	32.8084	8555.673
15	*Citharexylum spinosum*	Verbenaceae	44.3	19.685	9251.016
16	*Cochlospermum religiosum*	Cochlospermaceae	45	19.68	9543.258
17	*Elaeocarpus sphaericus*	Elaeocarpaceae	34	29.52	29745.560
18	*Ficus bengaliensis*	Moraceae	43	45.93	20336.674

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19	*Ficus microcarpa*	Moraceae	34.9	22.96	6696.830
20	*Ficus religiosa*	Moraceae	62	52.49	48317.731
21	*Garcinia gummi-gutta*	Clusiaceae	63	39.37	37419.079
			19	32.80	2835.486
			73	42.65	54426.016
22	*Limonia acidissima*	Rutaceae	27.5	16.40	2969.995
23	*Magnolia champaca*	Magnoliaceae	74	22.96	30107.999
24	*Manilkara sapota*	Sapotaceae	39	26.246	9557.396
			8	16.40	418.908
25	*Mangifera indica*	Malvaceae	58	32.8084	26422.652
26	*Moringa pterygosperma*	Moringaceae	18.5	28.707	2352.761
27	*Murraya paniculata*	Rutaceae	120	16.40	56552.644
28	*Neolamarckia cadamba*	Rubiaceae	43.3	39.37	17676.154
29	*Phyllanthus emblica*	Euphorbiaceae	25.5	39.37	3065.225
			40	39.37	15084.536
30	*Phyllanthus indofischeri*	Euphorbiaceae	35.8	36.08	11073.353
31	*Polyalthia longifolia*	Annonaceae	33	39.37	10266.912
			27.3	29.52	5268.515
32	*Pongamia pinnata*	Fabaceae	33	16.40	4276.793
33	*Pterocarpus rotundifolius*	Fabaceae	51.7	39.37	25199.567
			59.5	32.80	33368.416
34	*Saraca asoca*	Fabaceae	16	26.24	1608.608
			31	16.40	3774.103
35	*Simarouba glauca*	Simaroubaceae	21.5	22.96	2541.530
			11.2	22.96	689.690
36	*Syzygium malaccense*	Myrtaceae	51.7	36.08	23093.735
			23.5	32.80	4337.666
37	*Syzygium samarangense*	Myrtaceae	26	22.96	3716.765
38	*Terminalia arjuna*	Combretaceae	53	35.43	23832.492
39	*Terminalia bellarica*	Combretaceae	37.8	36.08	12345.159
40	*Wrightia tinctora*	Apocynaceae	25.4	29.52	4560.688

Graph 1: Carbon Dioxide sequestered by selected trees in the college campus

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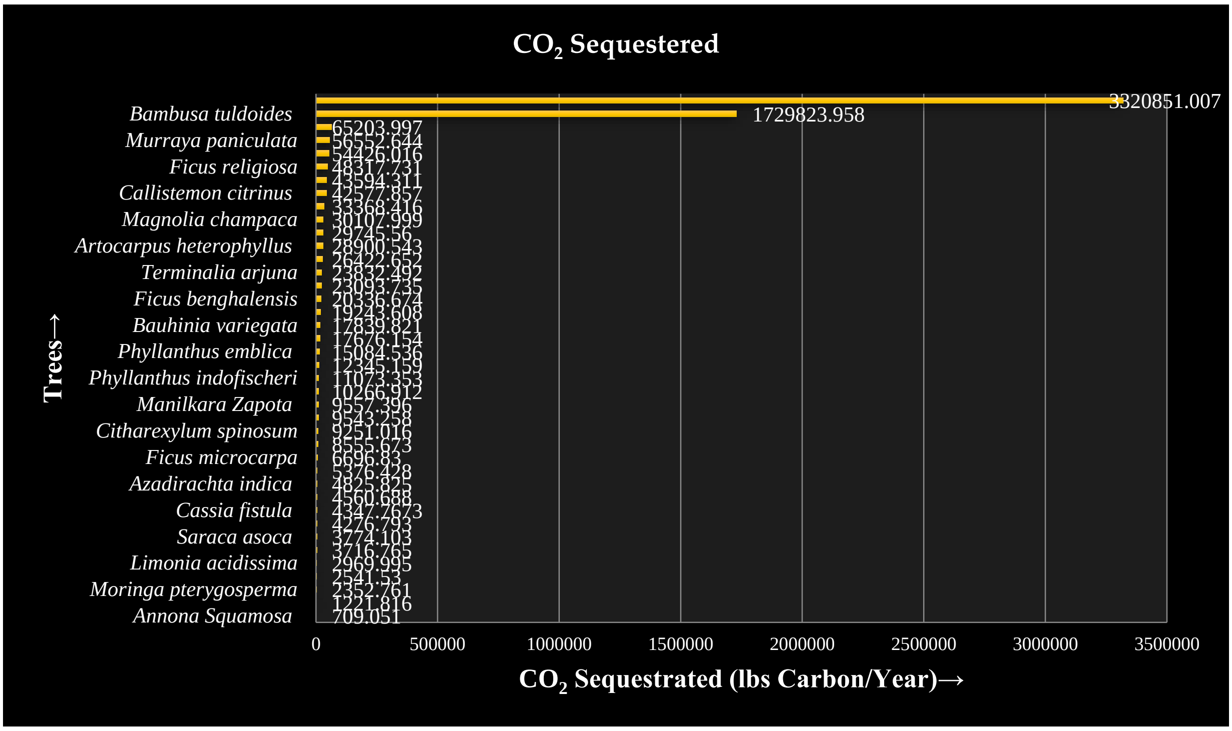
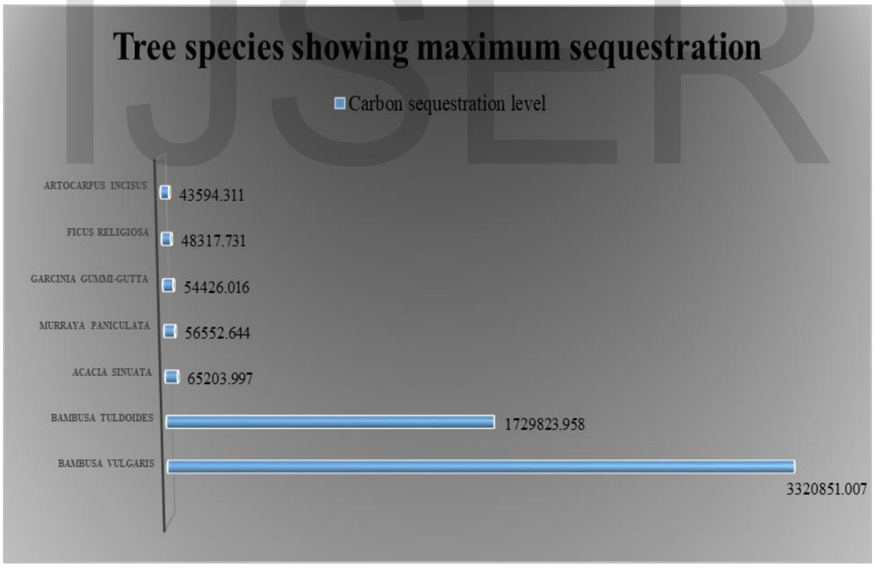


Graph 2. Selected tree species according to maximum Carbon sequestration value.



5. CONCLUSION

The present investigation "Assessment of tree carbon sequestration of Vimala College campus, Thrissur, Kerala", tried to find out the Carbon sequestration potential of selected tree species by following disciplines like the species identification through field survey, measuring of Tree Height and Diameter at Breast Height (DBH), determination of the weight of carbon dioxide sequestered in the tree, total green weight of the tree, dry weight of the tree, weight of carbon in the tree, weight of carbon dioxide sequestered in the tree. During the analysis, *Acacia sinuata*, *Artocarpus incises*, *Bambusa tuldoides*, *Bambusa vulgaris*, *Ficus religiosa*, *Garcinia gummi-gutta* and

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Murraya paniculata showed the maximum carbon sequestration potential and this makes them a good contributor for a sequestration model. Even though the most concern of this study was whether to add Bambusa species or not because of them being from a grass family (Poaceae) and also because of their hollow pith, but conversely, they showed highest carbon sequestration potential. In order to protect the livings from the polluted environment, the suggested model of sequestration using these tree species with high CO_2 sequestrating potential is suitable for the urban areas and urban campuses according to this study. This analysis can be implemented in other urban areas and also in rural areas to find out species with high carbon sequestration potential for better tree planning or for enhancing the current status.

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M Jayalakshmi is currently working as Assistant Professor in Botany in Vimala College, Thrissur, Kerala, India. E-mail: jayavilas10@gmail.com

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