ASSESSMENT OF CARBON SEQUESTRATION POTENTIAL OF TREES IN THE CAMPUS OF DR. D. Y. PATIL ACS COLLEGE PIMPRI, MAHARASHTRA, INDIA

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Abstract: ***The increase in atmospheric carbon dioxide is one of the main reasons of climate change and global warming. Trees have enormous potential to sequester carbon from the ambient atmosphere and alleviate the impacts of climate change in cities. The present study was carried out in Dr. D. Y. Patil Arts, Commerce and Science College campus, Pimpri, Pune, 411018, Maharashtra, India. In the present study, the amount of biomass and CO_2 sequestered in standing tree species was calculated. Assessment of carbon sequestration of only 20 trees species and 115 individuals was carried out. The aboveground biomass and below ground biomass was estimated using the non-destructive sampling method. Individual trees on the campus were measured for their height and diameter at breast height, and total carbon sequestered was estimated. The result showed that Ficus benjamina has the better carbon sequestration potential rate, which sequestered 36521.09 kg/tree of CO_2 whereas Prunus dulcis has the least sequestration rate which sequestered 5.43 kg/tree of CO_2 as compared to other species. Total tree count in the selected study area is 115 and total carbon dioxide sequestered by the trees 47.52 tons. The current work is a sustainability initiative to inventory of the tree species on the campus and assess their total carbon sequestration potential.***

Keywords: ***Carbon Sequestration; Biomass; Above Ground Biomass; Below Ground Biomass***

1. STUDY AREA

Dr. D. Y. Patil Arts, Science, and Commerce College, Pimpri (DYP ACS) campus is located in Pune City, Maharashtra, India. The areal extent of area is 73°49'20.34"E to 73°49'23.637"E east to 18°37'14.924"N to 18°37'19.046"N north. The area covered during this study is 11042.90 m^2 (Figure 1). The college has developed lush green campus by planting large number of plants.

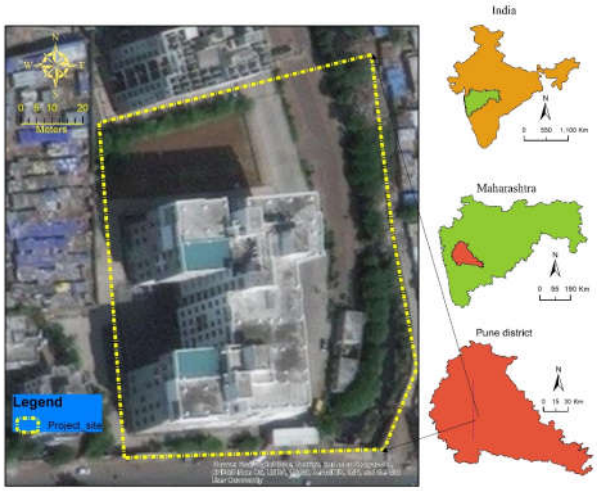

Figure 1: Location Map of Study Area (Dr. D. Y. Patil ACS College Campus)

2. INTRODUCTION

Trees play important role in the capturing of CO_2 from atmosphere through the process of photosynthesis. The capture and storage of CO_2 is the key factor for the reduction of green house gas effect. Carbon sequestration phenomenon is the absorption of the atmospheric CO_2 and its storage in terrestrial ecosystems for a very long period of time. The global concern about the climate change has shaped rising attention in trees to help lessen the level of atmospheric CO_2. Urban trees store carbon derived from CO_2, which is the major gas contributing to global climate change.

The basic process of carbon sequestration in the terrestrial biosphere involves transfer of atmospheric CO_2 into plant biomass through photosynthesis and conversion of biomass [1]. Carbon removed from the atmosphere is stored in the biosphere through the process of carbon sequestration [2]. India being a tropical nation, it has very high potential for carbon sequestration. More than 116 million tons of CO_2 per year is sequestered contributing to reduce atmospheric carbon [3].

Carbon detain rates differ by species, climate, soil, topography, management practice, etc. [4]. The larger tree stores nearly 1000 times more carbon than smaller trees. Trees with the diameter of 77 cm or more sequester about 90 times more carbon as compared to the small trees with the diameter 8 cm or less. A report published by International Council of Local Environmental Initiatives (ICLEI), South Asia, has stated that average per capita carbon discharges in India are higher in the metropolitan cities with about 1.19 tons per capita, as compared to the non-metropolitan cities with about 0.90 tons per capita. Reduction in carbon dioxide concentrations in the atmosphere can be achieved either by reducing the demand for energy, altering the usage of energy, or increasing the rates of removal of CO_2 through the trees through carbon sequestration, which can decrease the atmospheric carbon dioxide naturally [5].

Studies conducted by several scientists have claimed that urban green spaces can play a very important role in limiting the city's carbon footprint [6]. The vegetation and soil of a green space cannot only sequester carbon, directly contributing to a reduction in atmospheric CO_2 concentration, but also affect the carbon balance indirectly, through their effects on the urban energy balance and thus on CO_2 emissions related to energy use [7].

According to the Intergovernmental Panel on Climate Change (2006), the major five carbon pools of a terrestrial ecosystem involving biomass are above-ground biomass, below-ground biomass, dead wood, litter, and soil organic matter [8]. The carbon assimilated by trees is reserved for longer period with slight escape into the atmosphere. Annual rates of carbon sequestration mainly depend on the life span of the trees, size of the trees at maturity, and the growth rates of trees [9].

Gavali and Shaikh, 2016 [10] estimated tree carbon storage and biomass of vegetation in the Solapur University of Maharashtra and reported that urban green spaces are likely to have a wider impact per area of tree canopy cover in comparison to other nonurban forests due to faster growth rates and increased proportions of large trees. Marak and Khare, 2017 [11] estimated carbon sequestration potential of tree species in the campus of Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, and identified the important species with maximum carbon sequestration potential.

There are number of studies wherein carbon stock estimation is performed for university/ college campuses in India. Similar studies on carbon sequestration have been carried out in Jnanabharathi campus, Bangalore University [12], Bharathiar University campus at Coimbatore [13], Andhra University, Vishakhapatnam [14], North Maharashtra University Campus, Jalgaon [15], various educational institutes in Vijaypur, Jammu and Kashmir [16] and Vellore Institute of Technology (VIT) campus [17].

The plants are important sinks for atmospheric carbon as they have about 50% carbon dioxide in their standing biomass [18]. Tiwari & Singh, 1987 [19] and FSI, 1988 [20] has documented the importance of carbon sequestration forested areas. The major concern of increasing carbon emissions and its effects on the entire world are addressed in Kyoto protocol [2, 18]. Terrestrial vegetation and soil represent important sources and sinks of atmospheric carbon [21]. These studies emphasize the role of tree cover in the carbon sequestration and highlight the need for more attention on the selection of trees in the educational institutes that supports biodiversity and maximizes environmental services.

3. MATERIAL AND METHODS

The amount of biomass and CO_2 sequestered in standing tree species was calculated by using non-destructive method as described by Gavali and Shaikh, 2016 [10]. The biomass of tree was estimated based on diameter at breast height (DBH) and tree height. DBH can be determined by measuring tree Girth at breast height (GBH), approximately 1.3 meter above the ground. The GBH of trees were measured directly by using measuring tape.

3.1. Estimation of Above Ground Biomass (AGB)

The AGB of tree includes the whole shoot, branches, leaves, flowers, and fruits. It is calculated using the formula as mentioned below,

AGB in kg = Volume of Tree (in m^3) X Wood Density (in kg/m^3).

Where,

V = volume of the cylindrical shaped tree in $m^3 = \pi r^2 H$

R = the tree radius of in m

H = the tree height of in m

The radius of the tree is calculated from GBH of tree. Wood density from International Council for Research in Agroforestry (ICRAF) Database [22] was used for further calculations.

3.2. Estimation of Below Ground Biomass (BGB)

The BGB includes all biomass of live roots excluding fine roots. The BGB has been calculated by multiplying AGB value by 0.26 factor as the root: shoot ratio, BGB is determined by using following formula

BGB (in kg/tree) = AGB (in kg/tree) X 0.26

3.3. Estimation of Total Biomass (TB)

TB is the sum of the above ground biomass and below ground biomass.

TB (in kg/tree) = AGB (in kg/tree) + BGB (in kg/tree)

3.4. Estimation of Carbon

Generally, for any plant species 50% of its biomass is considered as carbon.

Total carbon = Biomass X 50 %

3.5. Determination of the Weight of CO_2 Sequestered in the tree

The weight of CO_2 is C + (O × 2) = 43.99915

Hence, the ratio of CO_2 to C is calculated as, 43.99915/12.001118 = 3.6663

Therefore, to determine the weight of carbon dioxide sequestered in the tree, the weight of carbon in the tree is multiplied by 3.6663

4. RESULTS AND DISCUSSION

A total of 115 standing trees of 20 different species were enumerated on the campus (Table 1). The most dominant species on the campus are *Alstonia scholaris* (about 40%) and *Ficus benjamina* (about 25%), with a total of 74 trees. It has been observed that among all the 20 plant species, *Ficus benjamina* sequestrated about 50% of total carbon (Figure 2).

Alstonia scholaris is significantly used for the plantations in metropolitan areas because of its hardy nature, capability to stay alive in dry conditions, and forbearance against air pollution [23]. *Ficus benjamina* is also commonly used for the plantations in metropolitan areas due to its dense canopy cover with shade tolerant ability, its ability to regenerate by cuttings, aerial roots or by seeds, survival in drought circumstances, flourish in a wide range of soil types and requires meagre maintenance [24].

The largest GBH is recorded within the campus for a *Ficus benjamina* tree measuring 1.96 m, and the lowest GBH is recorded for an *Azadirachta indica* tree measuring 0.05 m. The tallest and shortest standing tree recorded within the campus is of *Alstonia scholaris* with height of 11.59 m and 2.14 m, respectively. The total average AGB and total average BGB of all the standing trees within the campus are equivalent to 1085.31 kg and 282.18 kg, respectively. The total biomass accumulated is 1367.49 kg and the total carbon content of the campus trees is equal

to 683.74 kg. The total carbon sequestered by all the trees in a year is 47525.18 kg or 47.53 tons. In other words, on average, carbon sequestered by an individual tree on the campus is 413.26 kg or 0.41 tons.

Table 1: Total carbon and CO_2 sequestered by trees

Name of the Plant	No. of Individual	Average GBH (in m)	Average Height (in m)	Wood Density in (Kg/m3)	Average AGB (in Kg/tree)	Average BGB (in Kg/tree)	Total Biomass (in Kg/tree)	Total Carbon (in Kg/tree)	Total Carbon Seq. per Plant (in Kg)	Total Carbon Seq. (in Kg)
***Alstonia scholaris* (L.) R. Br.**	45	0.58	7.79	360.00	75.74	19.69	95.43	47.72	174.94	7872.33
***Ficus benjamina* L.**	29	1.03	9.90	650.00	545.23	141.76	686.99	343.49	1259.35	36521.09
***Schefflera arboricola* (Hayata) Merr.**	10	0.40	7.02	460.00	40.34	10.49	50.83	25.41	93.17	931.71
***Azadirachta indica* A. Juss**	6	0.43	5.85	690.00	58.71	15.26	73.97	36.99	135.61	813.64
***Cerbera odollam* Gaertn. var rubra**	3	0.48	6.51	320.00	38.61	10.04	48.65	24.32	89.18	267.54
***Psidium guajava* L.**	1	0.25	3.66	228.00	4.29	1.11	5.40	2.70	9.90	9.90
***Plumeria obtusa* L.**	3	0.35	3.36	800.00	25.75	6.70	32.45	16.22	59.48	178.43
***Saraca indica* L.**	1	0.20	3.36	600.00	6.62	1.72	8.34	4.17	15.29	15.29
***Tecoma stans* (L.) Kunth**	2	0.62	4.58	470.00	66.30	17.24	83.54	41.77	153.13	306.27
***Mangifera indica* L.**	3	0.20	3.25	520.00	5.56	1.45	7.01	3.50	12.85	38.54
***Caesalpinia pulcherrima* (L) Sw.**	1	0.25	7.02	840.00	30.27	7.87	38.14	19.07	69.91	69.91
***Casuarina equisetifolia* L.**	2	0.20	6.71	830.00	18.31	4.76	23.07	11.53	42.29	84.58
***Araucaria heterophylla* (Salisb.) Franco**	2	0.22	5.34	530.00	10.50	2.73	13.23	6.61	24.25	48.50
***Lagerstroemia speciosa* (L.) Pers.**	1	0.38	4.88	530.00	29.89	7.77	37.66	18.83	69.04	69.04
***Thuja orientalis* L.**	1	0.23	3.66	520.00	7.92	2.06	9.98	4.99	18.29	18.29
***Phyllanthus emblica* L.**	1	0.46	4.58	850.00	64.72	16.83	81.55	40.77	149.49	149.49
***Prunus dulcis* (Mill.) D.A.Webb**	1	0.13	3.05	600.00	2.35	0.61	2.96	1.48	5.43	5.43
***Samanea saman* (Jacq.) Merr.**	1	0.28	4.58	524.00	14.90	3.87	18.77	9.39	34.42	34.42
***Tabebuia aurea* Benth. & Hook.f.**	1	0.36	3.66	760.00	28.00	7.28	35.29	17.64	64.68	64.68
***Spathodea campanulate* P. Beauv.**	1	0.28	5.49	330.00	11.31	2.94	14.25	7.12	26.12	26.12
	115	**0.37**	**5.21**	**570.60**	**1085.31**	**282.18**	**1367.49**	**683.74**	**2506.81**	**47525.18**

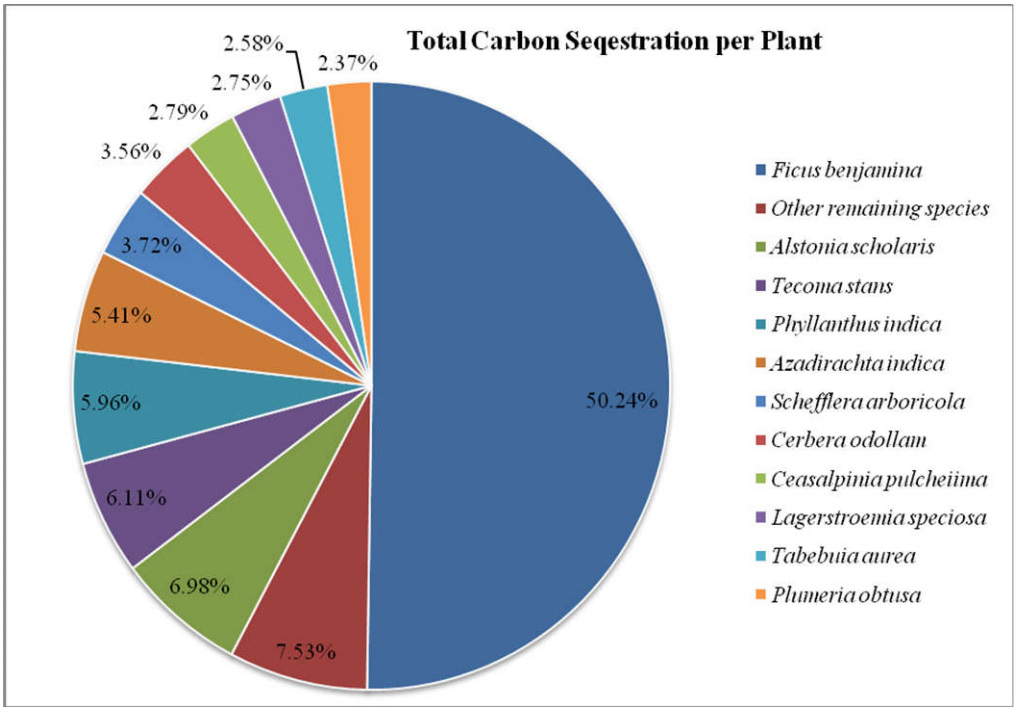

Figure 2: Total Carbon Sequestration per Plant

(Other remaining species includes *Casuarina equisetifolia, Samanea saman, Spathodea campanulata, Araucaria heterophylla, Thuja orientalis, Saraca indica, Mangifera indica, Psidium guajava, Prunus dulcis*)

5. CONCLUSIONS

Trees from urban area play a crucial role in reduction of the atmospheric carbon dioxide levels. Carbon stock was determined for *Alstonia scholaris, Ficus benjamina, Schefflera arboricola, Azadirachta indica, Cerbera odollam, Psidium guajava, Plumeria obtuse, Saraca indica, Tecoma stans, Mangifera indica, Ceasalpinia pulcherima, Casuarina equisetifolia, Araucaria heterophylla, Lagerstroemia speciosa, Thuja orientalis, Phyllanthus emblica, Prunus dulcis, Samanea saman, Tabebuia aurea*, and *Spathodea campanulata* in the campus of Dr. D. Y. Patil ACS College, Pimpri. Result shows that *Ficus benjamina* has the better carbon sequestration potential rate which sequestered 36521.09 kg/tree of CO_2 whereas *Prunus dulcis* has the least sequestration rate which sequestered 5.43 kg/tree of CO_2 as compared to other species. Total tree count of 20 species from the selected study area found 115 and total carbon dioxide sequestered by the trees 47.52 tones.

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