ISSN 2278-8808 SJIF 2015: 5.403
An International Peer Reviewed & Referred
SCHOLARLY RESEARCH JOURNAL
FOR INTERDISCIPLINARY STUDIES

ASSESSMENT OF BIOMASS CARBON POOL OF AN ACADEMIC INSTITUTION IN PUNE, MAHARASHTRA

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Abstract

The significance of urban plantations in carbon sequestration is conventional, and well renowned. We have estimated biomass carbon pool of Baburaoji Gholap College Campus, Pune; by considering above ground, belowground, herb biomass, litter biomass, dead wood, and soil organic carbon. We have sampled entire college campus for biomass and soil carbon. Soil samples were taken from soil profile up to 30 cm depth. Walkley- Black Wet Oxidation method was applied for measuring soil organic carbon. Total amount of above and belowground carbon sequestered was estimated to be 73.63 tonnes; herbaceous biomass carbon 11.34 tonnes, litter and deadwood 1.55, and soil organic carbon 23.95; and the sum of all were 110.47 tonnes. The exotic species sequester 25.219 tonnes and native sequester 13.907 tonnes of carbon. The rates of carbon in active markets are US$ 30 (Thirty dollars) per tonne. Putting a conservative value of US$ 30 per tonne of CO_2 locked in college campus, this carbon sink of about 110.47 tonnes of CO_2 is worth of US $ 3314.10 or Indian Rs. 2,25,673.64/-. It will help in mitigating the total carbon emissions in the college premises and thereby atmospheric carbon dioxide levels.

***Keywords**: Carbon sinks, Carbon pool, GHG, Soil Organic Carbon, Gholap College*

Introduction:

Change is a fundamental characteristic of the environment. But what is disturbing today are the human activities that lead to an unprecedented acceleration in climate changes. The scientific evidence suggests that the earth's climate is changing, the atmosphere is warming and this trend will continue. By the year 2050, scientists predict that the world will be warmer by an average of between 1.5 and 4.5^{0}C (IPCC, 2003, 2006). Carbon dioxide, which remains in the atmosphere for more than 100 years, is responsible for more than 55% of the current global warming from GHG's produced by human activities. Its concentration has increased by more than 30% since pre-industrial times (around 1750), and currently increasing by 1 % every year (Houghton, et.al, 1990).

To cope with the increasing carbon dioxide problem, the emerging trend is to reduce the excess carbon level in the environment and its sequestration by using the natural sources like forest ecosystems (Nowak and Crane, 2001). Carbon sequestration in soils, grasslands and woody perennials, and the transfer of carbon credits through market structures, represent win-win opportunity. Among the alternatives, tree planting offers perhaps the greatest potential. There is also considerable evidence that urban gardens including trees planted in educational institutes and large landscaping projects in developing countries provide substantial benefits to the environment and national economies (Miller, 1997). The outcomes of recent Paris Agreement has also emphasized on reducing the GHG's, more use of renewable energy, energy efficiency and working together for greener future and to attain a goal of below 1.5 degree centigrade for the rise of temperature.

A major part of the globe's terrestrial carbon, is sequestered in the standing biomass. Carbon sequestration is the extraction of the atmospheric carbon dioxide and its storage in terrestrial ecosystems for a very long period of time (Mathews et al., 2000). Trees, through their growth process, act as sink for atmospheric carbon. Therefore, growing trees in urban areas can be a potential contributor in reducing the concentration of CO_2 in atmosphere by its accumulation in the form of biomass (Baes et al., 1977). In terms of atmospheric carbon reduction, trees in urban areas offer the double benefit of direct carbon storage and stability of natural ecosystem with increased recycling of nutrient along with maintenance of climatic conditions by the biogeochemical processes (Grace *et al*., 2006). Carbon sequestration refers to the natural and deliberate processes through which carbon dioxide (CO_2) is either removed from the atmosphere or diverted from emission sources and stored in the ocean, terrestrial environments, and geologic formations. Through photosynthesis energy from sun is used to convert the carbon from atmospheric CO_2 in plant tissues as biomass. The sacred groves acts as a carbon sink and has great potential of carbon sequestration (Hangarge et.al, 2012; 2015). The urban managed gardens also plays crucial role in biomass carbon sequestration (Choudhari et.al, 2014; Shinde and Mahajan, 2015; Shinde and Mahajan, 2016).

This study is going to focus on quantifying the amount of baseline biomass carbon pool of college campus specifically in terms of aboveground and below ground biomass, herb biomass, litter biomass, dead wood, and soil organic carbon of educational institute. Also the study helped in estimating the potentiality of annual carbon sequestration by existing vegetation. Plantation in education institute inculcates a sense of environmental responsibility, awareness and helps to know various socio-economic and ecological benefits.

Materials and Methods:

Study area:

The work was carried out in Baburaoji Gholap College (Figure-1) Campus (an Educational Institute) located in Pune city at 18^0 34' 37.30" N latitude and the 73^0 48' 34.42" E longitude. The college is situated towards northeast of Pune and 160 km from Mumbai and located on the eastern side of Western Ghats. The topography is almost flat with an altitude of 565 m. The base rock throughout the area is Deccan Trap Basalt.

Materials Used:

Measuring tape, spring weighing balance, thread, polythene bags, sickle, worksheet, marker, and GPS instrument.

Sampling Design:

The methods suggested by Ravindranath and Ostwald (2008) were used for measuring the above and belowground biomass and estimation of carbon pool. Random sampling technique was used to collect soil samples in the study areas as it was a cost effective (Anonymous, 1998). As the study area was small in size, each and every tree was sampled for various parameters. The GPS instrument was used for measuring latitude and longitude of each and every tree.

Soil organic carbon is normally estimated to a depth of 0-30 cm since most of it is present in the top layers and root activity is also concentrated in this horizon. Wet digestion or titrimetric determination method was used to estimate the organic carbon content of soil (Kalara and Maynard 1991).

Figure-1: Baburaoji Gholap College Campus, Sangvi, Pune-411027

(Source: Google Earth)

Data recording formats as per Rabindranath and Ostwald (2008) have been used for trees and shrub species. The carbon pool was estimated based on data taken in sample area for carbon storage pools including live tree aboveground biomass, belowground biomass, herbs, litter, dead wood and soil organic carbon. Each and every plant species and individuals above 15 cm GBH were sampled. All tree positions were recorded using a GPS. Each plant was measured for its GBH (cm) and height (m).

Estimation of Carbon Stocks:

Terrestrial vegetation biomass can be divided into above-ground and below-ground carbon stocks/ pools. The analysis and calculation of carbon stocks involve conversion of field and laboratory estimates of various parameters from sample plots, such as diameter at breast height (DBH), height and soil organic carbon content, into tonnes of carbon per hectare. The carbon pools for which the stocks are to be estimated were: above-ground biomass, below-ground biomass, herbaceous biomass, litter and dead wood biomass and soil organic carbon.

Soil Organic Carbon at 0.30 M:

During the present investigation 10 soil samples were collected randomly and analyzed for soil organic carbon content (Schlesinger, 1999 and Matthews et.al, 2000).

Above and Below Ground Carbon Pool:

The random sampling method was used for measuring the above ground biomass of vegetation in period of 2016-2017. All plant species above 15 cm GBH within the college premises were sampled; and every individual plants diameter or girth at breast height (GBH) and height was measured. These parameter represents the volume or height of a tree, which can be converted to biomass per unit area (tonnes/hectare or tonnes/hectare/year). The breast height in DBH was recorded at 130 cm above the ground. Tree height was measured by using instrument 'Abney level'. Belowground biomass was estimated by the Root:Shoot ratio relationship. The total college area was about one hectare. For quantification of biomass the method suggested by Ravindranath and Ostwald (2008) has been used. The total carbon pool including herbaceous biomass, dead wood and litter biomass in the study area were estimated.

Results and Discussion

We have estimated a baseline biomass carbon pool of the college campus vegetation. Total number of trees were 432, out of which 251 were Big trees (More than 5 meters high), and 181 small trees (Less than 5-meter-high) (Figure-2). The total amount of biomass carbon was 110.47 tons. Out of total plant species, 29 were exotic and 21 native plants (Table 1, and Table 2). The exotic species sequester 25.219 tonnes and native sequester 13.907 tonnes of carbon (Figure-3). Total amount of above and belowground carbon sequestered was estimated to be 73.63 tonnes; herbaceous biomass carbon 11.34 tonnes, litter and deadwood 1.55, and soil organic carbon 23.95; and the sum of all were 110.47 tonnes (Table-3; Figure-4). The rates of carbon in active markets are US$ 30 (Thirty dollars) per tonne (Parry, Veung, and Heine, 2014). Putting a conservative value of US$ 30 per tonne of CO_2 locked in college campus, this carbon sink of about 110.47 tonnes of CO_2 is worth of US $ 3314.10 or Indian Rs. 2,25,673.64/-.

The annual increase in carbon will be 322.22 t/year. These values were calculated by using the carbon biomass expansion factor 1.17 recommended by IPCC (2003) (Figure-5).

Table-1: Contribution of Exotic plant species in carbon pool.

Local Name	Name of Plant Species	No. of Individuals	Total Biomass (Tonnes)	Total Carbon (Tonnes)
Nilgiri	*Eucalyptus tereticornis*	26	29.764	14.882
Rain tree	*Pithecelobium saman*	6	4.183	2.092
Kasod	*Cassia siamia*	18	3.424	1.712
Bottle palm	*Roystonia regia*	27	3.098	1.549
Sonmohar	*Peltophorum pterocarpum*	22	2.474	1.237
Areca Palm	*Dypsis lutescens*	33	1.771	0.885
Silver oak	*Grevillea robusta*	11	1.607	0.804
Subabhul	*Leucaena latisiliqua*	8	1.318	0.659
Gulmohor	*Delonix regia*	1	0.904	0.452
Fern tree	*Filicium decipiens*	9	0.365	0.183

Local Name	Name of Plant Species	No. of Individuals	Total Biomass (Tonnes)	Total Carbon (Tonnes)
Singapore cherry	*Muntingia calabura*	7	0.362	0.181
Giripushpa	*Gliricidia sepium*	1	0.285	0.142
Jungli Badam	*Terminalia catappa*	1	0.21	0.105
Madagascar almond	*Terminalia mantaly*	6	0.164	0.082
Cupressus	*Cupressus torulosa*	9	0.106	0.053
Papaya	*Carica papaya*	2	0.099	0.05
Boganbel	*Bougainvillea glabra*	9	0.082	0.041
Pichkari	*Spathodea companulata*	2	0.071	0.035
Vilayti chinch	*Pithecelobium dulce*	1	0.059	0.03
Hamelia	*Hamelia patens*	3	0.021	0.011
Rubber	*Ficus elastica*	1	0.018	0.009
Fan palm	*Licuala grandis*	1	0.015	0.007
Bottle brush	*Callistemon citrinus*	1	0.009	0.005
Morpankhi	*Platycladus orientalis*	5	0.009	0.004
Phoenix	*Phoenix canariensis*	3	0.005	0.003
Travellers palm	*Ravenala madagascariensis*	2	0.005	0.002
Yucca	*Yucca*	1	0.004	0.002
Champa	*Plumeria pudica*	1	0.001	0.001
Tecoma	*Tecoma castanifolia*	1	0.002	0.001
Total		**218**	**50.435**	**25.219**

Table-2: Contribution of Native plant species in carbon pool.

Local Name	Name of Plant Species	No. of Individuals	Total Biomass (Tonnes)	Total Carbon (Tonnes)
Ashoka	*Polyalthia longifolia*	24	9.138	4.569
Neem	*Azadirachta indica*	13	7.316	3.658
Wad	*Ficus benghalensis*	1	4.363	2.181
Nandruk	*Ficus benjamina*	142	1.845	0.923
Buch	*Milingtona hortensis*	9	1.483	0.742
Peepal	*Ficus religiosa*	1	1.262	0.631
Wavhal	*Holoptelia integrifolia*	1	1.232	0.616
Kanchan	*Bauhinia variegata*	3	0.644	0.322
Mango	*Mangifera indica*	3	0.217	0.109
Beheda	*Terminalia bellirica*	2	0.105	0.052

Local Name	Name of Plant Species	No. of Individuals	Total Biomass (Tonnes)	Total Carbon (Tonnes)
Naral	*Cocos nucifera*	1	0.088	0.044
Raktrohida	*Aphanamixios polystachya*	1	0.028	0.014
Amla	*Emblica officinalis*	2	0.027	0.014
Chich	*Tamarindus indica*	1	0.022	0.011
Plain bamboo	*Bambusa vulgaris*	1	0.007	0.004
Guava	*Psidium guajava*	1	0.008	0.004
Saptaparni	*Alstonia scholaris*	3	0.007	0.003
Umber	*Ficus recemosa*	1	0.005	0.003
Arjun	*Terminalia arjuna*	1	0.006	0.003
Belly Bamboo	*Bambusa ventricosa*	2	0.005	0.002
Son-chapha	*Michelia champaca*	1	0.003	0.002
Total		**214**	**27.811**	**13.907**

Table-3: Total amount of carbon sequestered.

Carbon pool	Estimated quantity (tonnes)
ABG and BGB carbon	73.63
Herb biomass carbon	11.34
Litter and deadwood carbon	1.55
Soil organic carbon	23.95
Total	110.47

Figure-2: Height (Meters) class wise distribution of plant species.

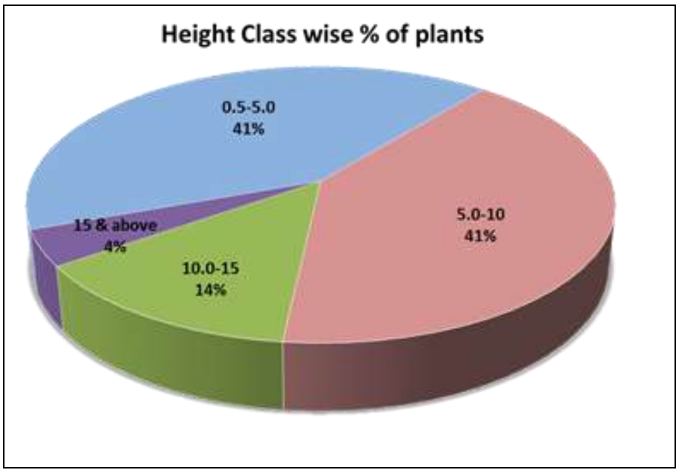


Figure-3: Proportion of carbon sequestered by native and exotic species

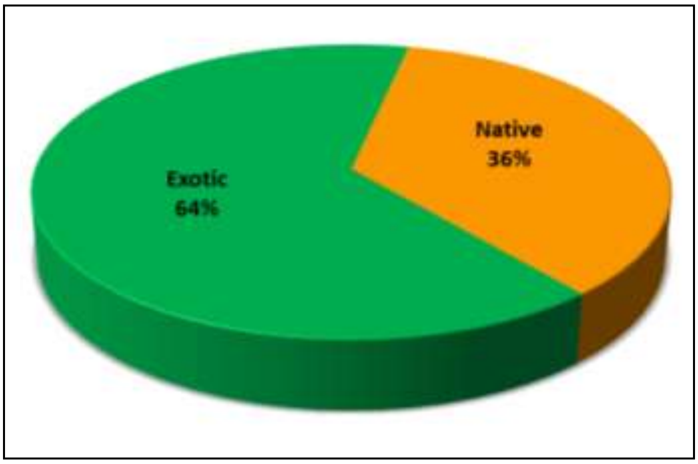


Figure 4: Amount of carbon pool in tonnes and percent

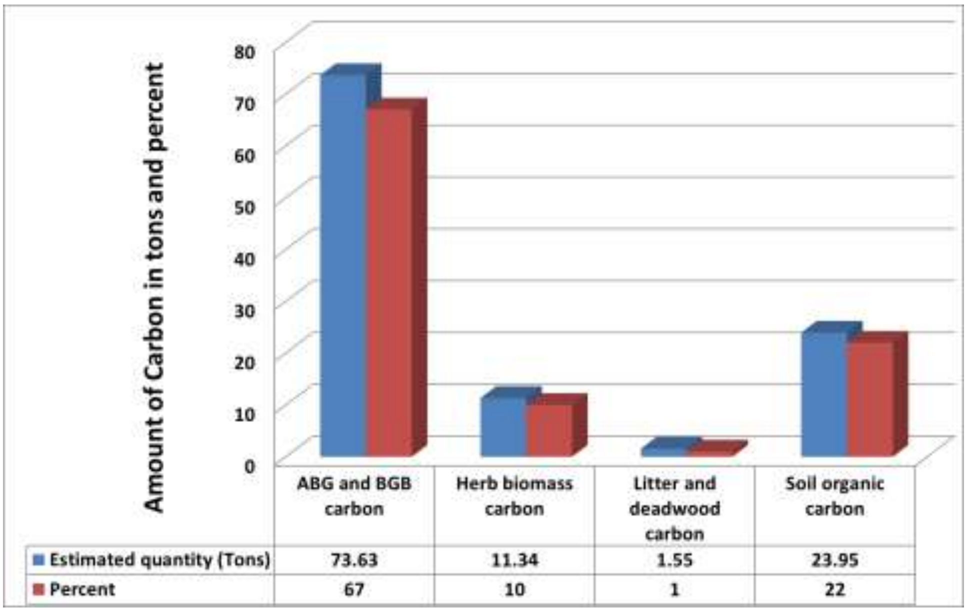
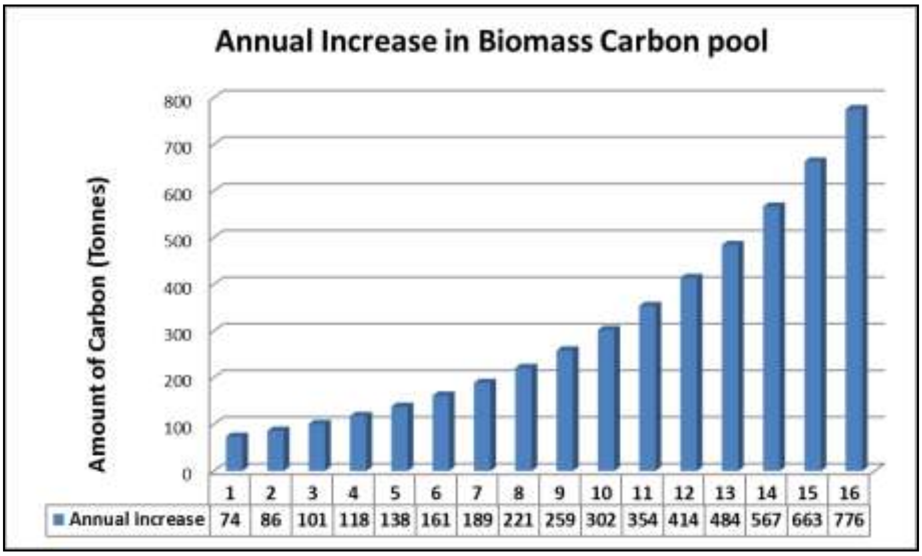


Figure 5: Annual increase in biomass carbon pool.



CONCLUSION:

The carbon pool of the college campus was estimated by considering above ground, belowground, herb biomass, litter biomass, dead wood, and soil organic carbon. The entire college campus was considered. Total amount of above and belowground carbon sequestered was estimated to be 73.63 tonnes; herbaceous biomass carbon 11.34 tonnes, litter and deadwood 1.55, and soil organic carbon 23.95; and the sum of all were 110.47 tonnes. The exotic species sequester 25.219 tonnes and native sequester 13.907 tonnes of carbon. The rates of carbon in active markets are US$ 30 (Thirty dollars) per tonne. Putting a conservative value of US$ 30 per tonne of CO_2 locked in college campus, this carbon sink of about 110.47 tonnes of CO_2 is worth of US $ 3314.10 or Indian Rs. 2,25,673.64/-. If the vegetation is maintained intact for 15 years, then the average carbon sequestration per year would be 322.22 t/year and after 15 years, the total of 776 tons of carbon will be locked in the vegetation (figure 5). It is also observed that the biomass sequestered more carbon than soil; this is because of the transported soil. It will take some more time to sink more soil organic carbon.

Based on the results it was suggested that the litter and dead wood biomass can be managed carefully from a viewpoint to increase the soil carbon content. It should not be burnt away; instead it must be used as a source of increasing carbon content in soil. Further study is required to determine precisely, how significant the net carbon sequestration benefit is to the environment? One can estimate the cost-benefit equation of such offsetting factors as fuel expense in maintaining green spaces, fertilizer and pesticide use, energy for water costs, etc. Our results are based on one time field measurement. However, long-term measurement of biomass is necessary for more accurate and precise results. While selecting the species for plantation in gardens and other areas, one can emphasize on considering the native species. The most important benefit in selecting the native species is that these species can be long lasting and better suited to the local climate, thereby continue to sequester the carbon for longer duration, whereas, exotics being new to such habitats may not survive for longer duration.

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