Quantification of CO_2 Absorption Rates of Few Tropical Trees of Konkan Region of Maharashtra

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Abstract

Trees grow and their biomass increases, thus trees absorb carbon from the atmosphere and store it in the plant tissues resulting in growth of different parts. Active absorption of CO_2 from the atmosphere in photosynthetic process and its subsequent storage in the biomass of growing trees or plants is the carbon storage. The study was undertaken for quantification of CO_2 absorption rates of few tropical trees of Konkan region to understand the rate of carbon assimilation by these tree species under given environmental conditions. The biometric parameters of the trees selected for quantifying CO_2 rates were measured. The diameter at breast height of the selected trees ranged between 1.59 to 14.32 cm, while, the tree height ranged between 9.00 m to 1.60 m. The canopy spread area ranged between 19.99 to 0.89 m^2. The LAI (Leaf area index) of the studied species was observed to be 0.93. The maximum of LAI was recorded in Peltophorum pterocarpium (2.74) and minimum in Pluemeria alba (0.312). The CO_2 assimilation rate was observed to be as high as 16.61 µ mol/m^2 /sec in case of Polyalthia longifolia and lowest of 9.39 µ mol/m^2/sec in Bauhinia perpuria. From the studies it was evident that Photosynthetically active radiation (PAR) clearly affects the CO_2 absorption of trees. The species like *Tectona grandis*, *Polyalthia longifolia*, *Oroxylum indicum*, *Cassia fistula*, *Ficus recemosa*, *Terminalia* spp, *Butea monosperma*, *Saraca asoca* etc. could be planted for better carbon assimilation and quality air in and around campus of the University.

Keywords : CO_2 absorption, carbon assimilation, tropical trees.

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Introduction

India is a large developing country known for its diverse forest ecosystems and is also known as mega-biodiversity region. Forest ecosystems in India are critical for agrarian biodiversity, watershed protection, and livelihoods of indigenous and rural communities. The National Communication of the Government of India to the UNFCCC has reported that the forest sector is a marginal source of CO_2 emissions. The increasing carbon emission is of major concerns; it has been well addressed in Kyoto protocol (Ravindranath *et. al*. 1997). Tree, shrub, soil and sea water play crucial role in absorbing atmospheric carbon dioxide and fixing it into biomass. The trees act as major CO_2 sink which captures carbon from the atmosphere and acts as sink, stores the same in the form of fixed biomass during the growth process. 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.

As trees grow and their biomass increases, they absorb carbon from the atmosphere and store it the plant tissues (Mathews *et. al.,* 2000) resulting in growth of different parts. Active absorption of CO_2 from the atmosphere in photosynthetic process and its subsequent storage in the biomass of growing trees or plants is the carbon storage (Baes *et al*, 1977). In terms of atmospheric carbon reduction, trees in forest ecosystem 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. Studies of Indian forests as part of the national forest carbon balance were undertaken by Ravindranath *et al*. 1997; Haripriya 2000; Chhabra and Dadhwal 2004; Manhas *et al.* 2006; Gupta 2009; Kaul *et al*. 2009. Various studies had examined strata and state/regional forest area changes. Their results range from the finding that the forests are a major source to the finding that they are a sink for atmospheric carbon. Chhabra and Dadhwal (2004) estimated the cumulative net carbon flux from Indian forests due to land use changes indicated that the Indian forest sector acted as a small source of carbon during the study period with the annual net carbon flux due to land use changes estimated as 5.65 Tg C/ yr. Dynamic model of carbon storage in forests, CO2FIX v. 3.1 was used by Masera *et al*. 2003; Schelhaas *et al*. 2004 to investigate the full carbon cycle of some important species in natural and short rotation plantation forestry in India. Carbon estimation can thus benefit by research results and methodology which already surround measurement and prediction of growth, productivity, biomass, wood yield and carbon relations of forests for a range of plantation species and forest types. The study on quantification of CO_2 absorption rates of few tropical trees of Konkan region was undertaken to understand the rate of carbon assimilation by these tree species under given environmental conditions.

Materials and Method

The study was conducted at Biodiversity park of the College of Forestry, DBSKKV, Dapoli. For the quantification of CO_2 influx by the trees, five middle aged healthy trees were selected. The marked trees were subjected to biometric analysis *viz.* diameter at breast height (dbh), height, canopy area and leaf area. Leaf area index (LAI) of the tree canopy was estimated in three seasons i.e monsoon, winter and summer. During monsoon and winter estimates were taken when there was complete leaf flush on the trees during the noon period (11:30 hrs to 12:30 hrs) when the sunlight was over the top of the canopy. The instrument Li-6400 Portable Photosynthesis System (LI-COR Inc., USA) was used to measure the CO_2 photosynthetic assimilation rate (PAR) and Leaf area index (LAI) was measured using Tree Canopy Analyzer (CID Inc, USA. Apart from carbon dioxide absorption (CO_2 $\mu mol \cdot m^{-2} s^{-1}$), the instrument also simultaneously measures the actual environmental conditions i.e. photosynthetically active radiation or PAR (photon $\mu mol \cdot m^{-2} s^{-1}$), ambient air temperature (25-27^oC), leaf temperature (25-27^oC), and CO_2 concentration in air (ppm).

The rate of carbon assimilation was determined by measuring the rate at which the leaf assimilates CO_2. A fully grown leaf was placed in the leaf-chamber of IRGA, with a known area of leaf enclosed. Once the chamber was closed, carbon dioxide concentration gradually declined as per preset program. When the concentration decreases past a certain point a timer was started, and was stopped as the concentration passes at a second point. The difference between these concentrations was noted and the difference was recorded as the change in carbon dioxide in ppm. (Williams *et al.*, 1982). The change in CO_2 was calculated as CO_2 flowing into leaf chamber in μmol / mol CO_2. Net photosynthesis per unit leaf area was derived by dividing net photosynthetic rate by the leaf area enclosed by the chamber. Net photosynthetic rate in micro grams carbon dioxide s^1 was estimated by the following formula

$$(V \times p \times 0.5 \times FSD \times 99.7) / t$$

where V = the chamber volume in liters,
p = the density of carbon dioxide in mg /cm^3,
FSD = the carbon dioxide concentration in ppm corresponding to the change in carbon dioxide in the chamber,
t = the time in seconds for the concentration to decrease by the set amount.

Results and Discussion

Trees play a vital role in carbon storage by the terrestrial biosphere to counter the anthropogenic emissions of CO_2 in the atmosphere. CO_2 is taken by plants vegetation during photosynthesis, converted to organic compounds, and stored in the forest until it burns, decays or is removed in a harvest. CO_2 is returned to the atmosphere by respiration of the vegetation and decay of the organic matter in soils and litter. The gross CO_2 fluxes are large; roughly a seventh of the total atmospheric CO_2 passes into vegetation each year and, in the absence of significant human interference, this large flux of CO_2 from the atmosphere to the terrestrial biosphere is balanced by the returned respiration fluxes.

Table 1 : Biometric parameters of selected trees to quantify Co_2 intake rates along with efficient leaf CO_2 update capacity.

Sr. No.	Species	DBH (cm)	Height (m)	Canopy area (m^2)	Leaf Area Index	CO_2 absorbed in Shade (µ mol/m^2/sec)		
						Monsoon	Winter	Summer
1	*Acacia auriculiformis*	5.36	3.5	3.95	0.45	12.5	2.27	2.27
2	*Acacia catechu*	6.39	2	6.58	0.44	11.96	8.19	1.78
3	*Acacia mangium*	4.3	6	5.26	0.86	13.7	7.27	2.45
4	*Anacardium occidentale*	6.68	6	10.53	0.85	12.03	5.37	1.37
5	*Azadirachta indica*	5.36	3	1.89	0.75	9.98	4.55	4.73
6	*Bauhinia perpuria*	7.16	7	31.58	1.04	9.39	1.37	1.37
7	*Bauhnia racemosa*	7.95	4.6	26.31	0.68	11.07	3.8	3.8
8	*Bixa orellana*	2.86	2	3.95	1.24	12.34	1.88	2.1
9	*Bridelia retusa*	8.43	7	42.10	1.43	12.92	6.86	2.58
10	*Bridelia squamosa*	12.41	8	46.05	1.78	10.16	4.17	1.36
11	*Butea monosperma*	3.18	3.5	7.89	1.31	10.74	6.26	2.58
12	*Caesalpinia bonducella*	4.3	2.75	6.58	0.75	11.79	5.64	1.76
13	*Caesalpinia pulcherrima*	1.91	3	7.89	0.44	10.43	2.17	1.53
14	*Caryota urens*	3.98	1.5	2.63	0.61	10.32	2.41	0.9
15	*Cassia fistula*	14.32	4	27.63	1.24	11.02	10.61	2.54
16	*Dalbergia sissoo*	15.36	8	25.64	0.79	10.25	5.87	3.09
17	*Ficus benghalensis*	16.7	7.5	182.88	0.78	11.14	4.18	4.18
18	*Ficus recemosa*	4.77	4	2.63	0.35	10.38	8.57	4.93
19	*Gliricidia sepium*	5.25	4	23.68	0.63	10.95	5.99	1.85
20	*Mangifera indica*	4.77	3	6.58	1.05	9.79	2.12	0.79
21	*Mimusops elengi*	11.29	7	19.74	1.17	13.4	2.09	0.77
22	*Murraya paniculata*	10.34	4	17.10	1.69	12.18	3.35	1.53
23	*Oroxylum indicum*	2.39	3.1	6.58	0.89	10.67	9.08	5.12
24	*Peltophorum pterocarpium*	6.84	6.5	43.42	2.75	11.11	7.29	5
25	*Phyllanthus emblica*	3.34	3.5	9.21	0.47	10.66	4.91	2.4
26	*Polyalthia longifolia*	3.18	3	0.89	0.79	16.61	5.59	2.84
27	*Pongamia pinnata*	3.50	3.5	1.41	0.25	12.59	3.08	2.04
28	*Plumeria alba*	3.5	1.9	3.95	0.31	10.91	3.04	1.04
29	*Santalum album*	4.14	3	6.58	0.90	9.88	8.3	4.26
30	*Saraca asoca*	13.04	6	199.99	1.29	12.54	4.26	2.36
31	*Semecarpus anacardium*	6.52	4	10.53	1.11	12.43	3.28	1.79
32	*Syzygium cumini*	6.84	4.5	18.42	0.67	10.77	3.25	2.86
33	*Sterculia foetida*	7.16	4	28.95	0.56	11.24	1.02	1.02
34	*Tectona grandis*	2.39	5	2.63	1.57	14.65	9.47	3.87
35	*Terminalia arjuna*	8.75	6	28.95	0.81	10.04	3.13	3.13
36	*Terminalia bellirica*	3.66	5	3.95	0.97	10.45	4.23	3.63
37	*Terminalia chebula*	7.32	6	19.74	0.72	12.67	4.29	1.56
38	*Terminalia elliptica*	11.14	9	19.74	1.15	13.2	5.56	3.02

The biometric parameters of the trees selected for quantifying CO_2 rates are presented in following table 1. The dbh (Diameter at Breast Height) of the selected trees ranged between 1.59 to 14.32 cm, while, the tree height ranged between 9.00 m to 1.60 m. So also, the canopy area was influenced by dbh and height. It also recorded that irrespective of the species the average height of the trees under study was 4.61 m with an average diameter at breast height of 7.23 cm. The canopy spread area ranged between 19.99 in *Saraca asoca* to 0.89 m^2 in *Polyalthia longifolia*. The wider canopy in *Saraca asoca* is due to open wide spreading crown, whereas lower in *Polyalthia longifolia* is due to the elongated canopy of the species. The average canopy spread area was 24.05 m^2 in all the species. However, it should also be noted that in some tree species smaller trees dimensions had widely spread canopy also or vice versa. The LAI is the major factor determining the amount of energy that is intercepted by the plant canopy, but it varies greatly with species and canopy structure. The LAI (Leaf area index) of the studied species was observed to be 0.93. The maximum of LAI was recorded in *Peltophorum pterocarpium* (2.74) and minimum in *Pluemeria alba* (0.312). LAI is considered to be an important parameter in carbon assimilation as it enviges the interaction between vegetation surface and the atmosphere, radiation uptake, precipitation interception, energy conversion, momentum and gas exchange, on the surface of the vegetation (Monteith and Unsworth, 1990).

As LAI is influenced by PAR reaching below the canopy, a lower value in Pluemeria alba is because the leaves, even though broad are vertically oriented, hence, less amount of light is intercepted resulting in lower LAI. The variation in LAI with the species is also reported by Antonarakis et al. 2014 and Tang et. al. 2016. The diurnal carbon dioxide absorption of the selected species is shown in table 1. As can be seen from table the CO_2 assimilation of all species was fluctuated during the monsoon period. The CO_2 assimilation rate was observed to be as high as 16.61 μ mol/m^2/sec in case of *Polyalthia longifolia* and lowest of 9.39 μ mol/m^2/sec in *Bauhinia perpuria.*

During the winter season CO_2 assimilation rate was observed to be as high as 10.61μ mol/m^2/sec in case of *Cassia fistula* and as low as 1.02 μ mol/m^2/sec in *Sterculia foetida,* whereas during the summer season CO_2 assimilation rateranged between 5.12 to 0.77 μ mol/m^2/sec in *Oroxylum indicum* and *Mimusops elengi*, respectively. The variation in CO_2 assimilation ratesas influenced by the seasons could be due to the light intensity variations and climatic conditions. It is also noted that during these seasons the light intensity (PAR) fluctuated. Such changes according to the local climatic conditions were also reported by Dou *et al.* 2005, Sunakorn and Kasemsap, 2010 and Baligar *et al.* 2012. It is also observed carbon fixation by tree canopies is influenced by genetic factors, but bioenergetics of photo assimilate formation and transport are set by basic physiology, and probably little genetic variation.

Conclusion

According to the results obtained it can be concluded that the carbon dioxide absorption rate in the same environmental condition depends on the species of trees. Photosynthetically active radiation (PAR) clearly affects the CO_2 absorption of trees.. It is implied that carbon dioxide absorption characteristics of these plant species are general to the prevelling environmental conditions at given time. Good management of green area in the campus could make better air quality not only for students and staffs, but also for city. The species like *Tectona grandis, Polyalthia longifolia, Oroxylum indicum, Cassia fistula, Ficus recemosa, Terminalia spp, Butea monosperma, Saraca, etc.* could be planted for better carbon assimilation and quality air in and around campus of the University.

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