Carbon Sequestration Potential of Trees in And Around University Campus of Aurangabad City, Maharashtra, (India)

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Abstract- *Urban Trees play crucial role in sequestering carbon release from different sources in the form of pollutants. Carbon storage and sequestration by urban trees in the Aurangabad city was quantified to assess the potential role of trees in relation to climate change. Urban tree surveyed field data from study area in the form of girth and height of trees were used to estimate the above ground biomass, below ground biomass, total biomass, total carbon and carbon dioxide from the study area.Selected tree species were Albizia lebbeck, Ailanthus excelsa, Cassia fistula, Alstonia scholaris, Achras sapota, Cassia siamea, Bambusa dendrocalamus, Callistemon citrinus, Carica papaya and Cascabela thevetia. It is found that Albizia lebbeck, has great potential to store the carbon and carbon dioxide whereas Cascabela thevetia has least potential of carbon sequestration from selected tree species. Present study shows that total tree count of species from the study area was 2706, total above ground biomass is 1924.826 kg, total below ground biomass 500.4538 kg, total biomass 2425.269 kg, total carbon is 1212.634 and total* CO_2 *sequestered 4445.888 kgs.Total* CO_2 *sequestered from the study area is 1260.955 tons. To protect the developing world from adverse effects of climate change and global warming, the sustainable management of urban trees with the objectives of carbon sequestration is the need of the time.*

Keywords- Girth, Height, CO_2 sequestration

I. INTRODUCTION

Carbon dioxide is removed from the atmosphere through the natural process of photosynthesis and store the carbon in the leaves, branches, stems, bark and roots by the trees. According to IPCC third assessment report (2001) shows recent and strong evidence indicates that maximum warming has been observed in last fifty years largely due to the human intervention and expected to continue in next hundred years and may alter the troposphere. Trees from urban centres have capacity to sequester substantial amount of carbon. Many cities in India have analyzed carbon sequestration potential of trees. According to US Census Bureau urban area is defined based on density of population which includes all territory, housing units and population from the area. Trees are known to be major sink of carbon and ecofriendly option for mitigation of climate change and increasing temperature of the earth. Environmental degradation can potentially be mitigated by urban trees. The increasing rate of urbanization process disturbs the thermal balance of an area changing in an urban heat island effect where cities can be several times morewarmer than rural areas. This warmer surrounding can make urban areas not comfortable places and can pose serious health problems. Trees act as a sink for carbon dioxide (CO_2) by fixing carbon during photosynthesis and storing carbon as biomass (Nowak et al., 2013). Carbon storage and fluxes in forests have been the focus of research in recent years because of the role of CO_2 in global climate change (Eduardo et al., 2013). The atmospheric concentration of CO_2 and other greenhouse gases increased by 70% between 1970 and 2004 (Eduardo et al., 2013).

Although there is not universal agreement on the cause, there is a growing consensus that global climate change is occurring, and many climate scientists believe that a major cause is the anthropogenic emission of greenhouse gases (GHGs) into the atmosphere.(Jose et al., 2008)

After the Kyoto Protocol many researchers and experts have developed different methods for estimation of carbon sequestration, many of them are complicated and expensive limited in their spatial coverage. As the issues concerned CO_2 emission continues control measures rely in the improvement and availaibility of accurate, ecofriendly and cost effective method for estimation of carbon sequestered.

Objective of this paper was to estimate biomass and carbon from the trees of Aurangabad city.

II. MATERIALS AND METHODS

Location

Aurangabad District is located mainly in the Godavari river basin and partly in the Tapi river basin. The district is from 19 to 20 degrees north longitude and 74 to 76 degrees east latitude. Aurangabad city is situated on the bank of river Kham a tributary of the Godavari river. The entire city is situated at the latitude of 19°53’50” N and longitude of 75°22’46” E. It is located 512 meters above Sea Level. The city is surrounded by hills of the Vindhya ranges and the river Kham passes through it. The study area comprises of five hundred hectares of area mainly B.A.M. University campus and Jaisingpura, Pahadsingpura etc. In this study, the amounts of biomass and CO_2 in standing woody biomass of selective ten tree species were calculated.

Methodology

Measurement of Tree Height and Diameter at Breast Height (DBH):

To estimate biomass of different trees, non-destructive method was used. The biomass of tree was estimated on the basis of DBH and tree height. DBH can be determined by measuring tree Girth at Breast Height (GBH), approximately 1.3 meter from the ground. The GBH of trees having diameter greater than 10 cm were measured directly by measuring tape (**Hangargeet al., 2012)** . The tree height measured by theodolite instrument.

Above ground biomass (AGB) of trees:

The above ground biomass of tree includes the whole shoot, branches, leaves, flowers, and fruits. It is calculated using the following formula (**Bandana and Sanjay, 2014).**

AGB kg = volume of tree (m^3) x wood density Kg/m^3

$V = \pi r^2 H$

Where V= volume of the cylindrical shaped tree in m^3, r = radius of the tree in meter, H = Height of the tree in meter, Radius of the tree is calculated from GBH of tree. The wood densities were obtained from the website - www.worldagroforestycentre.org/sea/products/AFDbases/WD/.,Height is measured with the help of the instrument Theodolite (Moumita and Ambarish, 2014). Wood density is used from Global wood density database (Zanne et al, 2009). The standard average density of 0.6 gm / cm is applied wherever the density value is not available for tree species (Moumita and Ambarish, 2014).

Table 1: Wood densities of tree species

Sr. No.	Tree Species (Scientific Name)	Local name	Wood density in g/cm^3
1	*Albizialebbeck*	Shiras	0.5964
2	*Ailanthus excelsa*	Maharib	0.66
3	*Cassia fistula*	Bahawa	0.8293
4	*Alstoniascholaris*	Saptaparni	0.3973
5	*Achrassapota*	Chiku	0.91
6	*Cassia siamea*	Kashid	0.6823
7	*Bambusadendrocalmus*	Bamboo	0.66
8	Callistemon citrinus	Bottle brush	0.66
9	*Carica papaya*	Papai	0.66
10	*Cascabelathevetia*	Yellow kanher	0.66

Estimation of Below Ground Biomass (BGB)

The Below Ground Biomass (BGB) includes all biomass of live roots excluding fine roots having < 2 mm diameter. The BGB has been calculated by multiplying AGB by 0.26 factors as the root: shoot ratio. BGB is calculated by following formula (MacDicken, K.G. 1997.,Hangarge et al., 2012)

BGB (Kg/tree) = AGB (Kg/tree) or (ton/tree) x 0.26

Estimation of total biomass (TB)

Total Biomass is the sum of the above and below ground biomass.

Total Biomass (TB) = Above ground Biomass + Below ground biomass (kg/tree)

Estimation of Carbon(C)

Generally, for any plant species 50% of its biomass is considered as carbon (Pearson et al., 2005) i.e., Carbon Storage = Biomass x 50% or Biomass/2 (kg/tree)

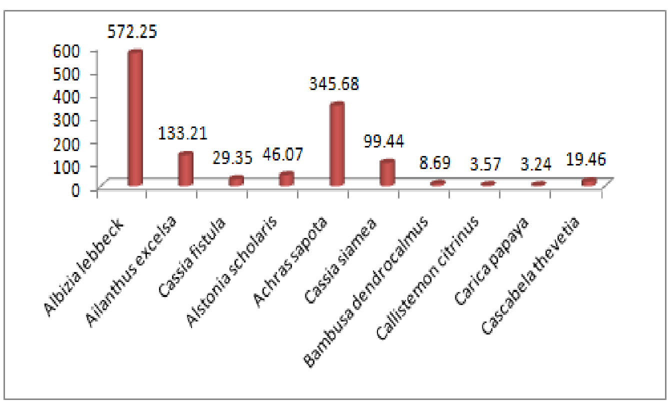
Determination of the weight of carbon dioxide (CO_2) sequestered in the tree

CO_2 is composed of one molecule of carbon and 2 molecules of oxygen. The atomic weight of carbon is 12.001115, the atomic weight of oxygen is 15.9994, the weight of CO_2 is C+2*O=43.999915. The ratio of CO_2 to C is 43.999915/12.001115=3.6663. Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.6663.

III. RESULTS AND DISCUSSION

The study was conducted in the Aurangabad city to estimate the carbon sequestration in the ten selected tree species. The present study was based on estimation of carbon and carbon dioxide.

Albizialebbeck has sequestered 2065.86 kg/tree of CO_2 which is highest compared to other tree species from the study area. It is due to highest DBH of tree and height i.e. 0.458 meters and 9.107 meters respectively. At the same time volume, AGB, BGB, total biomass, carbon is also highest in the *Albizialebbeck*. Total tree count is 277 and total CO_2 sequestered 572.24 tonnes. *Alianthusexcelsa* has the highest height after *Albizialebbeck* i.e. 8.83 meters compared to other tree species but DBH has only 0.270 meters. This is second highest tree species in terms of CO_2 sequestered per tree i.e. 774.48 kg. *Achrassapota* sequestered 345.67 tonnes of CO_2 which is second highest in terms of total co2 captured with highest number of trees from the study area i.e.1208 but sequestered only 286.156 kg/tree due to low DBH i.e. 0.168 meters. *Cassia siamea* is the second highest in terms of tree count after the *Achrassapota* having 488 tree individual species and sequestered 99.44 tonnes of CO_2. *Bambusadendrocalamus* has lowest DBH in comparison with all other tree species but has third highest in terms of height after *Albizialebbeck*, *Ailanthus excelsa* respectively. *Callistemon citrinus* and *Carica papaya* have only 28 numbers of tree individual tree species which are lowest from study area and *Carica Papaya* and *Callistemon citrinus* has sequestered lowest CO2 respectively. *Cascabelathevetia* has lowest height, and lowest CO2 in kg /tree i.e. 4.26 meters and 94.93 kg respectively.



Graph showing carbon dioxide sequestered in tree species (tonnes)

Present research work shows that total tree count of selected species from the study area were 2706. Total above ground biomass is 1924.826 kg, total below ground biomass 500.4538 kg, total biomass 2425.269 kg, total biomass is 1212.634 and total CO_2 sequestered 444.888 kgs. Total CO_2 sequestered from the study area is 1260.955 tons.

Based on the allometric equation used, most of the biomass was accumulated in the aboveground compartment of the plant, i.e. 80% biomass. Same results were coinciding with many studies giving percentages of aboveground biomass 81% (Annissa et al., 2013). Studies made by Westlake 1966, Brown & Lugo 1982, Schroeder 1992, Dixon 1994; Cannel et al. 1995; Ravindranath et al. 1997, Montagnini and Porras, 1998; Losi et al., 2003; Montagu et al., 2005 shows that approximately 50% of dry biomass comprises of carbon.
Assessment of tree biomass gives most crucial information on the functional and structural attributes and it is one of the important indicator shows sequestration in trees. Many approaches proved to be important to know the biomass in the trees like remote sensing, GIS and field data measurement. Field data measurement is one of the accurate method but assumed time consuming and complicated process.

Table 2. Total carbon and CO2 sequestered by trees.

Sr. No.	Tree Species (Scientific Name)	Common name	DBH in meter	Height in meter	Volume (m3)	Above ground biomass (kg/tree)	Below ground biomass (kg/tree)	Total biomass (kg/tree)	Carbon (kg/tree)	CO_2 sequestered (kg/tree)	Tree count	CO_2 sequesterd of all trees in tonnes
1	*Albizialebbeck*	Shiras	0.458	9.107424	1.499	894.4041	232.5450	1126.94	563.474	2065.86	277	572.2452
2	*Ailanthus excelsa*	Maharib	0.270	8.8392	0.508	335.3082	87.18014	422.488	211.24	774.484	172	133.2114
3	*Cassia fistula*	Bahawa	0.183	6.46176	0.1702	141.1832	36.70763	177.890	88.945	326.100	90	29.34906
4	*Alstoniascholaris*	Saptaparni	0.2322	8.180	0.3462	137.5656	35.76707	173.332	86.666	317.74	145	46.07302
5	*Achrassapota*	Chiku	0.168	6.144	0.1361	123.8896	32.21131	156.100	78.050	286.156	1208	345.6771
6	*Cassia siamea*	Kashid	0.163	6.1996	0.129	88.2238	22.93820	111.162	55.581	203.776	488	99.44307
7	*Bambusadendrocalmus*	Bamboo	0.120	8.473	0.096423	57.8540	15.04204	72.8960	36.44804	133.629	65	8.685914
8	*Callistemon citrinus*	Bottle brush	0.148	5.346	0.0919	55.15550	14.34043	69.4959	34.74797	127.396	28	3.567102
9	*Carica papaya*	Papai	0.148	4.8341	0.083	50.1426	13.0370	63.1796	31.5898	115.817	28	3.242899
10	*Cascabelathevetia*	Yellow kanher	0.143	4.2672	0.0684	41.0994	10.685	51.7853	25.8926	94.930	205	19.4607

Regression analysis

To estimate the closeness and relationships at various parameters level a regression analysis was performed with the help of SPSS 16.0 software.

Tables: - Regression of DBH, Height and Volume of tree species

Model Summary

Model	R (correlation coefficient)	R Square	Adjusted R Square	Std. Error of the Estimate
1	.986[a]	.972	.964	.01906

a. Predictors: (Constant), Volume, Height

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B (regression coefficient)	Std. Error	Beta	t (statistics)	Sig.
1	(Constant)	.128	.030		4.331	.003
	Height	.001	.005	.015	.183	.860
	Volume	.222	.019	.976	11.698	.000

a. Dependent Variable: DBH

Where,

R= Multiple correlation coefficient; R^2 and adjusted R^2 = Coefficient determination of variables

B= Regression coefficient; t = Statistics

Above table shows that shows strong correlation coefficient between the DBH with volume and height whereas adjusted R^2 shows 97% variability between DBH with height and volume. From above table regression equation can be written as follows

DBH= 0.128-0.01*height+0.222*volume

The relationship between DBH and Height with volume is nearly linear in all tree species. In other words maximum DBH have highest carbon present in its biomass. The regression models developed for the prediction of carbon and carbon dioxide from the trees to avoid the requirement of destructive sampling frequency. In this range maximum tree species have linear relationships in terms of diameter at breast height and carbon availability. Above table shows that volume is significant with DBH. As increase in DBH its metabolic energy and growth necessities would also increase (Jaiswal et al., 2014).

IV. CONCLUSION

Trees from urban area play a crucial role in reduction of atmospheric carbon dioxide levels. Carbon stock was determined for *Alibizia lebbeck, Ailanthus excelsa, Cassia fistula, Alstonia scholaris, Achras sapota, Cassia siamea, Bambusa dendrocalamus, Callistemon citrinus, Carica papaya* and *Cascabela thevetia,* in and around Aurangabad city which shows *Albizialebbeck* has the better carbon sequestration potential rate whereas *Cascabela thevetia* has the least sequestration rate as compared to other species. While on the basis of the girth class, the capacity to absorb carbon is the highest in the girth class more than average diameter 0.2794 meters. Among all tree species only *Albizia lebbeck* shows diameter more than 0.2794. Remaining tree species shows diameter less than 0.2794. in the present research work calculation of carbon and carbon dioxide sequestration potential rate of tree species was done by nondestructive method where theodolite instrument was used for height measurement. Wood densities were obtained from World Agroforestry Centre for the measurement of above ground biomass. To protect our beautiful earth from climate change and global warming sustainable management approach should be adopted with the prime focus on carbon sequestration. Before applying the approach of urban tree management, quantification of organic carbon in the urban region by nondestructive method will be helpful.

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