Potential of carbon sequestration and storage by trees in and around B.A.M. University campus of Aurangabad city in Maharashtra, India.

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Abstract- Urban development continues to change the shape of landscapes and impact over carbon storage capacity of the trees. To date, the influence of urban patterns on tree carbon density remains to be systematically evaluated. The study was carried out in and around Dr. B. A. M. university area of Aurangabad city to know the CO_2 sequestration from selected ten tree species. Assessment of carbon sequestration of urban trees was carried out through biomass estimation and quantification. Trees are identified to species level, and their diameter at breast height and height were recorded using ground measurements in terms of DBH, height and wood density of the tree. It is found that highest CO_2 2535.64 kg/tree captured by *Peltophorum pterocarpum* followed by *Limonia acidissima* which is captured 690.85 kg of CO_2 per tree. Total above ground biomass 2373.9, total below ground biomass 617.22, total biomass 2991.16, total carbon 1495.58 kg/tree. Total tree count of 2901 out of which *Limonia acidissima* found 2207 tree count which is maximum. It is found that total CO_2 sequestered by the selected area is 2252.16 tonnes. Carbon sequestration is a way to mitigate the accumulation of the GHG's (Green House Gases) in the atmosphere released by the incomplete burning of fossil fuels and other anthropogenic activities.

Index terms **- biomass, tree, CO_2 sequestration.**

I. INTRODUCTION

More than half of the global population now lives in urban regions, and this figure will continue to increase at a rate of 4% a decade by 2050 [1]. Trees from the urban regions currently store carbon, which can be released back to the atmosphere after the death of tree, and capture carbon as they grow. Trees from Urban area also influence temperatures of air and building energy use, and consequently alter carbon release from numerous urban sources [2]. Thus, urban trees potentially influence climate at the local level, carbon cycles, energy use and the climate change [3, 4,5,6,7]. Growing concern about the climate change and concerned problems led to the research quantifying the overall effects of trees from the urban area on atmospheric carbon dioxide (CO_2) [8, 9, 10, 11].. Most of these studies have found that urban trees can be major carbon sinks, although there is general lack of information on urban tree biomass allometry. Similarly, too little is known about the release of CO_2 into the surrounding from combustion of fuels used to power equipment and vehicles during the planting and tree care activities. Once dead, trees release most of the CO_2 they accumulated through decomposition. Anthropogenic causes of global warming at the global level have become a topic of concern in front of the Scientists and stakeholders because of the life threatening changes which could result from the increase in global heat and the temperature [15]. The rate of release depends on how the wood is utilized. To protect the developing world from the adverse effects of climate change and the global warming, the well planned sustainable management of the urban trees with the objectives of carbon sequestration is the need of the time.

II. MATERIALS AND METHODS

Location

The study area comprises of 2126 hectares of area mainly from B.A.M. University campus and Jaisingpura, Pahadsingpura etc. The district is from 19 to 20 degrees north longitude and 74 to 76 degrees at east latitude. Aurangabad is a historic city situated on the bank of river Kham which is a tributary of the Godavari river. The 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. Aurangabad District is located mainly in the Godavari river basin and partly in the Tapi river basin. The city is surrounded by hills of the Vindhya ranges and the river Kham passes through it. In this study, the amounts of biomass and CO_2 in standing woody biomass of selective ten tree species were calculated.

Measurement of diameter at breast height (DBH) and tree height:

To estimate the biomass of different trees, non-destructive method was used. The biomass of the tree was estimated on the basis of 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 having the diameter greater than 10 cm were measured directly by the measuring tape [12]. The tree height measured by the Theodolite instrument.

Above ground biomass (AGB) of trees:
The above ground biomass of the tree includes whole shoot, branches, flowers, leaves and fruits. It is calculated using the following formula. [13].
AGB kg = volume of tree (m3) x wood density Kg/m3
$V = \pi r^2 H$
Where H = Height of the tree in meter, V= volume of the cylindrical shaped tree in m3, r = radius of the tree in meter, Radius of the tree is calculated from the GBH of tree. The wood densities for trees were obtained from the website www.worldagroforestycentre.org. Height is measured with the help of the instrument Theodolite. The standard average density of 0.6 gm / cm is applied wherever the density value is not available for tree species [14].

Estimation of the Below Ground Biomass (BGB)
The Below Ground Biomass (BGB) includes all biomass of live roots excluding fine roots having < 2 mm diameter. The below ground biomass has been calculated by multiplying AGB by 0.26 factors as the root: shoot ratio. BGB is calculated by following formula [12, 14, 15].
BGB (Kg/tree) = AGB (Kg/tree) or (ton/tree) x 0.26

Table 1: Wood densities of tree species

Sr. No.	Tree Species (Scientific Name)	Local name	Wood density in g/cm^3
1	*Ficus racemosa*	Umbar	0.3758
2	*Peltophorum pterocarpum*	Rusty shield	0.6025
3	*Ficus religiosa*	Pimpal	0.443
4	*Leucaena latisiliqua*	Subabul	0.6411
5	*Limonia acidissima*	Kavath	0.771
6	*Michelia champaca*	Chafa	0.535
7	*Millingtonia hortensis*	Bapwan	0.6003
8	*Moringa oleifera*	Shevaga	0.262
9	*Nerium oleander*	Red kanher	0.6
10	*Nyctanthes arbor tristis*	Parijatak	0.88

Estimation of the total biomass:

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

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

Estimation of the Carbon

Generally, for any species of plant 50% of its biomass is considered as carbon [16]. 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 the 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 the CO_2 to C is 43.999915/12.001115=3.6663. Therefore, to determine the weight of the carbon dioxide sequestered in tree, multiply the weight of carbon in the tree by 3.6663.

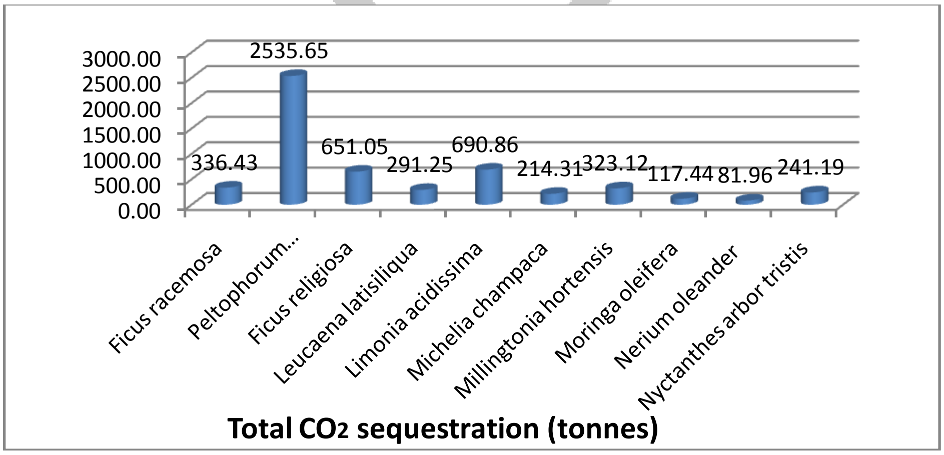
III RESULTS AND DISCUSSION

Environmental experts highlighted the role of urban forests as a place of social integration as they provide recreation and relief to the urban population from their hectic life. Carbon capture and sequestration is a theoretical approach to control and mitigate the contribution of emissions of fossil fuels to global warming, based on capturing carbon dioxide from large point sources such as the fossil fuel power plants. The tree can survive in the urban environment polluted with traffic-related contaminants [17]. It may be one of the crucial green region in the urban and industrial sectors. Carbon capture rates vary by species, soil, climate, topography and most important is management practice [14, 18].

Table 2: Total carbon and CO_2 sequestered by trees.

Sr. No.	Scientific name	Local name	DBH (Meters)	Height (Meters)	Volume (m^3)	AGB (kg/tree)	BGB (kg/tree)	TB (kg/tree)	C (kg/tree)	CO_2 (kg/tree)	Tree count	Total CO_2 (Tonnes)
1	*Ficus racemosa*	Umbar	0.250	7.913	0.388	145.65	37.87	183.52	91.764	336.43	12	4.037
2	*Peltophorum pterocarpum*	Rusty shield	0.425	12.850	1.822	1097.79	285.42	1383.21	691.609	2535.64	205	519.80
3	*Ficus religiosa*	Pimpal	0.314	8.242	0.636	281.86	73.28	355.15	177.57	651.05	184	119.79
4	*Leucaena latisiliqua*	Subabul	0.183	7.498	0.197	126.09	32.78	158.88	79.44	291.25	25	7.2812
5	*Limonia acidissima*	Kavath	0.239	8.681	0.388	299.10	77.76	376.86	188.43	690.85	2207	1524.7
6	*Michelia champaca*	Chafa	0.218	4.657	0.173	92.785	24.12	116.90	58.455	214.31	8	1.7144
7	*Millingtonia hortensis*	Bapwan	0.217	6.328	0.233	139.89	36.37	176.26	88.133	323.12	195	63.008
8	*Moringa oleifera*	Shevaga	0.203	6.011	0.194	50.843	13.21	64.062	32.031	117.43	3	0.3523
9	*Nerium oleander*	Red kanher	0.132	4.298	0.059	35.484	9.226	44.710	22.355	81.960	22	1.803
10	*Nyctanthes arbor tristis*	Parijatak	0.156	6.195	0.119	104.420	27.149	131.569	65.785	241.186	40	9.6474
		Average	0.233	7.2673	0.4209	237.394	61.72	299.116	149.558	548.325	290.1	225.2167
		Total	2.337	72.673	4.209	2373.94	617.225	2991.16	1495.58	5483.25	2901	2252.16

These findings can be used to assess the actual and potential role of the urban forests in reducing atmospheric CO_2. In addition, they provide insights for the stakeholders, decision-makers and the public to better understand the role of urban forests, and make better management plans for the urban forests. Despite extensive evidence of the important role played by the trees in city environments, urban planners and architects have often undervalued the important role played by the trees as firstly, urbanization affects climate; cities tend to become warmer and create what is known as an urban heat island.



Graph Showing Carbon dioxide captured by trees (in Tonnes)

Biomass assessment is very important for many purposes. It is aimed at resource utilization and for environmental management. In the light of environmental management, biomass evaluation is an important indicator in carbon sequestration. Most of the experts revealed that the above ground biomass is more strongly correlated with DBH [19]. Also, it is accepted by many researchers in this field that simple models with only diameters as input is one of the good estimator of above ground biomass [20]. Scientific proofs suggest that enhanced atmospheric carbon dioxide could have some better effects like improvement in tree productivity [14, 21].

The study was conducted in the Aurangabad city Marathwada region to estimate the above ground biomass, below ground biomass, total biomass, carbon, carbon dioxide from selective ten tree species. *Peltophorum pterocarpum* has sequestered 2535.646 kg/tree of CO_2 which is highest compared to other tree species from the study area. It is due to high DBH and maximum height of the tree. At the same time AGB 1097.79, BGB 285.42, total biomass 1383.21, carbon 691.60 which is highest in the *Peltophorum pterocarpum* which has 205 tree count and total CO_2 sequestered is 519.07 tonnes of CO2. *Nerium oleander* sequestered lowest CO_2 81.96 kg/tree compared to other trees which is may be due to lowest DBH i.e. 0.132 meters, total CO_2 sequestered found 1.803 kg/tree. Total AGB 35.48, BGB 9.22, TB 44.71, Carbon 22.35 found from the study area. Total tree count of the study area is 2910. Maximum 2207 trees found of *Limonia acidissima* and only 3 trees found of *Moringa oleifera* from the study area. Total AGB 2373.9, total BGB 617.22, Total biomass 2991.11, Total carbon 1495.58 and total CO2 sequesterd is 2252.16 tonnes. Trees having the diameter more than 77 cm sequester approximately 90 times more carbon as compared to the small healthy trees species which have the diameter less than 8 cm [22]. Large trees also store nearly 1000 times maximum carbon than smaller trees [14, 22].

REGRESSION ANALYSIS

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

Table 3: - Regression of DBH, Height and Volume of tree species

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.956[a]	.914	.889	.17291

a. Predictors: (Constant), Height, DBH

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.036	.181		-5.730	.001
	DBH	3.807	1.451	.616	2.624	.034
	Height	.078	.050	.367	1.564	.162

a. Dependent Variable: Volume

Where,

t = Statistics R= Multiple correlation coefficient; R^2 and adjusted R^2 = Coefficient determination of variablesB= Regression coefficient

Above table shows that strong correlation coefficient between DBH with volume and the height whereas adjusted R^2 shows 88% variability between the Volume with DBH and Height.

The relationship between DBH and height with volume is approximately linear in all major tree species. In other words maximum DBH have the highest carbon stock. The regression models developed for the prediction of the carbon and carbon dioxide from trees to avoid requirement of the destructive sampling frequency. In this range the maximum tree species have linear relationships in terms of the DBH and carbon availability. Above statistical table shows that volume is significant with DBH. As increase in DBH its metabolic and the growth necessities would also increase.

IV CONCLUSIONS

Trees from urban area play a crucial role in reduction of the atmospheric carbon dioxide levels. In the present research work calculation of carbon and carbon dioxide sequestration potential rate of tree species was done by nondestructive method. Theodolite instrument was used for height measurement. Wood densities were obtained from the World Agroforestry Centre for the measurement of carbon sequesterd by trees. Carbon stock was determined for *Ficus racemosa, Peltophorum pterocarpum, Ficus religiosa, Leucaena latisiliqua, Limonia acidissima, Michelia champaca, Millingtonia hortensis, Moringa oleifera, Nerium oleander, Nyctanthes arbortristis* in and around university campus of Aurangabad city. Results shows that *Peltophorum pterocarpum* has the better carbon sequestration potential rate which sequesterd 2535.64 kg/tree of CO_2 whereas *Nerium oleander* has the least sequestration rate which sequesterd 81.96 kg/tree of CO_2 as compared to other species. More field measurements are needed in urban regions to help improve carbon accounting and other functions of urban forest ecosystems. Total tree count of ten species from the selected study area found 2901 and total carbon dioxide sequesterd by the trees 2252.16 tonnes. To protect our beautiful planet from issues like climate change and global warming approach of sustainable management should be adopted at the international level with the prime focus on the carbon sequestration.

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