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Carbon sequestration potential of trees within and around Dr. Babasaheb Ambedkad Marathwada University campus in Aurangabad city

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ABSTRACT

Urban trees can potentially mitigate environmental degradation accompanying rapid urbanization via a range of benefits and services. 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 have been 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 has been found that highest CO_2 436.260 kg/tree is captured by *Areca catechu* followed by *Butea monosperma* which captures 424.445 kg of CO_2 per tree. Total tree count in area is 1590 out of which *Annona retiaculata* tree count is maximum 1152. It is estimated that the total CO_2 sequestered by the selected area is 440.391 tonnes. The sustainable management of urban trees with the objectives of carbon sequestration is the need of the hour to protect the developing world from adverse effects of climate change and global warming.

Keywords : *Environmental degradation, quantification, CO_2 sequestration, exotic plantation.*

1. Introduction

Carbon sequestration is a process of storage of CO_2 or other forms of carbon to mitigate global warming and its one of the important clause of Kyoto Protocol, through biological, chemical or physical processes; CO_2 is captured from the atmosphere. The Kyoto Protocol to the UN Framework Convention on Climate Change has provided a vehicle for considering the effects of carbon sinks and sources, as well as addressing issues related to fossil fuel emissions.

Carbon sequestration is a way to mitigate the accumulation of greenhouse gases in the atmosphere released by the burning of fossil fuels and other anthropogenic activities. Growing concerns about climate change and concerned problems led to research quantifying the overall effects of urban forests on atmospheric carbon dioxide (CO_2) [1-6]. Intergovernmental Panel on Climate Change (IPCC) reports suggest that even if substantial reductions in the anthropogenic carbon emissions which are achieved in the nearby future, overall efforts to sequester previously released carbon will be necessary to ensure the safe levels of atmospheric carbon and to mitigate the climate change. Research on sequestration has focused primarily on Storage of Carbon and Capture and reforestation with less attention to the role of soils as carbon sinks. Recent incidents like melting glaciers and ice sheets coupled with a years of record-breaking heat underscores the importance of the aggressive exploration of all the most possible sequestration strategies.

The different causes of recently raised global warming are still being subjected to the research. However, there is an overall scientific consensus which identifies human activities as the main cause of the increased levels of the GHGs which have been verified over duration of 50 years. In a bid to reduce global warming, artificially capturing and storing the carbons as well as increasing natural sequestration processes using the sinks are being explored. CO_2 sinks are ecosystems that store carbon dioxide in wood, roots, water, sediment, leaves and the soil. The two basic types of CO_2 sinks are the natural and artificial sinks. Most of these studies have found that urban forests can be important carbon sinks, although there is a general lack of information on urban tree biomass allometry. Similarly, little is known about the release of CO_2 into the atmosphere from combustion of fuels used to power equipment and vehicles during planting and tree care activities. Once dead, trees release most of the CO_2 they accumulated through decomposition. The rate of release depends on how the wood is utilized.

2. Materials and Methods

2.1 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 500 hectares of area mainly B.A.M. University campu. In this study, the amounts of biomass and CO_2, in standing woody biomass of selective ten tree species were calculated.

2.2 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 above the ground. The GBH of trees having diameter greater than 10 cm were measured directly by measuring tape [8]. The tree height measured by Theodolite instrument.

2.3 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 [9].

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

Where

V= ð r^2H = 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. Height is measured with the help of the instrument Theodolite. Wood density is used from Global wood density database. The standard average density of 0.6 gm / cm is applied wherever the density value is not available for tree species [7].

2.4 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 [7-8, 10].

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

2.5 Estimation of total biomass: Total Biomass is the sum of the above and below ground biomass.

Table 1. Wood densities of tree species

Sr. No.	Tree Species (Scientific Name)	Local Name	Wood Density (g/cm^3)
1	*Aegle marmelos*	Bel	0.78
2	*Annona retiaculata*	Ramphal	0.55
3	*Areca catechu*	Supari	0.88
4	*Bauhinia purpurea*	Apta	0.72
5	*Butea monosperma*	Palas	0.48
6	*Callistemon citrinus*	Bottle Brush	0.66
7	*Casurina equisetifolia*	Suru	0.66
8	*Citrus aurantifolia*	Nimbu	0.66
9	*Cocos nucifera*	Naral	0.61
10	*Ficus carica*	Anjir	0.66

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

2.6 Estimation of Carbon: Generally, for any plant species 50% of its biomass is considered as carbon ([11] i.e., Carbon Storage = Biomass x 50%) (kg/tree)

2.7 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=43.99 , The ratio of CO_2 to C is 43.99 /12.00 =3.66 . Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.66.

3. Results and Discussion

The tree can survive in the urban environment polluted with traffic-related contaminants [12] and it is one of the important green regions in urban and industrial sectors. Carbon capture rates vary by species, soil, climate, topography and most important is management practice [7,13].

These results can be used to help assess the actual and potential role of urban forests in reducing atmospheric CO_2. In addition, they provide insights for decision-makers and the public to better understand the role of urban forests, and make better management plans for urban forests.

Despite extensive evidence of the critical role played by urban trees in city environments, urban planners and architects have often undervalued the role played by trees as firstly, urbanization affects climate; cities tend to become hotter and create what is known as an urban heat island.

Biomass assessment is important for many purposes. It is aimed at resource use and for environmental management. In the light of environmental management, biomass assessment is an important indicator in carbon sequestration.

Discussion

Most of the researchers revealed that above ground biomass are more strongly correlated with DBH [14]. Also, it is accepted by many experts in this field that simple models with only diameters as input is one of the good estimator of AGB [15]. Scientific proofs suggest that enhanced atmospheric carbon dioxide could have some good effects like improvement in plant productivity [7, 16]. The study was conducted in the Aurangabad city to estimate the carbon sequestration in the ten selected tree species based on estimation of

Table 2. Total carbon and CO_2 sequestered by trees

Sr. No.	Scientific name	DBH (m)	Height (m)	Volume (m^3)	AGB (kg/tree)	BGB (kg/tree)
1	*Aegle marmelos*	0.12	4.60	0.05	41.82	10.87
2	*Annona retiaculata*	0.18	8.28	0.21	116.58	30.31
3	*Areca catechu*	0.19	7.59	0.22	188.88	49.11
4	*Bauhinia purpurea*	0.17	6.55	0.15	106.29	27.64
5	*Butea monosperma*	0.25	7.98	0.38	183.76	47.78
6	*Callistemon citrinus*	0.15	5.35	0.09	55.16	14.34
7	*Casurina equisetifolia*	0.16	7.21	0.14	81.18	21.11
8	*Citrus aurantifolia*	0.17	4.30	0.10	59.83	15.56
9	*Cocos nucifera*	0.20	8.82	0.28	169.67	44.11
10	*Ficus carica*	0.15	4.66	0.08	46.05	11.97
	Average	**0.17**	**6.53**	**0.17**	**104.92**	**27.28**
	Total	**1.73**	**65.34**	**1.69**	**1049.22**	**272.80**

Table 3. Total carbon and CO_2 sequestered by trees

Sr. No.	Scientific name	TB (kg/tree)	C (kg/tree)	CO_2 (kg/tree)	Tree count	Total CO_2 (Tonnes)
1	*Aegle marmelos*	52.69	26.35	96.59	2	0.19
2	*Annona retiaculata*	146.89	73.44	269.27	1152	310.19
3	*Areca catechu*	237.98	118.99	436.26	5	2.18
4	*Bauhinia purpurea*	133.92	66.96	245.50	4	0.98
5	*Butea monosperma*	231.54	115.77	424.45	2	0.85
6	*Callistemon citrinus*	69.50	34.75	127.40	28	3.57
7	*Casurina equisetifolia*	102.29	51.15	187.52	19	3.56
8	*Citrus aurantifolia*	75.39	37.69	138.19	58	8.02
9	*Cocos nucifera*	213.79	106.89	391.90	269	105.42
10	*Ficus carica*	58.03	29.01	106.37	51	5.43
	Average	**132.20**	**66.10**	**242.34**	**159**	**44.04**
	Total	**1322.01**	**661.01**	**2423.44**	**1590**	**440.39**

carbon and carbon dioxide. According to descending order of CO_2 sequestering potential of individual trees have been discussed below. *Arecha catechu* has sequestered 436.26 kg/tree of CO_2 which is highest compared to other tree species from the study area. It is due to high DBH of tree. At the same time volume, AGB, BGB, total biomass, carbon are also highest in the *Arecha catechu* which has five tree count and total CO_2sequesterd is 2.181 tonnes.

Second highest CO_2 sequestered species is *Butea monosperma* which has sequesterd 424.445 kg/tree. *Aegle marmelos* sequesterd lowest CO_2 i.e.96.59 kg/tree compared to other trees which is may be due to lowest DBH i.e. 0.122 meters total CO_2 sequestered found lowest 96.594 kg/tree. It is clear from calculations that the study area has Total AGB as 1049.21, BGB of 272.796, TB of 1322.01, Carbon of 661.005 and CO_2 2423.44 tonnes. Total tree count of the study area is 1590. Maximum 1152 trees belonged to *Annona retiaculata* and only two trees belonged to species of *Aegle marmelos* and *Butea monosperma* species which are lowest in number. Total CO_2 sequestered is 440.391 tonnes.

Several studies have found that the growing trees to sequester carbon could provide moderately low-cost net discharge reductions for a various countries. In relation to C capture, results have shown that species choice can

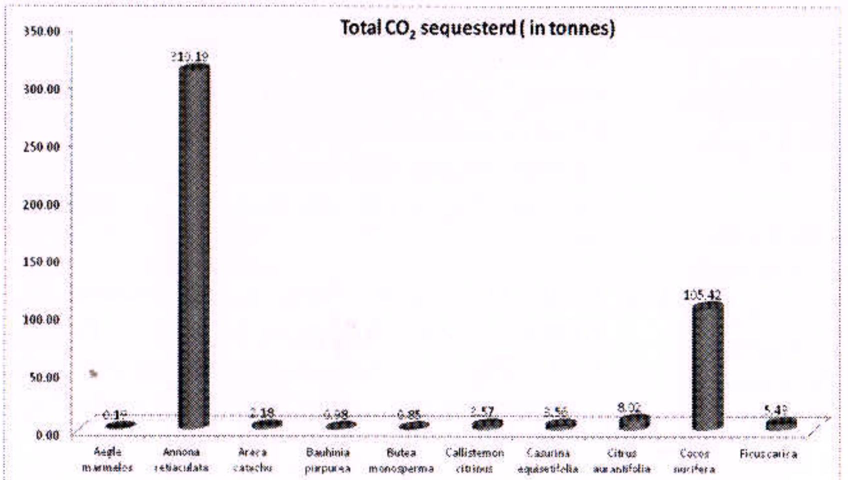

Fig 1. Showing Carbon dioxide captured by trees (inTonnes)

make a significant difference in the services as well as in the future storages of carbon in the living biomass. The substitution of present exotic plantations with local species in this region has the greatest efficiency for increasing carbon sequestration. Large healthy trees more than 77 cm in the diameter capture approximately 90 times more carbon as compared to the small healthy trees which have diameter less than 8 cm [17]. Large trees also preserve approximately 1000 times maximum carbon than smaller trees [7,17]. Environmentalists have 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. More research work is required on the overall effects of trees, soils and its proper management in the urban areas [18]. Carbon storage by tree species in woodlands at national level was 20.2 billion tonnes in 2008 [7,19]. As urban areas discharge large amount of emissions of carbon, tree creates an impact carbon emissions through changing in climates at micro level, albedo, use of energy, and maintenance of emissions require to be added with tree storage and capture estimates to improve a more complete evaluation of the role of trees of urban area on climate change [7,20].

4. Conclusion

Trees from urban area play a crucial role in reduction of atmospheric carbon dioxide levels. Carbon stock was determined for Aeglemarmelo, Annonaretiaculata, Areca catechu, Bauhinia purpurea, Buteamonosperma, Callistemon citrinus, Casurinaequisetifolia, Citrus aurantifolia, Cocosnuciferaand Ficuscarica., in and around Aurangabad city. Results shows that Arecha catechu has the best carbon sequestration potential rate which sequesterd 36.260kg/tree of CO_2 whereas Aegle marmrlos has the least sequestration rate which sequesterd 96.594 kg/tree of CO_2 as compared to other species. More field measurements are needed in urban areas to help improve carbon accounting and other functions of urban forest ecosystems. 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. Total tree count of ten species from the selected study area found 1590 and total carbon dioxide sequesterd by the trees as 440.391 tonnes. In order 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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