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Estimation of above Ground Biomass of Trees in BITS-PILANI, Dubai Campus

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Abstract. The role of biomass in of impact brought about by urbanization is well known and documented. A micro-level study of above ground biomass estimation and through that, carbon sequestration have been considered in BITS-PILANI,DUBAI CAMPUS, with the ideal trees marked out for their relevance and dominance in the campus; with maximum age possibility of 10 years(inception of the campus). Trees like Azadirachta indica, Delonix regia, Millingtonia hortensis and Conocarpus lancifolius have shown biomass growth rates at 1.08 tons/year, 0.305 tons/year, 0.917 tons/year and 1.052 tons/ year respectively, and CO_2 sequestered rates of 1.782 tons/year, 0.504 tons/year, 1.514 tons/year and 1.737 tons/year. These statistics are recorded in the campus. Techniques like regressional analyses and allometric equations were used to help determine these rates as that is the most effective way to sustain the ecosystem and get effective results. Tabular representation and factual data are further expanded and discussed.

Keywords: allometric equation, biomass estimation, regressional analyses.

1. Introduction

Biomass is understood as "the total amount of aboveground living organic matter in trees expressed as oven-dry tons per unit area (tree, hectare, region, or country). It is the difference in product between respiration and photosynthesis."

It is also expressed as **biomass density** when expressed as mass /unit area, e.g., kg/acre

"The total biomass for a region or country is obtained from the product of biomass density and the corresponding area of forests" [1]

It could also refer to plant or animal based material that's living, or recently living.

The concept of using allometric equations for specific species of trees predominant in the campus is definitely a very cost effective method and also environmentally sustainable, since the resources for destructive sampling of a large number of trees and measuring dry matter constitutes a futile attempt in tree conservation in sparsely covered areas in the deserted area. Also, using GIS satellite tracking method for biomass estimation is not a feasible method for a micro-level attempt in determining urbanization impacts in an isolated surrounding. Quick and non-destructive methods are required to find plant biomass if we want to find productivity without greatly disturbing the desert niche. Dimensional analyses [2]-[4] have been used for establishing statistical relationships between plant biomass its dimensions. This method has been used to find tree and shrub productivity, termed as dry-AGB [5].

The use of allometric equations can be categorized into two types: linear regression models and non-linear regression models. Linear regression models can have single entry data, multiple entry data, etc. and Non linear regression models depend on the variable that can increase exponentially/logarithmically and so on. These systems accommodate both linear and non linear systems as they both take into account 2

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important parameters needed for the equation estimation, i.e., DBH (which in most countries is allocated at 1.37m above the ground) and the total height are inputs for the equation and after the necessity of the wood density equations have also been factored in, the total calculation is made for the number of trees belonging to a set of class of diameters, and then , using the equations, the above ground biomass estimation of these trees.

Above ground biomass (AGB) is taken for the simple reason that that alone accounts mainly for the wind reduction along with the man made buildings. The root biomass equations aren't taken to account as parameters for temperature study or soil nutrient study aren't taken to consideration. The total trees available in the college exceed 900, consisting of ornamental trees, monocots and dicots consisting of exotic and indigenous trees, like *Azadirachta indica*, *Millingtonia hortensis*, *Pheonix dactliyfera*, *Acacia tortillis*, *Conocarpus lancifolius, Delonix regia* and so on.

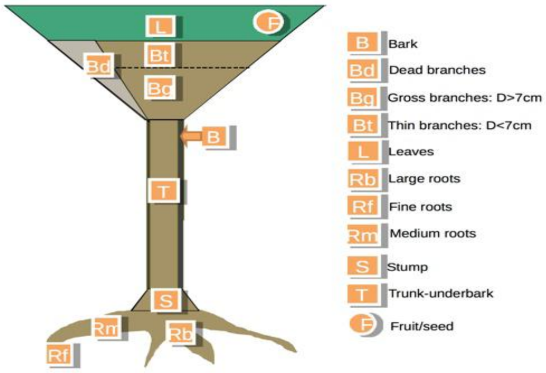

Fig. 1: Components of a tree

From this diagrammatic illustration, the main contributing factors for AGB are all the components except Large roots, Fine roots and Medium roots. The AGB along with its canopy is most relevant for the contribution of mitigation of carbon released in the atmosphere and also reducing high wind velocities from outside the campus (desert ecosystem) to inside the campus.

The allometric equations for biomass/biovolume are taken into consideration keeping these factors in mind and also the equations for the four species taken into consideration have the necessary coefficients already factored into the equation (SI units).

2. Sample Size

The trees present in the campus are all angiosperms which can be grouped under eudicots coming in the family of Fabacae, Combretaceae, Meliaceae, Bignoniaceae, Arecaceae and so on. The following species *Azadirachta indica, Millingtonia hortensis, Delonix regia, Conocarpus lancifolius* are considered based on their contribution in area coverage, number of trees, dominance in the tree flora. These species of trees are also considered for another reason, that they have a major dominant factor in helping to reduce the pollution by wind, soil erosion due to their high numbers, quick growth rates and also enormous canopy layers. For the measurement of the trees , a Sokia DT 600 Digital Transitional Theodolite was used to measure the height and a 5m measuring tape was used to measure the DBH of the trees.

Having decided the dominant species in the campus, a detailed study on the sample size was conducted and the result illustrated in Fig. 2. Not all trees were considered for biomass estimation, Only those trees with branching above 1.3m, dbh >=1.3m and diameter>10 cm were considered. The above mentioned parameters were taken as criteria according to the definition of a tree. [6]

The representation of these trees in the campus is illustrated below:

3. Biomass Estimation and Carbon Sequestration of Trees

From the estimation of the biomass, 50% of the biomass content is expected to be water and thus lost as water vapor when dry matter is extracted. From this, it is hypothesized that 45% of the total dry matter (excluding H_2O) is carbon. From this the amount of carbon dioxide sequestered per tree is calculated.

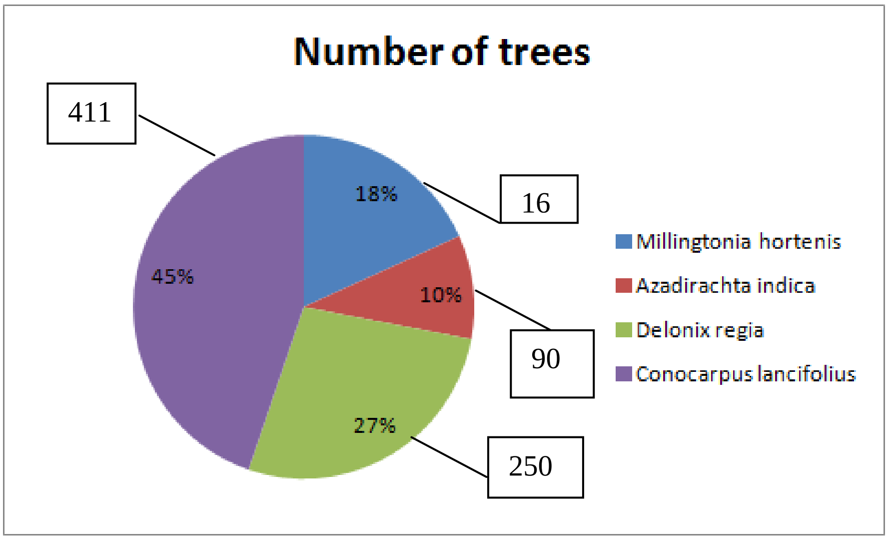

Fig. 2: Percentage of representation of dominant trees in the campus

3.1. Neem (Azadirachta indica)

Neem trees are broadly classified into angiosperms which are grouped into eudicots that come under the Meliaceae family. These trees are grown in the sub-continent and they are rapid growing, thus effective sequesters of carbon.

The allometric volume equation of the tree with adjusted volume parameters in the form of coefficients is

Y= (-0.00989 + 0.0000184*diameter (cm)*height (m) + 0.0000438*diameter (cm)*diameter (cm)* height (m)), where Y is the biovolume of the AGB of the tree in m^3 [7]

The biomass is calculated by multiplying the biovolume of trees with the wood density. Wood density for these trees being 820 g/cm^3 [8].

Using the above equation, the above ground biomass for the neem trees in the campus is calculated. Sample size of 40 out of the total 90 trees in the campus alone are considered for the calculation, as the rest did not satisfy the diameter and dbh criteria. The carbon sequestered per tree is calculated from the biomass and the results are summarized in Table 1.

3.2. Gulmohar (*Delonix regia*)

Gulmohar trees are broadly classified to angiosperms which are further grouped as eudicots that come under the Fabaceae family. Although these trees are indigenous to islands in Africa, they've been found to grow in North America and Asia.

The allometric biomass equation of the tree with adjusted volume parameters in the form of coefficients is mentioned:-

Y=0.0612*(diameter (cm)*height (m)) ^ (1.5811), where Y is the biomass of the AGB of the tree in kg [9].Wood density for these trees being 800 g/cm^3 [8]

Using the above equation, the above ground biomass for the gulmohar trees in the campus is calculated. Sample size of 69 out of the total 250 trees in the campus alone are considered for the calculation, as the rest did not satisfy the diameter and dbh criteria. The carbon sequestered per tree is calculated from the biomass and the results are summarized in Table 2.

3.3. Millingtonia (Millingtonia hortensis)

Millingtonia trees are usually classified as angiosperms with further grouping of eudicots. They're classified into the family Bignoniaceae. They are found in many regions in Asia, in the sub-continent and the south-east

Table 1: AGB and carbon sequestered per neem tree in the campus

Neem(*Azadirachta indica)*						
Class (diameter)(cm)	Number of trees	Average diameter(cm)	Average height(m)	Average biomass(kg)	Carbon content(kg)	CO_2 content(kg)
50-55	1	52	5.938	573.229	257.953	945.83
55-60	5	57.8	6.088	727.893	327.552	1201.023
60-65	13	62.1538	6.2718	869	391.05	1433.85
65-70	10	66.3	6.715	1061.048	477.47	1750.73
70-75	5	71.4	7.1682	1067.754	480.49	1761.794
75-80	1	75	7.289	1472.717	662.723	2429.983
80-85	4	82	7.398	1787.185	804.233	2948.855
105-110	1	106	7.743	3128.918	1408.04	5162.814
Total Number	**40**			**43209.379**	**19444.571**	**71295.47535**
Average biomass, carbon and CO_2 content				**1080**	**486**	**1782**

Table 2: AGB and carbon sequestered per gulmohar tree in the campus

Gulmohar(*Delonix regia)*						
Class (diameter)(cm)	Number of trees	Average diameter(cm)	Average height(m)	Average biomass(kg)	Carbon content(kg)	CO_2 content(kg)
20-25	3	23.67	4.581	101.051	45.473	166.734
25-30	8	27.75	4.685	134.634	60.585	222.145
30-35	18	32.22	4.759	174.771	78.647	288.372
35-40	12	36.75	4.828	220.133	99.06	363.219
40-45	7	41.29	5.017	281.213	126.546	464.002
45-50	9	46.56	5.486	391.637	176.237	646.202
50-55	3	52.67	5.785	517.599	232.919	854.038
55-60	3	56.33	6.266	653.082	293.887	1077.585
60-65	4	61.75	6.2805	757.942	341.074	1250.605
65-70	1	65	6.382	843.074	379.384	1391.073
70-75	1	70	6.743	1034.036	465.316	1706.160
Total Number	**69**			**21081.83616**	**9486.97**	**34785.02967**
Average biomass, carbon and CO_2 content				**305**	**137**	**504**

The allometric biomass equation of the tree with adjusted volume parameters in the form of coefficients is mentioned:-

Y= (0.000169*(diameter (cm) ^ (1.9282)*(height (m) ^ (0.6162)), where Y is the biomass estimated of the AGB of the tree in kg. [9].Wood density for these trees being 670g/cm^3 [8]

Using the above equation, the above ground biomass for the millingtonia trees in the campus is calculated. Sample size of 40 out of the total 167 trees in the campus alone is considered for the calculation, as the rest did not satisfy the diameter and dbh criteria. The carbon sequestered per tree is calculated from the biomass and the results are summarized in Table 3.

Table 3: AGB and carbon sequestered per millingtonia tree in the campus

Indian cork/Jasmine(*Millingtonia hortensis)*						
Class (diameter)(cm)	Number of trees	Average diameter(cm)	Average height(m)	Average biomass(kg)	Carbon content(kg)	CO_2 content(kg)
30-35	1	30	5.954	239.6356	107.836	395.399
35-40	2	37.5	6.014	371.65	167.243	613.223
40-45	4	43.25	6.07	491.176	221.03	810.44
45-50	7	47.14	6.15	584.9	263.205	965.09
50-55	4	51.75	6.316	711.18	320.031	1173.45
55-60	7	56.71	6.792	888.1	399.645	1465.365
60-65	7	62	7.331	1105.18	497.331	1823.547
65-70	3	67.33	7.65	1330.73	598.829	2195.705
70-75	2	72.5	7.768	1548.635	696.886	2555.248
75-80	1	75	7.775	1653.119	743.904	2727.646
80-85	1	82	7.91	1984.421	892.989	3274.295
85-90	1	85	8.015	2144.137	964.862	3537.826
Total Number	**40**			**36710.7566**	**16519.902**	**60572.748**
Average biomass, carbon and CO_2 content				**917**	**412**	**1514**

3.4. Damas (Conocarpus lancifolius)

Damas trees are classified as angiosperms that come under the category of eudicots, that are further grouped into the family Combretaceae. These trees are indigenous to the Arabian Desert and also the UAE.

The allometric volume equation of the tree with adjusted volume parameters in the form of coefficients is mentioned:-

Y= 0.32 *(diameter (cm)*diameter (cm)*height (m))^0.88, where Y is the volume of the AGB of the tree in m^3, which is then multiplied with wood density to get the biomass of the tree in kg.[10].Wood density for these being $600g/cm^3$ [6]

Using the above equation, the above ground biomass for the damas trees in the campus is calculated. Sample size of 120 out of the total 411 trees in the campus alone is considered for the calculation, as the rest did not satisfy the diameter and dbh criteria. The carbon sequestered per tree is calculated from the biomass and the results are summarized in Table 4.

From the samples of the trees taken, many have shown promising results .In terms of being a good carbon sink in an urban atmosphere from an ecological perspective, it should act as a carbon reservoir rather than source. [6] Even though they'll eventually release the carbon back to the atmosphere, the foresight to prolong the release of carbon to the biosphere will definitely prevail. The right mix of indigenous and exotic trees(tropical/sub-tropical conditions) is the key to ecological survival, as the rich tropical climate would definitely bring with it variations and thus trees can grow combined in both niches. The biomass growth rate annually of trees like *Azadirachta indica* (1.08 tons/year), *Delonix regia* (0.305 tons/year), *Conocarpus lancifolius*(1.05 tons/year)and *Millingtonia hortensis* (0.917 tons/year) illustrated in Fig. 3 is definitely a plus point for prolonging carbon sequestration.

Urban trees have a positive role to play in energy transfer and conservation between the buildings and the surroundings (due to heat reflected or conserved) and also this balance of conservation will result in reducing the atmospheric CO_2 to a large extent, as they'll be stored in trees, illustrated in Fig. 4.

Table 4: AGB and carbon sequestered per damas tree in the campus

Damas(*Conocarpus lancifolius*)						
Class (diameter)(cm)	Number of trees	Average diameter(cm)	Average height(m)	Average biomass(kg)	Carbon content(kg)	CO_2 content(kg)
25-30	1	26	4.923	241.444	108.65	398.38
30-35	6	30.5	5.046	326.89	147.1	539.37
35-40	6	36.83	5.08	459.17	206.63	757.63
40-45	28	41.57	5.161	575	258.75	948.75
45-50	16	46.63	5.125	655.15	294.82	1080.99
50-55	22	51.59	5.426	842	378.9	1389.3
55-60	10	56.9	6.37	1206.07	542.73	1990.01
60-65	8	61.63	6.725	1275.08	573.78	2103.88
65-70	8	65.75	6.895	1662.88	748.29	2743.75
70-75	7	72.29	7.501	2116.31	952.34	3491.91
75-80	3	77	7.904	2475.31	1113.89	4084.26
80-85	1	81	8.012	2841.8	1278.8	4688.97
85-90	1	85	8.356	2981.06	1341.477	4918.75
90-95	1	92	8.492	3606.588	1622.96	5950.87
95-100	1	97	8.771	4072.89	1832.8	6720.27
105-110	1	108	8.864	4966.395	2234.88	8194.55
Total Number	**120**			**126337.36**	**56851.87**	**208456.65**
Average biomass, carbon and CO_2 content				**1052**	**473**	**1737**

4. Results and Conclusions

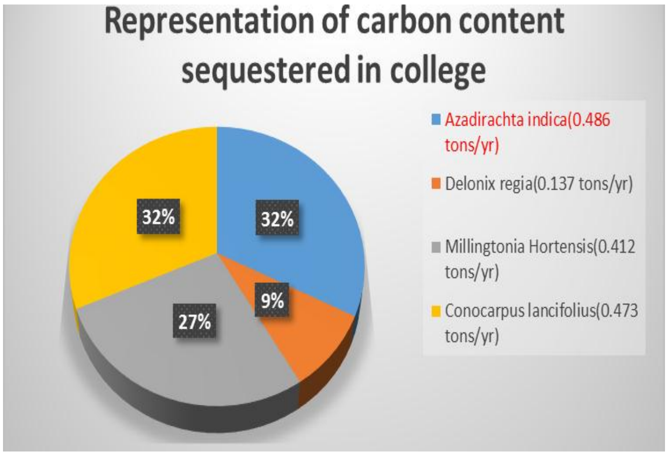

Fig. 3: Carbon and average biomass content of trees

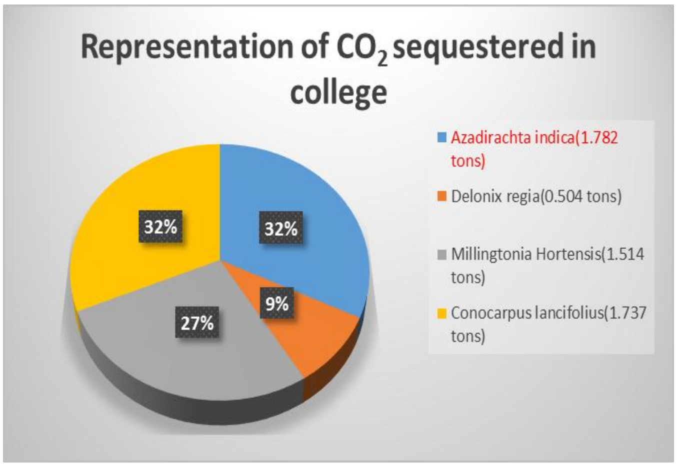

Fig. 4: Carbon dioxide content of trees

5. Acknowledgements

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6. References

[1]. Estimating biomass and biomass change of tropical forests: a primer. (FAO Forestry Paper - 134) (1997)

[2]. WHITTAKER RH (1965) Branch dimensions and estimation of branch production. Ecology 46:365-370.

[3]. WHITTAKER RH (1966) Forest dimensions and production in the Great Smoky Mountains. Ecology 47: 103-121.

[4]. WHITTAKER RH (1970) Communities and ecosystems.MacMillan Company, Toronto, Ontario.

[5]. WHITTAKER RH & GM WOODWELL (1971) Dimension and production relations of trees and shrubs in the Brookhaven Forest. Journal of Forestry 56: 1-25.

[6]. B. L. Chavan et. al. / International Journal of Engineering Science and Technology

[7]. NATURAL FOREST MANAGEMENT / BIODIVERSITY, V.P. Tewari, Arid Forest Research Institute, Jodhpur.

[8]. Oey Djoen Seng (1951) in Soewarsono (1990). Specific Gravity of Indonesian Woods and its Significance for Practical Use, FRDC, Forestry Department, Bogor, Indonesia p:133

[9]. Dung,N.T.,Toai,P.M., Hung,V.T., Anh, L.T., Khoa, P.V.(2012) Tree allometric equations in Evergreen broadleaf and Bamboo forests in the North Central region, Viet Nam, in (Eds) Inoguchi, A., Henry, M. Birigazzi, L. Sola, G. Tree allometric equation development for estimation of forest above-ground biomass in Viet Nam, UN-REDD Programme, Hanoi, Viet Nam

[10]. JKAU: Met., Env. & Arid Land Agric. Sci., Vol. 21, No.1, pp: 3-17 (2010 A.D./1431 A.H.) DOI: 10.4197/Met. 21-1.1, "Effect of Thinning on the above Ground Biomass of (Conocarpus erectus L.) Trees in the Western Regionof Saudi Arabia", A. Abohassan, S. F. A. Tewfik and A. O. El Wakeel. Department of Arid land Agriculture, Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia