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Carbon Sequestration Potential of Trees and Soil in Swami Shantiprakash Garden, Ulhasnagar

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ABSTRACT: The main objective of the study was to assess the total carbon sequestration potential of trees and soil from Swami Shantiprakash garden in Ulhasnagar. The garden under study covers an area of 1.90 acres (approximately 0.77 ha) and houses around 171 trees belonging to 29 genus. GIS interpretation of the garden was also piloted to predict the biomass. The colour scheme in the GIS map represents the vegetation density. Greener colour towards the north indicates higher density followed by yellow for moderate and red for scarce vegetation. The AGB (443.0058Kgs), BGB (115.1819Kgs) of all the trees was summed up to the Total biomass of 555.81982Kgs. The organic carbon of the standing live tree was 0.277 tons. *Samanea saman*(15) contributed around 190.0939Kgs while *Polyalthia longifolia* (72) contributed 191.4615 Kgs of biomass, together accounting to 68% of the total biomass. Maximum CO₂ was sequestered by *Polyalthia longifolia*(0.3509 tons) and *Samanea saman*(0.3484tons). However trees of *Samanea* were huge belonging to higher DBH class and may show decreased potential in future due to ageing, as compared to *Polyalthia* that are young trees belonging to lower DBH Classes. Carbon stock of the soil (SOC) was studied depth wise and found to be 41.39ton ha⁻¹, 28.65 ton ha⁻¹ and 30.52ton ha⁻¹ for depth at 10 cm, 20 cm and 30 cm, respectively. The sustainable development of the urban trees is important to protect the developing world from the adverse effects of climate change and global warming.

KEYWORDS: Ulhasnagar, Carbon sequestration, biomass, GIS, *Samanea saman*, SOC.

I. INTRODUCTION

Carbon is found in all living organisms and is the vital building block for the life on planet. Carbon found in various forms mostly occur as plant biomass and organic matter in soil with as the gaseous carbon dioxide in the troposphere and in the form of dissolved water in oceans [1]. In terms of atmospheric CO₂ decrease, trees in urban areas gives the maximum advantage of direct carbon accumulation and the avoidance of carbon dioxide generation by different fossil fuel power plants by energy conservation from trees [2]. These trees capture CO₂ by fixing carbon during photosynthesis process and accumulating extra carbon as biomass. Plant grows through the natural process of photosynthesis, in which carbon dioxide is captured and stored in cells of plants with growth. One of the most burning issues in the modern era is the problem of change in climatic conditions and harmful role of greenhouse gases play in the changing temperatures at the international level. Anthropogenic causes of warming in the globe have become a biggest topic of concern in front of the world because of the life threatening changes that could result from increase in global heat and temperature. In addition, the United Nations Framework convention on climate change and in particular the Kyoto Protocol recognize the importance of forest carbon sink and the need to monitor, preserve and enhance terrestrial carbon stocks, since changes in the forest carbon stock influence the atmospheric CO₂ concentration [3].

Green areas or pockets act as hot spot in urban biodiversity [4], moreover Ulhasnagar city exist few green pouches.

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Soil is one of the major natural resources, alongside air and water. It is one of the marvellous products of nature and without which there would be no life. Worldwide, the first 30 cm of soil holds 1500 pg of carbon [5] and for India it is 9pg [6]. In the present investigation Swami Shantiprakash garden was taken as a study site to estimate carbon sequestration potential of trees and soil in the garden.

II. MATERIALS AND METHODS

Study Area- Ulhasnagar once a barren land today is a municipal town with 57 Parks and gardens established by the municipal corporation. Swami Shantiprakash garden located at Ulhasnagar, District - Thane, Maharashtra was selected as the study area. The total area of the garden is 1.90 acres (approx. 0.77 ha), surrounded by many shops, buildings exhibiting an overcrowded zone on the Google map. The location of garden is 19° 20' 58" N latitude and 73° 16' 32" E longitude. The climate here is tropical. The average annual temperature in Ulhasnagar is 27.0°C and the precipitation averages to 2958 mm.

Total Biomass, AGB and BGB of the trees were estimated by non-destructive method [7] to calculate, carbon stock and the carbon dioxide sequestered [8]. The Soil Organic Carbon (%) was estimated [9] and later the carbon stock density of soil was calculated [10]. Arc view 10.2.1, software of Geographic Information System (GIS) was used to predict the biomass [11].

III. RESULTS

A total of 171 individuals including 30 species, 29 genera belonging to 21 different families were inventoried in Swami Shantiprakash Garden of Ulhasnagar. *Polyalthia longifolia* (72) was dominant followed by *Samanea saman* (15) and *Delonix regia* (12), while the rare listed trees like *Aegle marmelos*, *Ixora parviflora*, *Plumeria alba*, *Plumaria rubra*, etc. were represented by single individual in the garden. Larger number of trees like *Polyalthia longifolia*, *Samanea saman* and *Delonix regia* may be the result different plantation programmes adopted by government. The trees that dominated belonged to family Leguminosae, Myrtaceae and Palmae each represented by 3 different genus. Families like Apocynaceae and Bignoniaceae with 2 genus each while families like Anacardiaceae, Annonaceae, Rubiaceae, etc. were represented by single genus. The physiognomy status of trees showed 16 Evergreen out of which 7 were native and 9 tree species were introduced. Similarly there were 14 deciduous trees species out of which 11 were native (Table 1).

Table 1: Carbon stock in Trees of Swami Shantiprakash garden

Sr. No.	Family	Botanical Name with Tree density	Physiognomic Status	Total Biomass (Kgs)	Org C (Kgs)	CO ₂ seq. (tons ha ⁻¹)
1	Leguminosae	<i>Cassia fistula</i> (3)	D,N	14.351	7.1755	0.0263
2		<i>Delonix regia</i> (12)	D, N	10.1694	5.0847	0.01864
3		<i>Samanea saman</i> (15)	E, N	190.099	95.0469	0.3484
4	Myrtaceae	* <i>Eucalyptus globulus</i> (3)	E, I	8.1247	4.0623	0.01489
5		* <i>Eugenia jambolana</i> (4)	E, N	29.9945	14.9727	0.0548
6		<i>Psidium guajava</i> (2)	E, I	0.1207	0.06035	0.00022
7	Apocynaceae	<i>Alstonia scholaris</i> (2)	E, N	0.03152	0.01576	0.00005
8		<i>Plumeria alba</i> (1)	D, N	0.2239	0.1119	0.00041
9		<i>Plumeria rubra</i> (1)	D, N	0.3223	0.1611	0.00059
10	Palmae	<i>Cocos nucifera</i> (8)	D, N	0.2785	0.1392	0.00051
11		<i>Roystonea regia</i> (6)	E, I	3.0095	1.5047	0.00551
12		<i>Areca catechu</i> (1)	D, N	1.6636	0.8318	0.003

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 7, July 2017

13	Bignoniaceae	<i>Millingtonia hortensis</i> (1)	E, I	5.2167	2.6083	0.00956
14		<i>Spathodea campanulata</i> (2)	D, N	0.0449	0.0224	0.00008
15	Annonaceae	<i>Polyalthia longifolia</i> (72)	E, N	191.465	95.7307	0.3509
16	Rubiaceae	<i>Ixora parviflora</i> (3)	E, I	0.2687	0.1343	0.00049
17	Rutaceae	<i>Aegle marmoles</i> (1)	D, N	0.121	0.0605	0.00022
18	Aracuriaceae	<i>Araucaria curi</i> (2)	E, I	5.3286	2.6643	0.00976
19	Meliaceae	<i>Azadirachta indica</i> (1)	E, N	2.2255	1.1127	0.004
20	Caricaceae.	<i>Carica papaya</i> (1)	D, I	0.144	0.072	0.0002
21	Casuarinaceae	<i>Casuarina equisetifolia</i> (11)	E, I	42.2466	21.1233	0.07744
22	Urticaceae	<i>Ficus glomeratus</i> (1)	E, N	5.0387	2.5193	0.00923
23	Malvaceae	<i>Grevillea robusta</i> (2)	E, I	5.702	2.851	0.0104
24	Moringaceae	<i>Moringa oleifera</i> (1)	D, N	0.4402	0.2201	0.000806
25	Lythraceae	<i>Lagerstromia speciosa</i> (4)	D, N	5.9545	2.9772	0.0109
26	Combretaceae	<i>Terminalia catappa</i> (4)	D, I	8.2237	4.1118	0.015
27	Anacardiaceae	<i>Mangifera indica</i> (6)	E, N	19.0674	9.5337	0.0349
28	Sapotaceae	<i>Madhuca indica</i> (1)	D, N	5.5959	2.7979	0.01025
29	Verbenaceae	<i>Vitex nigundo</i> (1)	D,I	0.273	0.1365	0.0005
30	Magnoliaceae	<i>Michelia champaca</i> (1)	E, N	0.0834	0.0417	0.00015
		Total (171)		555.8198	277.8846	1.018106

(*E-Evergreen, D-Deciduous, N-Native and I- Introduced)

Carbon Store in tree species

Among the 171 individuals belonging to 30 tree species recorded in the study area, *Polyalthia longifolia* (72 trees) stored 95.7307 Kgs (34.44%) of organic carbon in its standing biomass followed by *Samanea saman* (15 trees) 95.0469 Kgs (34.20%), together accounting for > 68% of the total organic carbon stored by the plantation. *Casuarina equisetifolia* (11 trees) 21.1233 Kgs (7.60%), *Eugenia jambolana* (4 trees) 14.9727 Kgs (5.38%) and *Mangifera indica* (6 trees) 9.5337 Kgs (3.43%) are few of the trees in the garden adding up to the total organic carbon. Least organic carbon stored was by *Alstonia scholaris* (2 trees) 0.01576 Kgs (0.005%) (Table 1).

The DBH of trees is an important parameter to calculate the total biomass of tree. Trees showed large variation in their diameters irrespective of the species. For convenience the trees were categorised into five different class of DBH as Class I (6-12 inches), Class II (13-24 inches), Class III (25-36 inches), Class IV (37-48 inches), Class V (49 inches and above). Among the five categories of DBH classes, Class III (25-36 inches) had the highest density of trees with 56 trees (32.74%) and least in with only 13 trees in Class V (7.60%). There were a total of 54 trees in Class I (6-12 inches), *Polyalthia longifolia* was dominant (24). In Class II (13-24 inches) 24 trees were present; *Cocos nucifera* was maximum (08). The DBH Class III (25-36 inches), included 56 tree species, with *Polyalthia longifolia* maximum in number (28). In the diameter Class IV (37- 48 inches), 24 trees were present, out of which *Polyalthia longifolia* was maximum in number (15). Few trees were in the range of Class V (49-60 inches and above), represented by only tree species *Samanea saman*. Irrespective of the density of trees in various DBH class, the order of organic carbon reserves were found maximum 33.81% in DBH Class V (93.9727 Kgs) >31.98% in Class III (88.868 Kgs) >29.23% in Class IV (81.2324 Kgs) >3.50% in Class II (9.7368 Kgs) >1.32% in Class I (3.6732 Kgs) (Fig 1). With increasing age, the volume of biomass grows thus accumulating more carbon. Young leaves serve as C-sink and take up carbon through photosynthesis while the older leaves export C to the other parts within tree [12]. Thus the tree and stem, wood in its whole life span represent largest C-stock.

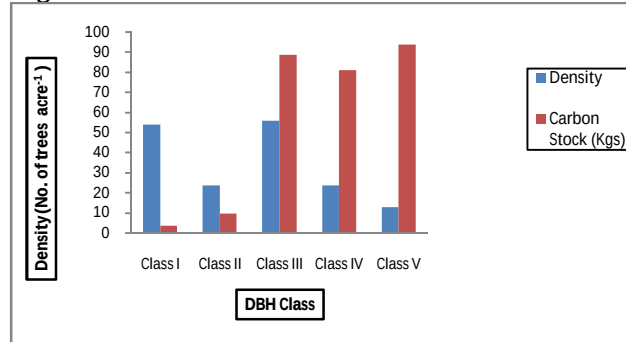
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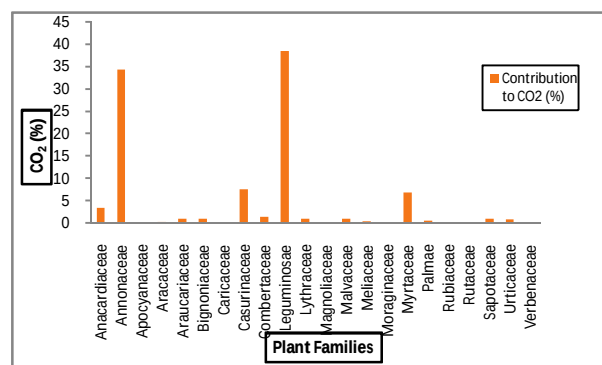
Vol. 6, Issue 7, July 2017

Fig 1: Distribution of Carbon stock within DBH classes



The standing biomass of 171 trees was about 555.8198 Kgs. The cumulative amount of Organic Carbon and CO₂ sequestered throughout in the study area was about 0.2755 and 1.0096 tons, respectively. When the Carbon dioxide sequestration potential of each family was studied, Leguminosae contributed about (0.3861 tons) 38.61% and is the highest followed by Annonaceae (0.3509 tons) 34.44%, Casuarinaceae (0.0774 tons) 7.601% and Myrtaceae (0.0709 tons) 6.8716%, respectively. (Fig 2) *Polyalthia longifolia* (72 trees) have sequestered 0.3509 tons (34.46%) of Carbon dioxide in its standing biomass followed by *Samanea saman* (15 trees) 0.3484 tons (34.22%), *Casuarina equisetifolia* (11 trees) 0.0774 tons (7.606%), *Eugenia jambolana* (4 trees) 0.0548 tons (5.382%) and *Mangifera indica* (6 trees) 0.0349 tons (3.427%) in the garden.

Fig 2: Contribution of Plant Families to total biomass in Swami Shantiprakash garden



GIS Interpretation

The application of GIS comes from a database management system that is designed to store and manipulate data [13]. Arc view 10.2.1, software of Geographic Information System (GIS) was used for predicting the biomass. The data helped to analyse and interpret better, and eventually conceptualize the above and below ground carbon sequestration in the entire area of Swami Shantiprakash Garden. GIS based map shows the location and value of above and below ground biomass for each tree species in the study area. Green colour represents higher density of AGB and BGB, yellow representing moderate density of trees and their AGB and BGB, shifting towards the red colour indicating lower concentration in the AGB and BGB (Fig 3 and 4). In the study area, old and huge trees of *Samanea saman* and *Madhuca indica* were in the northern region of the garden that appears as green zone in the GIS map. The yellow regions seen along the border of the garden were represented by trees like *Eugenia jambolana*, *Cassia fistula* and *Polyalthia longifolia*. Other trees were scattered in the red region. (Fig 3 and 4) Apart from its application for remote sensing data, GIS also offers the possibility of integrating further analysis of other types of information including data on soil types and population of a certain area in terms of different types of projects [14]. Similar work using GIS by

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Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

many researchers highlighted the importance and applicability of the tool in better assessment and easier understanding of carbon inventory projects at baseline level [15].

Fig 3: AGB Distribution in Swami Shantiprakash garden

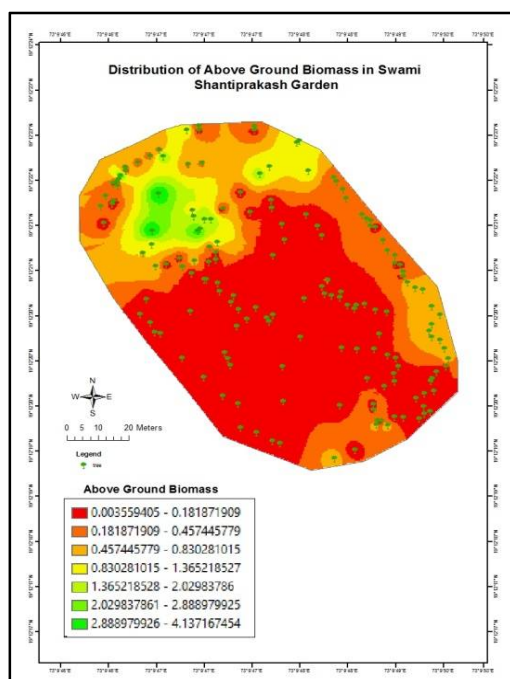
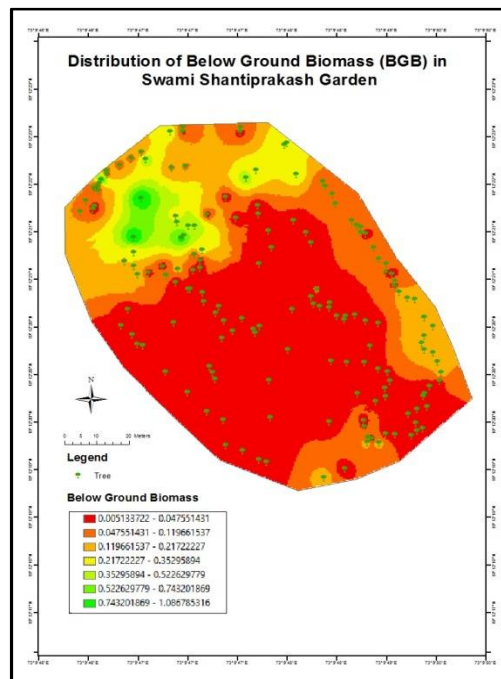


Fig 4: BGB Distribution in Swami Shantiprakash garden



Soil Organic Carbon (SOC)

Soil is deteriorating at an alarming rate in most of the developing countries due to land use changes [16], thereby lowering C sequestration. There is dire need to conduct studies related to C pools and C sequestration [17]. Comparatively few studies have been conducted in developing countries for carbon sequestration potential of soil. In view of this the finding of studies gives the amount of carbon in soil and its contribution carbon sequestration. Soil samples for the analysis were collected from 30 locations in the garden especially from the zone around the roots of different trees. The average depth wise SOC results (n=30) are presented in Fig 5. Decreasing trend in soil organic carbon was seen which ranged from 41.39 t ha⁻¹ for the depth of 0-10 cm and 28.65 t ha⁻¹ for the depth of 20-30 cm. Similar trend has been observed by many workers [18, 19]. It can be assumed that SOC was high at top soil due to the presence of vegetation compared to other two soil depths which had no vegetation except roots of the vegetation. This study also observed that, to estimate the carbon content of the soil in the parks were very complicated. And it was difficult to find untouched soil because most soils come from another place to increase the park soil fertility which means it was a disturbed soil. SOC is high when there is high amount of biomass present. Soil sample collected as can be observed in the from and near *Eugenia jambolana* (Av. 5.421 t ha⁻¹) as compared to other sub location in the garden. But it is not only one factor that affects SOC sequestration.

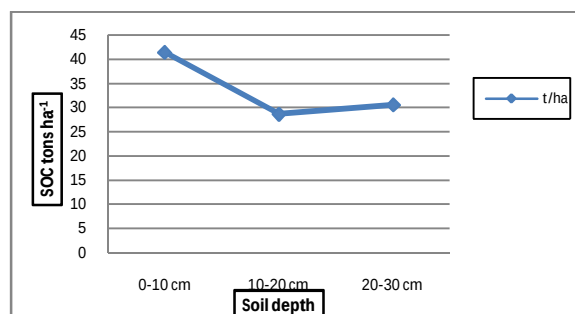
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 7, July 2017

Fig 5: SOC content at different Soil depths



Carbon sequestration is the capture and storage of carbon that would otherwise be or remain in the atmosphere and enhance the greenhouse effect process [20]. It is recommended to plant more trees to improve as the quality of urban life. Based on the IPCC report [21], more photosynthesis occurs more CO₂ is converted into biomass, thereby reducing carbon in the atmosphere and sequestering it in to plant tissue above ground and below ground. Besides, trees and natural environment improves the psychological well-being over scene of urban settings [22]. Trees also purify air and can lead to reduced cost of pollution reduction and prevention measures [23]. It has been reported by researcher [24], one ton of carbon storage in the tree represents removal of 44/12 or 3.67 tons of CO₂ e (carbon dioxide equivalent) from the atmosphere, and the release of 2.67 tons of oxygen back into the atmosphere. Therefore, in this scenario, besides beautifying the area trees also remove large amounts of air pollutants that consequently improve urban air quality.

IV. CONCLUSION

Keeping in mind the deteriorating condition of the environment and the health of the people in urban cities, the need for evaluating and assessing the trees in parks and gardens in an urban ecosystem has become imperative. Urban forest plays a significant role in carbon mitigation and thus needs to be effectively monitored, managed, protected and extended to achieve sustainable development goals. Planting trees that has the potential to sequester more carbon dioxide must be encouraged and promoted. In the present study, from the data obtained it can be concluded that *Eugenia jambolana*, *Samanea saman* trees can be planted more to improve the environment status of this urban city and also combat the issue of climate change.

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Vol. 6, Issue 7, July 2017

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