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Carbon stock potential of trees growing in an urban park of Guwahati, Assam, India

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ABSTRACT

A study on Carbon stock potential of trees growing in Amrit Udyan Park, Hengrabari, Guwahati, Assam was conducted between the year 2022 and 2023. All the trees in the park were inventoried and Circumference at breast height (CBH) measured. Biomass and Carbon stock of the trees were calculated using allometric formula. In the park, 83 tree individual (44.39 ha^{-1}) belonging to 38 tree species under 34 genera and 20 families were recorded. The present study revealed that the total above ground biomass (AGB), total below ground biomass (BGB), total biomass (TB), total Carbon stock (TCS) and CO_2 equivalent (CO_2 eqv.) were 522.03 Mg ha^{-1}, 135.73 Mg ha^{-1}, 657.76 Mg ha^{-1}, 328.88 Mg C ha^{-1} and 1206.99 Mg ha^{-1} respectively of all the trees growing in the park. The study revealed that urban park helped in conservation of trees and these trees helped in sequestration of CO_2 by storing Carbon as biomass which leads to mitigation of the global warming to some extent.

Key words: *Allometric formula, Biomass, CO_2 equivalent, Total Carbon stock,*

Introduction

Past few years have been the warmest year ever in the history of mankind, due to the rising atmospheric temperature globally. The expanding developmental activities like industrialization, urbanization, transportation etc. have raised the concentration of greenhouse gases. Among all the greenhouse gases, Carbon dioxide (CO_2) plays an important role in the global climate change. The rate of global warming can be barred by minimizing the CO_2 concentration in the air. The CO_2 concentration can be lessened in the atmosphere by alternating the consumption of energy or by plantation, which can reduce the concentration of CO_2 in the atmosphere. Naturally CO_2 absorbed from the atmosphere during photosynthesis by the trees and it stored as biomass in Carbon stock (Baes *et al*., 1977).

In the urban area, the population is much more than other places, so the protection of environmental services is more important in these areas. Urban green spaces play an important role in the environmental improvement (Linden *et al*., 2020).

Urban green spaces have potential to significantly support Carbon stock and Carbon sequestration; thereby mitigate CO_2 from the atmosphere. Biomass and Carbon stock estimation of trees were done in many urban areas across the world (Nowak *et al.*, 2013; Wang and Gao, 2020). However, no extensive studies have been done in urban green spaces of North Eastern India except in few university campuses (Deb *et al*., 2016; Yumnam and Dey, 2022). Taking into account the gap in studies, the study was premeditated to estimate the biomass and Carbon stock potential of trees in Amrit Udyan Park, Guwahati, Assam.

Materials and Methods

The study was carried out in Amrit Udyan Park, Hengrabari, Guwahati, Assam (Fig. 1) in the year between 2022 and 2023. It lies between 26° 9′1.44″ N and 91°47′37.32″ E and covers an area of 1.87 ha. The park was created honouring the freedom fighters of North Eastern States against British. It was inaugurated on 23rd August, 2022 by the Chief Minister of Assam. The park was developed in unutilized plot of Assam Khadi and Village Industries Board, Hengrabari through Guwahati Metropolitan Development Authority (GDMA) (https://gmda.assam.gov.in). It has undulated topography (consisting of plain and hillock) with trees and other vegetations. It hosted 8 statues of freedom fighters representing each state of North East India. It also has watch tower, children playing area, meditation centre etc. The area falls under humid subtropical climate (Koppen climate classification Cwa) (Peel *et al*., 2007).

The park was divided into several compartments such as entrance of the park, watch tower, children playing area, meditation centre etc. to make the survey easy. Inventory of all the trees in all the compartments were carried out and identified by referring to published literature (Hooker, 1877-1887; Kanjilal *et al*., 1934, 1936, 1938). Circumferences at breast height (CBH) of the entire tree were recorded directly with the help of measuring tape. The Above ground biomass (AGB) of tree species was estimated by the allometric equation given by Chave *et al* (2005). $ABG = \rho \times \exp(-1.499 + 2.148 \ln(D) + 0.207 (\ln(D)^2) - 0.0281 (\ln(D)^3))$, where, D is the diameter and ρ is the wood specific gravity (WSG) of the trees. The WSG of tree species, used here, had been taken from World Agroforestry database (https://www.worldagroforestry.org). When the WSG of tree species were unavailable, the standard average value of 0.62 gm cm^{-3} was used (IPCC 2003). Below ground biomass (BGB) was determined by multiplying the AGB with 0.62 (IPCC, 2003). The total biomass (TB) was calculated by summing up ABG and BGB. The total Carbon stock (TCS) of

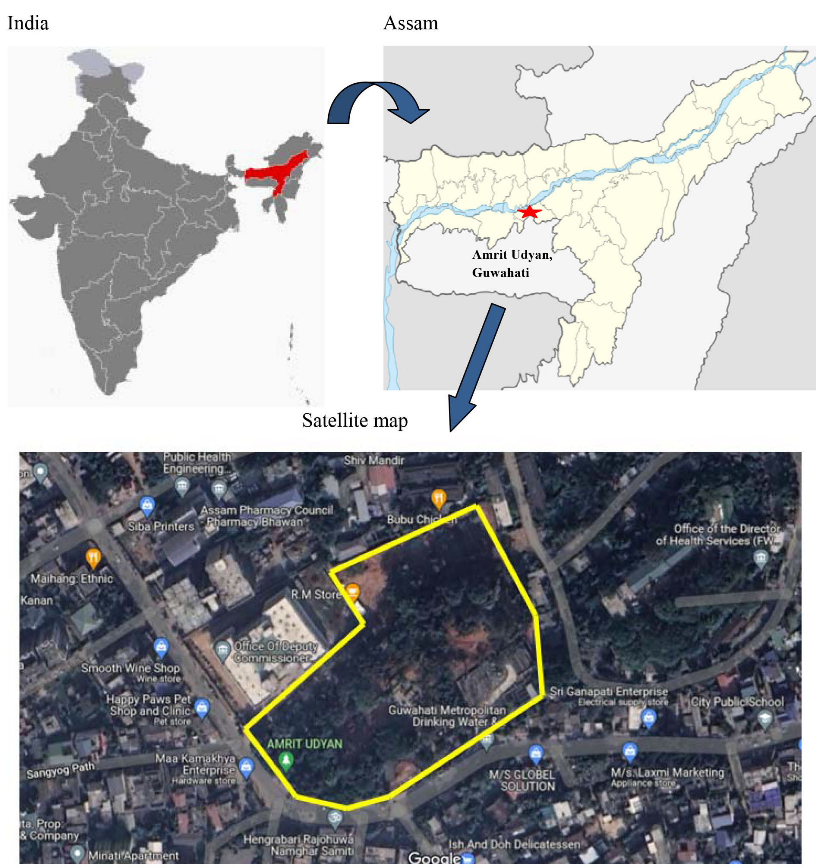

Fig. 1. Map showing study site

trees were determined by multiplying TB by a conversion factor of 0.5 assuming that carbon content is 50% of the TB (IPCC 2003). The TCS was converted to CO_2 equivalent (CO_2 eqv.) by multiplying the TCS with the 3.67 (Carbon Oxygen ratio).

Results and Discussion

A total 83 tree individual belonging to 38 tree species under 34 genera and 20 families were recorded in the park. The number of tree species reported was quite similar to the finding from the public parks of Bhubaneswar, Odisha (48 tree species) (Dash *et al.*, 2022). Fabaceae (22 species) was the dominant family followed by Combretaceae (9), Meliaceae (7) and Moraceae (6) (Fig. 2). Fabaceae was also the most dominant family in the campus of Cotton University, Assam (Yumnam and Dey, 2022). This could be due to the fact that fabaceae is one of the most widely distributed families in tropics (Schrire *et al*. 2005).

Total tree density in the park was 44.39 ha^{-1}. The highest tree density was represented by *Styphnolobium japonicum* (L.) (3.21 ha^{-1}). Many of the tree species (*Aegle marmelo* L., *Agathis dammara* (Lamb.) Poir., *Azadirachcta indica* A.H.L. Juss etc.) were represented by one individual (Table 1). The finding of the study was comparable to that of the urban parks of the city of Helsinki, Finland (22 to 28 ha^{-1}) (Linden *et al.* 2020) but less than that of Cotton University campus (369 ha^{-1}) (Yumnam and Dey, 2022). Less tree density in the park could be due to felling or translocation of trees to accommodate various amenities and facilities such statues, watch tower, children playing area, meditation centre etc. in the park.

Terminalia chebula L. had the highest WSG (0.83 g cm^{-3}) and *Moringa oleigera* Lam. (0.26 g cm^{-3}) had the lowest WSG among the tree found on the park (Table 1). WSG is an important factor in calculating biomass. Higher the WSG, higher is the potential in accumulating biomass and Carbon stock (Chave *et al*., 2005). Among all the trees present in the park *Terminalia arjuna* Roxb. had the highest DBH (505.70±48.20 cm) and *Jasminum grandiflorum* L. (7.80±1.50 cm) had the lowest DBH (Table 1). Most of the trees have DBH ranging from 7.80 to 67 cm (Table 1) except *Celtis philippensis* Blanco, *Terminalia arjuna* Roxb. and *Tectona grandis* Linn. which are large growing trees and probably these trees were growing in the area since long time ago.

The total AGB and BGB of all the tree species in the park was 522.03 Mg ha^{-1} and 135.73 Mg ha^{-1} respectively (Table 1). *Terminalia arjuna* Roxb. contributed maximum AGB and BGB (426.53 Mg ha^{-1} and 135. 73 Mg ha^{-1} respectively) and *Cornus alternifolia* L.f. had the lowest AGB and BGB (0.01 Mg ha^{-1} and almost nil respectively) (Table 1). The finding of the study was comparable to AGB and BGB (522.03 Mg ha^{-1} and 135.73 Mg ha^{-1} respectively) of the Cotton University campus (Yumnam and Dey, 2022). The TB of all the tree species in the park was 657.76 Mg ha^{-1} (Table 1). *Terminalia arjuna* Roxb. contributed maximum TB (537.43 Mg ha^{-1}) followed by *Terminalia catappa* L. (19.92 Mg ha^{-1}) and *Ficus religiosa* L. (18.99 Mg ha^{-1}). *Cornus alternifolia* Lf. (0.01 Mg ha^{-1}) had the lowest TB followed by *Jasminum grandiflorum* L. (0.03 Mg ha^{-1}) and *Trema orientalis* L. (0.08 Mg ha^{-1}) (Table 1). The finding of the study was higher than that of the Amity University (72.6 Mg ha^{-1}) (Sharma *et al.* 2021) but comparable to that of Cotton University campus (692.27 Mg ha^{-1}) (Yumnam and Dey 2022). Total TCS of the all species in the park was 328.88 Mg ha^{-1} (Table 1). *Terminalia arjuna* Roxb. contributed maximum TCS (268.71 Mg ha^{-1}) followed by *Terminalia catappa* L. (9.96 Mg ha^{-1}) and *Ficus religiosa* L. (9.49 Mg ha^{-1}); and *Cornus alternifolia* Lf. and *Jasminum grandiflorum* L. (0.01 Mg ha^{-1}) had contributed lowest TCS followed by *Trema orientalis* L. (0.04 Mg ha^{-1}) (Table 1). The finding of the study was higher than that of the Tripura University campus, India (5.91 Mg ha^{-1}) (Deb *et al.,* 2016) but comparable to that of Cotton University campus (346.14 Mg ha^{-1}) (Yumnam and Dey, 2022). Good amount of biomass and TCS of trees in the park could be due to the presence of trees with high WSG values and high DBH.

The TCS had weak positive correlation with WSG (R^2 = 0.06) and weak negative correlation with density (R^2 = 7E-05) (Fig. 3) of the trees growing in the park. Nevertheless, TCS showed strong positive correlation with avg. diameter (R^2 = 0.907) and TBC (0.996) (Fig. 3) of the trees growing in the park.

A total of 83 individuals (44.39 ha^{-1}) belonging to 38 tree species under 34 genera and 20 families were recorded from the study area. The present study revealed that the total AGB, total BGB, TB, TCS and CO_2 eqv. were 522.03 Mg ha^{-1}, 135.73 Mg ha^{-1}, 657.76 Mg ha^{-1}, 328.88 Mg C ha^{-1} and 1206.99 Mg ha^{-1} respectively. The study showed that urban park helped in conservation of trees and these trees

Table 1. Scientific name, Nativity, Family, Wood specific gravity, few Community characteristics, Biomass and Carbon stocks of the different tree species

Name of the species	Nativity	Family	WSG g cm^{-3}	Avg. D cm (± Std error)	TBC m^2 ha^{-1}	No. of ind	Den stem ha^{-1}	AGB Mg ha^{-1}	BGB Mg ha^{-1}	TBMg ha^{-1}	TCSMg C ha^{-1}	CO_2 eqv. Mg ha^{-1}
Aegle marmelos L.	Native	Rutaceae	0.78	19.74±0.00	1.64	1	0.53	0.17	0.04	0.21	0.11	0.39
Agathis dammara (Lamb.) Poir.	Exotic	Araucariaceae	0.59	57.00±0.00	13.64	1	0.53	1.92	0.50	2.42	1.21	4.43
Albizia lebbek Benth.	Exotic	Fabaceae	0.59	26.39±8.00	2.92	2	1.07	0.56	0.14	0.70	0.35	1.29
Alstonia scholaris L.	Exotic	Apocynaceae	0.39	29.26±8.68	3.59	4	2.14	1.45	0.38	1.83	0.91	3.36
Aphanamixis polystachya Wall.	Native	Meliaceae	0.60	38.00±0.00	6.06	1	0.53	0.71	0.18	0.89	0.45	1.64
Artocarpus heterophyllus Lam.	Native	Moraceae	0.62	17.16±2.00	12.24	2	1.07	0.19	0.05	0.23	0.12	0.43
Azadirachta indica A.H.L. Juss.	Native	Meliaceae	0.72	21.97±0.00	2.03	1	0.53	0.21	0.05	0.26	0.13	0.48
Caesalpinia pulcherrima L.	Exotic	Fabaceae	0.62	35.87±8.87	5.40	3	1.60	1.94	0.51	2.45	1.22	4.49
Cassia tora L.	Native	Fabaceae	0.62	57.32±90.00	13.79	2	1.07	5.72	1.49	7.21	3.61	13.23
Celtis philippensis Blanco	Exotic	Cannabaceae	0.71	127.00±0.00	67.71	1	0.53	14.78	3.84	18.62	9.31	34.18
Cornus alternifolia L.f.	Exotic	Cornaceae	0.59	7.90±0.00	0.26	1	0.53	0.01	0.00	0.01	0.01	0.03
Dimocarpus longan Lour.	Exotic	Sapindaceae	0.82	23.56±3.00	2.33	2	1.07	0.56	0.15	0.71	0.35	1.30
Dipterocarpus intricatus Dyer.	Exotic	Dipterocarpaceae	0.71	35.66±23.89	52.66	5	2.67	4.82	1.25	6.08	3.04	11.15
Elaeocarpus angustifolius Blume.	Exotic	Elaeocarpaceae	0.46	26.53±7.26	2.96	3	1.60	0.67	0.17	0.84	0.42	1.54
Erythrina variegata L.	Exotic	Fabaceae	0.29	24.26±9.22	2.47	5	2.67	0.61	0.16	0.76	0.38	1.40
Ficus religiosa L.	Native	Moraceae	0.44	91.78±65.85	35.36	3	1.60	15.07	3.92	18.99	9.49	34.84
Ficus pallida Vahl.	Exotic	Moraceae	0.44	73.00±0.00	22.37	1	0.53	2.59	0.67	3.27	1.63	6.00
Firmiana simplex L.	Exotic	Malvaceae	0.43	28.98±19.85	3.53	3	1.60	0.91	0.24	1.14	0.57	2.10
Gmelina arborea Roxb.	Native	Lamiaceae	0.43	23.88±0.00	2.39	1	0.53	0.15	0.04	0.19	0.10	0.35
Jasminum grandiflorum L.	Native	Oleaceae	0.62	7.80±1.50	0.26	2	1.07	0.02	0.01	0.03	0.01	0.05
Lithocarpus edulis (Makino) Nakai	Exotic	Fagaceae	0.71	27.38±0.00	3.15	1	0.53	0.36	0.09	0.46	0.23	0.84
Mangifera indica L.	Native	Anacardiaceae	0.59	45.69±86.50	8.77	2	1.07	3.61	0.94	4.55	2.27	8.34
Mallotus philippensis Muell.	Native	Euphorbiaceae	0.55	19.74±0.00	1.64	1	0.53	0.12	0.03	0.15	0.08	0.28
Xylia xylocarpa (Roxb.) Taub.	Exotic	Fabaceae	0.82	37.00±0.00	5.75	1	0.53	0.91	0.24	1.14	0.57	2.09
Moringa oleifera Lam.	Native	Moringaceae	0.26	14.98±11.60	0.94	4	2.14	0.15	0.04	0.19	0.09	0.34
Pericopsis elata Van.	Exotic	Fabaceae	0.64	57.00±0.00	13.64	1	0.53	2.08	0.54	2.62	1.31	4.81
Piscidia piscipula L.	Exotic	Fabaceae	0.62	29.62 ± 0.00	3.68	1	0.53	0.39	0.10	0.49	0.24	0.89
Psidium guajava Linn.	Exotic	Myrtaceae	0.67	34.39±33.50	4.97	3	1.60	2.53	0.66	3.18	1.59	5.84
Styphnolobium japonicum (L.)	Exotic	Fabaceae	0.63	28.44±3.13	3.40	6	3.21	2.15	0.56	2.71	1.36	4.98
Swietenia humilis Zucc.	Exotic	Meliaceae	0.54	24.80±0.00	2.58	1	0.53	0.21	0.06	0.27	0.13	0.49
Swietenia mahagonia L.	Exotic	Meliaceae	0.66	27.05±5.29	3.07	4	2.14	1.33	0.35	1.68	0.84	3.08
Syzygium cumini L.	Native	Myrtaceae	0.62	35.21±1.50	5.20	2	1.07	1.21	0.31	1.52	0.76	2.79
Tectona grandis Linn.	Native	Lamiaceae	0.61	101.00±0.00	42.82	1	0.53	7.64	1.99	9.62	4.81	17.66
Terminalia catappa L.	Native	Combretaceae	0.54	67.18±39.08	18.95	5	2.67	15.81	4.11	19.92	9.96	36.55
Terminalia chebula L.	Native	Combretaceae	0.83	40.92±61.50	7.03	2	1.07	3.34	0.87	4.21	2.10	7.72
Terminalia arjuna Roxb.	Native	Combretaceae	0.80	505.70±48.20	1073.53	2	1.07	426.53	110.90	537.43	268.71	986.18
Tipuana tipu Benth.	Exotic	Fabaceae	0.58	35. 03±0.00	5.15	1	0.53	0.56	0.14	0.70	0.35	1.29
Trema orientalis L.	Native	Cannabaceae	0.36	18.15±0.00	1.38	1	0.53	0.06	0.02	0.08	0.04	0.14
Total						83	44.39	522.03	135.73	657.76	328.88	1206.99

(*WSG=Wood specific gravity; Avg. D=Average Diameter; TBC=Total basal cover; No. of ind.=Number of individual; Den=Density; AGB=Above ground biomass; BGB=Below ground biomass; TB=Total biomass; TCS=Total Carbon stock; CO_2 eqv. = CO_2 equivalent)

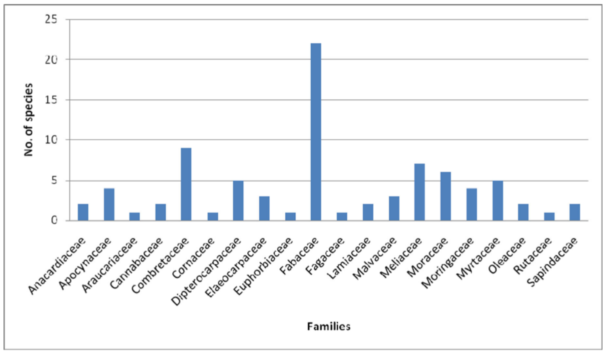

Fig. 2. Graph showing the no. of species belonging to different families

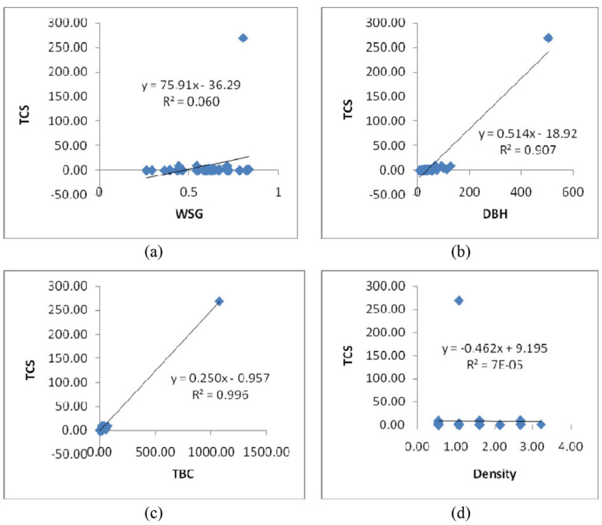

Fig. 3. Correlation of TCS with WSG (a), DBH (b), TBC (c) and Density (d).

helped in sequestration of CO_2 by storing Carbon as biomass which leads to mitigation of the global warming to some extent.

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Conflict of interest

Authors do not have any conflict of interest.

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