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Biomass and Carbon Stock Potential of Trees Growing in a Peri-Urban Park of Assam, India

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ABSTRACT

Altogether 35 species, belonging to 34 genera and 21 families, were recorded from a peri-urban park of Assam, India. Average diameter at breast height (DBH) of the trees in the park was 27.67±3.73 cm and total density of the trees in the park was 380 stem ha^{-1}. The wood specific gravity (WSG) of *Psidium guajava* (0.98 g cm^{-3}) was the highest and *Alstonia scholaris* (0.39g cm^{-3}) had the least among the trees in the park. Total above ground biomass (AGB) and total below ground biomass (BGB) of the trees in the park were 369.74 Mg ha^{-1} and 96.13 Mg ha^{-1} respectively. The total biomass (TB) and total Carbon stock (TCS) of the trees in the park were 465.87 Mg ha^{-1} and 232.93 Mg C ha^{-1} respectively. The CO_2 equivalent (CO_2 eqv) of the trees in the park was 852.54 Mg ha^{-1}. The park in addition to provide recreation and social gathering space to the people living in the area also functions as embankment to provide flood protection. It acts as home to wildlife particularly birds and small mammals too. Further, it provides ecosystem services such as reducing runoff of rainwater and soil erosion; aesthetic beauty, purified air, filtered noise. On top of all, the trees in the park also counter balance Carbon emissions through Carbon storage and sequestration. Therefore, setting up and management of park even in rural and peri-urban areas can deliver a considerable element to climate change mitigation strategies.

Keywords Above ground biomass, CO_2 equivalent, Carbon sequestration, Climate change, Ecosystem services.

INTRODUCTION

Deforestation and forest degradation are the basic land-use change in tropic and accounted for 12-20% of global anthropogenic greenhouse gases (GHG) emissions over the past two decades (Harris *et al*. 2012). Developmental activities including increased transportation activities furthermore augmented the concentration of air pollutants as GHGs, especially CO_2 (Chavan and Rasal 2010). These increase in CO_2 lead to increase in atmospheric temperature by the trapping certain wavelengths of heat radiation in the atmosphere, hence, it is of major concern, and was addressed in Kyoto Protocol (Ravindranath *et al*. 1997).

Plants through photosynthesis store Carbon as

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biomass, thus, forests and other green covers play a significant role in the global Carbon cycle through dynamic exchange of CO_2 with the atmosphere (Schlesinger 1997) and also storing over 80% of global terrestrial above ground Carbon (Dixon *et al*. 1994). Consequently, forests and other green covers are a critical component of the global Carbon cycle (Nowak and Crane 2002, Thangata and Hildebrand 2012). Thus, the management of forests and other green covers can deliver a considerable element to climate change mitigation strategies. REDD (Reducing Emissions from Deforestation and Forest Degradation) has been implemented to give importance to Carbon sequestration in forests and other green covers for climate change mitigation (Miles and Kopos 2008). Other than the stern political argument in establishing a global mechanism to fund climate change mitigation activities, its implementation vitally depends on reliable ground-based monitoring, reporting, and verification (MRV) protocols of Carbon storage (Tulyasuwan *et al*. 2012). Estimation of Carbon stock and stock changes in tree biomass (above and below ground) are crucial to understand climate change under United Nations Framework Convention on Climate Change (Green *et al*. 2007). Nevertheless, trees outside forests (TOF) which includes trees in streets, gardens, parks, educational institutions also play a critical role in sequestering atmospheric CO_2 (Strohbach and Haase 2012, Ngo and Lum 2018), reducing urban heat island effects (Zhang *et al*. 2007, Ngo and Lum 2018), reducing runoff of rainwater (Berland *et al*. 2017), besides giving aesthetic beauty, act as air purifier, noise filter (Zhang *et al*. 2007).

Importance of forests in Carbon sequestration is apparent and well represented in study. More ever, study on potential of trees in Carbon sequestration from urban forests (Liu and Li 2012, McPherson *et al*. 2013, Park *et al*. 2018, Amoatey and Sulaiman 2019), urban roads (Singh *et al.* 2022), educational institutions (Pragasan and Karthick 2013, Deb *et al.* 2016, Yumnam and Dey 2022) were attempted but such study from peri-urban (Majumdar and Selvan 2018) was limited. Peri-urban is defined as the area which is neither entirely urban nor purely rural in the traditional sense (Iaquinta and Drescher 2000) with rapid globalization and improvement in transportation system, there is a complete dynamic in growth in the form of overall development. Rural areas are under constant threat from urbanization. In the process, many areas are neither rural nor urban but peri-urban, which will very soon convert to urban areas. The present study was carried out considering the gap in the studies of the biomass and Carbon stock potential of trees growing in a peri-urban park of Assam, India.

MATERIALS AND METHODS

The present study was carried out during 2021 and 2022 in Netai Dhubuni Park (latitude 26˚1´17´´ N and longitude of 89˚59´41´´ E), a peri-urban park of Assam (Fig. 1) which is situated in Dhubri district by the bank of river Brahmaputra. The park was established in 1998. In the park, tree species *Monoon longifoliumis* were planted in vertical row throughout while many other tree species were scattered randomly. Many of these trees were grown in the area from before the establishment of the park. The district is 34 m asl and has humid subtropical climate (Peel *et al*. 2007).

In the park, depending on species-area curve, a total of 25 quadrats of 10m X 10m were laid down randomly for collection of data. All trees in all the quadrats were identified by referring to several authentic websites (https://www.cabi.org, https://indiabiodiversity.org and http://www.plantsoftheworldonline.org) and their circumferences at the breast height (CBH) were measured using a measuring tape. Trees having diameter less than 5cm were excluded because such trees hold a small portion of above ground biomass (AGB) in their habitat (Chidumayo 2002). The tree density (stem ha^{-1}) was calculated by using Misra's method (1968) (Misra 1968). Allometric equation given by Chave *et al*. (2005) for moist forest stands was used to measure the AGB of tree species. The world agroforestry database (https://www.worldagroforestry.org) was referred for the values of WSG of tree species. In case, if the data of WSG of a tree species was unavailable, the standard average value i.e. 0.62g cm^{-3} was taken into account (IPCC 2003). Below ground biomass (BGB) was estimated as AGB×0.26 (Zanne *et al*. 2010) where 0.26 is root shoot ratio. Sum of AGB and BGB gave total biomass (TB). Total carbon storage (TCS) is half of the total biomass, TB×50% or TB×0.5 (IPCC

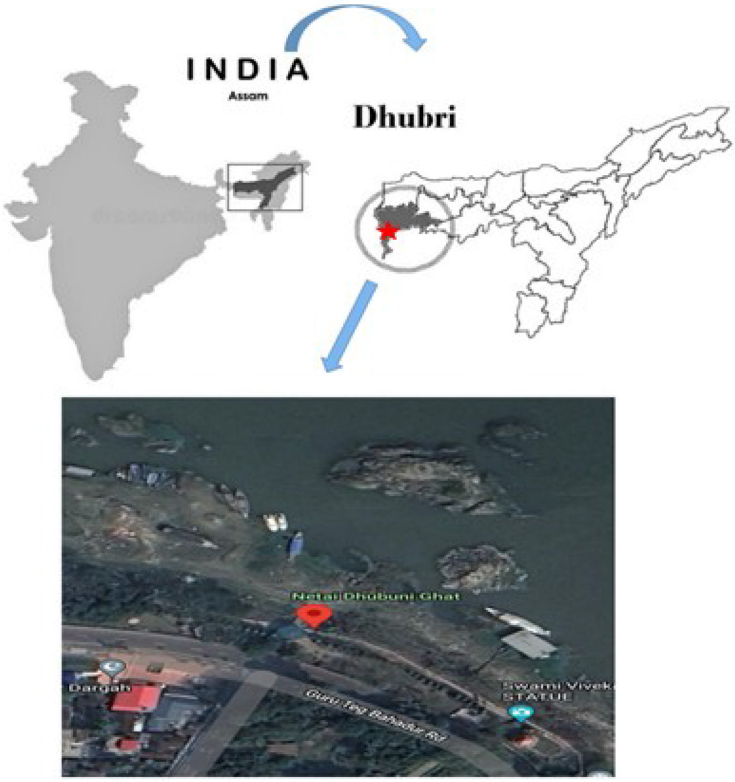

Fig. 1. Map showing study site (Netai Dhubuni Park, Dhubri, Assam).

2003). CO_2 equivalent (CO_2 eqv) was measured by multiplying TCS with 3.67 [CO_2 (molecular weight = 44g) contains 12g of Carbon and 32g of Oxygen. Thus, CO_2 eqv is given by 44/12 i.e., 3.67].

RESULTS AND DISCUSSION

A total of 35 species under 34 genera and 21 families (Fig. 2) were recorded from the park which was slightly less than that of Cotton University campus, Assam, India (47 species under 45 genera and 24 families) (Yumnam and Dey 2022) and urban trees of Agartala, India (111 species under 92 genera and 45 families) (Majumdar and Selvan 2018) but almost similar with that of urban spaces/parks of Varanasi, India (25 families) (Singh *et al*. 2022). Fabaceae (7 species) was the most frequent family more followed by Apocynaceae (3 species) while maximum families were represented by 1 species only (Fig. 2). Fabaceae was also the dominant family in Cotton University campus, Assam, India (Yumnam and Dey 2022). It was observed that *Monoon longifolium* (80 stem ha^{-1}) had the highest density followed by *Cocos nucifera* (40 stem ha^{-1}) and *Dypsis lutescens* (40 stem ha^{-1}) and *Plumeria alba* (4 stem ha^{-1}) had the lowest density (Table 1) in the park. Highest density of the trees was found *Monoon longifolium*, this could be due to fact that they were planted in row for the beautification of the park during the establishment of the park. The total tree density in the study site was recorded to be 380 stem ha^{-1} (Table 1) which was much greater than that of Tripura University campus, India (41 stem ha^{-1}) (Deb *et al*. 2016) but almost similar with that of Cotton University campus, Assam, India (370 stem ha^{-1}) (Yumnam and Dey 2022), Bharathiar University campus, Coimbatore, India (320 – 468 stem ha^{-1}) (Amoatey and Sulaiman 2019).

The WSG of *Psidium guajava* (0.98 g cm^{-3}) was highest among the trees in the study site, which

Table 1. Biomass and carbon stock of tree species in Netai Dhubuni Park, Dhubri, Assam.

Sl. No.	Name of the species	Family	Wood density ($g\ cm^{-3}$)	DBH* (cm)	Density (Stem ha^{-1})	AGB	BGB ($Mg\ ha^{-1}$)	TB ($Mg\ ha^{-1}$)	TCS ($C\ Mg\ ha^{-1}$)	CO_2 eqv. ($Mg\ ha^{-1}$)
1	*Aegle marmelos* (Linn.) Correa.	Rutaceae	0.78	37±0	4	6.45	1.68	8.12	4.06	14.86
2	*Alstonia scholaris* (L.) R. Br	Apocynaceae	0.39	30±10.5	8	3.77	0.98	4.74	2.37	8.68
3	*Annona reticulata* L.	Annonaceae	0.55	12±0	4	0.24	0.06	0.3	0.15	0.55
4	*Araucaria araucana* (Molina) K. Koch	Araucariaceae	0.5	15±0.82	12	1.18	0.31	1.48	0.74	2.71
5	*Artocarpus heterophyllus* Lam.	Moraceae	0.53	26±0	4	1.77	0.46	2.22	1.11	4.07
6	*Averrhoa carambola* L.	Oxalidaceae	0.59	18±0	4	0.75	0.19	0.94	0.47	1.73
7	*Azadirachta indica* A.Juss.	Meliaceae	0.72	12±2.5	8	0.62	0.16	0.79	0.39	1.44
8	*Butea monosperma* (Lam.) Taub	Fabaceae	0.44	25±5.31	12	3.97	1.03	5.00	2.50	9.16
9	*Caeselpinia pulcherrima* (L.) Sw.	Fabaceae	0.84	32±3	8	9.58	2.49	12.07	6.03	22.08
10	*Cassia fistula* L.	Fabaceae	0.82	30±5.66	20	19.79	5.15	24.94	12.47	45.64
11	*Cinnamomum tamala* (Buch.-Ham.) T.Nees and C.H.Eberm.	Lauraceae	0.57	10±0	4	0.15	0.04	0.19	0.10	0.35
12	*Cocos nucifera* L.	Arecaceae	0.61	33±3.25	40	37.63	9.78	47.42	23.71	86.77
13	*Dalbergia sissoo* Roxb.	Fabaceae	0.69	57±0	4	16.77	4.36	21.13	10.56	38.67
14	*Delonix regia* (Boj. ex Hook.) Raf.	Fabaceae	0.59	40±18.34	20	29.71	7.72	37.43	18.71	68.49
15	*Dypsis lutescens* (H.Wendl.) Beentje and J.Dransf.	Arecaceae	0.62	11±0.22	40	2.13	0.55	2.69	1.34	4.92
16	*Ficus religiosa* L.	Moraceae	0.44	124±235	8	130.08	33.82	163.90	81.95	299.94
17	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	0.63	11±7	8	0.43	0.11	0.55	0.27	1
18	*Mangifera indica* L.	Anacardiaceae	0.59	27±0	4	2.17	0.56	2.73	1.37	5
19	*Melaleuca viminalis* (Sol. ex Gaertn.) Byrnes	Myrtaceae	0.68	28±13.06	12	8.24	2.14	10.38	5.19	19
20	*Mimusops elengi* L.	Sapotaceae	0.88	35±16	8	12.62	3.28	15.90	7.95	29.1
21	*Monoon longifolium* Sonn. B.Xue and R.M. K.Saunders	Annonaceae	0.56	17±1.24	80	12.23	3.18	15.41	7.70	28.2
22	*Musa acuminata* Colla	Musaceae	0.62	23±2.5	8	3.00	0.78	3.78	1.89	6.92
23	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	0.55	16±0	4	0.51	0.13	0.64	0.32	1.18
24	*Nyctanthes arbor-tristis* L.	Oleaceae	0.88	10±0	4	0.24	0.06	0.3	0.15	0.54
25	*Peltophorum pterocarpum* (DC.) K.Heyne	Fabaceae	0.6	34±0	4	4	1.04	5.03	2.52	9.21
26	*Phyllanthus emblica* L.	Phyllanthaceae	0.72	11±0	4	0.25	0.06	0.31	0.16	0.57
27	*Pinus kesiya* Royle ex Gordon	Pinaceae	0.45	31±0	4	2.36	0.61	2.98	1.49	5.45
28	*Plumeria alba* L.	Apocynaceae	0.8	13±0	4	0.43	0.11	0.54	0.27	0.99
29	*Psidium guajava* L.	Myrtaceae	0.98	12±0	4	0.42	0.11	0.54	0.27	0.98
30	*Punica granatum* L.	Lythraceae	0.77	10±0	4	0.21	0.05	0.26	0.13	0.47
31	*Sesbania grandiflora* (L.) Poiret	Fabaceae	0.44	12±2.04	12	0.57	0.15	0.72	0.36	1.32
32	*Tecoma stans* (L.) Juss. ex Kunth	Bignoniaceae	0.46	13±0	4	0.25	0.06	0.31	0.16	0.57
33	*Terminalia arjuna* (Roxb.) Wight and Arn.	Combretaceae	0.8	72±0	4	34.15	8.88	43.03	21.51	78.74

Table 1. Continued.

Sl. No.	Name of the species	Family	Wood density (g cm^{-3})	DBH* (cm)	Density (Stem ha^{-1})	AGB (Mg ha^{-1})	BGB (Mg ha^{-1})	TB (Mg ha^{-1})	TCS (C Mg ha^{-1})	CO_2 eqv. (Mg ha^{-1})
34	*Terminalia chebula* Retz.	Combretaceae	0.65	64±0	4	20.93	5.44	26.37	13.18	48.25
35	*Thevetia ovata* L.	Apocynaceae	0.72	25±0	4	2.17	0.56	2.73	1.36	4.99
	Total:				**380**	**369.74**	**96.13**	**465.87**	**232.93**	**852.54**

*DBH= Diameter at breast height, AGB=Above ground biomass, BGB= Below ground biomass, TB= Total biomass, TCS= Total carbon stock, CO_2 eqv= CO_2 equivalent.

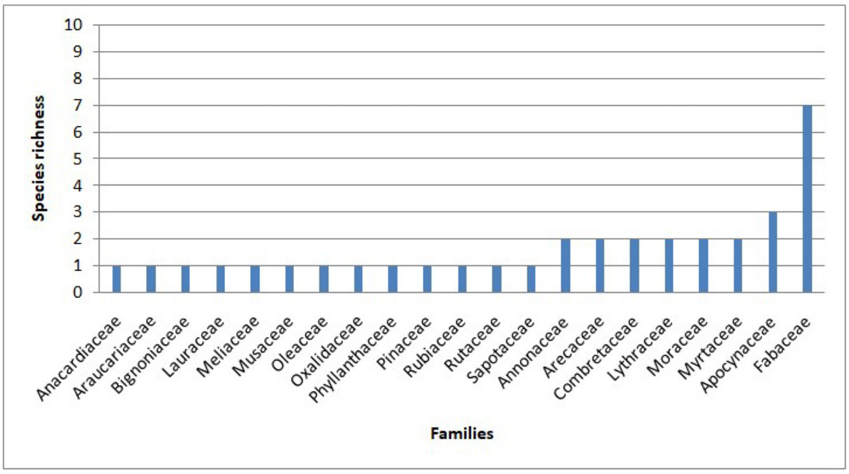

Fig. 2. Graph showing species richness against different families.

was followed by *Mimusops elengi* (0.88 g cm^{-3}), *Nyctenthes arbor-tristis* (0.88 g cm^{-3}) and *Alstonia scholaris* (0.39 g cm^{-3}) had the least WSG (Table 1). WSG is a key factor in estimation of biomass of trees. Higher the values of WSG, higher is the probability in accumulating biomass and Carbon stock (Yumnam and Dey 2022, Baker *et al*. 2004). *Ficus religiosa* (124±2.35 cm) had the highest avg. DBH followed by *Terminalia arjuna* (72±0 cm) and *Terminalia chebula* (64±0 cm) and *Punica granatum* (10±0 cm) had the least avg DBH (Table 1). Average DBH of the tree of the park was 27.67 cm (range between 10±0 cm and 124±2.35 cm) (Table 1) which was more or less same with the finding of urban forest of Shenyang, China (30 cm) (Liu and Li 2012) but less than Cotton University campus, Assam, India (35.75 cm) (Yumnam and Dey 2022), Tripura University campus, India (40.69 cm) (Deb *et al*. 2016) and urban forest of Los Angeles, USA (57 cm) (McPherson *et al.* 2013). Average DBH of the trees in the park was low because except for few species such as *Ficus religiosa*, *Terminalia arjuna* or *T. chebula* which were grown in the area before the establishment of the park however, many of the trees (*Monoon longifolium*, *Azadirachta indica*) were planted during the establishment of the park or later.

Ficus religiosa (130.80 Mg ha^{-1}) shared highest AGB among all the other trees in the site, followed by *Cocos nucifera* (37.63 Mg ha^{-1}) and *Cinnamomum tamala* (0.15 Mg ha^{-1}) had the lowest AGB (Table 1). In the case of BGB, it was observed that *Ficus religiosa* (33.82 Mg ha^{-1}) had highest value, followed by *Terminalia chebula* (5.44 Mg ha^{-1}) and *Cassia fistula* (5.15 Mg ha^{-1}). *Cinnamomum tamala* (0.04 Mg ha^{-1}) had the lowest BGB (Table 1). Total AGB and total

BGB of the tree species in the park were 369.74 Mg ha^{-1} and 96.13 Mg ha^{-1} respectively (Table 1), which were more than that of Tripura University campus, India (9.58 Mg ha^{-1} and 2.23 Mg ha^{-1} respectively) (Deb *et al.* 2016), Bharathiar University campus, Coimbatore, India (34.47 Mg ha^{-1} and 5.67 Mg ha^{-1} respectively) (Pragasan and Karthick 2013) but less than that of Cotton University campus, Assam, India (544.42 Mg ha^{-1} and 142.85 Mg ha^{-1} respectively) (Yumnam and Dey 2022). *Ficus religiosa* (163.90 Mg ha^{-1}) had the highest TB and *Cinnamomum tamala* (0.19 Mg ha^{-1}) had the lowest TB (Table 1) in the park. The TB of all the tree species in the park was 465.87 Mg ha^{-1} (Table 1) which was more than that of Bharathiar University campus, Coimbatore, India (48.05 Mg ha^{-1}) (Pragasan and Karthick 2013) and Tripura University campus, India (5.91 Mg ha^{-1}) (Deb *et al*. 2016) but less that of Cotton University campus, Assam, India (692.27 Mg ha^{-1}) (Yumnam and Dey 2022) and urban spaces/parks of Varanasi, India (4045 Mg ha^{-1}) (Singh *et al*. 2022).

Ficus religiosa (81.95 Mg C ha^{-1}) had the highest TCS. It was followed by *Monoon longifolium* (7.70 Mg C ha^{-1}) and *Caeselpinia pulcherrima* (6.03 Mg C ha^{-1}) and *Cinnamomum tamala* (0.10 Mg C ha^{-1}) had the lowest TCS (Table 1) in the park. Total TCS of trees in the park was 232.93 Mg C ha^{-1} (Table 1) which was much higher than that of trees growing in Bharathiar University (27.72 Mg C ha^{-1}) (Pragasan and Karthick 2013), urban area of Agartala, India (45.42 Mg C ha^{-1}) (Majumdar and Selvan 2018) and Leipzig, Germany (59 Mg C ha^{-1}) (Strohbach and Haase 2012), but less than that trees growing in the campus of Cotton University campus, Assam (346.14 Mg C ha^{-1}) (Yumnam and Dey 2022) and urban spaces/parks of Varanasi, India (1901 Mg C ha^{-1}) (Singh *et al*. 2022). Moraceae contributed maximum TCS (83.06 Mg C ha^{-1}) followed by Fabaceae (53.16 Mg C ha^{-1}) (Fig. 3) among the families reported from the park. Such finding was also reported from Cotton University campus, Assam (Yumnam and Dey 2022) where Moraceae and Fabaceae were also the major contributors of TCS among the trees in campus. The CO_2 eqv was highest in *Ficus religiosa* (299.94 Mg ha^{-1}) followed by *Cocos nucifera* (86.77 Mg ha^{-1}), *Terminalia arjuna* (78.74 Mg ha^{-1}), *Delonix regia* (68.49 Mg ha^{-1}) and *Cinnamomum tamala* (0.35 Mg ha^{-1}) had the lowest CO_2 equivalent (Table 1). The CO_2 eqv of the park was 852.54 Mg ha^{-1} (Table 1) which

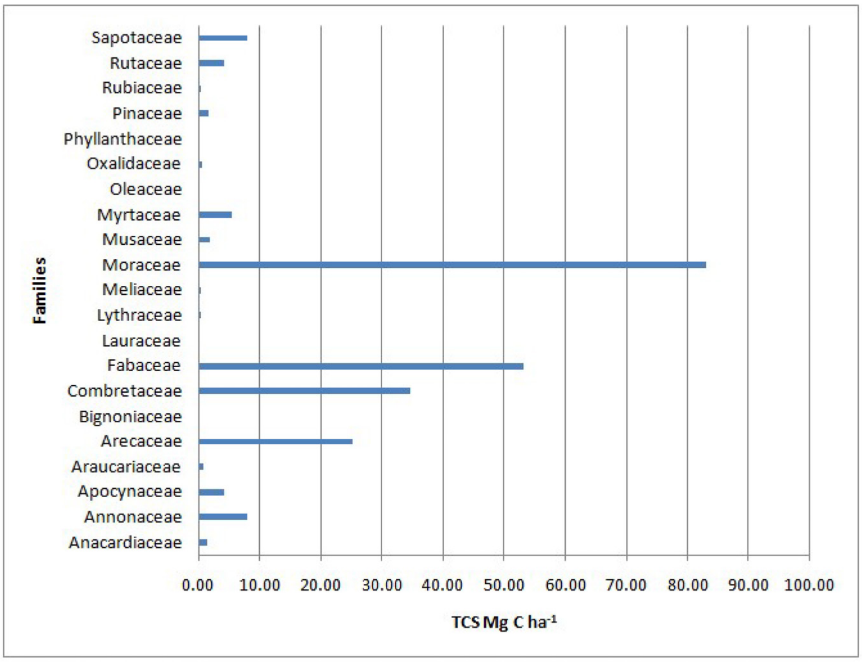

Fig. 3. Graph showing contribution of TCS Mg C ha^{-1} by different families.

was more than that of urban trees of Agartala, India (166.66 Mg ha^{-1}) (Majumdar and Selvan 2018) but less than that of urban spaces/parks of Varanasi, India (6977 Mg ha^{-1}) (Singh *et al*. 2022) and Muscat, Oman (11100 Mg ha^{-1}) (Amoatey and Sulaiman 2019).

The park in addition to provide recreation and social gathering space to the people living in the area also functions as embankment to provide flood protection. It acts as home to wildlife particularly birds and small mammals too. Further, it provides ecosystem services such as reducing runoff of rainwater and soil erosion; aesthetic beauty, purified air, filtered noise. On top of all, the trees in the park also counter balance Carbon emissions through Carbon storage and sequestration. Therefore, setting up and management of park even in rural and peri-urban areas can deliver a considerable element to climate change mitigation strategies.

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