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Research Article

URBAN GREEN PATCHES AS CARBON SINK: GUJARAT UNIVERSITY CAMPUS, AHMEDABAD

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ABSTRACT
Vegetation is next only to soil in carbon sequestration capability. Owing to an increase in the concentration of greenhouse gases (GHGs) especially carbon dioxide (CO_2) due to human interventions it has become important that the tree carbon sinks are identified for maximum carbon sequestration. This would help plantations to identify specific tree to bring down the level of CO_2, the main GHG. Gujarat University Campus (GUC) has a rich diversity of both flora and fauna. GUC has 60 tree species total 3379 in number. The total carbon stock of the trees was quantified through GBH and height of each tree was measured with measuring tape and altimeter respectively. Simultaneously, the soil was also analyzed for the organic carbon content. Thus, the total carbon stock in the trees and soil of GUC was calculated.

Key Words: *Carbon Stock, Tree Species, Gujarat University Campus*

INTRODUCTION
Anthropogenic activities, especially fossil fuel burning and deforestation (Pandey, 2002) have resulted in an increase in the concentration of GHGs particularly CO_2 which is accumulating at an alarming rate of 3.5 billion metric tons per annum (Jina *et al.,* 2008) resulting in global warming (Phani Kumar *et al.,* 2009) and climate change (CC). Since the beginning of the industrial revolution, carbon dioxide concentration in the atmosphere has been rising rapidly. Prior to the industrial revolution carbon concentration was around 270 ppm which increased to 372 ppm in 2005 (Kumar *et al.,* 2006; Ramachandran *et al.,* 2007**)**. Impact of CC on the ecology, economy and society is increasing (Pandey, 2002). There is need to mitigate CO_2 levels in the atmosphere controlling global warming.
Carbon sequestration involves the capture and storage of the carbon from the atmosphere which would otherwise go on accumulating in the atmosphere. Carbon dioxide is captured and stored naturally by the plants through the process of photosynthesis where in CO_2 is sequestered in the form of sugars which contribute to organic matter in the soil (Phani Kumar *et al.,* 2009). Hence, estimation of this C content both in vegetation and in soil becomes imperative to access the Carbon sequestration potential. The trees, as they grow sequester the CO_2 in their body (trunk, branches and roots) and this results in an increase in their biomass, indicative of an increase in carbon sequestered by them (Ramachandran *et al.,* 2007). Soil-vegetation systems play an important role in the global carbon cycle. Soil contains about three times more organic carbon than vegetation and about twice as much carbon than is present in the atmosphere (Dinakaran *et al.,* 2008; Kumar *et al.,* 2006 and Batjes and Sombroek, 1997)). Terrestrial vegetation and soil currently absorb 40% of global CO_2 emission from human activities (Sheikh, 2010).
Global warming risks from emissions of greenhouse gases (GHGs) by anthropogenic activities have increased the need for the identification of ecosystems with high carbon sink capacity as an alternative mitigation strategy of terrestrial carbon sequestration (Phani Kumar *et al.,* 2009). The present study deals with the estimation of the total carbon stock of the trees in Gujarat University campus by non-destructive method. Simultaneously, the soil was also analyzed for the organic carbon and other. Thus, the total carbon stock in the trees and soil of Gujarat University campus was calculated.

MATERIALS AND METHODS

Study Area

Gujarat University, situated in Ahmedabad has a campus which spreads over an area of 1.1km^2. It is situated between 23°02'11.44"N latitude and 72°32'46.63"E longitude at an elevation of 180 feet. It has dry semi-arid type of the climate according to the Koppen system of classification. The average summer minimum to maximum temperature varies from 23 to 45°C. The south-western monsoon results in a humid climate from mid-June to mid-September and the average annual rainfall is about 76.0 cms (Figure 1 and 2).

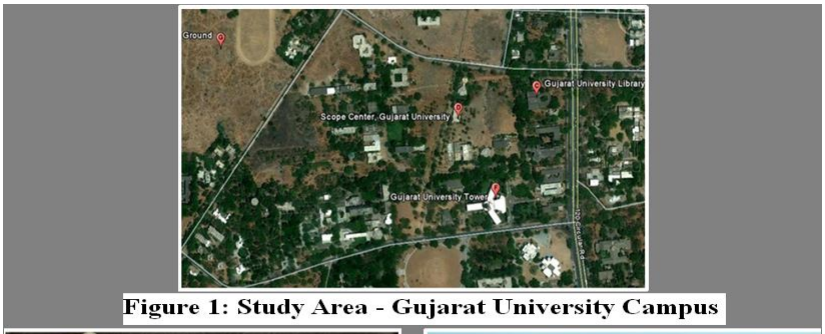

Figure 1: Study Area - Gujarat University Campus

Figure 2: Method of tree biomass computation. A & B: Haga's Altimeter to measure tree height. C: Measurement of GBH. D: Measurement of tree canopy.

Table 1: Carbon stock of tree species of Gujarat University Campus

Methodology

For the carbon stock estimation of each tree, the tree was measured for its height using Haga's altimeter, bole, GBH (girth at breast height) and canopy diameter with a measuring tape. The total carbon stock of the trees was therefore measured by non-destructive method using equations involving the total volume, total biomass, percentage of carbon sequestered and wood density (Phani Kumar *et al.*, 2009).

The GBH of the trees was measured. The total biomass was determined in terms of above ground biomass (AGB), below ground biomass (BGB) and tree canopy biomass values specific to each tree species. The AGB was measured based on the method of Phani Kumar *et al.,* (2009). The BGB is calculated by the method proposed by MacDicken, (1997). The biomass of leaf and branch cover of each tree was calculated with the help of crown volume (Phani Kumar *et al.*, 2009). The total volume was then multiplied by the specific density of the tree to get the total biomass. The specific density of the trees was

noted from The Indian Woods (Chowdhury and Ghosh, 1958). The carbon percentage of the trees was calculated (Pettersen, 1984; Chan, 1982).

A total of 33 soil samples were collected from different sites by random sampling method. Three soil samples were taken sequentially up to a depth of 20cm (surface sample, sample at a depth of 10cm and at 20 cm). It was dried and sieved through 2mm sieve. The undisturbed soil clumps were used to determine the bulk density. The soil was further ground with pestle and mortar and sieved through the 0.5mm sieve. The soil organic carbon was determined (Walkey and Black, 1934) for each soil sample. The soil was also analyzed for the pH, nitrogen, phosphorous and potassium. The total soil carbon stock was also determined (MacDicken, 1997).

RESULTS AND DISCUSSION

The Gujarat University campus has a rich floral diversity. The main tree species comprise of *Azadirachta indica* (neem), *Peltophorum ferrugineum* (copper pod tree), *Alianthus excelsa* (arduso), *Ficus religiosa*, *Cassia fistula* (amaltas), *Polialthia longifolia* (asopalav), *Limonia acidissima* (wood apple) and *Pongamia pinnata* (karanj).

The tree community in the Gujarat University campus comprised of 3379 individuals belonging to 60 species (Fig-2) and 28 families (Table-1). *Azadirachta indica* A Juss trees were the most dominant (910) followed by *Peltophorum pterocarpum* (DC) Baker (752), *Polyalthia longifolia* (Sonner) Thwaites (504), *Pongamia pinnata* (L) Pierre (132), *Ailanthus excelsa* Roxb (89) and *Eucalyptus globulus* Labill (97). Based on the average carbon stock of various tree species, maximum carbon sequestration in trees was found with *Terminalia chebula* Retz (76.93 t) followed by *Pithecellobium dulce* (Roxb) Bth (65.88 t) *Limonia acidissima* L (61.31 t) , *Ficus benghalensis* L (54.03 t), *Tamarindus indica* L (52.84 t), *Morus alba* L (47.92 t), *Ailanthus excelsa* Roxb (43.89 t), *Syzygium cumini* (L) Skeel (43.64 t), *Azadirachta indica* A Juss (43.11 t), F. *religiosa* L (42.79 t), *Albizzia lebbeck* (L) Bth (40.57 t) *Terminalia arjuna* (Roxb) W & A (38.21 t), *Eucalyptus globulus* Labill (35.9 t), *Mangifera indica* L (35.75 t) and *Casuarina equisetifolia* L (34.59 t) such trees with good carbon sequestration capability could be the ideal selections for CO_2 sequestration in the present scenario to mitigate climate change. While the trees like *Acacia nilotica* (L) Del (2.48 t) and the members of family Palmae like *Phoenix sylvestris* (L) Roxb (2.18 t), *Roystonea regia* (H B & K) O F Cook (1.24 t), *Musa paradisiaca* L (0.87 t), *Dicrostachys cinerea* (DC) (0.63 t) are found to have least carbon stock.

The soil pH is normal (7.8). The electrical conductivity of the soil is normal with a value of 0.72 (Table-2). The soil organic carbon was high (1.06%) indicating a good soil quality. The phosphorous content is very low. However, potassium content is high with nitrogen content being normal. The bulk density of 1.18 g/cm^3 is also very high.

The total carbon stock in the soil in GUC was calculated to be 2501.60 t/ha and the total carbon stock in the trees of GUC was found to be 661.30 t/ha. Hence, the total carbon stock of soil and trees of GUC is 3162.9 t/ha. This is in accordance with earlier studies which have demonstrated that soil contains about three times more organic carbon than vegetation and about twice as much carbon that is present in the atmosphere (Dinakaran *et al.*, 2008; Kumar *et al.*, 2006; Batjes and Sombroek, 1997).

Conclusion

The trees to be selected for maximum carbon sequestration in the present scenario with high levels of carbon dioxide in the atmosphere should have high wood specific density. The trees should be fast growing with increasing biomass at a fast rate and should have a huge canopy (Jana *et al.*, 2009). One of the eight national missions included in the India's National Action Plan on Climate Change comprises on the national mission for a "Green India" to increase forest cover and conserve biodiversity. The CDM, as under the Kyoto Protocol is encouraging the plantation of trees with a high carbon sequestration capability so as to bring down the concentration of CO_2 in the atmosphere. In fact the soil-vegetation systems play an important role in the global carbon cycle by sequestering emitted carbon in the atmosphere thereby mitigating global warming.

Table 1: Carbon stock of tree species of Gujarat University Campus

S. No.	Family	Scientific name of tree	No. of Trees	Avg. Carbon stock (t)
1	Annonaceae	*Polyalthia longifolia* (Sonner) Thwaites	504	9.66
2	Malvaceae	*Thespesia populnea* (L) Sol ex Correa	6	16.13
3	Bombacaceae	*Bombax ceiba* L	2	11.64
4	Sterculiaceae	*Guazuma ulmifolia* Lam	19	9.42
5	Rutaceae	*Aegle marmelos* (L) Correa	1	15.17
6		*Limonia acidissima* L	15	61.31
7	Simarubiaceae	*Ailanthus excelsa* Roxb	89	43.89
8	Meliaceae	*Azadirachta indica* A Juss	910	43.11
9	Rhamnaceae	*Zizyphus mauritiana* Lam	4	27.55
10	Anacardiaceae	*Mangifera indica* L	3	35.75
11	Moringaceae	*Moringa oleifera* Lam	44	5.92
12	Fabaceae	*Derris indica* (Lam) Bennet	132	16.851
13		*Gliricida sepium* (Jacq) Walp	15	9.38
14	Caesalpinaceae	*Bauhinia purpurea* L	2	11.64
15		*Cassia fistula* L	24	28.27
16		*Cassia javanica* L var *javanica*	2	21.75
17		*Cassia siamea* Lam	29	41.66
18		*Delonix elata* (L) Gamble	6	39.74
19		*Delonix regia* (Boj)	34	23.2
20		*Peltophorum pterocarpum* (DC) Baker	752	28.27
21		*Tamarindus indica* L	26	52.84
22	Mimosaceae	*Acacia auriculiformis* A Cunn ex Benth	8	21.94
23		*Acacia nilotica* (L) Del	41	2.48
24		*Albizia lebbeck* (L) Bth	102	40.58
25		*Albizia odoratissima* (L f) Bth	28	15.69
26		*Albizia procera* (Roxb) Bth	64	9.58
27		*Dichrostachys cinerea* (DC)	7	0.63
28		*Pithecellobium dulce* (Roxb) Bth	10	65.88
29		*Prosopis cineraria* (L) Druce	17	10.58
30	Combretaceae	*Terminalia arjuna* (Roxb) W & A	9	38.21
31		*Terminalia catappa* L	7	24.08
32		*Terminalia chebula* Retz	5	76.928
33	Myrtaceae	*Callistemon citrinus* (Curtis) Skeel	3	26.37
34		*Eucalyptus globulus* Labill	97	35.91
35		*Psidium guazava* L	5	4.23
36		*Syzygium cumini* (L) Skeel	10	43.64
37	Sapotaceae	*Manilkara hexandra* (Roxb) Dub	3	13.52
38		*Manilkara zapota* (L) van Royen	1	19.14
39		*Mimusops elengi* L	14	32.61
40	Salvadoraceae	*Salvadora persica* L	9	2.93
41	Apocynaceae	*Plumeria alba* L	7	4.55
42	Ehretiaceae	*Cordia dichotoma* Forst f	67	23.38
43		*Cordia gharaf* (Forsk) Ehrenb & Asch	5	9.53
44	Bignoniaceae	*Kigelia pinnata* (Jacq) DC	33	31.17
45	Euphorbiaceae	*Emblica officinalis* Gaertn	8	43.57
46	Ulmaceae	*Holoptelea integrifolia* (Roxb) Planch	48	15.45
47	Moraceae	*Ficus benghalensis* L	3	54.03
48		*Ficus hispida* Lf	8	12.07
49		*Ficus drupacea* Thunb	8	9.74
50		*Ficus religiosa* L	22	42.79
51		*Morus alba* L	2	47.92
52		*Streblus asper* Lour	1	33.05
53	Casuarinaceae	*Casuarina equsetifolia* L	9	34.59
54	Arecaceae	*Borassus flabellifer* L	4	17.36
55		*Cocos nucifera* L	2	28.68
56		*Phoenix sylvestris* (L) Roxb	1	2.18
57		*Roystonea regia* (H B & K) O F Cook	25	1.24
58	Zygophyllaceae	*Balanites roxburghii* (L) Del	11	2.43
59	Nyctagenaceae	*Bougainvillea spectabilis* Willd	1	8.46
60	Musaceae	*Musa paradisiaca* L	55	0.87

Table 2: Physicochemical properties of the soil of Gujarat University

Paramaters	Mean + SE
Bulk density (g/cm^3)	1.18 + 0.78
pH	0.78 + 0.78
Organic carbon (%)	1.06 + 0.61
Nitrogen (%)	15.23 + 0.87
Phosphorous (kg/ha)	17.37 + 0.17
Potassium (kg/ha)	604.8 + 0.29
Electrical Conductivity	0.72 + 0.86

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