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Evaluation of carbon sequestration efficiencies of selected tree species in Swaraj round, Thrissur, Kerala, India

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Abstract

Global warming and climate change due to escalating concentrations of carbon dioxide is a major issue of global concern today. Scientists have observed that CO_2 concentrations in the atmosphere have been increasing significantly over the past century, compared to the pre-industrial era (280 ppm). The recent average CO_2 concentration recorded at Mauna Loa observatory was 418.90 ppm (July 2022). Anthropogenic activities like burning of fossil fuels, land use change and deforestation along with fuel combustion activities, industrial processes and natural gas processing were reported to be the major carbon dioxide emissions sources. The increased atmospheric carbon dioxide levels have led to several adverse consequences and reduction of these carbon dioxide concentrations in the atmosphere can be achieved via carbon sequestration strategies. Among the various physical, chemical and biological carbon sequestration strategies, the biosequestration employing the trees has gained much attention as it offers an ecofriendly approach. Though the significance of forested areas in carbon sequestration has been well studied and documented, few attempts have been made to monitor the potentials of urban forests/ green spaces. In the present study an attempt has been carried out to assess the carbon sequestration potentials of selected trees of Swaraj Round, Thrissur, Kerala. For the present study trees belonging to the outer belt of Swaraj round were identified up to species level along with common name and the carbon sequestration efficiencies were worked out. Upon comparing the carbon assimilation potentialities of trees, the tree species belonging to Fabaceae family members were noted with enhanced carbon sequestration potentials. The present study highlights the significant role of urban green spaces which acts a local carbon sink.

Keywords: Carbon sequestration, Biosequestration, Urban green spaces, Fabaceae, Swaraj round.

Introduction

Escalating atmospheric concentration of GHGs due to anthropogenic activities has led to global warming and climate change. Among the major greenhouse gases like water vapour, carbon dioxide, methane, nitrous oxide and ozone, Carbon dioxide was considered as the most dangerous one. Climate scientists have observed that CO_2 concentrations in the atmosphere have been increasing significantly over the past century,compared to the rather steady level of the pre-industrial era (280 ppm). The recent average CO_2 concentration recorded at Mauna Loa was 421 ppm (June 2022).

The elevated levels of CO_2 levels in atmosphere lead to the rapid melting of glaciers, destruction of coral reefs, extinction of species[1,2,3] changes in amount of precipitation[4], forest fires, increasing water levels of seas and rivers[5] progressive increase the risk of floods[6] coastal erosion, gradual increase the flood risk, elevating air and ocean temperatures, extensive poverty, serious health risks on humans such as increase in diseases like Malaria, Cholera, Dengue[7] and increasing demands on food. Hence there is an urgent need to reduce these emissions. Reduction in carbon dioxide concentrations in the atmosphere can be achieved by reducing the demand for energy, altering the usage of energy or by increasing the rates of removal of CO_2. A promising approach in this direction is carbon sequestration in which CO_2 is captured from a source using an appropriate method and then transferred to a sink, which can be achieved via physical, chemical and biological methods. However several researchers concluded that both physical and chemical methods were noted to be costly, energy-consuming, and also offer marginal mitigation benefits.

Biosequestration is the storage and removal of carbon from the atmosphere by, generally by photosynthetic plants or algae. Among the various carbon biosequestration strategies the utilization of photosynthetic efficiencies of trees and conversion of carbon dioxide into biomass has been receiving significant attention[8] as it offers energy-saving and eco-friendly technology which can decrease the atmospheric carbon dioxide naturally. In this light, an attempt has been carried out to evaluate the carbon sequestration efficiencies of selected trees pertaining to the Swaraj round, Thrissur, Kerala.

Materials and methods

Description of the study area: The Thrissur city was developed around a centrally located hillock called Swaraj round or Thekkinkadu Maidan which spreads over 65 acres between the coordinates: 10.527573°N and 76.21447°E. Apart from being the venue of Thrissur pooram, the Swaraj round was one of the biggest commercial center and shopping areas of Thrissur city and with 17 roads joining to the round. Generally Thrissur city features a tropical monsoon climate. The maximum average temperature of city in summer ranges from 22.5 to 33ºC and in winter it ranges from 20 to 29ºC. The city receives an annual rainfall of 3000mm having around 124 rainy days a year.

Field Survey: Selection and identification of trees: Among the 65-acre, the trees belonging to the outer belt were selected for the study. The trees pertaining to outer belt were identified up to species level along with common name and habit using standard manuals and also with the aid of experts. The entire study was carried out during February 2022 – March 2022.

Carbon sequestration studies: Measurement of tree height and diameter: The height and diameter of trees were calculated by direct measurement method. Girth at Breast Height (GBH) is the volume or weight per tree and the diameter can be measured by wrapping a tape round the trunk at breast level, 4.5 feet above the ground. If the tree trunk split into several stems close to the ground level, the GBH of each stem was measured separately and combine the diameters into a single index. Here the tree GBH is calculated from the square root of the sum of all squared stem. The tree fork is present below breast height, then measure diameter of the main trunk below the fork by avoiding the swollen part of tree.

Determination of the weight of the carbon dioxide sequestered in the tree*:* Non-destructive method is the most preferable one to calculate the green weight and dry weight. By using the total green weight and dry weight of the tree, the weight of carbon in the trees can be assessed and subsequently the weight of carbon dioxide sequestered in the tree and the weight of CO_2 sequestered in the tree per year were calculated.

Determination of the total green weight of the tree: The green weight is the weight of the tree when it is alive and can be calculated by the following formula[9]:

$W_{above\text{-}ground}$ = Above-ground weight in pounds

$W_{above\text{-}ground} = 0.25D^2H$ (for trees with D<11)

$W_{above\text{-}ground} = 0.5\ D^2H$ (for trees with D>11)

Where: D = Diameter of the trunk in inches. H = Height of the tree in feet

The total green weight can be calculated by multiplying the root system weight, is about 20% of above ground. To determine the total green weight of the tree, multiply the above ground weight by 1.2:

$W_{total\ green\ weight} = 1.2 \times W_{above\text{-}ground}$

Determination of the dry weight of the tree: To determine the dry weight of the tree, multiply the total green weight of the tree by 72.5% because the average tree is 72.5% dry matter and 27.5% moisture[10].

$W_{dry\ weight} = 0.725 \times W_{dry\ weight}$

Determination of the weight of carbon in the tree*:* The average carbon content is generally 50% of the trees dry weight total volume. For the estimation of the weight of the carbon in the tree, multiply the dry weight of the tree by 50%[9].

$W_{carbon} = 0.5 \times W_{dry\ weight}$

Determination of the weight of CO_2 sequestered in the tree: The weight of CO_2 in the tree is determined by the ratio of CO_2 to C is 44/12=3.67. For the estimation the weight of CO_2 sequestered in the tree, multiply the weight of the carbon in the tree by 3.67[9]:

$W_{carbon\text{-}dioxide} = 3.67 \times W_{carbon}$

Results and discussion

Results of field survey were depicted in Table-1 and the results of carbon sequestration efficiencies of tree species were depicted in Table-2.

Field survey: Among the 65 acres of Swaraj round, the outer belt area was selected for the study. During the field survey (Table-1) 118 trees were recorded through census method. The trees were identified up to the species level using standard manuals and also with the aid of experts. Upon comparing the results it was observed that selected 118 tree species belongs to 11 families. The family Fabaceae comprises of maximum number of species (8) and *P.pterocarpum* was noted to be most abundant tree species (25). The minimum numbers of species were noticed with families Lecythidaceae, Meliaceae, Bignoniaceae, Rosaceae, Burseraceae with one representative each and most of the species were noted to be exotic.

Carbon sequestration studies: Measurement of tree height and diameter at breast height (DBH): Measurement of diameter and height is the most important parameter for calculating the carbon sequestration potential. Here the height and diameter of trees were reported in feet and inches respectively (Table-2). The maximum height was observed in *M.indica* (55.77 feet) and minimum in *C.fistula* (6.56 feet). The *M.indica* (159 inch) was recorded with maximum diameter and minimum diameter was observed in *C.fistula* (3 inches).

Assessment of carbon dioxide sequestration efficiencies: Upon comparing the values pertaining to carbon sequestration efficiencies of trees (Table-2) maximum value was noticed with *A.scholaris* (1086059.51 Carbon/year) and minimum with

C.fistula. (23.56 Carbon/year). Apart from *A.scholaris*, *M.indica*, (115461.64 Carbon/year), *P.pterocarpum* (911138.76 Carbon / year), *S.saman* (746731.41 Carbon / year), *P.pinnata* (404480.28 Carbon / year), *P.biglandulosa* (352106.36 Carbon / year), *A.heterophyllus* (272306.87 Carbon / year), *M.peltata* (135121.81 Carbon / year), *L.speciosa* (106662.12 Carbon / year), *F.religiosa* (89317.83 Carbon / year) also exhibited increased carbon sequestration potentialities.

While comparing the value pertaining to carbon assimilation of trees it was observed that the tree species belonging to Fabaceae family members were noted with enhanced carbon sequestration potentials. Similar observations were also reported by several researchers[11,12]. Apart from the recreational and culture services the present study highlights the significance of urban green spaces which can act as a nature based local carbon sink. By selecting suitable species and proper maintenance, considerable amount of urban carbon dioxide emissions can be reduced at local level. Moreover it is also imperative that more native species should be planted as compared to the exotic species.

Table-1: List of the trees species selected for the study

Botanical name	Total number of trees	Native/ Exotic species	Family	Common name
Samanea saman	12	Exotic	Fabaceae	Rain tree
Parkia biglandulosa	1	Exotic	Fabaceae	Badminton ball tree
Peltophorum pterocarpum	25	Exotic	Fabaceae	Yellow goldmohur
Cassia fistula	20	Native	Fabaceae	India laburnum
Aegle marmelos	1	Native	Rutaceae	Holy fruit tree
Lagerstroemia speciosa	4	Native	Lythraceae	Pride of India
Bauhinia purpurea	5	Exotic	Fabaceae	Butterfly tree
Garuga pinnata	1	Native	Burseraceae	Garuga
Prunus dulcis	1	Native	Rosaceae	Almond tree
Morinda citrifolia	1	Native	Rubiaceae	Indian mulberry
Mangifera indica	6	Native	Anacardiaceae	Mango tree
Pouteria campechiana	1	Exotic	Sapotaceae	Egg fruit
Caesalpinia coriaria	1	Exotic	Fabaceae	Dividivi plant
Spathodea campanulata	1	Exotic	Bignoniaceae	Scarlet-bell tree
Mimusops elengi	3	Native	Sapotaceae	Asian bullet wood
Artocarpus heterophyllus	6	Native	Moraceae	Jack fruit tree
Alstonia scholaris	9	Native	Apocynaceae	Devil tree
Azadirachta indica	2	Native	Meliaceae	Indian lilac
Macaranga peltata	2	Native	Euphorbiaceae	Podini
Pongamia pinnata	1	Native	Fabaceae	Hongay oil tree
Delonix regia	1	Exotic	Fabaceae	Royal poinciana
Couroupita guianensis	1	Exotic	Lecythidaceae	Cannon ball tree
Ficus religiosa	2	Exotic	Moraceae	Peepal tree
Anacardium occidentale	1	Exotic	Anacardiaceae	Cashew nut tree

Millingtonia hortensis	1	Exotic	Bignoniaceae	Indian crock tree

Table-2: Amount of carbon sequestered by trees under study.

Scientific name	Height (Feet)	Breadth (Inch)	Wcarbon-dioxide
Samanea saman	52.49	133.5	746731.41
Parkia biglandulosa	45.93	98	352106.36
Peltophorum pterocarpum	45.93	112	459893.93
Peltophorum pterocarpum	32.80	59	911138.76
Peltophorum pterocarpum	49.21	113	501574.64
Peltophorum pterocarpum	42.65	92	288150.92
Peltophorum pterocarpum	26.25	58	70487.25
Cassia fistula	42.65	31	32716.56
Aegle marmelos	19.68	12	2262.10
Samanea saman	36.08	22	13939.17
Samanea saman	32.80	80	167563.39
Samanea saman	29.52	62	90578.48
Cassia fistula	13.12	13	1769.88
Samanea saman	42.65	128	557781.74
Cassia fistula	19.62	7	384.87
Peltophorum pterocarpum	22.96	17	5296.57
Samanea saman	29.56	30.5	21949.74
Samanea saman	19.68	31	15096.41
Lagerstroemia speciosa	22.96	22	8870.38
Cassia fistula	18.04	14	2822.39
Bauhinia purprurea	19.68	22.5	7952.71
Cassia fistula	16.40	18	4241.44
Garuga pinnata	45.93	90	296966.04
Cassia fistula	22.96	18	5938.02
Samanea saman	42.65	59	118508.19
Cassia fistula	42.65	27	24818.29
Samanea saman	42.65	90	275758.79
Peltophorum pterocarpum	45.93	119	519177.29
Prunus dulcis	39.37	32	3280.34
Morinda citrifolia	13.12	13	1769.88
Mangifera indica	55.77	122	662591.14
Samanea saman	49.21	99	384989.67
Pouteria campechiana	29.52	22.5	11929.07
Peltophorum pterocarpum	52.49	110	506975.84
Mangifera indica	14.76	127	190028.66
Peltophorum pterocarpum	45.93	114	476465.51
Peltophorum pterocarpum	39.37	102	326957.33
Caesalpinia coriaria	13.12	59	36455.51
Samanea saman	45.93	98	352106.40

Peltophorum pterocarpum	29.52	97	221709.93
Cassia fistula	19.68	25	9818.16
Mangifera indica	49.21	159	993054.14
Spathodea campanulata	26.24	28	16421.21
Mimusops elengi	18.04	16	3686.39
Cassia fistula	9.84	3.5	48.10
Cassia fistula	6.56	3	23.56
Mimusops elengi	29.52	15.25	5480.01
Lagerstroemia speciosa	36.08	29	24220.76
Peltophorum pterocarpum	42.65	63	135121.81
Peltophorum pterocarpum	41.01	114	425426.75
Peltophorum pterocarpum	19.68	88	121651.02
Cassia fistula	8.20	6	117.81
Cassia fistula	11.48	6.9	218.14
Samanea saman	44.29	12	5090.88
Artocarpous heterophyllus	22.96	67	82271.00
Peltophorum pterocarpum	42.65	148.5	745706.26
Peltophorum pterocarpum	36.08	101	293788.37
Alstonia scholaris	41.01	96	301687.67
Alstonia scholaris	42.65	110	411935.98
Artocarpous heterophyllus	39.37	96	289623.10
Alstonia scholaris	52.49	161	1086059.51
Mangifera indica	16.40	7	320.72
Cassia fistula	14.76	4	94.25
Alstonia scholaris	49.21	141	780938.64
Artocarpous heterophyllus	32.80	89	207385.87
Peltophorum pterocarpum	32.80	95.5	238784.37
Alstonia scholaris	34.44	62	105674.90
Alstonia scholaris	34.44	72	142512.66
Alstonia scholaris	19.68	18	5089.73
Azadirachta indica	26.24	17	6053.21
Azadirachta indica	31.16	16	6367.40
Peltophorum pterocarpum	49.21	142	792055.07
Artocarpus heterophyllus	47.57	43	70209.41
Spathodea campanulata	29.52	25	14727.25
Macaranga peltata	26.24	32	21448.11
Azadirachta indica	32.80	32.5	27654.50
Pongamia pinnata	42.65	109	404480.28
Cassia fistula	26.24	28	11823.27
Delonix regia	26.24	35	25658.14
Cassia fistula	9.84	10	392.72
Mangifera indica	39.37	155	755012.49
Delonix regia	29.52	35	28865.41

Cassia fistula	26.24	30	18850.88
Couroupita guianensis	27.85	15	5001.87
Mangifera indica	32.80	71	131982.35
Mangifera indica	29.52	70	115461.64
Peltophorum pterocarpum	45.93	71	184815.53
Peltophorum pterocarpum	49.21	100	392806.56
Artocarpous heterophyllus	39.37	135	572741.00
Ficus religiosa	34.44	57	89317.83
Peltophorum pterocarpum	45.93	143	749710.93
Ficus religiosa	42.65	78	207125.49
Samanea saman	36.08	146	613899.90
Samanea saman	45.93	121	536775.28
Bauhinia purpurea	31.16	33	27086.36
Samanea saman	50.85	80	259774.34
Peltophorum pterocarpum	32.80	47	57835.55
Cassia fistula	9.84	8	251.34
Cassia fistula	13.12	9	424.14
Peltophorum pterocarpum	42.65	87	257681.27
Artocarpus heterophyllus	29.52	107.5	272306.87
Cassia fistula	31.16	23	13157.65
Spathodea campanulata	24.60	49	47146.84
Anacardium occidentale	26.24	23	11080.12
Samanea saman	50.85	110	491135.86
Alstonia scholaris	19.68	32	16086.08
Peltophorum pterocarpum	36.08	83	198402.91
Macaranga peltata	42.65	63	135121.81
Lagerstroemia speciosa	47.57	106	106662.12
Peltophorum pterocarpum	32.80	181	857741.29
Lagerstroemia speciosa	31.16	25	15545.43

Conclusion

Among the various carbon sequestration techniques, biosequestration efforts were considered as more preferable one due to its ecofriendly and economical approach. In the present study, an attempt has been carried out to estimate the CO_2 sequestration potential of selected tree species pertainingto the outer belt of Swaraj round, Thrissur. For experimentations each tree species were identified up to species level along with habit and common name. Among 118 trees belonging to 11 families, Fabaceae consists of maximum number of species and the *P.pterocarpum* was noted to be the most abundant tree species in the study area.

For the analysis of CO_2 sequestration, the diameter and height of each species were collected and sequestration potentialities were estimated. Among the 118 trees, *A.scholaris, S.saman, L.speciosa, P.pterocarpum, P.biglandulosa, P.pinnata, M.indica, M.peltata* and *A.heterophyllus* exhibited increased CO_2 assimilation potentialities. The present study highlights the significance of urban green spaces in which acts as local carbon sink in reducing the escalating carbon dioxide concentrations at local level.

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