Inventory of Vegetation and Assessment of Carbon Storage Capacity towards a Low Carbon Campus: a Case Study of Universiti Tun Husein Onn Malaysia, Johor Malaysia

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Abstract. Carbon dioxide, a vital greenhouse gas plays a key role in Earth's carbon cycle, a concentration above ambient temperature results in global warming. High CO_2 emission in Universiti Tun Husein Onn Malaysia is due to an increase in a number of automobiles and other greenhouse gases released from building facilities and nearby industries. A study was carried out on 22 common trees planted within the campus on the estimated amount of CO_2 sequestered. Estimation of carbon storage of trees was obtained through the assessments of standing biomass as well measurement of their photosynthetic capacity. Results indicated that *Spathodea campanulata* has the highest CO_2 absorption (14.40 µmol/ m^{-2}/s^{-1}) followed by *Acacia mangium* (14.03 µmol/m^{-2}/s^{-1}), and *Cananga odorata* with (12.80 µmol m^{-2} s^{-1}). *Alstonia scholaris* has the highest aboveground standing biomass accumulation of 106.94 kg, followed by *Samanea saman* (20.83 kg), and *Acacia mangium* (19.43 kg). The total biomass accumulated of all the tree species is 200.03 kg. Therefore, species of trees in Universiti Tun Husein Onn Malaysia main campus have the potential to absorb a significant amount of CO_2 from the atmosphere thereby contributing to mitigating-the localized effects of global warming.

Keywords: Carbon dioxide sequestration; tropical vegetation; global warming; climate change; biomass.

INTRODUCTION

The continuous increase of carbon dioxide (CO_2) emission in the University environment is a result of the increase in the consumption of energy use from fossils fuel to power automobiles as well as to run the facilities for the effective teaching, learning, residence and administrative use within the campus. The discharge of gases from the neighbouring industry and from passing vehicles on the roadsides indicates serious implication on the quality of air in the Universiti Tun Hussein Onn Malaysia environment.

Environmentalists consider carbon dioxide (CO_2) to be the most important anthropogenic greenhouse gas [1]. However, since the beginning of the industrial revolution, the percentage increased by 39 % (from 280 ppm to 388 ppm) [2]. As the trend continued, CO_2 increased from 280 parts per million (ppm) in 1850 to 394 ppm by 2012 [1, 3]. Presently, the concentration of CO_2 (400 ppm) is double as large as it was witnessed in eighteen thousand years that passed [4]. To minimise the increase of CO_2 concentration in the university campus and to derive benefit from trees, the situation necessitates the validation of the potential and capability of storage of carbon by the trees of Universiti Tun Hussein Onn Malaysia campus, and to find out which tree is suitable for the maximum absorption and sequestration of CO_2 to reduce the concentration to a minimal level.

Carbon dioxide sequestration takes into account both natural through biological, chemical, and physical processes of removing excess carbon from the environment. Naturally, trees act as a sink for carbon dioxide (CO_2) by fixing carbon during photosynthesis and storing carbon as biomass. Trees in urban areas (i.e. urban forests) sequester and store carbon as they grow, thereby affect local climate, carbon cy-

cles, climate change, air temperature and building energy use, and thus alter carbon emissions from many urban sources e.g., power plants [5]. Artificially it involves the elimination, capture, and sequestration of industrially produced CO_2 using subsurface saline aquifers, reservoirs, ocean water, aging oil fields, or other carbon sinks [6]. Oceans perform the function of the sinking of CO_2 emissions of about 2 gigatons of carbon per year [7, 8].

Higher CO_2 in the atmosphere can increase the greenhouse consequence and excessively heat in the earth's surface, but as trees grow they absorb and store carbon in them. In the presence of increased greenhouse gases in the atmosphere, forests become even more vital for removing CO_2 from the atmosphere to reduce its effects [9].

According to [10], as trees grow they absorb several tons of CO_2 out off thereby decreasing summertime air temperatures from evapotranspiration and straight shading [11]. California Climate Action Team report (2006), recommended planting 5 million trees in cities to reduce 3.5 million metric tons of CO_2. In their study, they discovered that by planting 1 million trees, the Million Trees LA program will decrease atmospheric CO2 by about 1 million tons over the next 35 years, which is like taking 7,000 cars off the road each year [12].

Authors [2] reported the ability of *Peltophorum pterocarpum* and *Samanea saman* among other trees to reach their maximum CO_2 uptake rates of 24.5 and 20.9 CO_2 $\mu mol/m^{-2}/s^{-1}$, when photosynthetically active radiation is 1100 and 1500 $\mu mol/m^2/s^{-1}$ respectively. They suggested the species as good carbon sinks and they should be planted more in the city for optimal CO_2 absorption. Authors [13] reported that total carbon storage and sequestration within cities increases with increase in urban trees cover and this is well pronounced with the increase in the proportion of large healthy trees with greater than 77 cm in diameter that can sequester approximately 90 times more carbon than small trees of less than 8 cm in diameter. In the study carried out by [14], indicate that *A. saman* had more biomass (75707.31 kg) followed by *Azadirachta. indica* (50203.26 kg) and *P pterocarpum* (29476.07 kg) among other plants study in estimating urban tree biomass.

Authors [15] observe that *Macaranga giggantea* with large Diameter at Breast Height stored more carbon (2560 kg C) when compared to *Adinandra dumosa* with (391 kg C), with small Diameter at Breast Height.

Authors [16] revealed the capability of *Delonix regia* to have the maximum carbon accumulation of (4028.97) tons ha^{-1}, among other trees studied in Bhubaneswar City of Odisha, India. In another study, CO_2 assimilation rate was observed to be as high as 16.61 $\mu mol/m^{-2}/s^{-1}$ in case of *Polyalthia longifolia* and lowest of 9.39 $\mu mol/m^{-2}/s^{-1}$ in *Bauhinia perpuria.* Therefore it was suggested that species could be planted for better carbon assimilation in the University.

In the study conducted by [17, 18], the total carbon stock inclusive of both aboveground and belowground of all adult trees in the University campus was 2590.48 Mg (8.7 *Mg C/ha*) and the highest carbon stock value was observed in *Acacia auriculiformis*. They concluded that the university campus is rich in tree species' diversity with a great carbon stocking potential similar to those of natural tropical dry forests [19], found out that *Swietenia mahogany* successively followed by *Albezia saman*, *Polyalthia longifolia*, *Drypetes roxburghii*, *Mangifera indica*, *Saraca asoca*, *Dolichandrone stipulate* and *Lagestroemia speciosa* are with high efficiency to sequester atmospheric CO_2 and the present author registers *Ficus benghalensis* as the best in this regard. Thus, the aim of this study was to determine the inventory of plants, capacity and their importance in carbon storage in Universiti Tun Hussein Onn Malaysia campus.

METHODOLOGY

The study was carried out at Universiti Tun Husein Onn Malaysia main campus with coordinate 1.8531° N, 103.0864°. There are 11,403 registered cars as of 21st February 2018. The overall area cover of the campus is 238.896 hectares. Out of this figure, 152.667 hectares are developed, while the remaining area stands as undeveloped / reserved. The trees within the Universiti Tun Husein Onn Malaysia main campus were surveyed and identified according to [20].

A significant statistics on the tree varieties and well-preserved samples of trees collected were deposited at Universiti Tun Husein Onn Malaysia botany repository for future research references. The study was conducted for quantifica-

tion of CO_2 intake by the trees through the measurement of CO_2 absorption capacity of the trees. The instrument Li-6400 Portable Photosynthesis System was used to measure the CO_2 photosynthetic assimilation rate. For a good estimation of CO_2 and to avoid fluctuation during measurement the air flow was set to 500 µmol, CO_2 at 360 µmol, block temperature 30 °C and photosynthetic active radiation light at 1000 µmol/m^{-2}/s^{-1}. However, the biomass accumulation of carbon by the trees was estimated through the procedure below.

A non-destructive method was used to estimate the biomass of different trees based on the Diameter at Breast Height and tree height. The Diameter at Breast Height was calculated by measuring tree diameter at breast height, approximately 1.3 meters above the ground. The diameters of trees were measured directly by the measuring tape (D-tape). The tree height was measured by the use of Theodolite instrument.

The general multi-species biomass equation $Y = \exp\{3.2249 + 0.9885In(d^2h)\}$ develops by [21] for estimating the total aboveground standing biomass of trees was used.

The below ground biomass was calculated by multiplying AGB (Kg/tree) or (ton/tree) × BGB Kg/tree (0.26) [22].

The Leaves Carbon Content was obtained by the leaf ash method by [23], and the resulting ash content was used to determine the leave carbon content of the study plants.

RESULTS AND DISCUSSION

The species of trees in Universiti Tun Husein Onn Malaysia studied in their capacity had the potential to absorb and store CO_2 (biomass accumulation) through the process of photosynthesis. Trees play important role in carbon storage to reduce the emission of CO_2 in the atmosphere. The knowledge of numbers of trees and their potentials in the absorption and storage of CO_2 will give an insight on how to increase the numbers of trees by allocating space for planting more trees that can function in reducing of environmental pollution and CO_2 emission in the environment [24].

The result of the study is shown in (Table 1, Figures 1–2), total standing biomass and CO_2 absorption capacity rate is estimated.

Table 1 – Showing quantifies of biomass accumulation of common species of trees and CO_2 absorption capacity.

No	Species Scientific Name	No of individuals	CO2 Assimilation (µmol/m^{-2}/sec^{-1})	LAI (cm^2)	STC	S/F	LCC (kg)	TSB (kg)
1	*T. rosea*	1505	4.97 ± 1.62	1.04 ± 0.02	6.00 ± 2.52	0.26	0.02	2.3± 0.01
2	*L. speciosa*	1007	4.96 ± 3.84	1.20 ± 0.09	3.00 ± 0.58	0.04	0.02	0.15±0.03
3	*F. benjamina*	677	9.42 ± 2.15	0.21 ± 0.02	14.00 ± 1.73	0.06	0.01	0.2±0.03
4	*S. saman*	486	7.68 ± 3.20	0.50 ± 0.00	14.00 ± 2.65	1.13	0.03	20.83±0.02
5	*C. verum*	373	9.12 ± 1.11	0.43 ± 0.15	7.00 ± 0.58	0.07	0.02	0.31±0.04
6	*P. pterocarpum*	276	9.79 ± 0.83	0.08 ± 0.00	19.00 ± 7.02	0.41	0.01	4.26±0.02
7	*E. fusca*	179	12.03 ± 2.36	0.21 ± 0.12	8.00 ± 2.89	0.06	0.01	0.2±0.001
8	*M. elengi*	171	5.98 ± 0.58	0.47 ± 0.03	8.00 ± 2.00	0.13	0.01	0.65±0.03
9	*C. junghuhniana*	165	4.41 ± 0.06	0.10 ± 0.00	5.00 ± 1.00	0.1	0.02	1.54±0.01
10	*C. odorata*	143	12.80 ± 1.77	1.11 ± 0.04	24.00 ± 2.31	0.05	0.02	0.1±0.01
11	*S. campanulata*	132	14.40 ± 4.06	0.56 ± 0.06	45.00 ± 16.46	0.27	0.01	2.28±0.05
12	*M. indica*	111	6.63 ± 3.87	0.82 ± 0.14	14.00 ± 2.64	0.81	0.02	10.7±0.08
13	*X. chrysanthus*	87	9.54 ± 0.40	0.42 ± 0.08	21.00 ± 1.73	0.16	0.01	1.05±0.06
14	*P. longifolia*	67	5.2 ± 0.21	0.69 ± 0.13	12.00 ± 1.53	0.23	0.02	1.8±0.08
15	*K. senegalensis*	65	5.29 ± 0.12	0.46 ± 0.04	41.00 ± 13.50	0.51	0.03	6.99±0.04
16	*A. scholaris*	53	8.5 ± 1.19	0.58 ± 0.7	41.00 ± 9.50	3.04	0.01	106.94±0.01
17	*C. equisetifolia*	52	1.91 ± 0.15	0.39 ± 0.45	33.00 ± 7.02	0.05	0.02	1.04±0.001
18	*F. frangrans*	48	9.71 ± 4.48	0.26 ± 0.03	8.00 ± 2.00	0.98	0.03	17.28±0.03
19	*S. polyanthum*	47	9.16 ± 0.11	0.54 ± 0.12	46.00 ± 917	0.08	0.02	0.32±0.01
20	*S. grande*	45	4.54 ± 1.42	1.58 ± 0.13	41.00 ± 3.79	0.2	0.02	1.63±0.02

No	Species Scientific Name	No of individuals	CO2 Assimilation (μmol/m^{-2}/sec^{-1})	LAI (cm^2)	STC	S/F	LCC (kg)	TSB (kg)
21	*P pinnata*	43	8.56 ± 0.75	1.05 ± 0.10	45.00 ± 10.54	0.07	0.01	0.05±0.01
22	*A. mangium*	42	14.03 ± 0.55	0.93 ± 0.07	31.00 ± 8.54	1.05	0.02	19.43±0.04
	Total number	5716	181.45					200.03

Notes: S/F – Species Factor, TSB - Total Standing Biomass, LCC - Leaf Carbon Content, LAI - Leaf Area Index, STC - Stomatal Count.

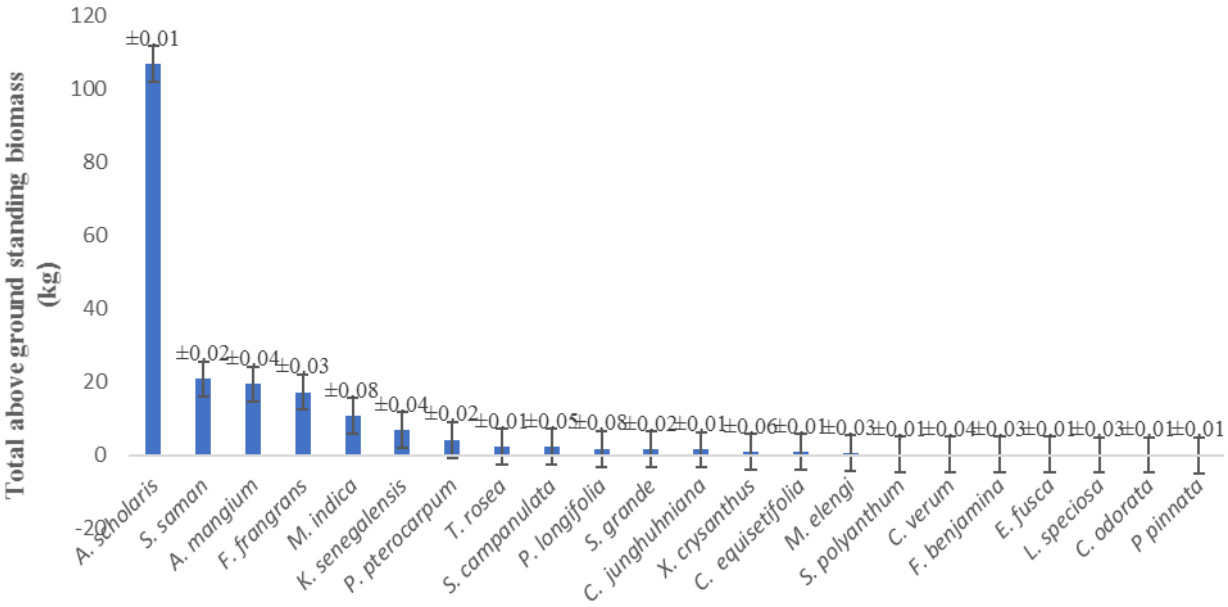

Figure 1 – Graph showing total above ground standing biomass

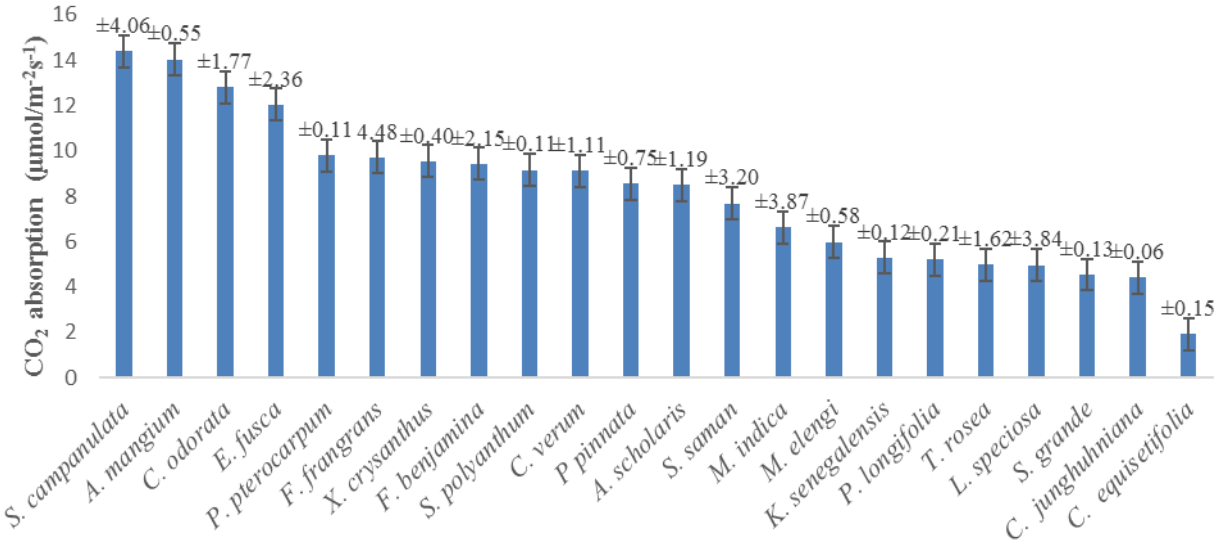

Figure 2 – Graph Showing CO2 Absorption

It was observed that *A.scholaris* sequestered 106.94 kg/tree, which is the highest compared to other tree species from the study area. This could be due to higher Diameter at Breast Height and height of the trees (15.40 heights, 2.28 Diameter at Breast Height), with a total number of 53 species [20, 21]. This is followed by *S. saman* with 20.83 kg with a total number of 486 species and *A.mangium* with 19.44 kg. *P. pinnata* sequestered the lowest CO_2 of 0.05 kg with 43 species which probably might be due to lower Diameter at Breast Height of

0.17 m [20], reported that large trees store nearly 90 times more carbon than smaller trees. However, from the findings, *S. campanulata* was found to have the highest CO_2 absorption (14.40 μmol/m^{-2}/s^{-1}). While *C. equisetifolia* (1.91 μmol/m^{-2}/s^{-1}) has the lowest CO_2 absorption.

CONCLUSION

Trees in urban setting play a significant role in the reduction of atmospheric carbon dioxide level. From the result obtained, *A. scholaris* has a higher and better CO_2 accumulation rate, whereas, *P. pinnata* sequestered the lowest. *S. campanulata* was found to have the highest CO_2 absorption. Therefore, the above species could be recommended for planting in the university campus for better sequestration and assimilation of carbon from the atmosphere and to enrich the quality of air in campus and the nearby community.

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