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Inventory and Assessment of Carbon Storage Capacity of Non-Timber Plants in Universiti Tun Husein Onn Malaysia, Main Campus, Batu Pahat, Johor Malaysia

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Abstract: Carbon dioxide, an important greenhouse gas performs a fundamental role in Earth's carbon cycle. Its continuous rise has been observed to result to enhanced greenhouse effect which has led to global warming. The increase in CO_2 discharge in UTHM (238.8964 ha), owing to more vehicles, and other greenhouse gases from building amenities and close by industries is a concerning issue. Nineteen most common nontimber plants were studied for their capacity to sequester significant amount of CO_2. Estimation of carbon storage of non-timber plants was obtained by assessments of standing biomass and their photosynthetic capacity. Results indicate that *Sanchezia speciosa* has the highest CO_2 absorption capacity (15.37μmol m^{-2} s^{-1}) followed by *Hibiscus rosa S.* (11.27μmol m^{-2} s^{-1}), and *Ixora coccinea* with (9.90μmol m^{-2} s^{-1}). *Baphia nitida* has the highest aboveground biomass accumulation (*1*.0620 kg), followed by *Tabernae montana* (0.6842 kg), and *Cordyline fruticosa* (0.1597 kg). *Ixora coccinea* has the highest biomass accumulation (646.4160 kg), followed by *Tabernae montana* (220.9966 kg), and *Baphia nitida* (129.5640 kg) on species abundance. The total biomass captured by the all the species is 1319.2486 kg (1.3192 tons) of carbon. Hence, species of non-timber plants in UTHM have the capacities to absorb a substantial quantity of CO_2 from the atmosphere thus contributing to reducing the effects of world-wide warming and climate alteration.

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

1. Introduction

Universiti Tun Hussein Onn Malaysia is one of the fastest growing institutions of higher learning located at Parit raja Batu Pahat in the state of Johor Malaysia (1.8531° N, 103.0864°). It covers a total land area of 238.8964ha and occupying mainly with facilities ranging from automobiles, management and classroom gadgets used for the running of the institution. A statistic from the office of the assistant security officer (UTHM) shows that there are about 6403 registered cars as at 21/2/2017. The increase in the number of automobiles can result to increase in the discharge of more CO_2 and other green gases from within the University community and the nearby industry lead to a higher emission of gases into the University which ultimately with time, will gradually affect and change the local climate within the locality of Parit Raja. This is evidently seen from the report of UTHM carbon emission report which of more than 20,000 tons of carbon is emitted into the environment each year [1]. Presently, world-wide environmental warming is at increase than ever. Record of the perceived rise in universal normal heats is owed to the continuous increase of CO_2 in our atmosphere, i.e. from 280 parts per million (ppm) in 1850 up to 394 ppm in 2012 [2]. The trend continued to as much as 400 ppm concentration of CO_2 which it has doubled as large as it was witnessed in 8000yrs that passed [3]. Consequently, due to the continuous global increase in the emission of CO_2, the United Nation Framework Conference on Climate Change (UNFCCC), at its 16th Conference of the Parties held in 2010, parties to the UNFCCC agreed that future global warming should be limited below 2°C relative to the pre-industrial temperature level. This resulted to the formulation of the Kyoto Protocol (2008-2012), which was then followed by the Paris Agreement (2017-2022).

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There are different species of plants in UTHM that function in their capacity to absorb CO_2 emitted in the environment. In this study, emphasis was laid on the contribution of shrubs plants in their ability to absorb CO_2 emitted in the environment.

2. Roles of Non-Timber Plants in Carbon Storage and its Importance

Higher CO_2 in the atmosphere can increase the greenhouse consequence and excessively heat at the Earth's surface, but as plants grow they absorb and store carbon in them. Mori *et al.* (2016) reported the ability of some shrub plants - *Arbutus unedo*, *Elaeagnus ebbingei*, *Laurus nobilis*, *Ligustrum japonicum*, *Photinia fraseri*, *Viburnum lucidume and Viburnum tinus*, that under optimal water availability. *E. ebbingei* had the highest carbon gain (both expressed on leaf area basis and of the whole plant) when grown under ideal water availability, essentially because of greater water use efficiency than the other species [4].

However, they further expressed that under optimal conditions, there is a good correlation between carbon uptake and growth rate, which confirms that *E. ebbingei and L. nobilis* as the best species for carbon sequestration among those investigated if resources are not limiting. In conclusion, under optimal water availability, *E.ebbingei* was the species showing the highest daily carbon uptake, the highest growth rate, and the highest allocation to woody biomass, which make this species a very promising shrub for carbon sequestration in the well-watered urban area. A report from the northern institute of applied climate change, indicates that Forests (Urban forest inclusive) play a specific and important role in the global carbon cycle by absorbing CO_2 during photosynthesis, storing carbon above and belowground into their biomass, and producing oxygen as a by-product of photosynthesis [5].

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 [6]. Rashidi *et al.* (2016), reported the ability of some urban shrubs *Jasminium sambac*, *Durantha erecta gold* and *Acalypha siamensis* to have the highest sequestration of 94.04kg of CO_2 each in the study conducted at International Islamic University Malaysia campus. In a similar study, it was reported that *Eugenia oleina* sequestered the highest CO_2 (506.38), compared to other shrubs in the Assessment of Urban park landscape setting Design towards carbon sequestration rate [7]. Georgina *et al.* (2013), reported that *Acacia aroma*, *Acacia gilliesii*, *Larrea divaricata,* and *Mimozyganthus carinatus* showed more biomass at a given DLS than did *Aloysia gratissima*, *Capparis atamisquea*, *Celtis ehrenbergiana*, and *Moya spinosa* on shrub biomass estimation in the semiarid Chaco forest: a contribution to the quantification of an underrated carbon Stock [8]. Azhari (2012) reported capability of some shrubs *Cordyline fruticosa* and *Ixora coccinea* with significant correlation at 0.05 level values (0.643, 0.680 and 0.608 as the most suitable species to be introduced into the environment as a biomonitoring agent and to be further studied as a medium for low and medium level pollution bioremediation [9].

3. Methodology

The study was carried out at Universiti Tun Husein Onn Malaysia (UTHM) main campus environment with coordinate 1.8531° N, 103.0864°. The University has a total number of two thousand two hundred and fifty-two staffs (2252), a total number of fifteen thousand three hundred and forty-four students (15344), with a complete number of recorded cars, six thousand four hundred and three as at 21/2/2017. The general area cover of the campus is 238.8964 hectares. Out of this figure, 152.6667 acres are developed, whereas the remaining area stands as undeveloped/reserved. Most of the species are found around UTHM STP water treatment plant beside biodiesel unit, and behind the convocation hall and also along the main road from the main libray linking through FPT, FPTV, FKASS, FKMP and back to main library. The shrubs within the UTHM main campus were surveyed and identified as described by [10]. Substantial numbers of shrubs varieties and well-preserved samples of shrubs collected were placed at UTHM botany herbarium for future study references. The study was carried out for quantification of CO_2 sequestration by the shrubs through the measurement of CO_2 absorption ability of the shrubs. The device Li-6400 Portable Photosynthesis System (LI-COR Inc., USA) was used to measure the CO_2 photosynthetic assimilation rate (PAR), it is automatic and has an autonomous control leaf chamber CO_2, H_2O, temperature and light. For a better estimation of CO_2 and to evade instability during measurement, the air flow was set at 500 µmol, CO_2 at 360 µmol, block temperature 30^0 C and PAR (Photosynthetic active radiation) light at 1000nm. The biomass accumulation of carbon by the shrubs was estimated through the procedure below.

3.1 Measurement of Diameter at Breast Height (DBH) and Shrubs Height

A non-destructive method was used to estimate the biomass of different shrubs. The shrubs biomass was estimated base on the diameter at breast height (DBH) and the height. DBH was calculated by measuring shrubs diameter at Breast Height (BH), approximately 1.3 meters above the ground. The diameters of shrubs were measured directly by the measuring tape. The shrubs heights were measured by the used of measuring pole of height 5m called staff.

3.1.1 Above Ground Biomass (AGB) of Shrubs

The equation $dbh^{2.2046}xH^{0.498}$ by [11] was used to calculate the biomass of shrubs. Where dbh is the diameter at breast height and H is the height of the shrubs.

3.1.2 Below Ground Biomass (BGB)

The Below Ground Biomass (BGB) includes all biomass of live roots excluding fine roots less than 2 mm diameter. The below-ground biomass was calculated by multiplying AGB by 0.26 factors as the root: shoot ratio. BGB is calculated by following formula. BGB (Kg/tree) = AGB (Kg/tree) or (ton/tree) x 0.26 [12].

However, Leaves carbon content (LCC) was obtained by the leaf ashing method as described by Peacock (1992) [13], and the resulting ash content was used to determine the leaves carbon content of the study plants.

4. Results and Discussion

The species of shrubs in UTHM selected for study in their ability can absorb and accumulate CO_2 via the process of photosynthesis and therefore, can lead to a build-up of carbon into their biomass. Shrubs play a significant part in carbon storage to decrease the release of CO_2 into the atmosphere. Therefore it is important to validate the potentials of shrubs plants in the absorption and storage of carbon dioxide into their biomass, by this shrubs plants can function in the reduction of environmental pollution and the CO_2 emission in the environment [13]. Table.1 below shows the 19 common species of shrubs used in the study, there are more introduced shrubs species than the native, and few are endangered, and no species are in extinction. There are about eleven thousand four hundred and forty-six individual species of all the shrub plants (11446).

I. coccinea has the largest number (4824), while *T. mantaly Buccida Variegated* has the lowest number (45). The result in Table 2 indicated that, *B. nitida* sequestered (1.062 kg), which is highest compared to other shrubs species, followed by *T. montana* (0.6842 kg), and *C. fruticosa* (0.1597 kg). *I. coccinea* has the highest biomass accumulation (646.416 kg), followed by *T. montana* (220.9966 kg). And *B. nitida* 129.564 kg on species abundance. Azhari (2012) reported capability of some shrubs, *Hibiscus spp. C. fruticosa* and *I. coccinea* with Significant correlation at 0.05 level values (0.643, 0.680 and 0.608) respectively as the most suitable species to be introduced into the environment as a bio- monitoring agent and to be further studied as a medium for low and medium level pollution bioremediation [9].

The total standing biomass captured by all the shrubs species is 1319.2486kg (1.3192 tons) of carbon. The diurnal CO_2 absorption of the studied species is also shown in Table 2. *Sanchezia speciosa* was found to have the highest CO_2 absorption (15.3667 µmol m^{-2} s^{-1}) followed by *Hibiscus rosa* (11.27µmol m^{-2} s^{-1}) and *Ixora coccinia* with (9.90µmol m^{-2} s^{-1}), while *T. mantly, Buccida V*. and *D. repen variegated* had the lowest absorption. However, *Ixora coccinia* has the highest CO_2 absorption (47773.52 µmol m^{-2} s^{-1}),

Table 1 A check list of Shrubs species showing introduced, native, endangered, extinction and their total number.

Shrubs						
S/No	Species of plant	Introduced	Native	Endangered	Extinction	T/No
1.	*Tabernae montana*	√				323
2.	*Bougainvillea spectabilis*	√				129
3.	*Murraya paniculata*		√			1376
4.	*Hibiscus rosa S.*	√				514
5.	*Podocarpus macrophyllus*	√		√		65
6.	*Bauhinia blakeana*	√				84
7.	*Osmoxylon lineare*		√			746
8.	*Cordyline fruticosa*		√			102
9.	*Sanchezia speciosa*	√				154
10.	*Baphia nitida*	√				122
11.	I. *coccinea, small leaves*	√				1633
12.	*I. coccinea, large leaves, red flowers*	√				4824
13.	*Calliandra tergemina*	√				138
14.	*Duranta repen variegated*	√				288
15.	*Loropetalum chinense*		√			379
16.	*Terminalia mantaly Buccida Variegated*	√				45
17.	*Senna siamea*		√			47
18.	*Excoecaria cochinchinensis*		√			886
19.	*Schefflera arboricola*	√				370
	Total number					11446

NB: T/No means Total number of each species counted

Table 2 Parameters of common Shrubs to quantify biomass accumulation with AGB and BGB, and CO_2 absorption capacity.

			Above ground biomass								
S/N	Species Scientific name	No. species	Height (m)	DBH (cm)	S/F	LCC (kg)	BGB (kg)	TAGB (kg)	TSB/Abundance(kg)	CO2 Absorption (µ mol/m2/sec)	CO2 Absorption/Abundance (µ mol/m2/sec)
1	*Tabernae montana*	323	4.7478	0.21	0.611	124	0.026	0.6842	220.9966	9.6667	3122.34
2	*B. spectabilis*	129	1.3911	0.2689	0.005	0.0353	0.026	0.063	8.127	9.5407	1231.56
3	*Murraya paniculata*	1376	1.0111	0.5644	0.0217	0.0196	0.026	0.058	79.808	5.4433	7489.981
4	*Hibiscus rosa S.*	514	2.0478	0.1578	0.0019	0.014	0.026	0.041	21.074	11.27	5792.78
5	*P. macrophyllus*	65	2.2046	0.6633	0.0455	0.0544	0.026	0.14	9.555	3.4733	225.7645

6	*Bauhinia blakeana*	84	5.1522	0.3544	0.0174	0.014	0.026	0.072	6.048	8.63	724.92
7	*Osmoxylon lineare*	746	1.0978	0.7983	0.0486	0.0149	0.026	0.083	6.918	5.9367	4428.78
8	*Cordyline fruticosa*	102	1.8333	0.5144	0.2567	0.1095	0.026	0.1597	16.289	4.9033	500.134
9	*Sanchezia speciosa*	154	2.1256	0.1067	0.0008	0.0403	0.026	0.067	1.005	15.3667	230.5
10	*Baphia nitida*	122	6.4244	0.2522	0.622	0.0268	0.026	1.062	129.564	5.203	634.8
11	*I. coccinea, small leaves*	1633	0.7189	0.1433	0.0009	0.0149	0.026	0.041	66.953	2.3533	3842.94
12	*I. coccinea,large leaves*	4824	0.9011	0.2211	0.0026	0.0174	0.026	0.044	646.416	9.9033	47773.52
13	*Calliandra tergemina*	138	2.9011	0.0733	0.0004	0.0133	0.026	0.039	5.382	4.5533	628.36
14	*D. repen variegated*	288	0.3544	0.1456	0.0007	0.0149	0.026	0.041	11.808	0.7537	217.07
15	*Loropetalum chinense*	379	1.0044	0.0711	0.0002	0.0119	0.026	0.038	14.402	6.5461	2612.13
16	*T. mantaly Buccida V.*	45	1.8222	0.1344	0.0012	0.0171	0.026	0.043	1.935	0.3793	17.07
17	*Senna siamea*	47	5.8244	0.2333	0.0073	0.0132	0.026	0.05	2.35	6.0733	285.45
18	*E. cochinchinensis*	886	1.4834	0.4103	0.013	0.0293	0.026	0.063	55.818	4.85	4297.1
19	*Schefflera arboricola*	370	0.7978	0.2078	0.0021	0.0136	0.026	0.04	14.8	5.4233	2006.62
T/NO		11446							1319.2486		83710.8195

NB: T/No: Total number, DBH-Diameter at breast height, S/F-Species factor, BGB- Below ground biomass, TAGB-Total Above ground biomass, TSB-Total standing biomass and LCC-Leave carbon content.

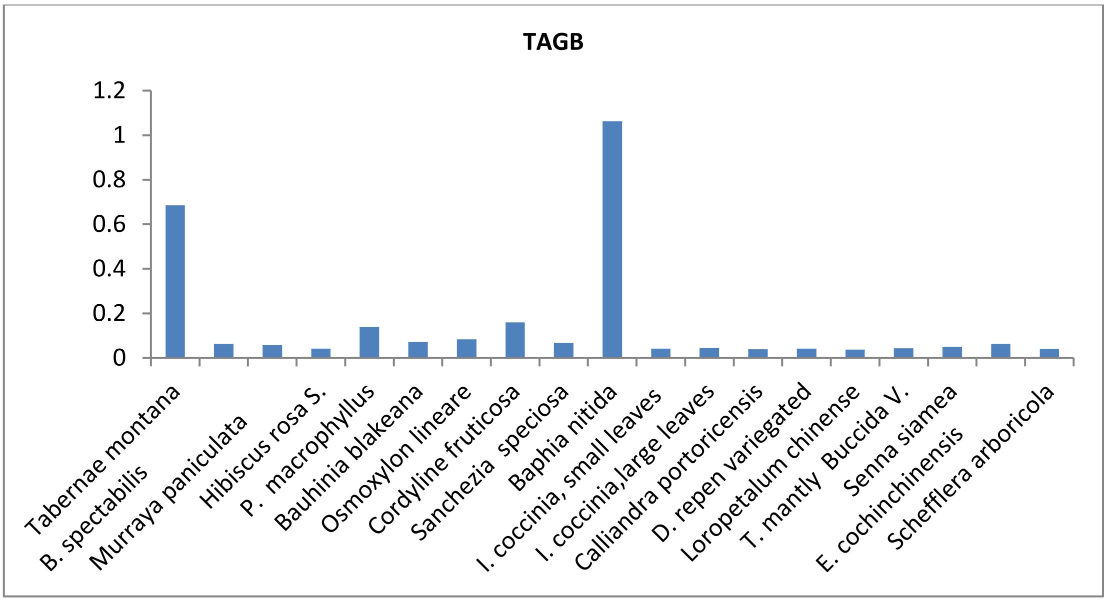

Fig. 1 Graph showing total above ground biomass

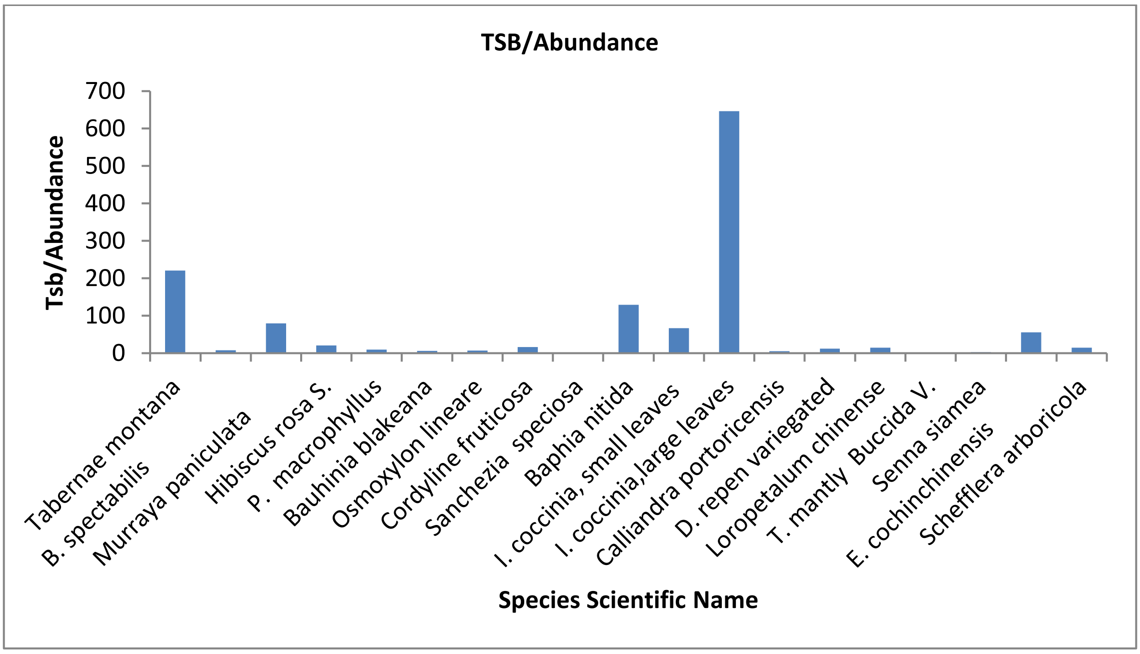

Fig. 2 Graph showing total standing biomass/abundance

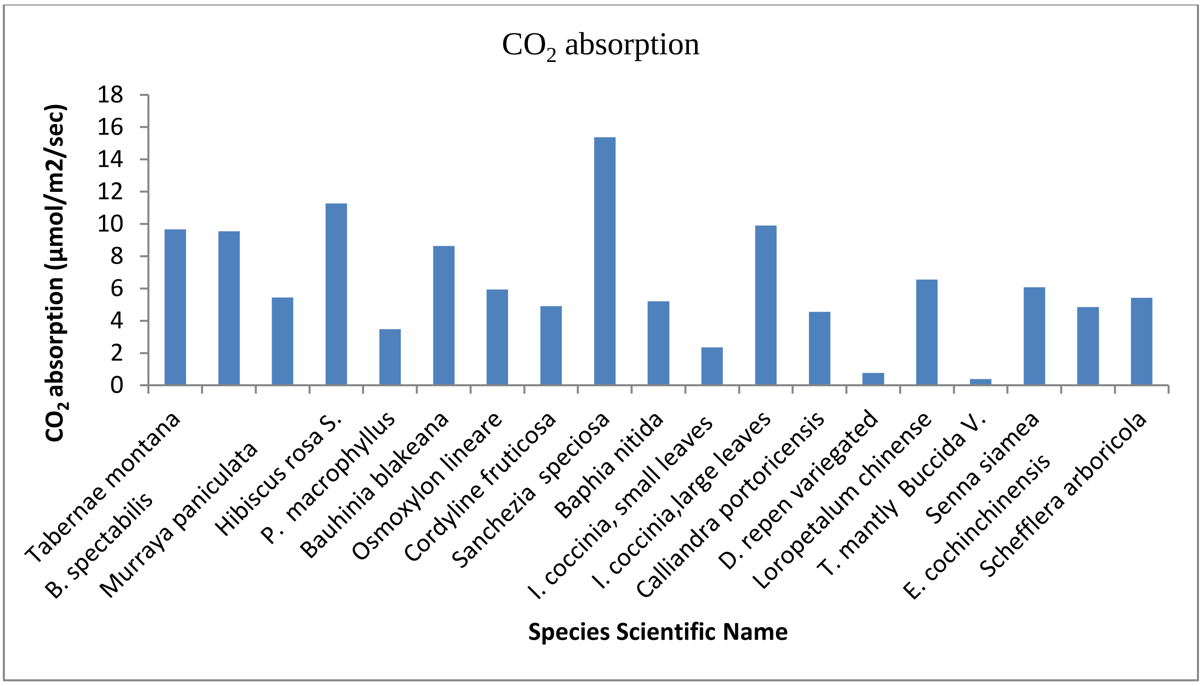

Fig. 3 Graph showing CO_2 absorption

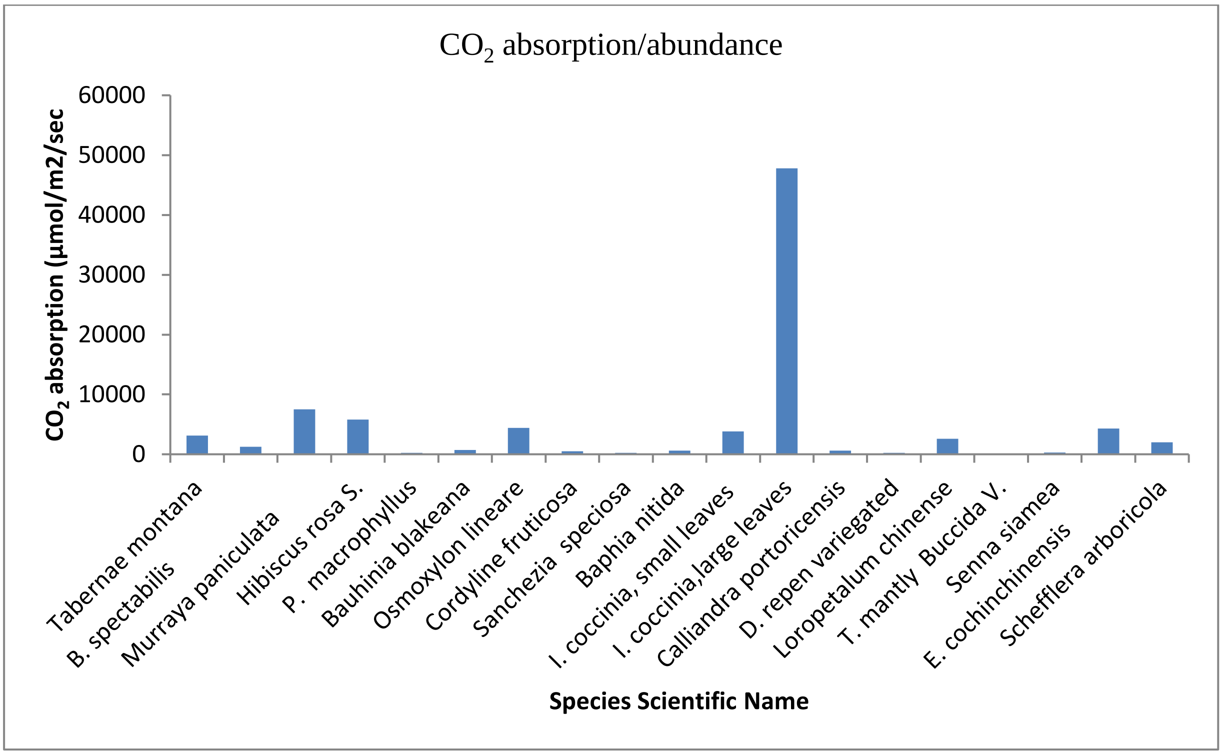

Fig. 4 Graph Showing CO_2 absorption/abundance

followed by *Murraya paniculata* (7489.9808 µmol m-^{2} s-^{1}), and *Hibiscus rosa* on species abundance. The overall total diurnal CO_2 absorption for all the species is 86061.9053 µmol m-^{2} s-^{1}, in the abundance of the species.

5. Conclusion

Shrubs in urban setting play a significant role in the reduction of atmospheric carbon dioxide level. From the result obtained, it can be concluded that CO_2 absorption and sequestration determined for nineteen most common shrubs species shows that *Baphia nitida* has a highest and better CO_2 sequestration rate of (1.062 kg), and *Sanchezia speciosa* was found to have the highest CO_2 absorption (15.3667 µmol m^{-2} s^{-1}). Therefore, *Baphia nitida*, *Sanchezia speciosa* sequestered CO_2 better when compared to other species and therefore could be recommended for the planting of more species in the university campus for better sequestration and assimilation of carbon from the atmosphere and to enrich the quality of air on campus and the nearby community.

Essentially, the shrub plants play a key role in absorbing the excess CO_2, thus reducing the negative effect on the environment and making it conducive and habitable for (UTHM) community. However, more research should be carried out on the uncommon shrubs in the campus using the non-destructive method to have a better knowledge on the role shrubs play in sequestering CO_2. In a wider perspective, building a low-carbon society will be ensured. Finally, the plants' function in providing shelter, erosion control, and a green beautification of the environment, the evergreen vegetation may provide the wildlife with food, protection and a nesting ground.

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