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ORIGINAL RESEARCH

Estimation of carbon stock of trees in urban parking lots of the Federal University OF Technology, Akure, Nigeria (Futa)

A.I. Okunlola*, M.A. Opeyemi, A.O. Adepoju, V.A.J. Adekunle

Department of Crop, Soil and Pest Management, The Federal University of Technology Akure, Nigeria

***Corresponding Author:** E-mail: okunlolaa1.hort@gmail.com

ABSTRACT

Trees in University parking lots are of utmost importance as it helps to provide shade for parked vehicles and man. In addition, the trees are very valuable as carbon sink. The current and potential carbon stock of trees in different parking lots located at the Federal University of Technology Akure (FUTA), were assessed to evaluate their contribution to climate change mitigation. The total carbon stocks (TCS) of all live trees were determined by the non-destructive method using tree density and volume (Newton's formulae). Regression models were developed for the prediction of carbon stock (CCS) of each tree with their corresponding age. The DBH, diameters at the top (Dt), middle (Dm), and base (Db) and the total height of every tree in the selected parking lots were measured. The carbon stock of individual tree is estimated at 50% of its biomass. This study showed that Terminalia cattapa stored the highest carbon with respect to other tree species in the university parking lots by frequency and it is strongly recommended for planting in university parking lots for effective trapping of atmospheric carbon to mollify global warming and its adverse effects.

Keywords: Carbon (iv) oxide, Tree Biomass, Tree density, Tree Volume.

Introduction

The increase in developmental activities alongside transportation have led to the increase in the amount of air pollutants such as greenhouse gases, especially carbon(iv) oxide (CO_2) (Kabisch, 2013) resulting in increased atmospheric temperature through the trapping of certain wavelengths of heat radiation in the atmosphere. Trees act as a sink for CO_2 through photosynthesis, they also store carbon as biomass; reducing the concentration of this gas and its negative effect on the atmosphere (Comess et al., 2002).

The earth's atmospheric CO_2 and other greenhouse gases (GHGs) have made our planet to be warmer than it would otherwise be. As the level CO_2 rises, the planet mean temperature also increases. Ultimately, as long as the concentration of carbon flowing into the atmosphere as carbon(iv)oxide (CO_2) and out in form of plant material and dissolved carbon are balanced, the carbon level in the atmosphere will remain constant (Nowak D. G., 2013).

Trees actas major CO_2 sink which size carbon from the atmosphere and acts as sink or storage, and stores the carbon in the form of a fixed biomass during its growing process. Therefore, growing trees in urban parking lots is an additional advantage in reducing the concentration of carbon(iv)oxide (CO_2) in the atmosphere by carbon accumulation inbiomass form. As trees grow and their biomass increases, they absorb carbon dioxide from its immediate atmosphere and store it in plant tissues resulting in growth of different parts (Grahn, 2003). Active absorption of CO_2 from the atmosphere in photosynthetic process and its subsequent storage in thegrowing tree biomass or plants is the carbon storage. In terms of atmospheric carbon reduction trees in the urban surroundings (such as parking lots, gardens) offer the double benefit of direct carbonsink (Zhenga, 2013). Therefore, tree growth through CO_2fixation by photosynthesis has the potential of decreasing concentration of carbon in the atmosphere (Chavan and Rasal, 2010). As trees grow in size and shape and their biomass increases, they absorb carbon from the atmosphere and store it in the plant tissues resulting in growth of different parts which in turns decrease environmental pollution concentration. However this can be accomplished with the presence or establishment urban green infrastructure. Unfortunately, research efforts have not been intensified to estimate the efficiency of the urban trees greens in reducing air pollution through carbon stock beside other benefits. In Nigeria as it has been reported that carbon dioxide use by trees during photosynthesis varies from species to species (Chavan and Rasal, 2010). Hence, this research work is set to estimate tree species efficiency and carbon storage in Akure, Ondo State Nigeria. Hence, the study aim is to evaluate the amount of carbon stored in the different tree species in the study site which shows the extent of carbon sequestered over the years and the potential future capacity of the trees to store more carbon.

Materials and Method

Study area

The study was conducted at the parking lots of the Federal University of Technology, Akure (FUTA). The University is located on latitude $7^0$18'18.48" and longitude $5^0$8'20.65". FUTA is situated in Akure, capital of Ondo State, Nigeria. Ondo State is located in the South-Western part of Nigeria and lies between latitude 50 45" and 80 15" North and longitude 40 30" and 60 East. The climate of the State is humid and hot, the rainy season is from April to October, with 1524mm rainfall per year (approximately). The temperature varies from 28^0 c to 31^0 c with mean annual relative humidity of about 80%.

Methods of data collection

This university consists of fourteen (14) parking lots located in areas that are occupied by buildings for teachingand learning,laboratories, administrative blocks, students' hostels and staff residents. Tenparking lots in the university were chosen at random which indicated 80% of the sampling size. All the trees in each of the selected parking lots were enumerated so as to get accurate result. The total carbon stock (kg) of each tree species was determined by non-destructive methods which include, field inventory exercise and the use of allometric equations and the following growth variables were measured on each tree in the selected parking lots: Diameter at breast height (cm)which was measured withgirth/diameter tape, Height (m), diameter middle, and the top(cm) all measured with a standard metric relaskop. DBH for each species was measured at 1.3 meter from surface of the soil to obtain the basal area (m^2). Diameter at the base (DB), Diameter at the middle (DM), Diameter at the top (DT), and total Height (HT) of all the trees in study area were measured for volume estimation (m^3).

Both the botanical and the common names of all living trees encountered at the parking lots were identified. When a tree's botanical name was not known immediately, it was identified by its local name or commercial name. Such local name or commercial name was translated to its correct botanical names by using (Keay, 1989). Each tree was recorded individually on the field and possible effort was made not to omit any eligible stem in the parking lots. This is because any species omitted will indicate that such species is absent in the parking lot.

Method of data analysis

After obtaining the variables for volume estimation, the following were determined using Microsoft Excel.

Volume of Each Tree: $V = \frac{\pi Ht}{24}(Db^2 + 4(Dm^2) + Dt^2)$

Where: π = 3.142, Ht = Height of the tree, Db=Diameter at the base, Dm = Diameter at the middle, Dt = Diameter at the top.The biomass contained within each three was then calculated following the allometric equation of Hall *et al* (2001) as Biomass **=** Density x Volume. The value for specific density of each tree species was obtained from literature such as the Timber Mechanics Division forest Research institute, 2012 and the internet, And the current potential carbon stock was estimated to be 50 percent of the total biomass.

The potential carbon stock was calculated by relating the current carbon stock of each tree in each parking lot with their corresponding ages which was obtained from the records in the university library as all trees in the parking lot were established the same year with the establishment of the buildings around them. This was executed by using the current individual tree carbon in relation with the age of each trees to project (predict) the future carbon stock of the trees in the next 10 years. The potential carbon stock was estimated with the formula by (Burnham and Anderson, 2002).

Results

The frequency the tree species and their total number in each parking lot were estimated (table 2). The table 2 showed the sampled different parking lots in Federal University of Technology Akure. The table 3 showed the total current carbon stock of tree species based on their frequencies in each parking lot. It showed that *Terminaliacattapa*stores the highest carbon with respect to frequency and biomass urban parking lots.

Table 1. list of trees in each FUTA urban parking lot.

No.	Parking lot	Tree species	Common name	Total number of tree
1	Microbiology/PhysicsDept	*Terminaliacattapa*	Almond fruit tree	3
2	Senate Building	*Terminaliacattapa,*	Almond fruit tree	26
		Bauhinia purpureum	Orchid tree	
3	School of engineering and engineering Technology	*Terminaliacattapa,*	Almond fruit tree,	15
		Magniferaindica	Mango tree	
4	School of agriculture and agricultural Technology	*Terminaliacattapa,*	Almond fruit tree	39
		Azadiracthtaindica	Neem	
		Huracrepitans	Possum tree	
		Delonixregia	Flamboyant tree	
		Adenantherapavonina	Red lucky seed	
		Ceibapenthandra	Kapok tree	
		Polyalthialongifolia	Masquarade tree	
		Pinuscaribaea	Pine	
5	Center for continuous education	*Terminaliacattapa*	Almond fruit tree	14
6	School of environmental Technology	*Terminal cattapa*	Almond fruit tree	Eight (8)
7	School of earth and minerial resources	*Terminal cattapa*	Almond fruit tree	Twenty one (21)
8	School of managemet Technology/ Central laboratory	*Terminal cattapa*	Almond fruit tree	Nine (9)
		Bauhinia purpureum	Orchid tree	
9	School of sciences	*Terminaliacattapa,*	Almond fruit tree	Sixteen (16)
		Pinuscaribaea	Carribean Pine tree	
10	SAAT extension/Annex	*Terminaliacattapa*	Almond fruit tree	Eighteen (18)

This is due to itsabundance in the parking lots. It dominated most of the parking lots on the campus.The table 4 showed the total potential carbon stock of tree species with a projected year of 10years in each parking lot.

The result showed that each trees tends to store more carbon in relation to the projected year of 10years. Furthermore, *Terminalia cattapa* shows more tendencies to store more carbon than other species in FUTA parking lots. *Terminaliacattapa and Polyalthialongifolia*stores more carbon compared to other pioneer species that were identified in this study in order to assess which of the pioneer species stores more carbon.

Trees with large D.T, D.M, D.B and Height stored more carbon compare to small D.T, D.M, D.B and Height. It showed by total frequency of *Terminaliacattapa*that stored 1835.91 kg C in the parking lot 1 followed by *Polyalthialongifolia* that stores 1218.00 kg C while other specie store lower carbon.

Table 2. List of urban parking lots with trees in FUTA.

Lot number	Locations of the parking lots
LOT 1	School of earth and mineral resources (SEMS)
LOT 2	School of environmental Technology (SET)
LOT 3	School of sciences (SOS)
LOT 4	School of management technology (SMAT)/ Central laboratory
LOT 5	Senate
LOT 6	School of engineering and engineering Technology (SEET)
LOT 7	Center for continuous education (CCE)
LOT 8	Physics/Microbiology
LOT 9	School of agriculture and agricultural Technology (SAAT)
LOT 10	SAAT Annex

Discussion

This work recorded only ten parking lots comprises of trees. Total of 168 individuals of trees were identifiedwithin the ten urban parking lots at the university premises.Onlyone parking lot (Lot 9) consist all the named species. The tree frequency in each FUTA parking lots as showed in table 1 and 2.The dominant species in these parking lots was*Terminalia cattapa*. Table 3 showed the trees species in each parking lot, the tree frequency, tree biomass and the tree species total carbon stock.

The analysis of table 3 showed that *Terminalia cattapa* stored the highest carbon than other tree species (*Magnifera indica, Bauhinia purpurea, Pinuscaribaea, Delonix regia, Hura crepitan, Polyalthia longifolia, Ceiba penthandra, Adenanthera pavonina and Azadiracthta Indica*) in FUTA parking lots.

At the 10 year projects a significantly larger gap is forming between the current and potential carbon stocks. In the 10-year periodof 2015 to 2025, the tree species in the parking lots are expected to store more carbontwice its current carbon amount (Pouyat, 2002).

Table 3. Total current carbon stock of trees in FUTA parking lots.

Parking lot	Species	Family	Frequency	Biomass	Total carbon stock (Kg)
Lot 1	T. cattapa	Combretaceae	21	3671.82	1835.91
Lot 2	T. cattapa	Combretaceae	8	1296.9	648.45
Lot 3	T. cattapa	Combretaceae	14	1813.04	906.52
	P. caribaea	Pinaceae	2	337	168.50
Lot 4	T. cattapa	Combretaceae	4	275.7	137.85
	B. purpurea	Leguminosae	5	140.16	70.08
Lot 5	T. cattapa	Combretaceae	20	1446.96	723.48
	B. purpurea	Leguminosae	6	462.76	231.38
Lot 6	T. cattapa	Combretaceae	9	301.46	150.73
	M. indica	Anacardiaceae	5	526.78	263.39
Lot 7	T. cattapa	Combretaceae	14	365.22	182.61
Lot 8	T. cattapa	Combretaceae	3	731.54	365.77
Lot 9	T. cattapa	Combretaceae	12	398	199.00
	A.indica	Meliaceae	2	508	254.00
	H.crepitan	Euphorbiaceae	5	1688	844.00
	D.regia	Fabaceae	6	1710	855.00
	A.Pavonina	Leguminosae	1	286	143.00
	C.penthandra	Malvaceae	1	528	264.00
	P.longifolia	Annonaceae	6	2436	1218.00
	P.caribaea	Pinaceae	6	846	423.00
Lot 10	T. cattapa	Combretaceae	18	891.06	445.53

Terminalia cattapa however has a life expectancy that nearly doubles other species leaving much room for the tree to increase in size and subsequently, carbon stock capacities. In another 10, years the tree species have doubled their carbon stock capacity. Until the tree species begin to reach their ultimate lifespan and die off, (Streck and Scholz, 2006) they will continue to store relatively the same quantity of carbon from year to year. Through each of the study years that were analysed for carbon storage, *Terminalia cattapa* was the most productive. *Polyalthia longifolia, Delonix regia* and *Huracrepitans* also showed a steady progression of carbon storage through the 10 year projection.

Table 4. Total Potential carbon stock of trees in FUTA parking lots for 10Years.

Parking lot	Species	Family	Frequency	Age of trees	Current carbon stock (Kg)	Potential carbon stock (Kg)
Lot 1	T. cattapa	Combretaceae	21	9	1835.91	3875.81
Lot 2	T. cattapa	Combretaceae	8	10	648.45	1296.90
Lot 3	T. cattapa	Combretaceae	14	17	906.52	1439.77
	P. caribaea	Pinaceae	2	17	168.50	267.62
Lot 4	T. cattapa	Combretaceae	4	5	137.85	413.55
	B. purpurea	Leguminosae	5	5	70.08	210.24
Lot 5	T. cattapa	Combretaceae	20	20	723.48	1085.22
	B. purpurea	Leguminosae	6	20	231.38	347.07
Lot 6	T. cattapa	Combretaceae	9	3	150.73	653.16
	M. indica	Anacardiaceae	5	25	263.39	368.75
Lot 7	T. cattapa	Combretaceae	14	11	182.61	348.62
Lot 8	T. cattapa	Combretaceae	3	27	365.77	501.24
Lot 9	T. cattapa	Combretaceae	12	13	199.00	352.08
	A.indica	Meliaceae	2	25	254.00	355.60
	H.crepitan	Euphorbiaceae	5	25	844.00	1181.60
	D.regia	Fabaceae	6	25	855.00	1197.00
	A.Pavonina	Leguminosae	1	25	143.00	200.20
	C.penthandra	Malvaceae	1	25	264.00	369.60
	P.longifolia	Annonaceae	6	25	1218.00	1705.20
	P.caribaea	Pinaceae	6	25	423.00	592.20
Lot 10	T. cattapa	Combretaceae	18	4	445.53	1559.36

Terminalia cattapa, Polyalthia longifolia, Delonix regia and *Huracrepitans* were expected to produce higher results in the 2025 projection based on height and diameter and also their frequency, though has the ability of storing carbon values greater than the lot average. *Bauhiniapurpurea*, *Adenanthera pavonina, Ceiba penthandra, Pinus caribaea* were four species that showed lower storage capabilities compared to the other species in the study.This analysis of projected 10 years carbon stocks demonstrates the dramatic increase in carbon stock considering the site's overall tree growth. The progressive increase of the lots over the 10 year period shows immense capacities of carbon stored by the trees on this lot, helping to improve the urban setting of Federal University of Technology, Akure. The success of the tree species in the parking lots in storing carbon over the next few decades ultimately relies on the types of trees that occupy the lots and the growth capacities that characterize them (Jackson, 2003). While the emphasis is placed on size and frequency when it comes to carbon storage, smaller specimens have their place in tree stands as well (Baisden, 2006). Despite inability to store as much carbon as their larger trees, smaller species contribute to pollution remediation, and wildlife habitat(Davies, 2011). Every individual counts.

The major concern should be matching tree growth and site characteristics. The connection between these two reforestation factors will be important in promoting tree health (Haase, 2013). Proper tree selection will result in the total productivity of the parking lots and make a sustainable urban environment more attainable (Nowak, 2002). However, total count of tree species indicates the amount of carbon stored by each species.

Therefore, more trees should be planted to sustained carbon balance in the atmosphere (Hutyra, 2011). Carbon balance means total carbon output equal the carbon stored. It is also observed that the carbon stored by each species is dependent on Diameter at the Middle (D.M), Diameter at Breast Height (D.B.H), Diameter at the top (D.T) and the Height (H.T) of the tree.

Conclusion

*Terminaliacattapa and Polyalthialongifolia*stores more carbon compared to other pioneer species that were identified in this study in order to assess which of the pioneer species stores more carbon. Trees with large D.T, D.M, D.B and Height stored more carbon compare to small D.T, D.M, D.B and Height. Therefore, planting of these species in an urban parking lot in our immediate environment is very necessary to reduce global warming, later reduce amount of carbon(iv)oxide in the atmosphere. However in measuring carbon sink in trees, data from carbon stock in soil is also important and will reveal carbon balance in an ecosystem.

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