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Assessing the Carbon Sequestration Potentials of Indigenous Trees among Academic Parks in Federal University of Agriculture, Abeokuta, Nigeria

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ABSTRACT: Air quality, cool air temperatures, as well as captured carbon are enhanced by trees on campus. Human activities in and around academic areas within the university indicate possible high level of Carbon dioxide in thoe specific areas. Therefore, the objective of this study is to assess the Carbon capture potentials of indigenous trees in selected academic area parks (COLAMRUD Park, COLANIM Park, COLERM Park, Motion Ground Park and Multi-purpose Building Park) of Federal University of Agriculture Abeokuta, Nigeria using a non-destructive sampling technique. Results show that there are a total of 10 different tree species across the parks some of which include; *Azadiratcha indicia, Albezia lebbeck, Entandrophragma cylindricum, Khaya senegalensis* and *Mangifera indica*. The weight of Carbon captured was observed to be highest in the *Entadophragma cylindricum* (19.68 x 10^6 kgm^{-2}) followed by *Cedrela ordorata* (10.84 x 10^6 kgm^{-2}) while the least was *Cola millenni* (1.43 x 10^6 kgm^{-2}). Carbon capture potential was significantly ($p<0.05$) higher (2.90 x 10^6) at MPB park when compared with others. The native species carbon sequestration order is; EC>SS>CO>MI>AI>AL>KS>SM>TR>PL. The presence of trees on university campus boosts carbon sequestration, clear-felling of these trees species while constructing new structures should be extremely reduced and more trees should be introduced in places with much human daily activities.

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Carbon dioxide concentrations in the atmosphere can be modified either by altering the usage of energy, lessening the request for energy or increasing the degrees of elimination of CO_2 via the trees through carbon sequestration (Indian Infrastructure Report, 2010). Urban green space as well as urban forest comprise of garden trees, parks trees, campus trees and those trees found along the roads, streets and waterway metropolis (Ugle *et al.,* 2010). Urban spaces offer a variety of ecosystem services such as improving air quality, cushioning of noise pollution and biodiversity conservation (Singh *et al.*, 2018). According to Strohbach *et al.,* (2012), findings of quite a lot of researchers have shown that urban green spaces are be able to play a seemly central role in restraining the carbon impact in the city. The soil and vegetation of green space directly contribute to a reduction in atmospheric CO_2 concentration and similarly affect the carbon balance indirectly, through their effects on the urban energy balance and thus on CO_2 emissions

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linked to energy consumption (Churkina *et al.,* 2016). These invariably lead to the promotion of the standards of urban living through abetting the comfort and health of the people by lessening stress and facilitating relaxation. A collection of communal services such as spiritual and religious, recreational, ecotourism and aesthetics are delivered by urban green spaces (Chang *et al.,* 2017). There are five key carbon pools of a terrestrial ecosystem involving biomass these are; above-ground biomass, below-ground biomass, dead wood, litter and soil organic matter. Consequently, urban green spaces can inhibit atmospheric carbon in three ways (Intergovernmental Panel on Climate Change, 2006). First of all, through the autotrophs which take up carbon dioxide from the atmosphere, release part of it back and store the remnants in the plant tissues below and above ground with a resultant effect in the plant growth in the form of biomass. Hence, trees are considered to be the major carbon sponges or sinks (Kruize *et al*., 2019). There is retention of carbon assimilated by trees for longer period with slight leakage back into the atmosphere and also, annual rates of carbon seizure is basically dependent on the size of the tree at maturity, growth rates and life span (Nowak *et al.* 2002). The biomass either goes into the food chain or the soil as soil carbon after the trees die (Keryn *et al.* 2022). Moreover, the soils are another dominant contributor to the carbon stocks. Litter and woody debris are not a major carbon pool as they contribute only a small fraction to the total carbon sinks. Lastly, the demand for cooling houses or office blocks through the provision of shade and evapotranspiration plus heating living spaces by reducing wind speed is decreased by urban vegetation. Subsequently, the burden on fossil fuel burning to generate electricity is eased, thus counteracting carbon emissions (Jo, 2002). Large expanse of land for urban tree plantations offered by big university campuses can be a prospective solution for climate change mitigation. Realization of the amount of carbon an urban green space is able to offer is obliging due to the fact that it can assist a university campus cherish its green spaces and counterbalancing its emissions (Gavali *et al.* 2016). Federal University of Agriculture, Abeokuta is a large community housing students and staff that go through daily activities that lead to the emission of carbon dioxide to the University environment which is harmful to all that is within and outside its premises. Several structural development are ongoing in the study area that leads to the destruction of indigenous tree species with little or no replacement. However, little or no data have been recorded on the sequestration of Carbon within the Campus especially academic area parks with high vehicular movement. The University each year experiences an increasing number of students, staff, buildings and consequently carbon emitting gadgets and machines such as cars, generators, and farm machineries, hence the need to assess the sequestration capacity of trees within the campus. Therefore, the objective of this study is to assess the carbon capture potentials of indigenous trees in selected academic area parks (COLAMRUD Park, COLANIM Park, COLERM Park, Motion Ground Park and Multi-purpose Building Park) of Federal University of Agriculture Abeokuta, Nigeria.

MATERIALS AND METHODS

Description of the study area: This study was carried out in Federal University of Agriculture, Abeokuta (FUNAAB) south-western region of Nigeria. This area lies within Latitude 7°N and 7°58 and Longitude 3°20'E and 3°37'E in a tropical climate with a bimodal distribution of rainfall; it lies within the humid lowland tropical rainfall with two distinct seasons (the wet season from March to October and the dry season from November to February). The mean annual rainfall is about 1113mm which peaks in July and September. The relative humidity of the area is 82.4% and average monthly temperature of 35.8°C (Aiboni, 2001). Five different parks where human activities were evident within the academic areas of the university were purposively selected for this study.

Academic area parks assessed: The academic area parks being assessed were COLAMRUD Park (College of Agricultural Management and Rural Development; COLANIM park (College of Animal Science and Livestock Production; COLERM Park (College of Environmental Resources Management);
Motion Ground frontage (MG)
Multipurpose Building (MPB)

Indigenous trees encountered across the five parks: The botanical names of indigenous trees encountered across the five parks are *Azadiratcha indica* (AI); *Albezia lebbeck* (AL); *Cedrela odorata* (CO); *Entandrophragma cylindricum* (EC); *Khaya senegalensis* (KS); *Mangifera indica* (MI); *Cassia fistuta* (CF); *Spondias mombin* (SM); *Senna siamea* (SS); *Cola millenii* (CM).

Measurement of girth and tree height: Measurement of tree height and GBH (Girth at Breast Height) of indigenous trees in the four academic area parks on campus was achieved using a non-destructive approach. The girth of individual tree species was obtained with girthing tape. Tree Height was measured using Haga Altimeter which was standardized before usage depending on the height.

Estimation of the sequestered Carbon: In order to estimate amount of carbon sequestered in the indigenous trees assessed, the Total green volume of the tree, dry weight of the tree and the weight of carbon in the tree were determined.

Tree total green weight: The Total green weight of the tree = W X 120 % (since the root system weighs about 20 % as much as the above-ground biomass of the tree). Above Ground Biomass (ABG) for each tree was obtained by adopting an algorithm by Clark *et al.* (1986).

For trees with D < 11; $W = 0.25D^2 H$
For trees with D $\geq$ 11; $W = 0.15D^2 H$

Where W = Above Ground Biomass (kg); D = Girth at Breast Height (cm); H = Height of the tree in metres (m)

Dry weight of the tree: This was calculated using the method of Aboal *et al*., (2005) and DeWald *et al*., (2005), an average tree is 72.5 % and 27.5 % dry matter and moisture respectively taking all species into account. The dry weight of the tree was therefore determined by multiplying the total green weight of the tree by 72.5 %.

Weight of carbon in the tree: The average carbon content is normally 50 % of the trees total volume (Birdsey, 1992; Aboal *et al.* 2005). Therefore, the dry weight of the tree was multiplied by 50 % in order to determine the weight of carbon in the tree.

Statistical analysis: The obtained data were subjected to descriptive and inferential statistics using Statistical Package for Social Sciences (SPSS). Duncan's Multiple Range Test was used for means separation, at $p < 0.05$.

RESULTS AND DISCUSSIONS

A total of 10 trees which belong to ten different species were identified at different parks on campus with the carbon sequestration potential of 2.90×10^6 kgm^{-2}.

Girth at Breast Height (GBH) of tree species: Entadophragma cylindricum (452 cm) at Motion Ground Park had the highest Girth at Breast Height while the lowest value was obtained at COLERM in *Cassia fistuta* (62 cm). Girth at Breast Height was significantly different ($p<0.05$) between the parks assessed (Table 1).

Height of tree species: Albezia lebbeck was the shortest (1200 cm) as well as the tallest (1900 cm) indigenous tree species recorded across the parks assessed. They were identified at Motion Ground and Multipurpose Building respectively (Table 2).

Table 1: Girth at Breast Height (GBH) of tree species at different parks (cm)

	Parks				
Trees	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
Azadiratcha indica (AI)	-	252^{d}	149^{k}	-	-
Albezia lebbeck (AL)	-	-	-	153^{j}	227^{g}
Cedrela odorata (CO)	-	-	308^{b}	-	-
Entandrophragma cylindricum (EC)	-	-	-	452^{a}	-
Khaya senegalensis (KS)	-	213^{h}	-	-	149^{k}
Mangifera indica (MI)	-	-	-	-	286^{c}
Cassia fistuta (CF)	-	-	62^{n}	-	-
Spondias mombin (SM)	-	-	-	-	232^{f}
Senna siamea (SS)	-	-	240^{f}	-	200^{i}
Cola millenii (CM)	129^{m}	-	-	144^{l}	-

Means with different superscripts in the same column indicate significant difference at p<0.05 (DMRT)

Table 2: Height of tree species at different parks (cm)

	Parks				
Trees	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
AI	-	1475^{f}	1530^{ef}	-	-
AL	-	-	-	1200^{g}	1900^{a}
CO	-	-	1750^{bc}	-	-
EC	-	-	-	1476^{f}	-
KS	-	1600^{def}	-	-	1680^{bcd}
MI	-	-	-	-	1800^{ab}
CF	-	-	1610^{def}	-	-
SM	-	-	-	-	1655^{cde}
SS	-	-	1800^{ab}	-	1800^{ab}
CM	1316^{g}	-	-	1303^{g}	-

Above Ground Biomass of Tree species: Above Ground Biomass (AGB) of the tree species ranged from 3.29 x 10^6 at COLAMRUD to 45.26 x 10^6 kgm^{-2} at Motion Ground park. *Cola millenii* had the lowest AGB and the highest value was recorded for *Entandrophragma cylindricum* (Table 3).

Total Biomass of tree species: Highest total biomass was observed as *Entadophragma cylindricum* at Motion Ground having 54.31 x 10^6 kgm^{-2} while it was lowest at COLAMRUD in *Cola millenii* having 3.95 x 10^6 kgm^{-2} (Table 4).

Dry weight of tree species: Dry Weight (DW) of tree species ranged from *Cola millenii* at COLAMRUD observed lowest as 2.86 x 10^6 to *Entadophragma cylindricum* at Motion Ground observed highest as 39.37 x 10^6 kgm^{-2} (Table 5).

Table 3: Comparison of Above Ground Biomass (kgm^{-2}) of tree species at different parks

		Parks			
Trees	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
AI	$14.06E6^{de}$	$5.10E6^{g}$	-	-	-
AL	-	-	-	$4.22E6^{gh}$	$14.69E6^{de}$
CO	-	-	$24.92E6^{b}$	-	-
EC	-	-	-	$45.26E6^{a}$	-
KS	-	$10.90E6^{f}$	-	-	$5.60E6^{g}$
MI	-	-		-	$22.10E6^{c}$
CF	-	-	$0.93E6^{i}$	-	-
SM	-	-	-	-	$13.37E6^{e}$
SS	-	-	$15.56E6^{d}$	-	$10.97E6^{f}$
CM	$3.29E6^{h}$	-	-	$4.06E6^{gh}$	-

Means with different superscripts in the same column indicate significant difference at $p<0.05$

Table 4: Total Biomass (TB) at different parks

			Parks		
Trees	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
AI	-	$16.87E6^{de}$	$6.12E6_{g}$	-	-
AL	-	-	-	$5.06E6_{gh}$	$17.63E6_{de}$
CO	-	-	$29.90E6_{b}$	-	-
EC	-	-	-	$54.31E6_{a}$	-
KS	-	$13.08E6_{f}$	-	-	$6.72E6_{g}$
MI	-	-	-	-	$26.52E6_{c}$
CF	-	-	$1.11E6_{i}$	-	-
SM	-	-	-	-	$16.05E6_{e}$
SS	-	-	$18.68E6_{d}$	-	$13.16E6_{f}$
TR	*$3.95E6_{h}$*	-	-	*$4.87E6_{gh}$*	-

Means with different superscripts in the same column indicate significant difference at $p<0.05$

Table 5: Dry Weight of tree species at different parks

			Parks		
Trees	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
AI	-	$12.23E6^{de}$	$4.44E6^{g}$	-	-
AL	-	-	-	$3.67E6^{gh}$	$12.78E6^{de}$
CO	-	-	$21.68E6^{b}$	-	-
EC	-	-	-	$39.37E6^{a}$	-
KS	-	$9.48E6^{f}$	-	-	$4.87E6^{g}$
MI	-	-	-	-	$19.22E6^{c}$
CF	-	-	$0.81E6^{i}$	-	-
SM	-	-	-	-	$11.63E6^{e}$
SS	-	-	$13.54E6^{d}$	-	$9.54E6^{f}$
TR	$2.86E6^{h}$	-	-	$3.53E6^{gh}$	-

Means with different superscripts in the same column indicate significant difference at $p<0.05$

Weight of Carbon of tree species: Weight of Carbon sequestered was significantly high in the following trees: *Entadophragma cylindricum* (19.68 x 10^6 kgm^{-2}), *Cedrela odorata* (10.84 x 10^6 kgm^{-2}) *Mangifera indica* (9.61 x 10^6 kgm^{-2}) at Motion ground, COLERM, and Multipurpose Building respectively. Trees that performed woefully in Carbon sequestration potentials are: Cola millenii (1.43 x 10^6 kgm^{-2}); (1.76 x 10^6 kgm^{-2}) and *Albezia lebbeck* (1.83 x 10^6 kgm^{-2}) at COLAMRUD, Motion Ground, and Motion Ground respectively (Table 6).

Means of parameters assessed: Multipurpose Building had the highest Carbon being sequestrated within selected Academic areas parks. COLAMRUD was the park with less Carbon absorbed when compared with others. Highest GBH, tree height, ABG, TB, DW and WC (109.40, 883.50, 6.85, 8.01, 5.81 and 2.90) were obtained at Multipurpose Building (Table 7).

Table 6: Weight of Carbon (WC) of individual tree species at different parks

	Parks				
Trees	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
AI	-	6.11E6[de]	2.22E6[g]	-	-
AL	-	-	-	1.83E6[gh]	6.39E6[de]
CO	-	-	10.84E6[b]	-	-
EC	-	-	-	19.68E6[a]	-
KS	-	4.74E6[f]	-	-	2.43E6[g]
MI	-	-	-	-	9.61E6[c]
CF	-	-	0.40E6[i]	-	-
SM	-	-	-	-	5.81E6[e]
SS	-	-	6.77E6[d]	-	4.77E6[f]
TR	1.43E6[h]	-	-	1.76E6[gh]	-

Means with different superscripts in the same column indicate significant difference at p<0.05

Table 7: Means of parameters assessed at different parks

	Parks				
Parameters	**COLAMRUD**	**COLANIM**	**COLERM**	**MG**	**MPB**
GBH	12.90[c]	46.50[bc]	75.90[ab]	74.90[ab]	109.40[a]
HT	131.60[c]	307.50[c]	689.00[ab]	397.90[bc]	883.50[a]
AGB	0.33E6[c]	2.50E6[bc]	4.65E6[ab]	5.35E6[ab]	6.85E6[a]
TB	0.40E6[c]	3.00E6[bc]	5.60E6[ab]	6.43E6[ab]	8.01E6[a]
DW	0.29E6[c]	2.17E6[bc]	4.05E6[ab]	4.66E6[ab]	5.81E6[a]
WC	0.14E6[c]	1.09E6[bc]	2.02E6[ab]	2.33E6[ab]	2.90E6[a]

Means with different superscripts in the same column indicate significant difference at p<0.05

Human activities in and around academic areas within the university indicate possible high levels of CO_2 in those specific areas. The amount of carbon sequestered varied with species and locations (parks). Carbon stocking and other nutrient assimilation and storage vary with different plant species and parts (Durrani *et al.* 2004; Chauhan, 2010; Narwaria and Kush, 2012). Park that sequestered the greatest carbon was Multi-purpose building followed by COLERM and COLAMRUD. The highest value obtained at Multipurpose building could be attributed to the corresponding high values of height and GBH at this park. This is an indication that the available tree species in this park are adapting to enormous carbon dioxide levels experienced here due to frequent human activities. *Entadophragma cylindricum* recorded the highest carbon sequestration even though it was not the tree species with the greatest height value. This corroborates the findings of Negi *et al.* (2003) and Sulpice *et al.* (2000) who reported that different tree species give varied responses to carbon consumption and the entire carbon captured would not partake in growth. Exposure of tree species to increased CO_2 from various human activities over a long period of time resulted in significant growth and biomass production at Multipurpose building even though Zepeda *et al.* (2022) and Bhatt, *et al.* (2010), reported that higher rates of photosynthesis do not lead to a corresponding rise in biomass and yield. This growth could be as a result of production of complementary photosynthetic enzymes and their division into several plant portions to finally increase the total biomass production. Total dry biomass accumulation stimulated high levels of CO_2 which is a conspicuous biological reaction to raised CO_2 (Righetti *et al.*, 1996). The results of Baker *et al.* (2005) supported that tree species covering photosynthetic rate is significantly influenced by CO_2 augmentation. Variation in the tree species Above Ground Biomass (AGB) recorded in this study substantiates the similar studies of Poorter and Nagel, 2000 in which tree species responded to a reduction in soil resources with an improvement in the biomass allocation to the roots.

Disparity in tree variables such as diameter height, and biomass recorded may be due to the significance of morphological and physiological characteristics that control the carbon sequestration in their various body parts. This is in consonance with the work of Johnson and Gerhold, (2001) as well as Khan and Miria, (2013) who reported that Carbon stocking varies among tree species even of the same diameter, The order of carbon sequestered across the parks assessed includes; MPB > MG > COLERM > COLANIM > COLAMRUD. The native species' carbon sequestration order is; EC>SS>CO>MI>AI>AL>KS>SM>TR>PL with *Entadophragma cylindricum* and *Cassia fistuta* having maximum and least carbon respectively. Hence, indigenous tree species have the potential for carbon sequestration.

Conclusion: The presence of many indigenous tree species on the university campus enhances carbon sequestration and this in turn encourages the conservation of these tree species. These tree species within the campus ecosystem not only beautify the academic areas but also have great carbon sequestration potential. The campus ecosystem should be filled with not only fast-growing indigenous tree species but also those capable of capturing more carbon, thereby enhancing cool air temperatures. More trees should be introduced in places with many human activities especially those that involve the emission of CO_2.

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