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EVALUATION OF CARBON SEQUESTRATION IN ABOVE-GROUND BIOMASS OF THREE AVENUE TREE SPECIES PLANTED IN UYO METROPOLIS, AKWA IBOM STATE, NIGERIA

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ABSTRACT

There is dearth of quantitative scientific information on carbon sequestration potentials of most commonly planted tree species in Nigerian urban areas, which are needed in the synergy for climate change mitigation and adaptation. Accordingly, three avenue tree species, viz: *Terminalia mantaly*, *Delonix regia* and *Hura crepitans*, of about thirteen years old planted along some avenues in Uyo metropolis, Akwa Ibom State, Nigeria were randomly sampled and assessed for carbon stocks in above-ground biomass. All the randomly sampled trees were measured for stem diameters and heights. Algorithm functions were employed for the determination of above-ground biomass and sequestered carbon. The data obtained were subjected to descriptive statistical analysis and one-way analysis of variance. Separation of means of significant differences between variables was done using least significant difference test. The results revealed that *D. regia* had the highest mean tree above-ground biomass of 1.58 ton and mean tree carbon stock of 0.79 ton, while *T. mantaly* had the least of 0.88 ton and 0.44 ton respectively for mean tree above-ground biomass and mean tree carbon stock. There were significant differences between the tree species above ground biomass and carbon stocks ($p<0.05$). The separation of means indicated that significant differences specifically occurred between *D. regia* and *T. mantaly; H. crepitans* and *T. mantaly*, while there was no significant difference between *D. regia* and *H. crepitan*. It is therefore concluded that *D. regia* should be the most preferred species for planting in the study area to mitigate global warming, because it had the highest mean tree above-ground biomass and carbon stock.

Keywords: Avenue trees; Above-ground biomass; carbon sequestration; Climate change; Mitigation

INTRODUCTION

Astronomical increase in human population in Nigerian towns and cities has caused considerable decimation of natural ecosystems through massive construction of houses, building of infrastructure and establishment of industrial estates (Soladoye and Oromakinde, 2013). The available infrastructural facilities in the cities have been over-stretched, while some have become dilapidated because of the pressures from heavy human population. The

Nigerian urban areas are generally characterised by environmental pollution (Eneh, 2011; Onuora *et al*., 2017). The atmosphere over the cities are usually heavily polluted with the exhaust fumes from industries and automobiles (Kuchelmeister, 2000; Ana and Ajewole, 2011). The exhaust fumes consist of obnoxious gases such as carbon dioxide, carbon monoxide, methane and nitrous oxide, which are greenhouse gases causing global warming and exacerbating climate change. Global warming phenomenon is more evident in the urban areas than in the rural villages where there are still appreciable tracts of natural vegetation, especially forest and presence of scanty automobiles (BOTH-END, 2007). Global warming, which is an increase in earth ambient temperature, is a phenomenon confronting the comfortable living of man on earth. The phenomenon of global warming is indeed a precursor of climate change.

Excessive carbon dioxide (CO_2) in the lower part of atmosphere (troposphere) has been identified as the principal gas causing global warming (IPCC, 2007). The gas absorbs infra-red radiation emitted by the earth and prevent it from escaping into space, thereby raises global temperature. However, trees have been identified to be an excellent biological purifier of atmosphere from CO_2 through the physiological processes of photosynthesis and biomass production (Sukhdev, 2010). The tropical forest trees are absorbing nearly five billion tonnes of CO_2 released yearly into the atmosphere through burning of fossil fuels and other sources thereby substantially buffering the rate of climate change (Sato, 2008 and Sukhdev, 2010).

The current urban renewal projects and infrastructural development being embarked upon in many Nigerian cities and towns have urban greening as one of its major components. The urban greening involves planting of trees along the major roads, open spaces and premises of public buildings to beautify and ameliorate the polluted atmospheres over the urban areas. Properly planned and executed urban afforestation constitutes a significant factor in carbon sequestration, carbon sink, carbon conservation and carbon substitution through the living trees that use carbon dioxide from the atmosphere for the processing photosynthesis and biomass production (Nowak and Daniel, 2002; Larinde, 2010 and CEI-BOIS 2006). About 90 percent of carbon stored in a tree is in the above-ground biomass (Akindele, 2004 and Abad, 2015). However, there is a dearth of quantitative scientific information on the carbon sequestration potentials of the commonly planted avenue tree species in Nigeria.

Thus, this study was carried out to assess carbon sequestration in the above-ground biomass of three avenue tree species planted along selected major avenues in Uyo metropolis, Akwa Ibom State, Nigeria. The information obtained would help in the choice of appropriate tree species for planting and its management to provide environmental and aesthetic benefits.

MATERIALS AND METHOD

Study Area

The study was carried out on the three avenue tree species planted along three major roads in Uyo city, Akwa Ibom State, Southern Nigeria (Figure 1a and 1b). The roads and planted tree species are Nsikak Eduok Avenue. *Terminalia mantaly*; Abak Road: *Hura crepitan* and Atiku Abubakar Avenue: *Delonix regia*. The distances of the roads vary between 3 – 5km. The trees were planted as seedlings at approximately 5 m apart between years 2006 and 2007. All the trees had been subjected to lopping on several occasions. The study area is in the rainforest belt, and lies between latitudes 4°59' and 5°04'N and longitudes 7°53' and 8°00'E. The mean annual rainfall is about 2500 mm with mean sunshine of 8.30

hours per day. The average relative humidity is 80% and mean temperature range is 26°C – 28°C (Akpabio and Chukukere, 2004). The soil texture is loamy sand (Ubom *et al*., 2013).

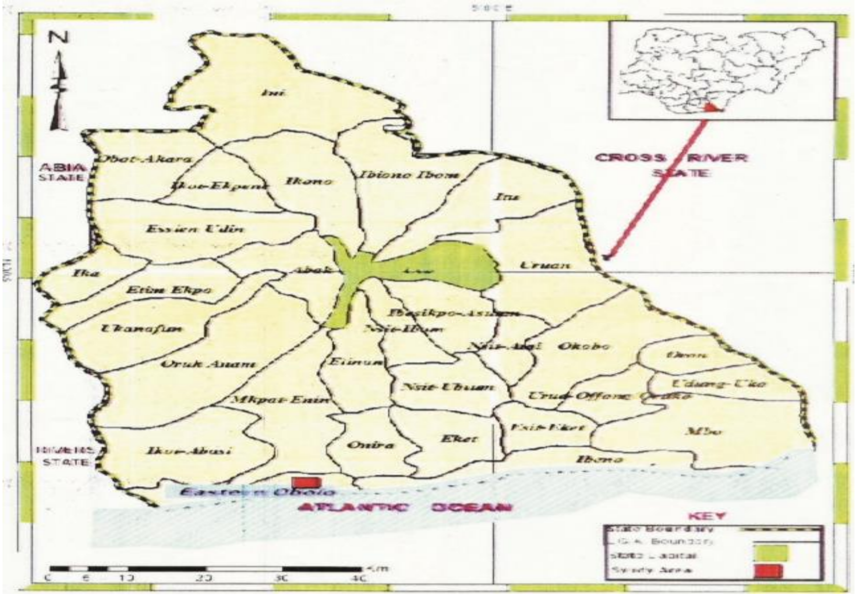

Figure 1a: Map of Akwa Ibom State showing the Study Area

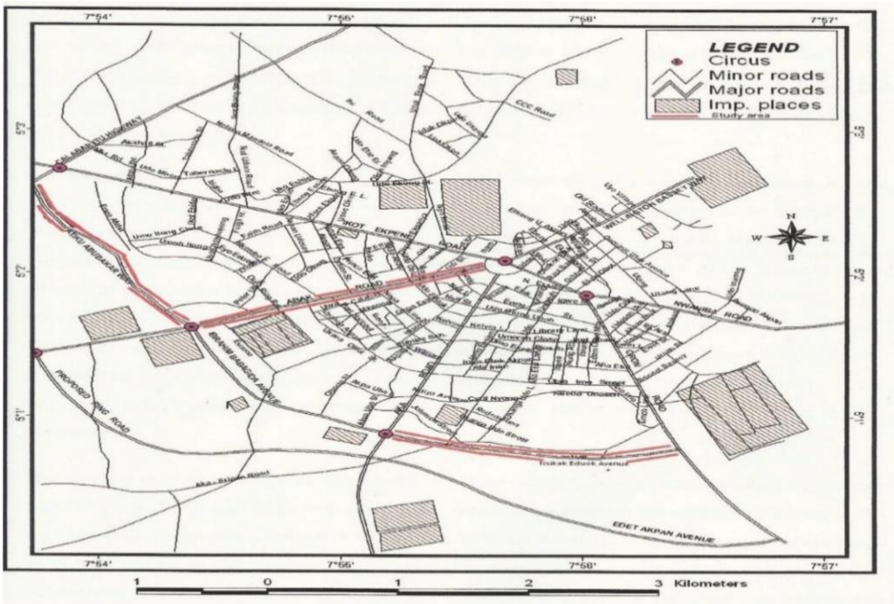

Figure 1b: Uyo Urban – the Study Area

Data Collection and Computation

All the trees along the three major roads were serially numbered with indelible paint. Subsequently, thirty percent of the population of the trees along each avenue was randomly selected for data collection. Thus, this translated to 31 stands of *Terminalia mantaly*, 29 and 30 for *Delonix regia* and *Hura crepitan* respectively. All the randomly selected trees were measured for stem diameter at the ground level using diameter-tape. For buttressed trees, stem diameter measurements were made above the buttresses. The trees' heights were measured using Suuto clinometer.

Determination of Above-Ground Green Weight of Trees

The algorithm functions of Alexander *et al.* (1986), which is the average of all tree species were employed to determine the above-ground green weight of the trees. The algorithm functions are expressed as:

$$W = 0.25D^2H \qquad (1)$$

For trees with $D \leq 28$ cm

$$W = 0.15D^2H \qquad (2)$$

For trees with $D > 28$ CM

Where, w = Above-ground green weight (ton), D = stem diameter (cm), H = total height of tree (m)

Determination of Above-Ground Dry Weight of Trees

The above-ground biomass of each standing tree was determined using the functions of Chavan and Rasal (2010) which provided the average dry weight for different tree species and stated that average tree is 72.5% dry matter and 27.5% moisture. The functions are expressed as:

$$DW = 0.25D^2H \times 0.725 \qquad (3)$$

When $D \leq 28$cm

$$DW = 0.15D^2H \times 0.275 \qquad (4)$$

When $D > 28$ cm

Where:

DW = Dry weight (tonn)
D = Stem diameter (cm)
H = Height of tree (m)

Computation of Sequestered Carbon in Above-Ground Biomass

The content of carbon in woody biomass is generally 50% of a tree volume (Paladinic *et al*., 2009; Afzal and Akhtar, 2013; Eneji *et al.*, 2014). Accordingly, the weight of carbon in a tree was computed by multiplying the dry weight of the tree by the factor 0.5.

Data Analysis

The data collected and obtained were subjected to descriptive statistical analysis and one-way analysis of variance was used to test the significant difference between the above-ground biomass and carbon stock or stored in the tree species using. The significant difference between the species was separated using the least significant difference test (LSD).

RESULTS

The stem diameters ranged from 22 – 55 cm (mean = 36.87 cm), 29 – 72 cm (mean = 48.86 cm) and 27 – 76 cm (mean = 48.87 cm) respectively for *T. mantaly*, *D. regia* and *H. crepitans* (Table 1). The tree's heights ranged from 4 – 7.2 m (mean = 5.52 m), 3 – 8 m (mean = 5.77 m) and 2.6 – 6.8 m (mean = 4.78 m) respectively for *T. mantaly*, *D. regia* and *H. crepitans* (Tables 2 and 5). The above-ground biomass of *T. mantaly* ranged from 0.32 – 1.84 tonn (mean = 0.88 tonn), while 0.46 – 3.61 tonn (mean = 1.58 tonn) for *D. regia* and 0.25 – 3.77 tonn (mean = 1.36 tonn) for *H. crepitans* (Tables 3 and 5). The sequestered carbon ranged from 0.16 – 0.92 (mean = 0.44 tonn) and 0.23 – 1.88 tonn (mean = 0.79 tonn) and 0.13 – 1.88 tonn (mean = 0.75 tonn) respectively for *T. mantaly*, *D. regia* and *H. crepitans* (Tables 4 and 5).

The analysis of variance of the above-ground biomass of the three tree species showed significant difference ($p<0.05$) among them (Table 2). The separation of the means for above-ground biomass indicated that differences occurred between *D. regia* and *T. mantaly; H. crepitans* and *T. mantaly* (Table 3). Similarly, the analysis of variance of the sequestered carbon indicated significant difference between the species (Table 4), while the separation of means also showed that differences really occurred between *D. regia* and *T. mantaly; H. crepitans* and *T. mantaly* (Table 5).

Table 1: Summary statistics of growth parameters and carbon stock in above-ground biomass of three avenue tree species in Uyo, Nigeria

Statistics	Diameter	Height	Biomass	Carbon
		T. mantaly		
Mean	36.87	5.52	0.88	0.44
Standard Deviation	5.91	0.74	0.35	0.18
Minimum	22	4	0.32	0.16
Maximum	55	7.2	1.84	0.92
Sum	1143	171	27.43	13.75
		D. regia		
Mean	48.86	5.77	1.58	0.79
Standard Deviation	9.66	1.28	0.82	0.41
Minimum	29	3	0.46	0.23
Maximum	72	8	3.61	1.8
Sum	1417	167.2	45.78	22.91
		H. crepitans		
Mean	48.87	4.78	1.36	0.75
Standard Deviation	15.00	1.05	1.00	0.55
Minimum	27	2.6	0.25	0.13
Maximum	76	6.8	3.77	1.88
Sum	1466	143.4	40.75	22.57

Table 2: Analysis of variance of above-ground biomass of three avenue tree species in Uyo, Akwa Ibom State, Nigeria

SV	df	SS	MS	F-ratio	F-critical
Species	2	7.59378	3.79689	6.393464*	3.101296
Error	87	5.166674	0.593871		
Total	89				

SV = source of variation, df = degree of freedom, SS = sum of squares, * = significant ($p<0.05$)

Table 3: Separation of the means' above-ground biomass

Species	Means' difference	LSD value
D-T	0.7	0.39*
D-H	0.22	0.40^{ns}
H-T	0.48	0.39*

D = *D. regia,* T = *T. mantaly, H. crepitans,* *significant ($p<0.05$), ns = not significant

Table 4: Analysis of variance of sequestered carbon in above-ground biomass of three avenue tree species in Uyo, Akwa Ibom State, Nigeria

SV	df	SS	MS	F-ratio	F-critical
Species	2	2.197933	1.098966	6.661958*	3.101296
Error	87	14.35165	0.164961		
Total	89	16.54958			

Table 5: Separation of the means' sequestered carbon

Species	Mean difference	LSD value
D-T	0.35	0.21*
D-H	0.04	0.21^{ns}
H-T	0.31	0.20*

D = *D. regia,* T = *T. mantaly, H. crepitans,* *significant ($p<0.05$), ns = not significant

DISCUSSION

Carbon sequestration capability of a tree species is a function of its morphological characteristic, growth-form, rates and efficiency of physiological processes of photosynthesis respiration and eventual biomass accumulation, which are dictated by its genetic composition. Thus, the variation in the estimated quantities of carbon sequestered in the above-ground biomass of the three tree species can be ascribed to their different growth rates which in this study are exemplified by different means' diameter at breast height (stem sizes) and means' tree height of the species. Most especially the difference in stem sizes might be accounted for the significant difference observed in the quantities of sequestered carbon in their above-ground biomass. It has been reported that much of the above-ground biomass of trees is in the stems, and consequently, the highest bulk of the carbon stock in trees is stored in the stems (Akindele, 2004; Olajide *et al*., 2012 and Abad, 2015). Moreover, the variation in the carbon stocks in the above-ground biomass of the tree species may also be ascribed to different gravities of injuries from unnecessary cuttings on them and other forms of abuse by the urban dwellers, which would invariably slow down their rates of biomass production and consequently slow the rate of carbon sequestration. It has been reported that urban trees are often subjected to various unhealthy treatments which vitiate or debase their capability to render environmental protection services (Kuchelmeister, 2000; Ana and Ajewole, 2011; Onyekwelu, 2013).

CONCLUSION

The rate of biomass production by a tree species would dictate the amount of its carbon sequestered or stored. Although there are no significant differences between *D. regia* and *H. crepitan* with respect to the means' tree above-ground biomass and carbon stock, but however, *D. regia* had the overall highest mean carbon stock. Therefore, *D. regia* should be the most preferred species for urban planting for the purpose of sequestrating carbon to ameliorate the phenomenon of global warming and mitigation of climate change.

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