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Determination of Wood Density of Selected Plant Species from the Luki Biosphere Reserve in the Democratic Republic of the Congo for Reforestation

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Abstract

This study was conducted on wood fragments of the forest species ***Canarium schweinfurthii***, ***Gilletiodendron kisantuense***, ***Milicia excelsa***, ***Rauvolfia vomitoria***, *and* ***Ricinodendron heudelotii***, collected from the Luki Biosphere Reserve in Kongo Central Province, Democratic Republic of the Congo, with the aim of determining the wood density of the different plant species under study. These parameters were determined using an experimental method involving oven-drying and water displacement techniques in an Erlenmeyer flask filled with water. The results obtained varied from one species to another and followed the following descending order: ***Gilletiodendron kisantuense*** *(0.90)*, ***Milicia excelsa*** *(0.78)*, ***Ricinodendron heudelotii*** *(0.63)*, ***Rauvolfia vomitoria*** *(0.61)*, *and* ***Canarium schweinfurthii*** (0.59). These values will contribute to the development of allometric equations necessary for estimating the amount

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of carbon sequestered in the tissues of the five species studied.

Subject Areas

Dentistry

Keywords

Density, Wood, Deforestation, Carbon, Biomass

1. Introduction

Global warming is a major concern, partly because of the increase in atmospheric carbon dioxide. The capacity of undisturbed Amazonian forests to absorb atmospheric carbon has been declining for approximately three decades, owing to increased tree mortality attributed to climate change [1]. African forests play an increasingly recognized global role in climate regulation by sequestering approximately 40 Gt of carbon [2]. With an estimated area of about 200 million ha in January 2020, including 184.7 million ha without visible signs of disturbance [3], they have become a major tropical forest massif for carbon sequestration [4].

Nearly 9% of the area of Central Africa's humid tropical forests has disappeared since 2000, corresponding to approximately 18 million ha [5]. Dense humid forests require further study to improve knowledge of biomass production and their capacity to produce organic matter [6]. Implementing mitigation strategies and combating climate change require accurate estimates of aboveground biomass and carbon stocks [7]. The objective of our study is to determine the wood density of some plant species from the Luki Biosphere Reserve, such as *Canarium schweinfurthii*, *Milicia excelsa* (see Figure 1 and Figure 2) and others. This parameter is involved in establishing allometric equations necessary for the evaluation of carbon sequestered in wood tissues.

Figure 1. *Canarium schweinfurthii Engl.* (*Burseraceae*) in its natural habitat. Photograph taken in the field in January 2026 in the Luki Biosphere Reserve, Kongo Central Province, Democratic Republic of the Congo. Photo: J. Luboya Muisangie.

Figure 2. *Milicia excelsa* (*Welw.*) *C.C. Berg* (*Moraceae*) in its natural habitat. Photograph taken in the field in January 2026 in the Luki Biosphere Reserve, Kongo Central Province, Democratic Republic of the Congo. Photo: J. Luboya Muisangie.

2. Materials and Methods

2.1. Study Area

The Luki Biosphere Reserve, located in Kongo Central Province (see Figure 3), constitutes an important natural laboratory for research. It covers approximately 32,700 to 33,000 hectares and contains 1050 to 1530 plant species distributed among 146 families. It has a humid tropical climate (AW5 according to the Köppen classification), characterized by two seasons: an eight-month rainy season and a four-month dry season.

Four soil types are found in the reserve: red soils, reddish-purple soils, yellow soils, and alluvial soils.

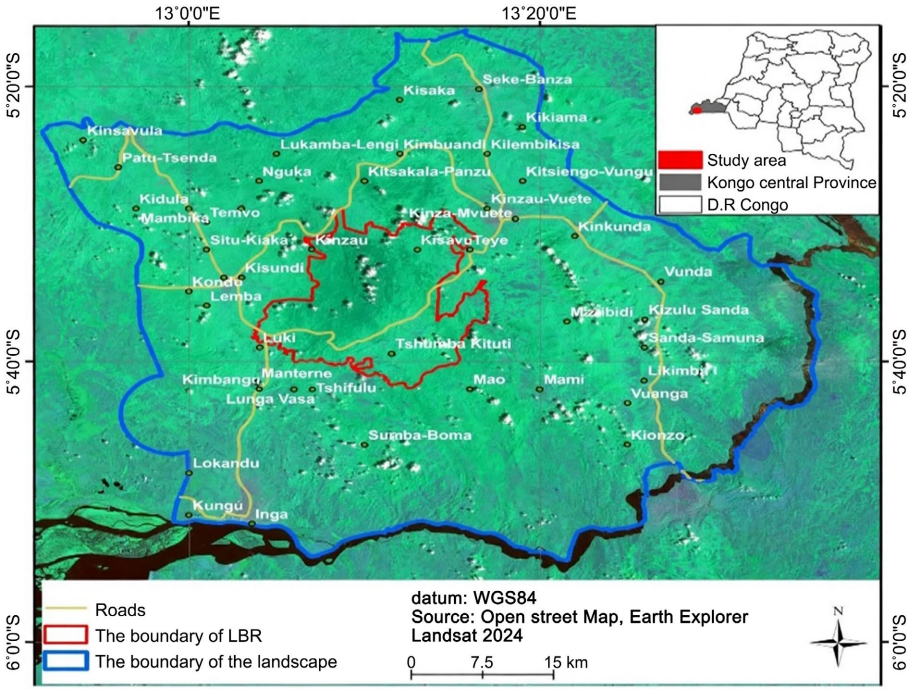

Figure 3. Map of the Luki Biosphere Reserve, Kongo Central Province, Democratic Republic of the Congo. Data source: LBR shapefiles, Geographic coordinate system, WGS 1984 datum. Produced by Bumbulu KHONDE.

2.2. Materials

The biological material used in this study consisted of wood fragments from the forest species *Canarium schweinfurthii*, *Gilletiodendron kisantuense*, *Milicia excelsa*, *Rauvolfia vomitoria*, *and Ricinodendron heudelotii* (see Figure 4), collected from the Luki Biosphere Reserve in Kongo Central Province, Democratic Republic of the Congo. Their systematic positions and botanical descriptions are presented below.

Figure 4. Wood samples of five species (*Canarium schweinfurthii*, *Gilletiodendron kisantuense*, *Milicia excelsa*, *Rauvolfia vomitoria and Ricinodendron heudelotii*) were collected in January 2026 in the Luki Biosphere Reserve, Mayombe, Kongo Central Province, Democratic Republic of the Congo, in collaboration with a team of environmentalists, agronomists and indigenous peoples.

Taxonomic Classification of the Five Studied Forest Species

Table 1. Taxonomic classification of the five studied forest species according to the Angiosperm Phylogeny Group [8].

Division	Spermatophyta	Spermatophyta	Spermatophyta	Spermatophyta	Spermatophyta
Sub Division	Angiospermae	Angiospermae	Angiospermae	Angiospermae	Angiospermae
Class	Dicotyledonae	Dicotyledonae	Dicotyledonae	Dicotyledonae	Dicotyledonae
Order	Sapindales	Fabales	Rosales	Gentianales	Malpighiales
Family	Burseraceae	Fabaceae	Moraceae	Apocynaceae	Euphorbiaceae
Genus	*Canarium*	*Gilletiodendron*	*Milicia*	*Rauvolfia*	*Ricinodendron*
Species	*Canarium schweinfurthii*	*Gilletiodendron kisantuense*	*Milicia excelsa*	*Rauvolfia vomitoria*	*Ricinodendron heudelotii*

Table 1 presents the taxonomic classification of the five forest species studied in the Luki Biosphere Reserve.

2.3. Data Collection

Wood fragments from the following plant species were used: *Canarium schweinfurthii*, *Gilletiodendron kisantuense*, *Milicia excelsa*, *Rauvolfia vomitoria*, and *Ricinodendron heudelotii*. Samples from these five species were collected in the Luki Biosphere Reserve, located in the Mayombe region of Kongo Central Province, Democratic Republic of the Congo, by a team of environmental scientists and agronomists, with the assistance of local indigenous communities. Three sam-

ples from each species were used as experimental material for laboratory analysis (see Figure 5).

Figure 5. Different wood fragments of the five species under study. Photograph taken in February 2026 by Mrs. Luboya Muisangie Jeannette at the Analytical Chemistry Laboratory, University of Kinshasa, Democratic Republic of the Congo.

The wood density of the studied forest species was determined by measuring the mass and volume of each sample. The samples were wrapped in aluminum foil and placed in an oven set at 105˚C. They were weighed regularly using an HRBE303 precision electronic balance until a constant mass was obtained (see Tables 2-6). To determine the volume, each sample was immersed in a water-filled container, and the displaced overflow water was collected in a graduated cylinder to measure the corresponding volume (see Table 7) This procedure was repeated three times for each forest species, and the mass-to-volume ratio was used to calculate wood density (see Table 8).

3. Results

This section presents the results of the experiments conducted on the fresh mass of wood, changes in wood mass over time, wood volume, and wood density of the studied species.

3.1. Fresh Mass and Changes in the Mass of Wood Fragments over Time

This section presents the results of the experiments conducted on the fresh mass of wood, changes in wood mass over time, wood volume, and wood density of the studied species.

Table 2. Constant mass of fresh and oven-dried wood fragments of *Canarium schweinfurthii*.

Canarium ***schweinfurthii***	Fresh mass (g)	Mass after 24 h (g)	Mass after 48 h (g)	Mass after 72 h (g)	Mass after 96 h (g)	Mass after 120 h (g)	Mass after 144 h (g)
Wood sample 1	1350	1300.9	1283.7	1265.8	1250.8	1250	1250
Wood sample 2	1300	1270.6	1234.5	1200.3	1200	1200	1200
Wood sample 3	1250	1210.9	1160.7	1120.8	1100.8	1100	1100

The result shows that a constant dry mass of *Canarium schweinfurthii* wood samples was reached after 96 hours.

Table 3. Constant mass of fresh and oven-dried wood samples of *Gilletiodendron kisantuense*.

Gilletiodendron kisantuense	Fresh mass (g)	Mass after 24 h (g)	Mass after 48 h (g)	Mass after 72 h (g)	Mass after 96 h (g)	Mass after 120 h (g)	Mass after 144 h (g)
Wood sample 1	850	820	808.5	800.6	800	800	800
Wood sample 2	800	792 .5	787.1	780.6	780	780	780
Wood sample 3	*780*	*776.4*	*772.8*	*770.2*	*770*	*770*	*770*

The results showed that a constant dry mass of *Gilletiodendron kisantuense* wood samples was reached after 96 hours.

Table 4. Constant mass of fresh and oven-dried wood samples of *Milicia excelsa*.

Milicia excelsa	Fresh mass (g)	Mass after 24 h (g)	Mass after 48 h (g)	Mass after 72 h (g)	Mass after 96 h (g)	Mass after 120 h (g)	Mass after 144 h (g)
Wood sample 1	1400	1357.8	1305.6	1258. 3	1250	1250	1250
Wood sample 2	1300	1250.9	1228.6	1200.7	1200	1200	1200
Wood sample 3	1000	905.8	870.4	855 .2	850	850	850

Table 4 shows that a constant dry mass of *Milicia excelsa* wood samples was reached after 96 hours.

Table 5. Constant mass of fresh and oven-dried wood samples of *Rauvolfia vomitoria*.

Rauvolfia vomitoria	Fresh mass (g)	Mass after 24 h (g)	Mass after 48 h (g)	Mass after 72 h (g)	Mass after 96 h (g)	Mass after 120 h (g)	Mass after 144 h (g)
Woodsample 1	1430	1400.4	1370.7	1360.2	1350	1350	1350
Wood sample 2	1400	1350.6	1310.8	1300.4	1300	1300	1300
Woodsample 3	1300	1260.3	1240.7	1205.2	1200	1200	1200

The results showed that a constant dry mass of *Rauvolfia vomitoria* wood samples was reached after 96 hours.

Table 6. Constant mass of fresh and oven-dried wood samples of *Ricinodendron heudelotii*.

Ricinodendron heudelotii	Fresh mass (g)	Mass after 24 h (g)	Mass after 72 h (g)	Mass after 72 h (g)	Mass after 96 h (g)	Mass after 120 h (g)	Mass after 144 h (g)
Wood sample 1	900	850	835.5	800.7	800	800	800
Wood sample 2	850	750	725.6	705.8	700	700	700
Wood sample 3	800	450.9	420.5	400.8	400	400	400

Table 6 presents the changes in the moisture content of *Ricinodendron heudelotii* wood and shows that a constant dry mass of the wood samples was reached after 96 hours.

3.2. Wood Volume of the Studied Species

Table 7. Wood volume of the studied species.

Studied Species	Volume of wood sample 1 (ml)	Volume of wood sample 2 (ml)	Volume of wood sample 3 (ml)	Total volume (ml)	Mean volume (ml)
1. Canarium schweinfurthii	2070	1970	1880	5920	1973
2. Gilletiodendron kisantuense	880	860	850	2590	863
3. Milicia excelsa	1500	1420	1280	4200	1400
4. Rauvolfia vomitoria	2140	2070	2025	6235	2078
5. Ricinodendron heudelotii	1100	1005	750	2855	951

The results presented in Table 7 show that the mean wood volumes of the species considered range from 863 to 2078 ml. The highest mean wood volume was recorded for *Rauvolfia vomitoria*, followed by *Canarium schweinfurthii* and *Milicia excelsa*, them *Ricinodendron heudelotii*, and finally *Gilletiodendron kisantuense.*

3.3. Wood Density of the Studied Species

Table 8. Wood density of the studied species descriptive statistics by species.

Studied Species	N	Mean	Median	Minimum	Maximum	Standard deviation (SD)	Coefficient of variation (CV%)	Variance
1. *Canarium schweinfurthii*	3	0.595	0.600	0.585	0.600	0.009	10.19	0.00008
2. *Gilletiodendron kisantuense*	3	0.907	0.900	0.890	0.930	0.021	2.30	0.00043
3. *Milicia excelsa*	3	0.780	0.800	0.660	0.880	0.111	14.28	0.01240
4. *Rauvolfia vomitoria*	3	0.613	0.600	0.590	0.650	0.032	5.24	0.00103
5. *Ricinodendron heudelotii*	3	0.630	0.690	0.500	0.700	0.113	17.89	0.01270

The results presented in Table 8 show that the wood-density values obtained show that density varies among species. *Gilletiodendron kisantuense* had the highest mean value (0.907 ± 0.021 g/cm^3), followed by *Milicia excelsa* (0.78 ± 0.111 g/cm^3) and *Ricinodendron heudelotii* (0.63 ± 0.113 g/cm^3), while *Rauvolfia vomitoria* (0.613 ± 0.032 g/cm^3) and *Canarium schweinfurthii* (0.59 ± 0.009 g/cm^3) had lower values. The mean wood-density values ranged from 0.59 to 0.90 g/cm^3, with *Gilletiodendron kisantuense* showing the highest mean density.

Table 9. Comparison of wood density values obtained in this study with reference values from the literature.

No	Studies species	Our wood density (g/cm³)	Reference value (g/cm³)	Source and year	Absolute difference (g/cm³)	Difference (%)	Density class according to our study
1	*Canarium schweinfurthii*	0.595	0.41 ± 0.06	GWDD-Zanne et al. (2009)	+ 0.185	+45.1	Mean density
2	*Gilletiodendron kisantuense*	0.90	0.86	GWDD-Zanne et al. (2009)	+ 0.040	+4.7	Heavy wood
3	*Milicia excelsa*	0.78	0.58 ± 0.06	GWDD-Zanne et al. (2009)	+0.200	+34.5	Heavy wood
4	*Rauvolfia vomitoria*	0.61	0.472	Data reference 2016	+0.138	+29.2	Mean density
5	*Ricinodendron heudelotii*	0.63	0.25	ITTO-Data reference	+0.380	+152.0	Mean density

The results presented in Table 9 demonstrate that *Gilletiodendron kisantuense* (0.90 g/cm³) is very close to the GWDD value of 0.86 g/cm³. The difference is only 0.04 g/cm³, which suggests good agreement between our measurement and the literature. In contrast, our values for *Canarium schweinfurthii* 0.595 g/cm³ and *Milicia excelsa* 0.78 g/cm³ are significantly higher than the respective GWDD mean values.

4. Discussion

Wood density can vary depending on geographical origin, ecological conditions, tree age, the position of the sample within the trunk, moisture content, and the method used to determine volume. Depending on the species, wood density ranges from 0.1 to 1.5 g/cm³ [9]. Species with high wood density generally exhibit slower growth because of their higher construction costs, but they tend to have longer lifespans due to the physical and biological resistance associated with high wood density [10]. In the present study, the mean wood densities obtained ranged from 0.567 g/cm³ for *Canarium schweinfurthii* to 0.907 g/cm³ for *Gilletiodendron kisantuense*. *Milicia excelsa* showed a mean wood density of 0.780 g/cm³, whereas *Rauvolfia vomitoria* and *Ricinodendron heudelotii* had mean values of 0.613 and 0.630 g/cm³, respectively.

Because of their relatively low wood densities, *Ricinodendron heudelotii*, *Rauvolfia vomitoria*, and *Canarium schweinfurthii* may exhibit relatively rapid growth and, consequently, may contribute to relatively rapid atmospheric carbon dioxide uptake during biomass accumulation. However, low wood density should not be considered the sole determinant of carbon sequestration capacity, as carbon storage also depends on biomass production, tree size, growth rate, longevity, and stand dynamics.

The values obtained in this study therefore constitute reference data that could be incorporated into allometric models for the species studied in the Luki Biosphere Reserve. However, the present study was not designed to directly establish allometric equations. Nevertheless, these results provide a useful scientific basis for future studies aimed at estimating biomass and carbon stocks and supporting

the sustainable management of forest resources in the Luki Biosphere Reserve, in line with Sustainable Development Goals (SDGs) 13 and 15.

5. Conclusion

In this study, we determined the wood density of five forest species: *Canarium schweinfurthii*, *Gilletiodendron kisantuense*, *Milicia excelsa*, *Rauvolfia vomitoria*, and *Ricinodendron heudelotii*. The results show a variation in wood density among the species, with the highest mean values observed for *Gilletiodendron kisantuense* (0.90 g/cm^3) and *Milicia excelsa* (0.78 g/cm^3), while *Ricinodendron heudelotii* (0.63 g/cm^3), *Rauvolfia vomitoria* (0.61 g/cm^3), and *Canarium schweinfurthii* (0.59 g/cm^3) had lower values. The values obtained thus constitute reference data that can be used for the development or improvement of future allometric equations adapted to the species of the Luki Biosphere Reserve and, consequently, for a more accurate estimation of stored carbon. However, this study did not allow for the direct establishment of allometric equations, as these require a larger sample size and additional dendrometric and biomass data. Nevertheless, the results obtained constitute a useful scientific basis for future work dedicated to biomass and carbon estimation and to the sustainable management of forest resources in the Luki Biosphere Reserve. Finally, extending the study to a large number of species and a greater number of individuals would help to strengthen knowledge on the variability of wood density and to develop allometric models that are more representative of the ecological conditions of the Luki Biosphere Reserve.

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Ethical Considerations

This article was prepared in accordance with research ethics principles and in strict compliance with applicable scientific and ethical standards.

Author Contributions

Conceptualization, E.K.T., P.N.M. and C.L.A.; supervision, E.K.T. and C.L.A.; investigation and data curation, M.T.Z.; writing—review and editing, D.L.O. and J.M.F.; software and laboratory analysis, T.B.L., T.M.M., D.M.E.M., B.D.W., F.K.M. and S.S.S.; writing—original draft preparation, D.D.M.B., M.S.W. and J.C.L.I.; visualization and formal analysis, F.O.O., A.L.N. and P.I.L.H.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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