WOOD SPECIFIC GRAVITY IN THE CONGO BASIN : ITS DETERMINATION AND VARIATION

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1. INTRODUCTION & AIMS

Wood density, together with diameter at breast height and height, is an important factor for forest biomass estimations. As approximately 50% of plant biomass is carbon, this has implications for carbon dioxide emissions from deforestation and degradation. Currently, there is little understanding of wood densities - and how these vary - of tree species in dense tropical central African forests. We used historic wood samples from the xylarium at the Museum for Central Africa in Tervuren, Belgium. This collection is the largest in the world for Central African woods.

The **aim** of this research is twofold: **(i)** to determine a reliable methodology for measuring the volume of dry historical xylarium samples that must be preserved (non-destructive sampling) and **(ii)** to investigate the variation of wood density within 54 common species in the Congo Basin while taking their geographic origin into account.

Picture of xylarium collection.

2. METHODOLOGY

Density or in this case wood specific gravity is calculated by dividing oven dry mass of a sample by its volume at a given % of moisture content (in this case 8%). Determining volume precisely for dry historic samples that need to be conserved is challenging. The study consists of two main parts:

(i) Measuring volume

Five different methods were tested on 100 samples. Two solid displacement methods (sand & glass micro beads) and three variations of the hydrostatic method (samples wrapped in laboratory parafilm; not wrapped in parafilm and not taking into account water absorption; and not wrapped in parafilm and accounting for water absorption).

Picture of glass beads method.

Picture of sand method.

Picture of samples wrapped in laboratory parafilm.

Picture of hydrostatic method.

(ii) Wood specific gravity

Wood specific gravity was measured for 54 different species totalling 976 wood samples. The samples were selected based on their information of provenance. The hydrostatic method accounting for water absorption was used. For oven-dry mass, samples were dried: 4 hours at 60 ℃, 20 hours at 80 ℃ and 24 hours at 103 ℃. The temperature was built up slowly in order to prevent the wood from cracking. Moisture content for the volume measurements was 8%.

3. RESULTS & DISCUSSION

(i) Measuring volume

• Measuring volume using the hydrostatic method while taking into account water absorption is the most reliable method for volume measurements on dry historic wood samples. It has the lowest average standard deviation (0.13) and the lowest average coefficient of variation (0.40).

•The hydrostatic methods score better than both solid displacement methods, of which the sand method appears to be the least reliable method.

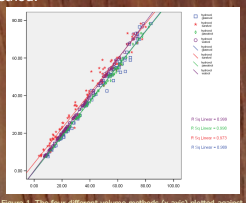

Figure 1. The four different volume methods (x axis) plotted against hydrostatic volume method taking into account water absorption (y axis). Unites are cm3. We observe that the hydrostatic method without taking water absorption into account is second best, followed by the hydrostatic method using parafilm around the samples, followed by the glass beads method and finally sand.

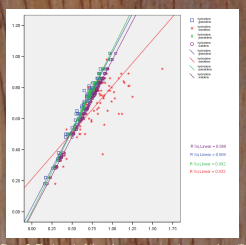

Figure 2. The impact of the volume measurements on wood specific gravity. The four different methods (x axis) plotted against the hydrostatic method taking into account water absorption (y axis). Units are g/cm3. We observe that the volume impact is particularly important in the sand method, which has the lowest R squared value.

(ii) Wood specific gravity

We calculated the specific gravity for 54 species. Table 1 and figure 3 show that the variation of specific gravity within species is considerable.

Table 1. Summary table of species specific gravity, specific gravity ranges, standard deviations and number of countries in Central Africa the samples come from.

Species	# of samples	Average specific gravity (g/cm3)	Min specific gravity (g/cm3)	Max specific gravity (g/cm3)	SD	# of countries
Albizia adianthifolia	15	0.56	0.38	0.86	0.13	2
Albizia gummifera	19	0.57	0.43	0.71	0.08	1
Alstonia congensis	12	0.35	0.27	0.62	0.09	1
Autranella congolensis	20	0.88	0.56	1	0.09	1
Canarium schweinfurthii	15	0.44	0.22	0.57	0.1	3
Celtis pentandra	10	0.29	0.17	0.38	0.06	2
Dacryodes edulis	11	0.62	0.5	0.94	0.13	4
Diospyros crassiflora	6	1.05	0.93	1.14	0.08	4
Entandrophragma angolense	21	0.57	0.44	0.8	0.08	2
Entandrophragma candollei	23	0.58	0.33	0.75	0.1	2
Entandrophragma cylindricum	24	0.6	0.5	0.7	0.05	3
Entandrophragma utile	17	0.59	0.5	0.75	0.06	4
Figuera macrophylla	16	0.71	0.49	0.96	0.13	2
Gilbertiodendron dewevrei	41	0.78	0.64	0.87	0.06	2
Guarea cichata	17	0.63	0.55	0.78	0.06	3
Guarea laurentii	15	0.63	0.56	0.72	0.05	1
Hallea stipulosa	21	0.56	0.44	0.77	0.1	1
Khaya anthotheca	19	0.54	0.41	0.67	0.07	4
Klainedoxa gabonensis	17	0.87	0.47	1.05	0.16	3
Lovoa trichilioides	18	0.58	0.47	0.77	0.08	4
Mansonia altissima	8	0.44	0.36	0.82	0.16	2
Mammea africana	21	0.7	0.44	0.85	0.09	3
Milicia excelsa	48	0.57	0.37	0.73	0.07	4
Minetia laurentii	19	0.79	0.67	0.9	0.06	3
Morinda lucida	14	0.6	0.53	0.75	0.07	1
Musanga cecropioides	27	0.21	0.13	0.46	0.09	3
Myrianthus arboreus	7	0.55	0.47	0.6	0.05	2
Nauclea diderrichii	10	0.71	0.63	0.8	0.04	4
Ongokea gore	20	0.77	0.62	0.88	0.07	2
Oxystigma oxyphyllum	9	0.75	0.56	0.83	0.08	1
Oxystigma stenophyllum	16	0.6	0.5	0.8	0.06	2
Parkia olivacea	10	0.67	0.57	0.81	0.07	1
Pentaclethra eetveldeana	15	0.73	0.55	0.95	0.13	3
Pentaclethra macrophylla	15	0.8	0.54	1.03	0.13	3
Pericopsis elata	14	0.71	0.6	0.89	0.08	3
Petersianthus macrocarpus	45	0.73	0.46	0.9	0.09	2
Piptadeniastrum africanum	29	0.72	0.61	0.83	0.05	2
Prioria balsamifera	12	0.48	0.32	0.72	0.08	2
Pterocarpus soyauxii	20	0.71	0.52	0.86	0.08	5
Pterocarpus tinctorius	14	0.65	0.31	0.9	0.2	1
Ricinodendron heudelotii	14	0.26	0.15	0.47	0.08	5
Scorodophloeus zenkeri	16	0.76	0.45	0.87	0.1	1
Staudtia stipitata	51	0.8	0.62	0.94	0.07	5
Strombosia grandifolia	16	0.75	0.67	0.84	0.05	2
Strombosiopsis tetrandra	18	0.73	0.51	0.89	0.08	2
Symphonia globulifera	20	0.68	0.51	0.84	0.09	3
Syzygium guineense	6	0.71	0.64	0.87	0.08	2
Terminalia superba	14	0.52	0.34	0.64	0.08	3
Tetrorchidium didymostemon	8	0.44	0.32	0.55	0.07	2
Tieghemella africana	5	0.67	0.59	0.78	0.07	1
Trema guineensis	26	0.51	0.3	0.82	0.15	2
Uapaca guineensis	9	0.71	0.62	0.84	0.08	1
Vitex madiensis	6	0.55	0.47	0.72	0.09	1
Xylopia aethiopica	21	0.59	0.44	0.77	0.1	1

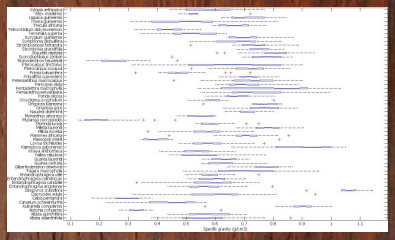

Figure 3. Horizontal box plot per species. The box plot gives the smallest observation, lower quartile, median, upper quartile, largest observation and outliers. The boxes are notched, which represents a robust estimate of the uncertainty about the medians for box-to-box comparison. Boxes whose notches do not overlap indicate that the medians of the two groups differ at the 5% significance level.

(iii) Future analyses

The next step of the analysis will be to analyse - for species with very good location information and enough samples - if there is a measurable regional variation of specific gravity within species. We also plan to compare the specific gravity values and their ranges with other published and unpublished data for Central Africa. A phylogenetic analysis of wood specific gravity will also be undertaken for selected species .

4. CONCLUSION

This study has tested various methods for precisely measuring volume of dry xylarium samples without causing any permanent damage to them. The most **robust method** proved to be the **hydrostatic method taking into account water absorption**. We can observe **considerable variation of wood specific gravity within species** and will test whether or not this can be explained due to phylogeny and/or locality.

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