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The Effect of Oven Dry Density on Thermal Conductivity of Fifty-Two Selected Nigerian Timbers.

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ABSTRACT

The effect of oven dry density on thermal conductivity of fifty-two selected Nigerian timbers was analyzed. The results showed that *C. vogelli* and *G. arborea* with thermal conductivity of 10.06 x10^{2} µmoh/cm recorded ODDs of 36.6 x10^{-2}g.cm^{-3} and 40.3 x10^{-2}g.cm^{-3} respectively; *G. kola* and *C. barteri* with thermal conductivity of 10.92 x10^{-2} µmoh/cm had ODDs of 48.5 x10^{-2}g.cm^{-3} and 49.9 x10^{-2}g.cm^{-3} respectively. It is however observed that the ODDs of those timbers with equal thermal conductivity were very close. The timber; *D. barteri* with the least thermal conductivity of 4.28 x10^{-2} µmoh/cm had ODD of 82.2 10^{-2}g.cm^{-3} while *B. brevicuspe* with the highest thermal conductivity of 51.34 x10^{-2} µmoh/cm had ODD of 22.3 x10^{-2}g.cm^{-3}. The results also showed that thermal conductivity of timber can be increased as the ODD decreases and at the same time decreases as the ODD is increased.

Keywords: Thermal conductivity, Oven dry density, Building materials and Timbers.

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INTRODUCTION

Thermal conductivity is a measure of the rate of heat flow in response to a temperature gradient. In wood, the rate depends on the direction of heat flow with respect to the grain orientation [1]. Dry wood is one of the poorest conductors of heat and this characteristic renders it eminently suitable for many of the uses to which it is put everyday e.g as a building material, internal wall paneling and as handles of cooking utensils [2].

The transmission or conduction of heat depends on two factors:

- The specific conductivity and
- The specific heat of the intervening material.

Although, the specific conductivity of dry wood substance is low, that of timber is even lower. Wood is a cellular substance, in the dry state, the cell cavities are filled with air which is one of the poorest conductors known. The cellular structure of wood also partly explains why heat is conducted about two to three times as rapidly along the grain compared with across it and that heavy woods conduct heat more rapidly than light porous ones [1] and [2].

The specific heat of a substance is the amount of heat required to raise the temperature of one gram of that substance by 1^oC. The specific heat of wood is about 50 percent higher than that of air and four times as high as that of copper [1]. The reaction of timber to heat has an important bearing on its suitability as a fire-resistant material. Because of the relatively high specific heat and poor conductivity of wood, wooden doors are often effective in preventing the spread of a fire for a considerable period.

Thermal conductivity is influenced by density. It is linearly proportional to density, so for denser woods, the thermal conductivity is higher. It is also influenced by the amount of water in a piece of wood. For wood with moisture content greater that 40%, thermal conductivity is about 1/3 greater than a piece with moisture content less than 40% (more H_2O, more conductivity) [2]. The aim of this research was to determine the effect of oven dry density on thermal conductivity of fifty-two selected Nigerian timbers.

MATERIAL AND METHODS

Sample Collection and Preparation

The Fifty- two (52) timber samples were collected from fourteen States in Nigeria. The States are Anambra, Enugu, Ebonyi, Imo, Delta, Edo, Cross River, Akwa Ibom, Abia, Oyo, Lagos, Kano, Sokoto and Rivers State. The timber samples were obtained from the timber sheds at Nnewi, Awka, Enugu, Abakaliki and Benin. The States from where these timbers were collected were ascertained from timber dealers and confirmed by literature [3], [4]. The timber dealers were able to give the Local or common names of the timbers while the botanic names were obtained with the aid of forest officers and the literature [3], [4].

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The samples were taken to the saw mill at Nnewi Timber Shed where each timber was cut into two different shapes and sizes. Also dust from each timber was realized. The timbers were cut into splints of dimensions 30x 1.5 x 0.5cm and cubes of dimensions 2.5cm x2.5cmx 2.5cm i.e. 15.625 cubic centimeters. The splints were dried in an oven at 105^0C for 24 h before the experiments.

Table.1 Names of the Selected Fifty-Two (52) Timbers Used For This Research

S.No	Botanical Names	Igbo Names	Yoruba Names	Hausa Names	Areas of Location in Nigeria
1.	Monodora tenuifolia	ehuru ofia	lakesin	gujiyadanmiya	Port Harcourt
2.	Pycnanthus angolensis	Akwa-mili	akomu	akujaadi	Calabar, Awka
3.	Moringa oleifera	okwe oyibo	ewe igbale	zogallagandi	Lagos, Ibadan
4.	Protea elliottii	okwo	dehinbolorun	halshena	Nsukka
5.	Caloncoba glauca	udalla-enwe	kakandika	alibida	Onitsha
6.	Barteria nigritiana	ukwoifia	oko	idonzakara	Nsukka, Enugu
7.	Bacteria fistulosa	oje	oko	kadanya	Awka
8.	Anogeissus leiocarpus	atara	ayin	marike	Onitsha, Awka
9.	Rhizophora racemosa	ngala	egba	loko	Calabar
10.	Allanblackia floribunda	egba	eku,eso roro	guthiferae eku	Calabar, Ikom
11.	Garcinia kola	adi	orogbo	namijin-goro	Onitsha, Nnewi
12.	Glyphae brevis	anyasu alo	atori	bolukonu kanana	Calabar
13.	Hildegaridia barteri	ufuku	eso, shishi	kariya	Okigwe
14.	Sterculia oblonga	ebenebe	oroforofo	kukuki	Ibadan
15.	Cola laurifolia	ufa	aworiwo	karanga	Onitsha, Calabar
16.	Bombax brevicuspe	akpudele	awori	kurya	Ikom
17.	Bridelia micrantha	ogaofia	ida odan	kirni	Calabar, Ikom
18.	Bridelia ferruginea	ola	ira odan	kirni and kizini	Onitsha, Awka
19.	Uapaca guineensis	Obia	abo-emido	wawan kurmi	Onitsha
20.	Antidesma venosum	okoloto	aroro	kirni	Onitsha, Udi
21.	Parinari robusta	ohaba-uji	idofun	kasha-kaaji	Onitsha
22.	Cynometra vogelii	ubeze	anumutaba	alibida	Onitsha, Abakali
23.	Amphimas pterocarpoids	awo	ogiya	waawan kurmii	Umuahia, Iko
24.	Lovoa trichiliodes	sida	akoko igbo	epo-ipa	Calabar
25.	Berlinia grandiflora	ububa	apodo	dokar rafi	Enugu
26.	Albizia adianthifolia	avu	anyimebona	gamba	Enugu, Nsukka
27.	Oncoba spinosa	akpoko	kakandika	kokochiko	Onitsha
28.	Dichapetalum barteri	ngbu ewu	ira	kirni	Onitsha, Agulu
29.	Afzelia bipindensis	aja	olutoko	rogon daji	Benin
30.	Afzelia bella	uzoaka	peanut	epa	Owerri, Orlu
31.	Erythropleum ivorense	inyi	erun	idon zakara	Ogoja, Ijebu
32.	Dichrostacys cinerea	amiogwu	kara	dundu	Onitsha
33.	Pentaclethra macrophylla	ugba	apara	kiriya	Onitsha
34.	Tetrapleura tetraptera	oshosho	aridan	dawo	Onitsha
35.	Stemonnocoleus micranthus	nre		waawan kurmi	Ukpor, Awka
36.	Piliostigma thonningii	okpoatu	abafe	kalgo	Kano,Oyo
37.	Hymenocardia acida	ikalaga	orupa	jan yaro	Awka, Enugu
38.	Afrormosia laxiflora	abua ocha	shedun	don zakara	Sokoto
39.	Phyllanthus discoideus	isinkpi	ashasha	baushe	Enugu, Ikom
40.	Gardenia imperialis	uli	oroto	karandafi	Jos
41.	Macaranga hurifolia	awarowa	ohaha		Awka
42.	Sacoglottis gabonensis	nche	atala	chediya	Rivers
43.	Cassipourea barteri	itobo	odu	daniya	Eket
44.	Combretodendron macrocarpum	anwushi	akasun		Udi, Owerri
45.	Lophira lanceolata	okopia	iponhon	namijin kadai	Udi
46.	Homalinum letestui	akpuruukwu	out,obo-ako		Ikom
47.	Cordial millenii	okwe	omo	waawan kurmii	Owerri
48.	Gmelina arborea	gmelina	igi Melina	kalankuwa	Ibadan
49.	Drypetes aframensis		tafia		Ibadan
50.	Khaya ivorensis	ono	oganwo	madachi	Calabaar
51.	Spathodea campanulata	imiewu	Oruru	delinya	Onitsha
52.			Shanty		

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Determination of thermal conductivity of timbers by the ash method

The thermal conductivity of each timber sample was obtained from fraction of ash of the samples. It was calculated thus:

$$\text{Fraction of ash} = \frac{W_o}{W_I}$$

Where W_O = ash weight (g)

W_1 = dried sample weight (g)

$$\text{Percentage of ash} = \frac{W_O}{W_1} \times \frac{100}{1}$$

The thermal conductivity of the timber samples was finally obtained by comparing the percentage of the ash obtained with conductance Ash Table for low conductivity cell [5].

RESULTS

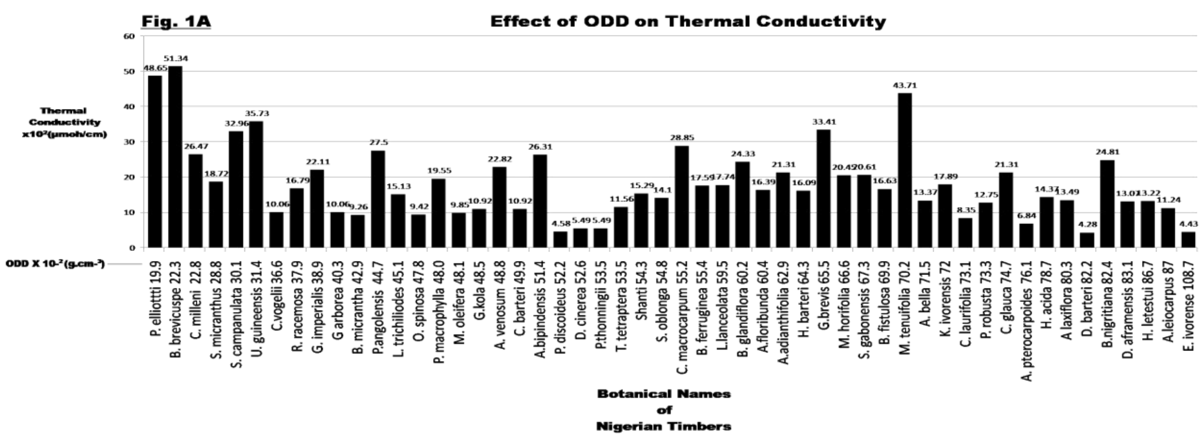

Figure 1A represents the graph of thermal conductivity against ODD

DISCUSSION

Some set of timbers with equal thermal conductivities and varied ODD were as Follows *C. vogelli* and *G. arborea* with thermal conductivity of 10.06 $\times 10^{2}$ µmoh/cm had the ODDs of 36.6 $\times 10^{-2}$g.cm^{-3} and 40.3 $\times 10^{-2}$g.cm^{-3} respectively; *G. kola* and *C. barteri* with thermal conductivity of 10.92 $\times 10^{-2}$ µmoh/cm had the ODDs of 48.5 $\times 10^{-2}$g.cm^{-3} and 49.9 $\times 10^{-2}$g.cm^{-3} respectively. It was however observed that the ODDs of those timbers with equal thermal conductivity were close. The small difference in ODDs of different timbers with equal thermal conductivity can be explained by attributing it to the effect of differences in anatomical structure of different woods and the possible influence of certain inorganic extractives present in some woods [4].The timber; *D. barteri* with the least thermal conductivity of 4.28 $\times 10^{-2}$

μmoh/cm had ODD of 82.2 10^{-2}g.cm^{-3} while *B. brevicuspe* with the highest thermal conductivity of 51.34 x10^{-2} μmoh/cm had ODD of 22.3 x10^{-2}g.cm^{-3}. It was observed from Figure 1A that thermal conductivity of the timber increases somewhat as the ODD decreases and decreases as the ODD increases. Moreover there exist some timbers with low thermal conductivity at low ODD and some with high thermal conductivity at high ODD. This observation shows that in the absence of differences in anatomical structures, there is an inverse relationship between thermal conductivity of these timbers and their ODD.

CONCLUSION

In conclusion, the results above showed that thermal conductivity of timber can be increased as the ODD decreases and at the same time decreases as the ODD is increased. Moreover there exist some timbers with low thermal conductivity at low ODD and some with high thermal conductivity at high ODD.

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