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**Research Article**

# Comparative Study between Water Saturation Capacity (WSC) and Oven Dry Density (ODD) As Fire Characteristics of Some Tropical Timbers (ODD)

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**Abstract** Timber is an essential raw material needed in constructing one thing or the other in all fields of human endevour. It is combustible. In this research, fire characteristics of fifty-seven (57) tropical timbers were investigated. The characteristics studied are: flame duration (FD) and oven dry density (ODD). The tropical timbers with the highest FD are *C. nitida, P. carribean, A. bateri, A. indica, M. altissima,I. tomentosa, G. gnetoides, B. gracilipes* and a variety of *M. indica* respectively.The one with the highest ODD is *Manilkara*. The ones with the least of these fire characteristics (FD) were *B. bonopozense and S. campanulala* (1.4 x 10 sec). Although some tropical timbers with lower ODDs possess high FD, some of the timber with higher ODDs possess lower FD, it can be said that there is neither inverse nor direct relationship between the FD of the tropical timbers and their oven dry densities. Though density is an important factor, in determining the fire characteristics of timber, the cellular structure, molecular composition, orientation of fiber (direction of grain) and timber extractives (*e.g.* resins) deserve a special attention in explaining the results. The aim of this work is to identify the timbers that are fire resistant and those that are not and to compare the FD of these tropical timbers with their oven dry densities.

**Keywords** Tropical timbers, flame duration, ODD, fire characteristics, fire and non-fire resistant timbers.

## Introduction

Absolutely dry wood offers practically complete resistance to the passage of an electric current, but the presence of contained moisture renders it a partial conductor. This phenomenon is the basic principle used in the design of electric moisture meters. Besides the moisture content of a piece of wood, its density and the species influence its electrical conductivity. For example, *Lignum vitae* and certain other dense woods, have been used for insulation purposes; they are sometimes impregnated with wax to keep out moisture, thereby maintaining their insulating properties [1]. The small differences in electrical conductivity of different woods of the same density can be explained by attributing such variations to the effect of differences in anatomical structure of different woods and the possible influence of certain inorganic extractives present in some woods [2].

Like other organic materials wood is combustible; under suitable conditions it will burn, and its constituents undergo oxidation with the liberation of energy in the form of heat. The fuel value of a timber depends largely on the amount of wood substance in a given volume, *i.e.* on the density, and on the chemical composition of the wood substance, and on the state of dryness of the wood. Desch and Dinwoodie (1981) asserted that the denser the timber the higher its potential fuel value, but this may be modified by the presence in the wood of such substances as resin [1]. The fuel value of resin is about twice that of wood substance, and, other things being equal, resinous woods have higher fuel values than non- resinous woods. The influence of moisture content will readily be understood: wet wood has a much lower heating value than dry wood of the same species, because much heat is lost in transforming the contained moisture into steam. It is, therefore, anything but economical to use damp firewood: it lasts longer but gives out much less total heat than the same amount of seasoned wood, even on a dry-weight basis.

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**Experimental procedures**

*Sample collection and preparation*

The fifty-seven (57) tree species samples were collected from eleven states in Nigeria. The states are: Anambra, Imo, Enugu, Sokoto, Katsina, Kano, Kebbi, Yobe, Edo, Zamfara and Gombe.

Some of the tree species were living trees cut down . Some were the already felled trees. Dulmer machine was used to cut out part of the tree drunk. Thirty-two timbers were obtained from the timber sheds or saw mills at Onitsha, Nnewi and Awka. The states from where these timbers were collected were ascertained from the timber dealers. The tree species were authenticated by the Forest Officer in each of the State or the Local Government Area where the timbers were collected. The timber dealers or the saw millers were able to say the botanical names of few timbers collected from the timber shed. Most of the timbers collected there were taken to the Forest Officer in that Local Government Area where the tree species were got. By mentioning the local or common name of tree species and by having a look at the parts of tree species, the Forest Officers were able to say the botanical names of the tree or timber species.

After the collection and authentification, they were occasionally conveyed to the saw mill where each timber was cut into two different shapes and sizes; They are:

(i) Splints of dimensions of 30cm x 2.5cm x 0.6cm

(ii) Cubes of dimensions of 2.5cm x2.5cm x2.5cm i.e. 15.625 cubic centimeters. The splints of timber were dried in an oven at 105$^0$C for 48hours before the experiment. American Standard for Testing and Materials (ASTM) was employed in the analysis.

**Determination of water saturation capacity**

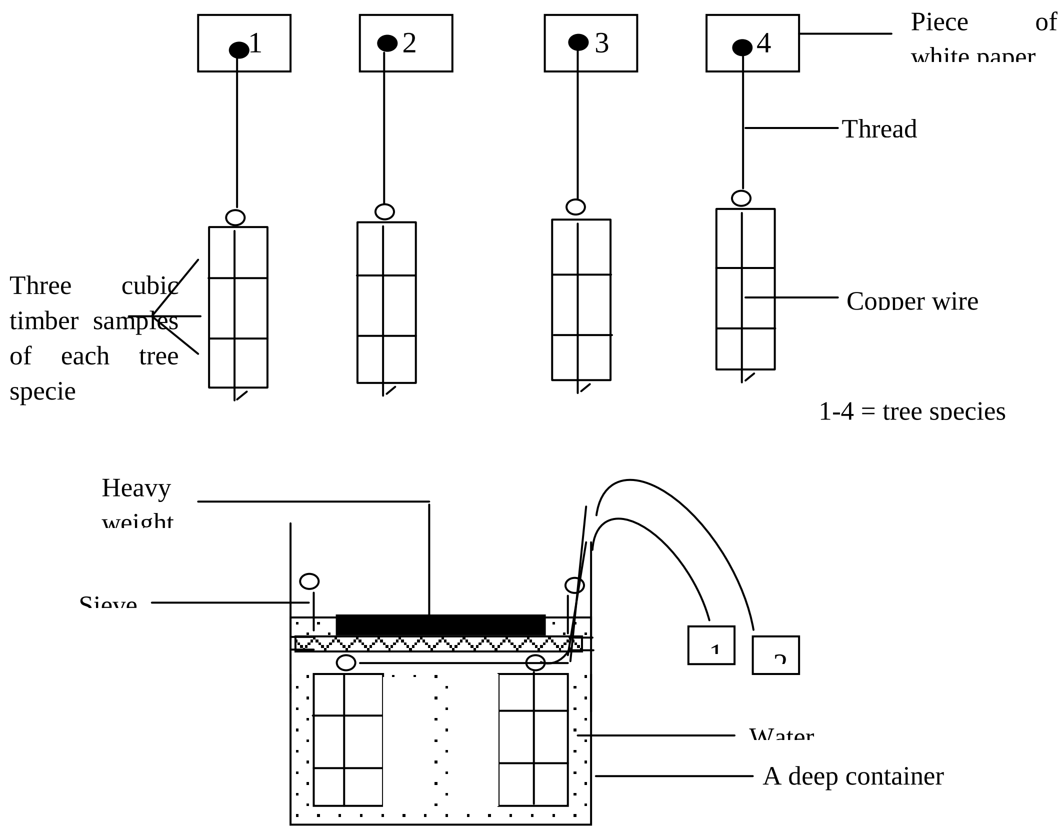


*Figure 1: Immersion of tree cubes species in water*

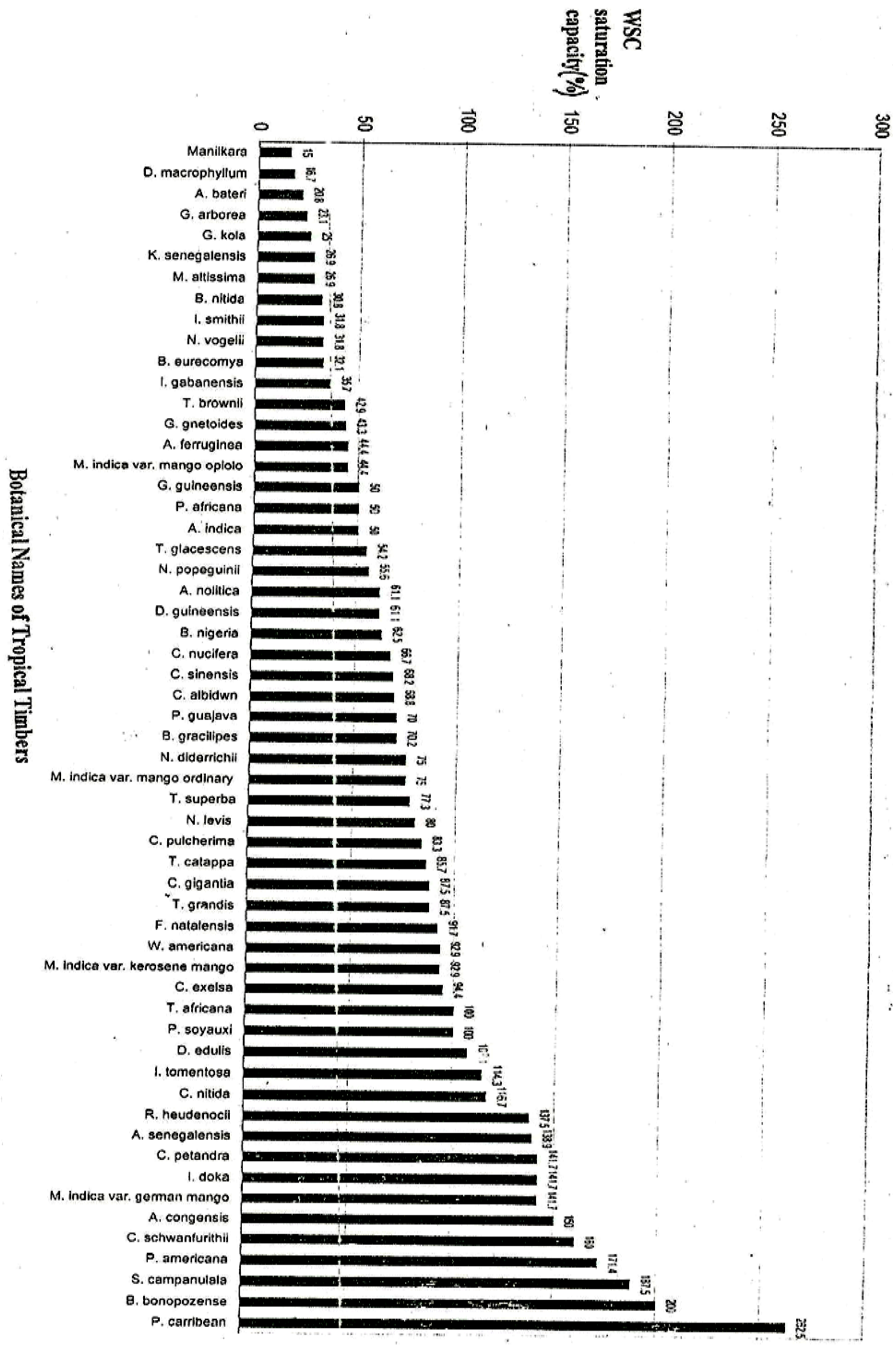


*Figure 2: Graph of Water saturation capacity of 57 tropical timbers*

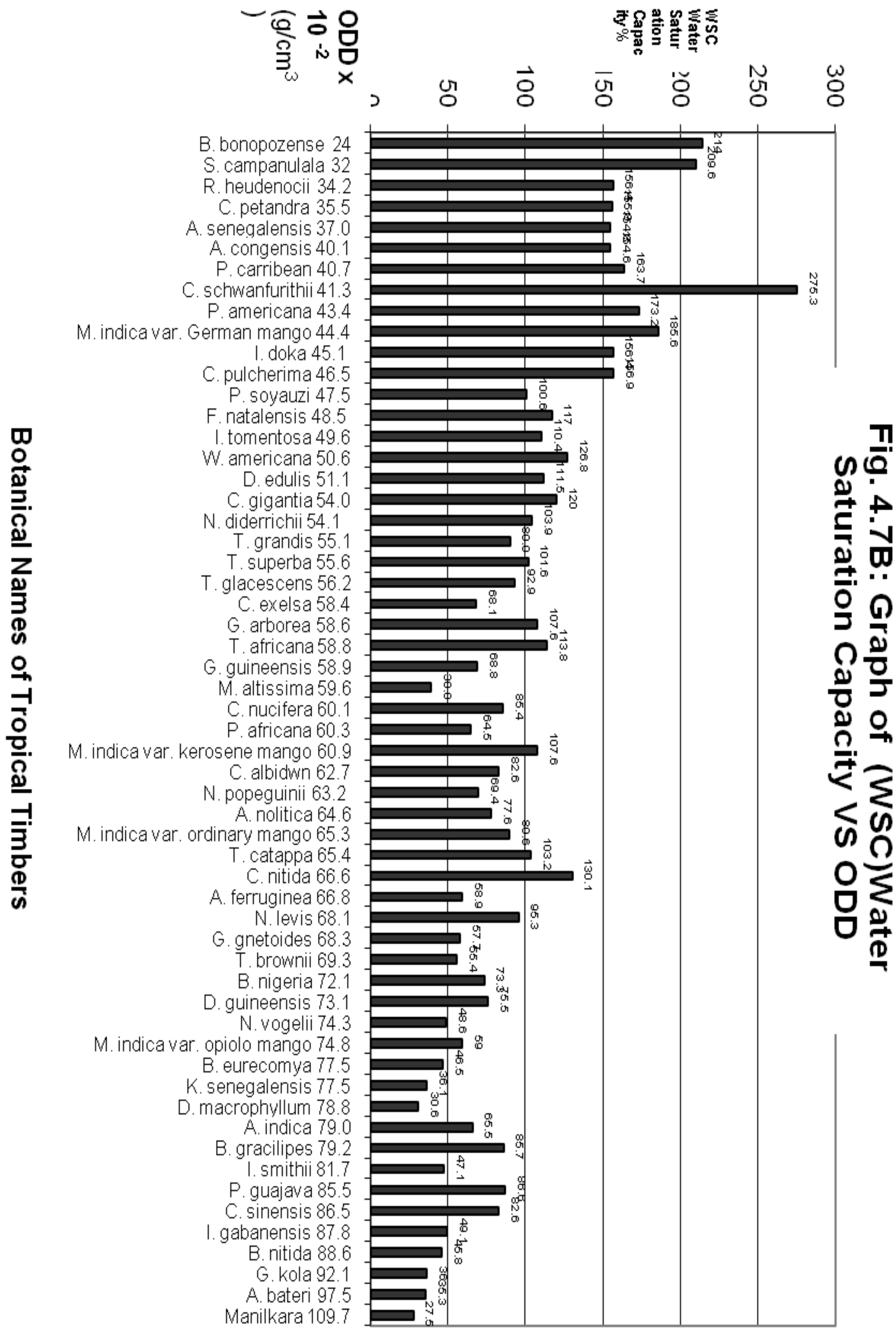


*Figure 3: Graph of Water saturation capacity (WSC) vs ODD*

Three cubic samples of each tree species were used. They were tied together with a Cu wire. The knobbed end of the Cu wire was connected to one end of the thread attached to a labeled piece of white paper (Fig.1). The number (1, 2, 3 etc) represents each tree species. The tied samples were taken in a deep plastic bucket containing some water. A sieve containing a heavy load was placed on top of the samples to make sure that the dried cubic samples would not float and to ensure that they were properly covered by water. The set up was left for twenty-four hours before re-weighing. The average initial oven-dry weight of the samples was recorded. After re-weighing, the whole samples were again transferred into fresh water and left for another 24 hours before re-weighing again. This procedure is continued till a constant weight is obtained for the samples. In other words, the samples were said to be saturated with water molecules. Thus water imbibition of each tree species was determined. The average weight of a cubic sample (Wo) was determined. The final average weight (Wد) of a saturated cubic sample was obtained by subtracting the initial weight from the final weight. Then the percentage quantity of water it can absorb was calculated thus;

$$\frac{W\text{د} - Wo}{Wo} \times 100$$

The water saturation capacity of each tree species was obtained by adding its moisture content and the percentage water it can adsorb.

| | | | | |
|---|---|---|---|---|
| **water saturation capacity %** | **=** | **moisture content %** | **+** | **water it can absorb %** |

**Determination of Oven Dry Density (ODD):**

Three 2.5cm cubes of each timber were randomly selected from one hundred and eighty cubes of the tree species. Each was weighed with Top loading balance, Model: PL 203, Make: Mettler Toledo. After recording the initial weight, the sample was transferred into the drying oven at the temperature of 105 $^{o}$C. The sample was left in the oven for three hours. After the heating, the oven was switched off, and the sample left overnight to cool. The sample was re-weighed after twelve hours. Care was taken to ensure that sample did not absorb moisture before and during weighing. After recording the second weight for each, the samples were taken back into the oven for another 3 hrs at that same temperature. This was repeated until any two subsequent weights were equal *i.e.* constant weight attained. Three cubes of each tree species were tied together with a copper wire and weighed as a single entity. Cu wire was removed and the three samples re-weighed. The weight of a cube was obtained by calculating the average of the three samples of each tree species. The dimensions of the three 2.5 cm cubes were measured and the volume of each was calculated. The average volume of the three samples was recorded as the volume of each sample of the timbers. Finally the oven dry density of each tree species was determined by dividing the average dry weight of the three samples by the average volume of three samples.

$$ODD = \frac{\text{Average dry wt of samples} \quad g/dm^3}{\text{Average volume of samples}}$$

**Discussion**

*Figure 2 brings before the sight the graph of water saturation capacity of tropical timbers. The tropical timber with the least water saturation capacity (porosity index) is Manilkara (15%) while P. carribean has the highest porosity index of 262.5%. About nine sets or group of tropical timbers were observed to possess the same porosity index, but this observation cannot be explained in relation to any collected data. The group of tropical timbers with equal porosity index are; K. senegalensis and M. altissima with 26.9%, I. smithii and N. vogelii (38.8%), A ferruginea and M. indica var opiolo mango (44.4%), G.guineensis, P.africana and A. indica (50%), A. nolitica and D. guineensis (61.1%), N. diderrichii and M. indica var.ordinary mango (75%), C.gigantia and T. grandis (87.5%), W. americana and M. indica var, Kerosene mango (92.9%), T. africana and P. soyauxi (100%), C. petandra, I. doka and M.indica var german mango (141.7%). It is remarkably observed that the four varieties of M. indica showed big variation in their porosity index.*

Figure 3 is the graph of water saturation capacity Vs ODD. The tropical timbers- *B. bonopozense* with the least ODD ($24x10^{-2}g/cm^3$) has porosity index of 214% while *Manilkara*, the tropical timber with the highest ODD ($109.7x10^{-2}g/cm^3$) has the least porosity index (27.5%). The tropical timber that possesses the highest porosity index (275.3%) is *C. schwanfurithii.* It has the ODD of $41.3x10^{-2}g/cm^3$.Greater majority of timbers with low $ODD_S$ have high porosity index while greater majority of timbers with high $ODD_S$ have low porosity index. It is also interesting to note that *Manilkara* with the highest ODD of $109.7x10^{-2}g/cm^3$ has the least porosity index. It is observed that the last seven timbers with the highest ODD indicate gradual increase in their porosity index starting with *Manilkara* which has the highest ODD. The last seven timbers are; *Manilkara, A. bateri, G. kola, B. nitida, I. gabanensis, C. sinensis and P. guajava*. These are written in their decreasing order of ODD. Their porosity index are as follows; 27.5%, 35.3%, 36%, 45.8%, 49.1%, 82.6% and 86.6% respectively. Figure 3 reveals that there is inverse relationship between the porosity index and ODDs of these tropical timbers. This means that as the porosity index decreases, the ODD increases and vise versa.

Many problems concerning timber utilization are bound up with the fact that wood is hydroscopic, absorbing or losing water according to atmospheric conditions. Dry wood is lighter than wet wood, and stronger in most strength properties, although wet wood is tougher.

Changes in moisture content of timber are accompanied by changes in shape, for wood swells as its moisture content increases and shrinks as it loses water; swelling and shrinkage are not equal in all directions and thus stress arise which may lead to splitting and warping as water is lost.

Fibre saturation point, a somewhat theoretical concept, is the point at which the lumina are empty but the walls saturated with water. At fiber saturation point wood contains, 25-30% of its oven-dry weight of water" (The Encyclopedia Americana (1829); Chambers Encyclopedia, New Revised Edition, Volume XIII; Funk and Wagnalls New Encyclopedia, Vol. 27 [3-5].

## Conclusion

Water saturation capacity of tropical timbers should be considered for one to make wise choice of timber.

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