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Table 1.0 Proximate Analysis of *Cissus populnea*

Parameters	Amount in percentage (%)
Moisture	20.10
Ash	12.59
Insoluble Ash	00.10
Fat	12.31
Crude Fibre	60.71
Protein	04.35

Source: Alakali et al. (2009)

2.0 MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Locally sourced fresh *cissus populnea* stems of about 10cm long and 90% moisture content were manually de-pithed and oven dried to a constant mass. The fibres were removed and cut into length of 20 -30mm suitable for reinforcement. A bag of Portland cement (elephant brand) procured for the production of the boards was stored in a tight sealed container to avoid moisture absorption before use and the waste papers that were recycled into pulp were obtained from spent office papers in Federal College Forestry Ibadan, Oyo state Nigeria. The papers were soaked in water for three days, digested by using a disintegrator and finally drained before oven drying to a constant mass.

The matrix for the production of the boards was shown in Table 2.0. Each proportion was mixed to form a slurry before pouring into wooden mold of 150mmx150mmx20mm placed on polythene nylon. The surface of the mold was also covered with polythene nylon before the cold pressing to enhance the surface smoothness of the board surface. Thereafter, the mold was vibrated using motorized vibrator to allow uniform distribution of the slurry across the entire surface area of the mold.. Hydraulic cold press machine rated 25bar maximum pressure was used to compress the boards. Proposed sample thickness of 10mm was obtained at a pressing pressure of 5bar and this pressure was constantly maintained and left for 24hrs before de molding. All samples were cured in water for 12hrs and air dried for 24hrs under room temperature of 21-27^{0}C before they were subjected to impact energy, water absorption, thickness swelling, thermal conductivity and density tests.

Table 2.0 Cissus fibre, Pulp fibre and Cement Mixing Proportion for Board Production

% Fibre by weight of cement (g)	Dry pulp fibre (g)	Cement (g)	Total weight of matrix (g)
0	**5**	**100**	**105**
2	**5**	**100**	**107**
4	**5**	**100**	**109**
6	**5**	**100**	**111**
8	**5**	**100**	**113**

2.2 Physical properties Test

The samples were prepared in accordance with Standards for testing materials (ASTM D743-13, 2013.) The final size of each test sample was 150mm X 100mm X 10mm and 36 samples were tested for the selected properties.

2.2.1 Water Absorption and Thickness swelling (immersion method)

Initial weight of test samples at room temperature of 25^{0}C-27^{0}C were determined prior to horizontal submerged of the samples in water. The samples were removed from water after 24hrs and allow to drain before final weights were taken. The water absorption and thickness swelling of the samples were computed using equation 4 and 5

$$\% \text{ Water Absorption } (WA) = \frac{W2 - W1}{W1} \times \frac{100}{1} \quad \text{.........} (4)$$

$W1$ (g) = Initial weight before soaking

$W2$ (g) = Final weight after 24hrs.

$$\% \text{ Thickness Swelling } (WT) = \frac{T2 - T1}{T1} \times \frac{100}{1} \quad \text{.........} (5)$$

T_1 (mm) = is the thickness of the sample before immersion

T_2 (mm) = is the thickness of the sample after immersion

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2.2.2 Density

The mass of each sample was determined using sensitive weighing scale of 5kg maximum weighing capacity and the densities of the samples were determined using equation 6

Density $= m/v$ --------------------6

m=mass of the sample (kg)

v=volume of sample (m^3)

2.3 Impact Energy Test (Free Fall Method)

A sample was suspended on two ends support of span 100m placed at the base of calibrated impact energy testing equipment and a steel ball of known mass was allowed to drop freely on the sample from a recorded least vertical height, the initial height from where the ball falls was gradually increased until failure (cracking) of the sample occurred. The final height at which failure occurred was recorded and the impact energy was computed in joule (J) using equation 3

E = mgh …………………………………3

m = mass of steel ball (kg)

g= acceleration due to gravity m/s^2

h = height of the fall at which sample failure occurred (m)

E= Impact energy (J)

2.4 Thermal conductivity test (Non- steady state method)

Thermal conductivity test was carried out using digital KD2 pro-thermal properties analyzer, (KD2 pro utility). The probe of the equipment was directly inserted into each sample and the value of the thermal conductivity displayed on the KD2 meter screen was recorded for evaluation.

2.5 Statistical Analysis

Data obtained were subjected to descriptive statistics, analysis of variance (ANOVA) and line graph.

3.0 RESULTS AND DISCUSSION

3.1 Results

Table 3.0: Computed mean values of the properties of *Cissus populnea* stem fibre and pulp fibre reinforced-cement boards

Mass of fibre (g)	Mass of dry pulp fibre (g)	Mass of cement (g)	Total weight of Composite matrix(g)	Impact Energy(J)	Water Absorption (%)	Thickness Swelling (%)	Density (kg/m^3)	Thermal Conductivity (W/m.K.)
0	5	**100**	**105**	3.08	0.24	0.52	670	0.085
2	5	**100**	**107**	3.14	0.26	0.53	690	0.087
4	5	**100**	**109**	3.61	0.27	0.57	710	0.092
6	5	**100**	**111**	3.98	0.27	0.83	720	0.088
8	5	**100**	**113**	3.64	0.30	0.90	735	0.075

Table 4. Engineering and material science standards for ceiling boards

Density (KG/M^3)	Compression strength (KPA)	Impact strength (J)	Hardness $\times 10^3$	Water absorption, WA (%)	Thermal conductivity (W/M.K)	Thermal resistivity (M.K/W)
350-400	448 – 868	_	0.800	0.64	0.052-0.057	17.5 – 19

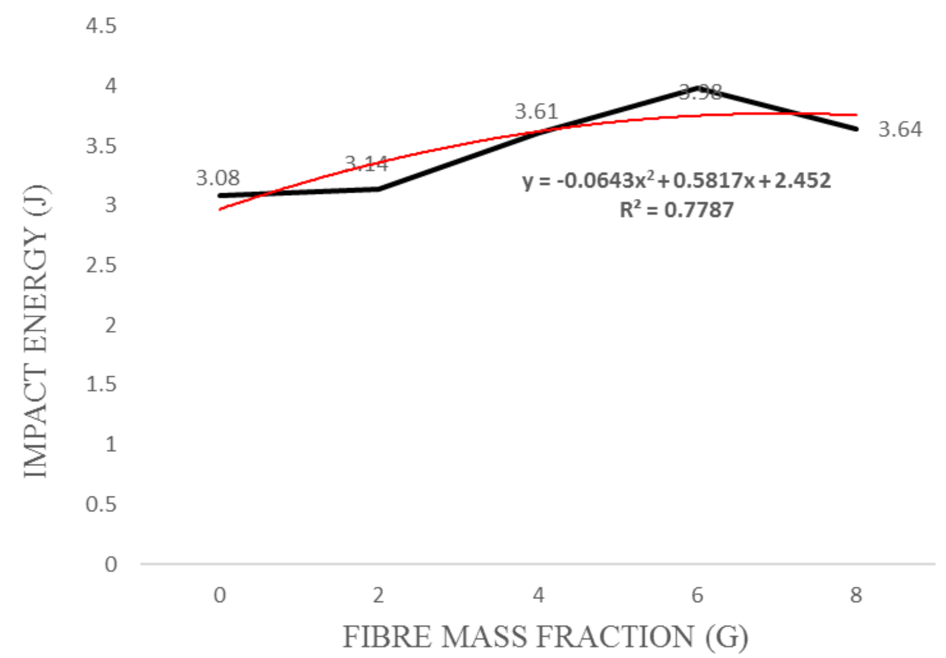

FIG.1. IMPACT ENERGY VS FIBER

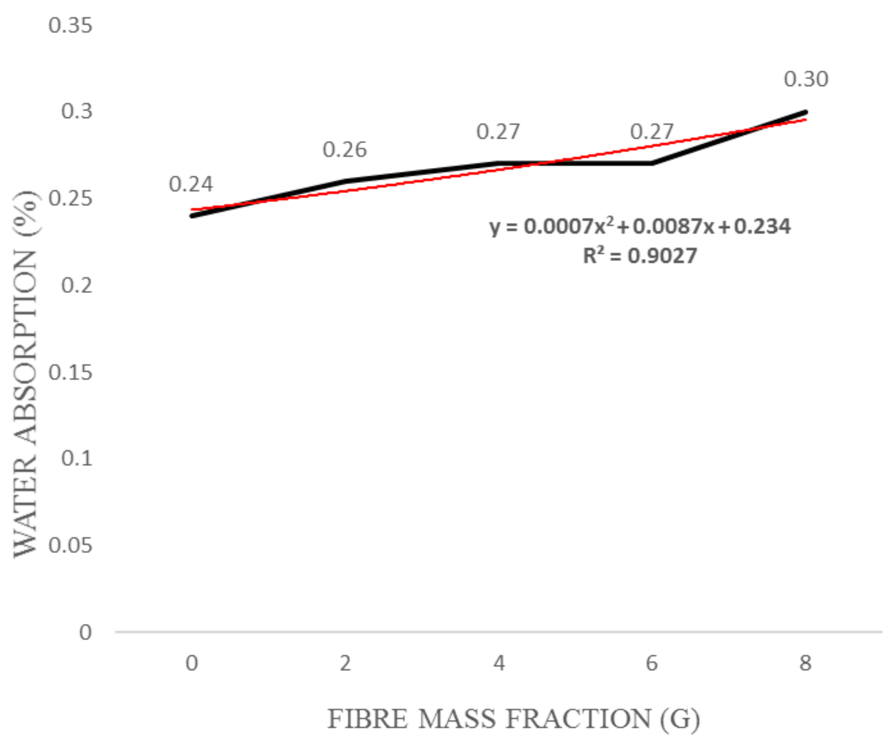

FIG.2.WATER ABSORPTION VS FIBRE

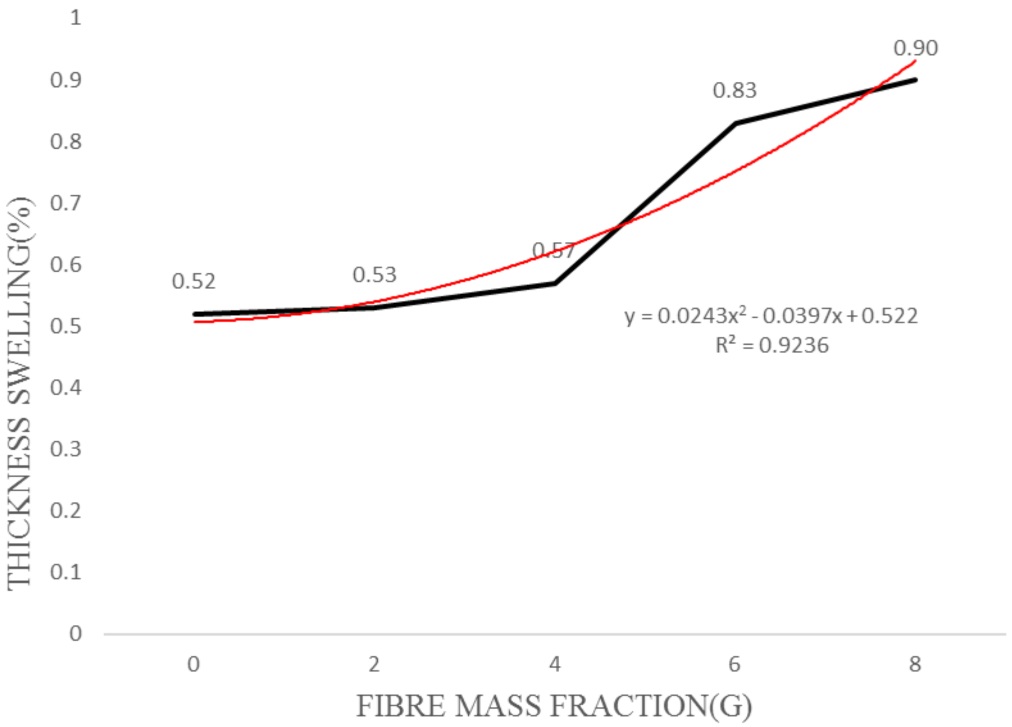

FIG.3. FIBRE VS THICKNESS SWELLING

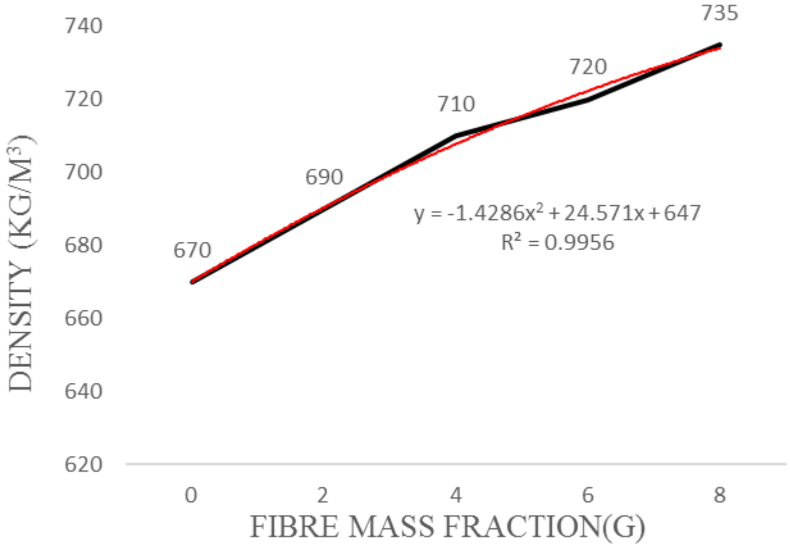

FIG.4.FIBRE VS DENSITY

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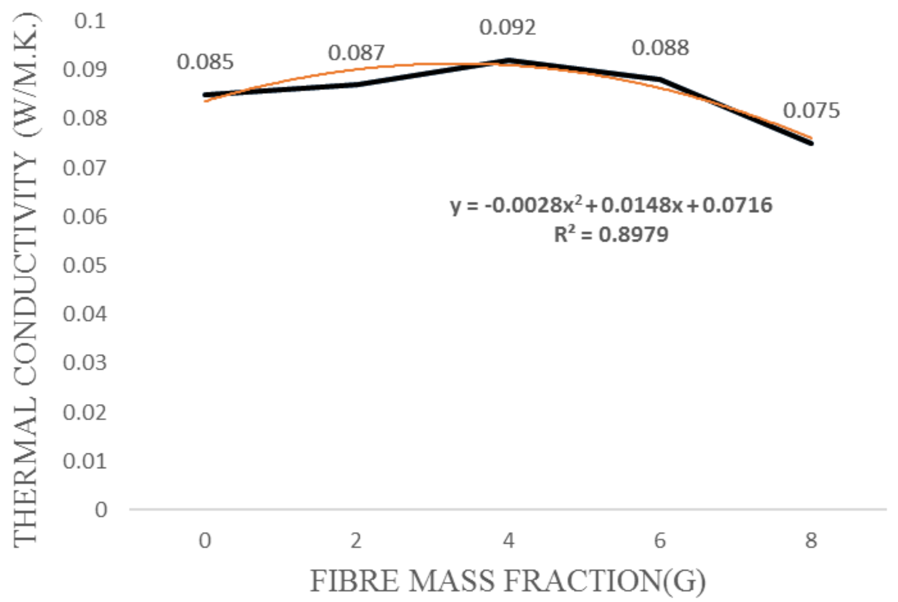

FIG.5. FIBRE VS THERMAL CONDUCTIVITY

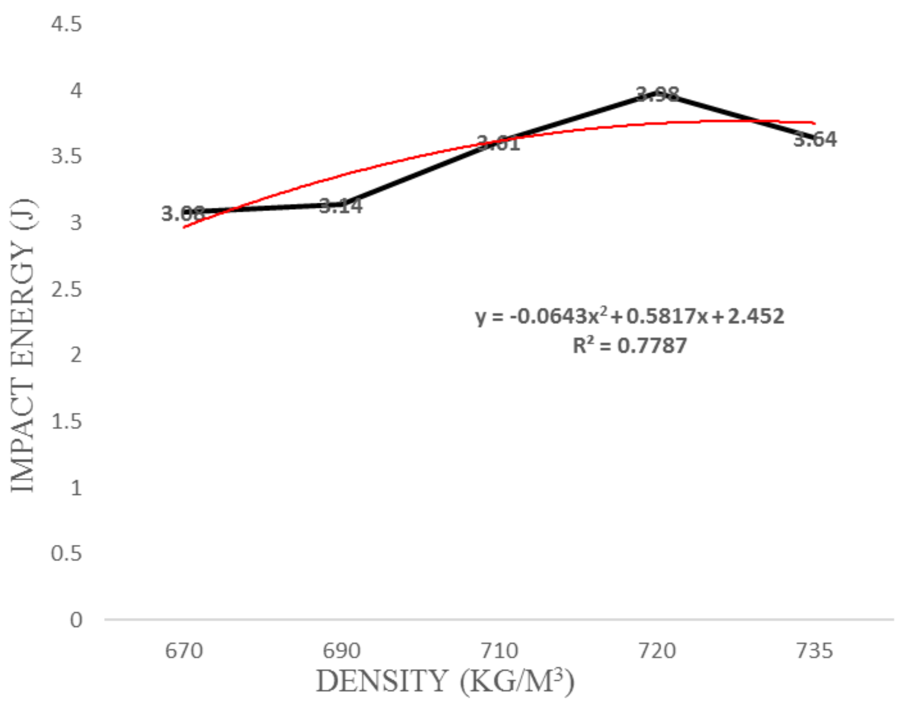

FIG.6. CORRELATION BETWEEN DENSITY OF THE BOARDS AND IMPACT ENERGY

DISCUSSION

Thickness swelling and Water absorption values range between 0.52% - 0.90% and 0.24%-0.30% respectively. The highest values of water absorption, 0.90% and thickness swelling, 0.30%, were obtained at maximum cissus fibre reinforcement of 8%. This implies that, increasing the fibre percentage in the board will increase the board affinity for water absorption. This increased rate for water absorption and Thickness swelling may have occurred due to hygroscopic nature of lignocelluloses fibres which allow for moisture intake. The trend obtained in this result correlate with Olawale, (2009)

Density of the boards is a function of fibre – cement ratio, it ranged between 670kg/m^3 and 735kg/m^3. The density increases with increased cissus fibre. The pulp fibre in the matrix which serve as both reinforcement and filler material control the density of the boards within acceptable range of 500kg/m^3 – 800kg/m^3 for medium density fibre board. The polynomial rank correlation, R^2=0.78 between density and impact energy of the boards as depicted in Fig 6 indicate that the impact energy of the board is also a function of density of the boards.

The impact energy obtained from the free fall method is the energy required to cause the failure of the board when subjected to impact loading. It can also be interpreted as the maximum impact loading beyond which failure will occur. The values ranged between 3.08J and 3.98J, it is maximum at 8% cissus fibre reinforcement. The energy increased between 0% and 6% and reduces between 6% and 8% fibre reinforcement. This trend showed that, increasing the reinforcement of the composite above 8% fibre reduces the impact energy of the board and will therefore affect its ability to withstand more impact loading, this behaviour can also be traceable to excess fibre to cement ratio of the composite board. The same findings was reported on natural sponge fibre – reinforced cement boards by Olawale, 2009. Comparing the values obtained to the findings of Ekpunobi et al 2015 on the mechanical properties of waste paper ceiling board, it was observed that, the use of cissus fibre as additional reinforcement material is a factor that increase the impact energy values of the boards.

The thermal conductivity of the composite board determined heat conductivity potential of the board with respect to time and change in temperature when use as ceiling or wall siding material for construction. It ranged between 0.075W/m.K and 0.092W/m.K. The maximum thermal conductivity of 0.092W/m.K was obtained at cissus fibre reinforcement of 4% while the least 0.075W/m.K was obtained 8%. It was observed that increasing cissus fibre above 4% reduces the thermal conductivity of the boards, which is attributed to high interlock bonding spaces between the cissus fibre and cement. The thermal behaviour of this board correlate with the result of the thermal conductivity of the board produced from rice husk and waste paper by Ataguba, 2016.

CONCLUSIONS AND RECOMMENDATION

The results obtained from the study showed that, using cissus fibre as reinforcement materials for production of medium density board for ceiling and walling applications. This will eliminate energy consumption and environmental hazard caused by synthetic fibres The range values of the board impact energy, thermal conductivity, water absorption and thickness swelling fall within the standard values that will make the boards acceptable for use as light load bearing member for construction, the use of cissus fibre alone or in combination with other lignocelluloses fibre as reinforcement material and extension to production of fibre based composites for other applications such as roofing and flooring is hereby recommended.

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