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Comparative Study on the Effect of Density on Water Absorption of Particle Boards Produced from Nipa Palm Fibres with HDPE Wastes

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ABSTRACT

Nipa palm fibres were used in producing fibre boards with different mixtures of waste HDPE fibres. Density, swelling thickness and water absorption of the boards were determined and compared to know the combination that would yield the best quality. The relationship between the densities of boards produced and their ability to absorb water was also established. The significance of the results implies that the boards have special water resistant property, a feature that makes them suitable for use in areas of high humidity or occasional wetness. It is also noted that as more plastic waste is incorporated into Nipa fibres, the less density impacted on the particle boards and, hence, more water is absorbed.

Keywords: Nipa palm, fibre board, HDPE, density, production

INTRODUCTION

Fibre board is a type of engineered wood product that is made out of wood fibres (The American Heritage Dictionary of the English Language., 2004; Carll, 1986). Types of fibre board in order of increasing density include particle board, medium-density fibre board and hard board, also called high-density fibre board. Fibre board is sometimes used as a synonym for particle board, but particle board usually refers to low-density fibre board. Fibre board, particularly medium-density fibre board, is heavily used in the furniture industry. For pieces that will be visible, a veneer of wood is often glued onto fibre board to give it the appearance of conventional wood. Medium Density Fibreboard (MDF) was first developed in the United States during the 1960s, with production starting in Deposti, New York (Laurel, 1996). A similar product, hard board (compressed fibre board), was accidentally invented by William Mason in 1925, while he was trying to find a use for the huge quantities of wood chips that were being discarded by lumber mills (Laurel,

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1996). He was attempting to press wood fibre into insulation boards but produced a durable thin sheet after forgetting to shut down his equipment. This equipment consisted of a blow torch, an eighteenth-century letter press, and an old automobile boiler. Wood chips, shavings and sawdust typically make up the raw materials for fibre board (Margosian, 1995; Koenig, 1996). However, with recycling becoming the norm today as a result of global concerns over an increasing degraded environment, waste paper, corn silk and even bagasse (fibre from sugar cane) are now being used as well to produce MDF. Other materials are being recycled into MDF as well. One company is using dry waste materials at a rate of 100,000 tons a year (Laurel, 1996). In addition to waste wood, cardboard, cardboard drink containers containing plastics and metals, telephone directories and old newspapers are being used at this company. Synthetic resins (Dimethylol urea-DMU/urea formaldehyde -UF, melamine formaldehyde-MF and phenol formaldehyde-PF) are used to bond the fibres together and other additives such as fire retardants-FRs may be used to improve certain properties (Buschfeld *et al*., 1991; Cartridge & Sharpe, 1975; Robitschek & Christensen, 1976). Agricultural biomass has also been used to make particle or fibre boards (Uhland *et al*., 2003). Another method for recycling rubber scrap to yield a final product of various thicknesses and various widths and lengths capable of consolidation into a variety of building product materials is also available (Jamison, 1995).

The massive presence of Nipa palms in the coastal ecosystem of Nigeria has contributed to the migration of fauna resources to areas that cannot cope with the volume both physically and ecologically; hence, reduction in breeding and reproduction has become a need . Nipa does not absorb pollutants, thus toxic particulates or sediments become a source of micro fauna and flora depletion (Fagbemi *et al*., 1988). Nigeria has the largest mangrove wetland in Africa with its rich floristic mangals and fauna population (Fagbemi *et al*., 1988). The greatest concentration of mangrove germplasm is in the Niger Delta Region of Nigeria (Kahn, 1988). A combination of factors, including anthropogenic and ecological factors, is threatening to reduce the relevance of mangrove wetland in the environmental and socio-economic scheme of things. When Nipa palm seedlings were introduced into Nigeria in 1906 in Calabar, nobody thought of the ecological consequences that might follow (Peters, 1995). The changes to the environment that have resulted from the introduction of Nipa palm into Nigeria has given rise to several negative appellations being given to Nipa palm (Umotong, 1997; Ojebo, 2002; Ekpunobi *et al*., 2012). They include: “prostate alien palm”, “good for nothing”, “exotic invader”, ecological disaster”, “tragic mistake”, “worthless plant”, “the nuisance plant”, “unfruitful palm”, “useless palm” and “environmental menace”, to mention but a few. In the bid to fight this ‘intrusion’ of the Nipa palm, the mid-ribs of the palms are cut and thrown away; these wasted mid-ribs were the focus of this research, which studied the feasibility of producing fibre board from the cut-away sections of the Nipa palm after mixing with waste HDPE fibres. The densities of the boards produced were then determined. The effect of density on the ability of the boards to absorb water was also determined.

MATERIALS AND METHODS

The mid-ribs of Nipa palm were collected from the coastal region of Oron, with the help of the staff of the Nipa palm Utilization Project Centre, National Museum, Oron, Akwa Ibom State, Nigeria. The mid-ribs of Nipa palm and plastic waste (HDPE) were utilised in production of fibre board as described (Ekpunobi *et al*., 2012). One kilogramme of particles together with the crushed plastic wastes for each composition was blended with epoxy resin with melamine serving as filler and formed into mats and then hot-pressed into solid panels. The following compositions were made on a dry-matter basis.

- 100% fibre (fibre only)
- 90% fibre (90% fibre + 10% plastics)
- 80% fibre (80% fibre + 20% plastics)
- 70% fibre (70% fibre + 30% plastics)
- 60% fibre (60% fibre + 40% plastics)

The mixture of binder and inert filler was constant throughout the composition and is in the ratio 6:4 respectively. Compressing was done at 176^{o}C , 2–3MPa (47.7KN) and for 60 minutes each using a hydraulic press of Model Cat c 43/3, Serial No. 9403626 and Capacity 2000KN. The mould for compressing was a metal cylindrical mould with 161.6mm internal diameter, with a nominal capacity of 950cm^3 and a height of 116.3m fitted with a detachable collar and a base plate. After compressing, the boards were left for 3 days in an air-conditioned room for drying. The different panels produced were weighed and recorded. The volume was calculated by measuring the different sides and recorded. Chunks of 45-by-22mm^2 of all samples were further subjected to 24-hr water-soaking according to ASTM D 1037 standard. This was in order to calculate the swelling thickness (ST) of the samples as well as the water absorption of the panels produced. Thickness measurements of panels were done at the edge one (E_1), Centre (C), and the other end edge (E_2) at the end of soaking. The readings were recorded and the average taken as AT_1 (Initial average thickness) and AT_2 (Final average thickness)

$$\%S.T = \frac{AT_2 - AT_1}{AT_1} X \frac{100}{1} \tag{1}$$

(Ekpunobi *et al*., 2012; Quinglin, 2001; Van Vlack, 1975)

All the samples at the end of soaking were weighed, and the weights noted (W_1); they were then oven-dried at 103^{o}C to a constant weight and the weights noted (W_2) again. The water absorption was calculated thus (Ekpunobi et al., 2012);

$$W.A = \frac{W_1 - W_2}{W_1} X \frac{100}{1} \tag{2}$$

RESULTS AND DISCUSSION

The density for each board type is shown in Fig.1 in comparison with European Standard EN312-3 specification for interior finish. The general density profile of the samples had a polynomial shape indicating an irregular density gradient and all were seen to be slightly lower than the EN standard except for the 70% and 60% fibre which showed a great disparity. Density of the 100% fibre (fibre only) 648kg/dm^3 was lower than that of 90% fibre (10% HDPE) 678kg/dm^3 and 80% fibre (20% HDPE) 669kg/dm^3 but higher than 70% fibre (30% HDPE) 601kg/dm^3 and 60% fibre (40% HDPE) 536kg/dm^3.

Swelling thickness as a function of % fibre is shown in Fig.2 after 24 hours of water soaking. A uniform swelling across the edges was obtained for all the samples except for 60% fibre, which gave a higher swelling at edge 2 followed by the centre and then edge 1 as shown in Table 1. A linear relationship was obtained. There was a gradual increase in the swelling thickness as % fibre decreases. 100% fibre has a swelling thickness value of 4.8, 90% fibre, 4.9, 80% fibre, 4.8, 70% fibre, 6.9 and 60% fibre, 8.0. In comparison with EN Standard, all but 60% fibre met the Standard value.

TABLE 1
Swelling across the edges

% Fibre	E1 (mm)	C (mm)	E2 (mm)	Ave (mm)
100	1.20	1.20	1.20	1.20
90	1.25	1.25	1.25	1.25
80	1.25	1.25	1.25	1.25
70	1.70	1.70	1.70	1.70
60	1.90	1.95	2.00	1.95

Water absorption as a function of % fibre is shown in Fig.3. There was a slight decrease in water absorption from 90% fibre of value 10 to 80% fibre of value 9.7, after which the water absorption increased in linear fashion from 90% fibre to 50% fibre value 13. The increase was thought to have been due to low interaction of high dosage of HDPE waste with the binder as well as to the particle size distribution of the plastic waste. A predictive model equation was obtained by regression analysis as shown in equation (3). The equation gives an indication of what is expected from the water absorption capabilities of boards produced as the different % plastic wastes are incorporated into the Nipa palm fibres, invariably altering the density. The significance of this result implies that the boards have special water resistant property, a feature which makes them suitable for use in areas of high humidity or occasional wetness.

Predictive model equation :

$$Y= 0.0833x^4- 1.0667x^3+ 4.9667x^2 - 8.9833x + 15 \quad (3)$$

$R^2 = 1$

Where Y = Dependent variable = Swelling thickness

X = Independent variable = % Fibre

R^2 = Fitness coefficient

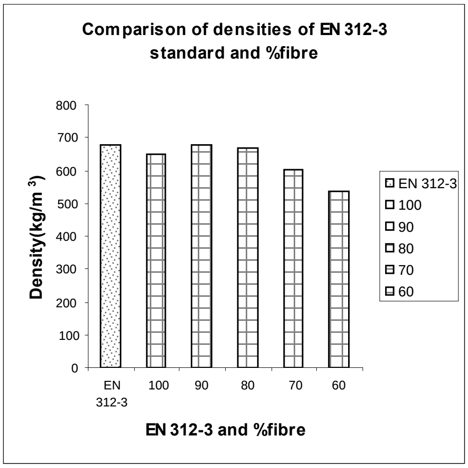

Fig.1: Densities of samples in comparison with EN Standard

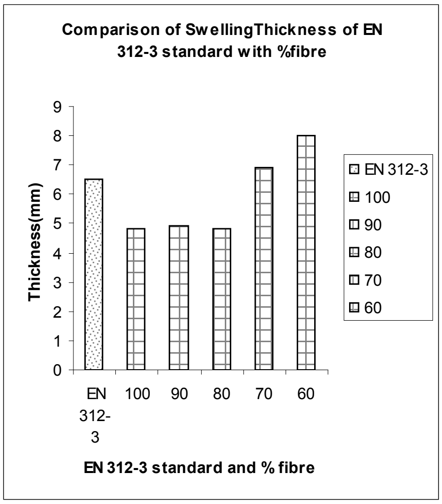

Fig.2: Swelling thickness in comparison with EN Standard

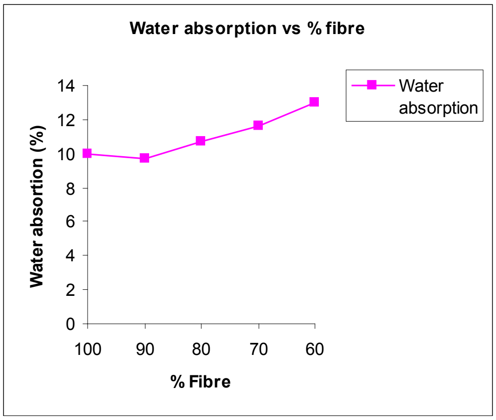

Fig.3: Water absorption as a function of % fibre

On comparing the densities of the boards with the level of water absorption, it was observed, as given in Table 2, that as the density of the boards increased, the ability of the board to absorb water decreased and vice versa.

TABLE 2
Comparison of density and water absorption of boards

Fibre %	Density (kg/m^3)	% W.A
100	648	10.0
90	678	9.7
80	669	10.7
70	601	11.6
60	536	13.0

CONCLUSION

It is observed that the mid-ribs of the Nipa palm can be put to profitable use in particle-board production for targetted interior decoration application rather than simply throwing them away once they are cut. It is also observed that as more plastic wastes are incorporated into the Nipa fibres, the boards become less dense, and more water is absorbed. It is therefore possible to conclude that these Nipa-palm particle boards have a special water-resistant property, making them suitable for use in areas of high humidity or occasional wetness.

The impact of this finding on the future of Nigeria and other countries with a similar climate, for instance, Malaysia, is indeed significant. In the near future, an industry arising from uses of the Nipa palm may not only provide employment for ever increasing populations especially in the developing world; it can also yield an income for these countries that area able to nurture the Nipa palm.

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