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POTENTIALS OF SAWDUST AND DISPOSED WATER SACHET WASTES FOR WOOD PLASTIC COMPOSITE PRODUCTION

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ABSTRACT
The study investigated the potential of sawdust and disposed water plastics for the production of wood plastic composite. The sawdust was obtained from the plank market in Yola, while, the water sachets were hand-picked within the Modibbo Adama University premises. The gathered sawdust were sieved into 1.0 and 2.0 mm particle sizes, thoroughly mixed with already melted water sachet plastics at a ratio of 1:25 (100: 2500 ml) and 1:30 (100:3000 ml) respectively,. The mixtures were heated at (105.2^0 C,) and then filled into an already constructed oiled Aluminum mold of size 1.5 x 6 x 15 cm. Pressure was applied for two hours to compress the composite before removal from the mold. The samples were then trimmed according to sample size requirement, for mechanical and physical property properties tests. The results revealed that, the plastic composite produced from 2mm sawdust particles and mixed at ratio of 1:25 has the highest mean hardness (14.99 ± 3.54 MPa), The mean highest impact strength (1.24 ± 0.12 J) was obtained in the sample with particle size 1 mm and plastic ratio of 1:30, while, the highest mean water absorption percentage (2.27 ± 0.132) was obtained in particle size 2 mm and plastic ratio of 1:25.The Analysis of variance conducted shows that, sawdust particle size and mixing ratio had significant effect on both physical and mechanical properties of the produced plastic composite ($p < 0.05$). The study had demonstrated that the use of disposed sachet water plastics and sawdust waste without adhesive is a good material for the production of wood plastic composite.

Keywords: Wood plastic composite, Impact strength, Absorption, Particle size

INTRODUCTION

Forest industries add a great value to tropical forest resources and thereby contributing to their sustainable management (International Tropical Timber Organization, 2014). In Nigeria, these industries (Mill industries) are affected by structural and managerial deficiency resulting in an inefficient conversion process. One of the major problems with wood conversion and utilization in Nigeria, like many developing countries, is the inability to make efficient use of large volumes of residues generated during the wood conversion process. The generated wood waste during wood conversion and processing constitutes a large volume of the log input. This is usually due to poor saw doctoring, poor staffing, saw kerfs sizes and log dimensions etc. According to Badejo and Giwa, (1985), the waste generated in sawmill has been estimated to be about 40-50% of the log input over the past years. This wood waste ends up in the form of sawdust or wood shavings, which are later dumped and burnt in the incinerators. The smoke comings out of the incinerator constitute an hazard to the environmental, which may likely affect the health of the inhabitant of the area.

Aside from wood waste, Plastics container has become a popular material due to its increasing and sustainable use by industries and household. This has lead to increase in large volume of plastics of different types been generated in our society, most of these plastics containers after evacuating the liquids inside becomes waste which litters our environment. For example, empty sachet water bags when improperly disposed, litter the streets and cause environmental pollution. Technologically, this wood waste and plastic waste when combined or molded, can be converted to a useful by-product "wood-plastic composite" which can be used to produce other products or materials using heat and pressure. Thermoplastic materials like Polyethylene (PE), Polypropylene (PP), and Polyvinylchloride (PVC), though, being a part of the product serves as a major binding material (Li and Wolcott, 2003). The product formed can be made into any form, shape, size, color, design or quality depending on the producer's concept, and the intended end use.

The awaiting market for WPC is huge, it presents a promising raw material source or new value added products due to the large amount of daily waste generation and low cost (Najafi et al., 2007; Adhikary et al., 2008)). WPC commercial products are increasingly replacing many products in many applications especially; the construction related ones (Yeh et al., 2009). WPCs have gained an ever larger share; especially for decks and other outdoor structures (Youngquist et al., 1992).

The study investigated the potentials of sawdust waste and disposed sachet water waste for the production of wood plastic composite.

MATERALS AND METHODS

Study Area

The experiment was conducted at the Department of Forestry and Wildlife Management Laboratory, Modibbo Adama University, Yola, Adamawa State. It is located on Latitude 9˚ 20' 00" and 9^0 21'30 N, and Longitude 12^0 29'0" and 12^0 30'30"

E in the savanna area of North East Nigeria, with an altitude of 158.8m above sea level (Adebayo and Zemba, 2020). It covers an area of about 54 hectares (GIS Unit, Department of Geography, Mautech, 2017).

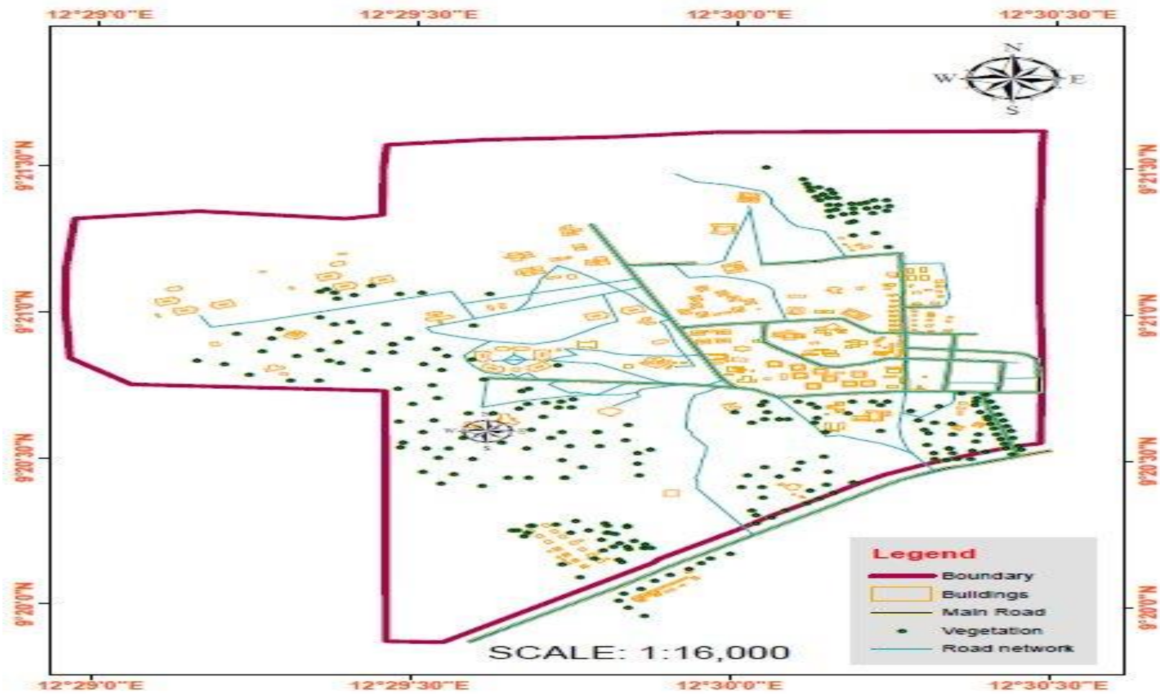

Figure 1. Map of Modibbo Adama University, Yola, showing the study area.
(Source: Extracted from Saka et. al., 2021)

Methodology
The materials used for this study are sawdust and disposed sachet water. Sawdust was obtained from Timber shed in Yola, Adamawa State, while the sachet water polythene was gathered within Modibbo Adama University, Yola. The collected saw dust particles were sieved, using 1.0 mm and 2.0 mm sieve respectively. The meshed wood waste was dried in a furnace for 4 hours to eliminate the moisture within wood waste particles up to almost 100%. The furnace temperature was set at 115^0 C. This temperature was decided to be increased not more than 115^0 C due to safety reasons as to avoid wood waste burning. The shredded particles were later fed into the furnace to form a paste at a ratio of 1:25 (100:2500 ml) and 1:30 (100:3000 ml) making up of the four samples (Treatment) used for this study (Table 1.)
The paste (mixture of wood waste and water sachet) was then placed in already constructed oiled Aluminum mould of size (15 x 6 x 1.5 cm). Each treatment was replicated 15 times. A pressure was then applied for two hours, using, hydraulic compression moldin machine to compress the WPC before detaching the samples from the mould. Finally trimming and cutting processes of the samples were done according to ASTM D 4761,(2006) requirements as reported by El-Haggar et al., (2011) for both physical andmechanical properties test.

Table 1: Experiment Layout for Wood Plastic Composite

Sample	Sawdust Particle Size (mm)	Wood/plastic mixing ratio	Number of Replicate
Sample 1	1.0	1:25	15
Sample 2	1.0	1:30	15
Sample 3	2.0	1:25	15
Sample 4	2.0	1:30	15

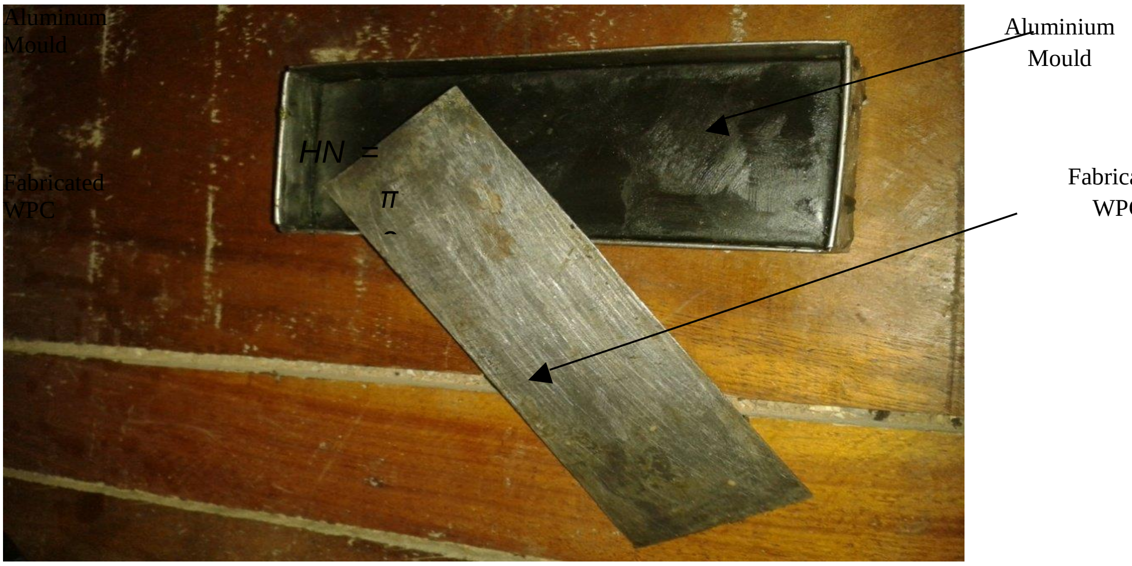

Plate 1. Showing the Aluminum mold and the fabricated WPC

Physical Property
The physical property of the wood plastic composites was assessed through Water absorption percentage. The test samples measuring 50 x 50 mm in size (British standard:BS-373, 1986) was used to determined the physical property of the WPC. Samples of known weights were immersed in water for 24 hours. The weight after immersion was then taken with the aid of electronic weighing balance. The weight gained was then determined using the following equation (Eq. 1) as adopted by Aina et al., (2014).

$$WA = \frac{W2 - W1}{W2} \times 100 \quad (1)$$

where:
WA = Water Absorption (%), W2 = Initial weight (g), W1 = Final weight (g).

Mechanical Properties
The mechanical properties of the Wood plastic composite were assessed through Hardness and Impact strength properties.

Hardness Strength
To test for hardness strength, the samples were trimmed to 2.5 × 2.5 mm. before being placed on the floor of the apparatus; a load is then release to create indentation on the surface of the samples. The hardness properties were obtained, using, Meyer's hardness formula (Eqn. 2):

$$HN = \frac{F}{\frac{\pi}{2}\left(d - \sqrt{d^2 - D^2}\right)} \quad (2)$$

where:
HN = Hardness (MPa), F = Load (kg/m^2), d = Diameter of indenter (cm), D = Diameter of indentation (cm).

Impact Strength
For the impact strength test, Charpy impact strength test was used. The samples were trimmed to 2 × 15 × 55 mm with a tip radius of 0.25 mm. The samples were supported at its two ends on an anvil and struck on the opposite face to the notch by the pendulum. The amount of energy absorbed in fracturing the test-sample is measured and this gives an indication of the notch toughness of the test material.

Data Analysis
Analysis of variance (ANOVA) was carried out to evaluate the variation among the samples, using statistical package for social scientist (SPSS) software, while, Fisher's Least Significant Difference (LSD) was used for separating the sample means.

RESULTS AND DISCUSSION
Physical Property
The result of percentage water absorption by the wood plastic composites revealed that samples with sawdust particle size 2mm and 1:30 wood-plastic ratio had the highest water absorption 2.27 ± 0 .158%, followed by composites produced from particle size 1 mm and 1:25 wood-plastic ratio with 2.01 ± 0.131% water absorption, while, composites produced 2 mm particle size and 1:30 wood-plastic ratio had the least1.85 ± 0 .082% (Fig 2). When subjected to analysis of variance, significant difference ($p < 0.005$) obtained among the sample treatments at 5% probability level.
In addition, Fisher's Least Significant Difference (LSD) was used for mean separation.
(Table 2). The result implied that the more the plastic content in the composite, the more resistance the wood-plastic composite to water uptake. Similar observations was reported on the effect of wood/plastic ratio on WPCs (Behzad, 2012; Aina et al., 2013). Polymers do absorb moisture slightly; this is due to the moisture that is being absorbed by the cellulosic material in matrix of the composite. Composite materials are often optimized by selecting components for their strength, stiffness, flexibility, and durability. When compared with individual materials, composites may also offer more consistent performance, lower production costs, and create an avenue for the utilization of renewable resources.

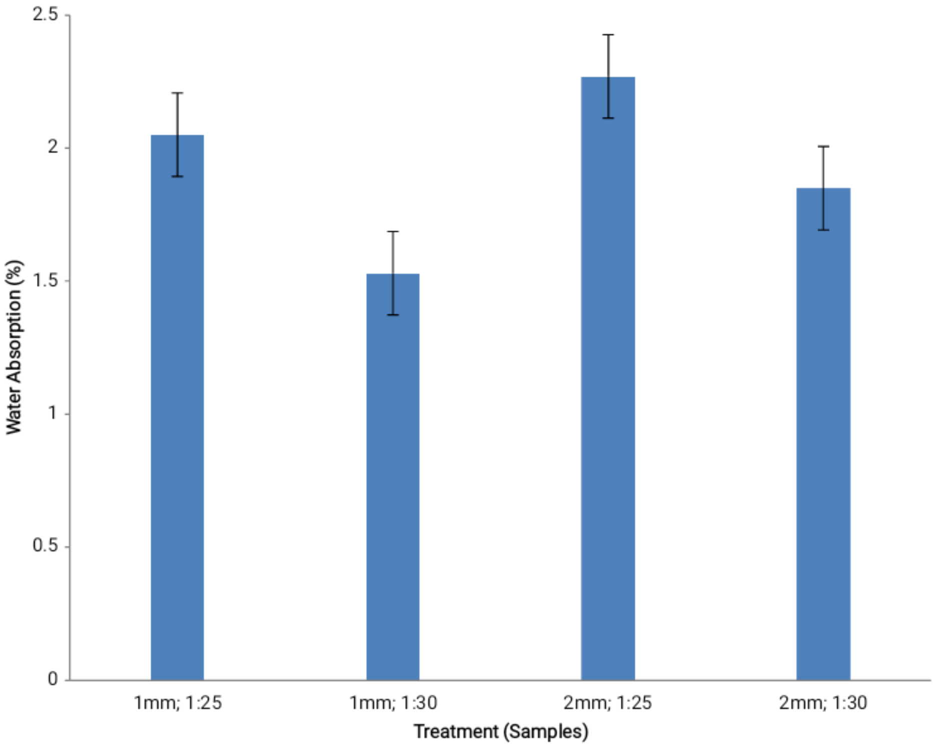

Figure 2: Mean Value of wood-plastic Composite (Water Absorption)

Mechanical Properties Test

Hardness Strength Test

The result of Hardness strength test illustrated in Figure 3 shows that sample particle size 2mm and 1:25 wood-plastic ratio had the highest mean, 14.99 ± 3.54 MPa,. followed by 14.14 ± 3.68 MPa obtained from composites of particle size, I mm and 1:25wood-plastic ratio, while, the least, 8.17 ± 2.27 MPa was obtained in composite produced from saw dust particle size 1 mm and plastic ratio 1:30.

Meanwhile, the analysis of variance presented in Table 1 revealed a significant difference ($p < 0.05$) among the samples at 5% probability level. Same with, LSD presented in Table 2. The hardness of samples increases with an increase in the wood to plastics ratio in the mixture, this is similar with what was reported by Taghi et al. (2011) in his work on the use of recycle materials to produce composites. The material hardness properties increased with more wood waste in the mixing ratio and also with sawdust particle sizes. Increase particle size results in better flowof molten composite, lower mold shrinkage, and higher flexural strength (Klyosov, 2007). The result of analysis of variance shows that sawdust particle sizes and mixing ratio has a significant effect on the hardness of wood plastic composites.

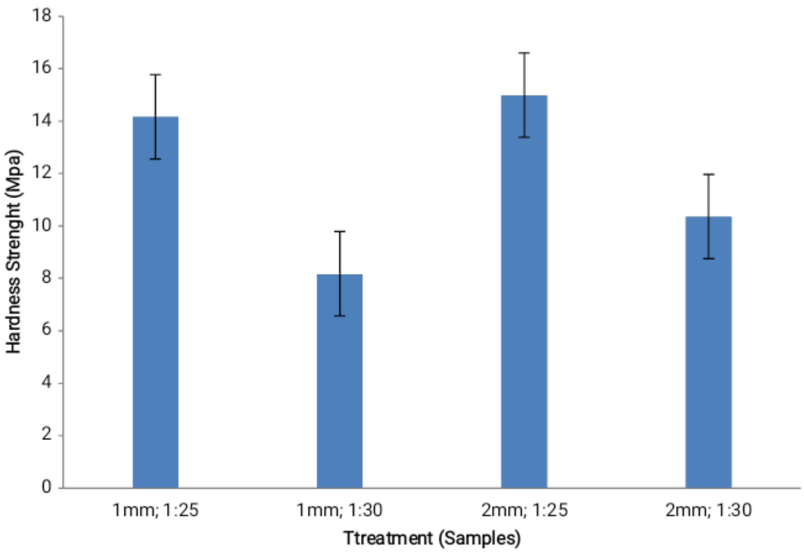

Figure 3: Mean Value of wood-plastic composite (Hardness Strength)

Impact Strength Test

The graphical illustration in Figure 4 showed that the highest impact strength averaged, 1.24 ± 0 .12 J was obtained in woo-plastic composites from saw dust particle size 1mm and wood-plastic ratio 1:30, followed by 1.21 ± 0 .12 J obtained in those produced from sawdust particle size 2mm and wood-plastic ratio 1:30, while the least 1.11 ± 0.10 J was obtained in samples produced from saw dust particle size 2 mm and wood-plastic ratio 1:25. Meanwhile, the result of analysis of variance showed significant difference among the samples ($p < 0.05$) (Table 3).

The Charpy impact strength of the wood-plastic composite decreased with much wood content is much compared to the plastic. This finding is similar to the work reported on DSC analysis and mechanical properties of wood plastic composite by Cui et al. (2010). The smaller the particle size the better the performance (Takatani et al., 2000). As wood is hydrophilic and plastic is hydrophobic, therefore the higher the quantity of plastic and the lesser the quantity of wood, the better the dimensional stability of wood-plastic composites

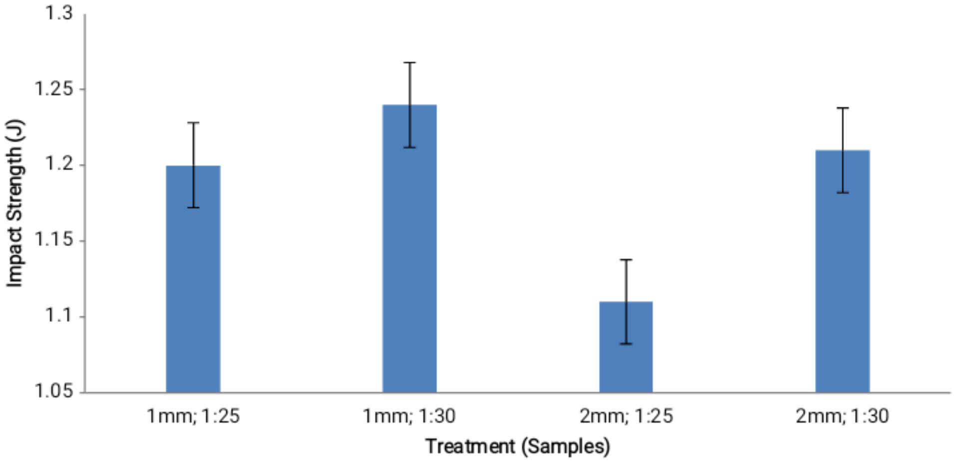

Figure 4: Mean Value of wood-plastic composite (Impact Strength)

Table 2: Analysis of Variance for the Physical and Mechanical Properties of wood-plastic composite

Variables	Source of Variance	Degree of Freedom	Sum of square	Mean of square	Computed F	Sig.
Water Absorption	Treatment	3	4.261	1.420	79.272	0.000*
	Error	56	1.003	0 .081		
	Total	59	5.265			
Hardness Test	Treatment	3	4.62.59	154.198	16.751	0 .000*
	Error	56	515.510	9.206		
	Total	59	978.105			
Impact Test	Treatment	3	0 .151	0 .050	3.200	0.030*
	Error	56	0 .883	0 .016		
	Total	59	1.034			

*Significant

Table 3: Post hoc Test (Fisher's Least Significant Difference)

Water Absorption		**Hardness Strength**		**Impact Strength**	
Treatment	**Mean**	**Treatment**	**Mean**	**Treatment**	**Mean**
2mm; 1:25	2.27^{a}	2mm; 1:25	14.99^{a}	1mm; 1:30	1.24^{a}
1mm; 1:25	2.05^{b}	1mm; 1:25	14.14^{a}	2mm; 1:30	1.21^{a}
2mm; 1:30	1.85^{bc}	2mm; 1:30	10.36^{b}	1mm; 1:25	1.20^{a}
1mm; 1:30	1.53^{d}	1mm; 1:30	8.17^{bc}	2mm; 1:25	1.11^{b}
LSD Value	**0.209**	**LSD Value**	**2.226**	**LSD Value**	**0.093**

Means followed with the same letter are not significantly different ($P > 0.05$) across the column

CONCLUSION

This study has shown that the production of wood plastic composite from sawdust and disposed sachet water plastic is attainable if rightly mixed in good proportion. It can be concluded that WPC can be used as a substitute for wood due to its hardness and impact strength value as deduced from the study. In addition, the use of plastic waste and wood waste in WPC production will also help, in reduction of environmental pollution being caused by burning of this hazardous waste through incinerators as well as depleting the natural resources.

RECOMMENDATIONS

Based on findings from this study, the following recommendations are made;

i. Disposed sachet water plastics and sawdust can be used for the production of wood plastics composite without adding adhesive.
ii. Wood-plastic composite produced from 1 mm particle size and wood-plastic ratio of 1:30 has a better physical and mechanical property when compared with other samples produced in the study.
iii. The fabricated wood-plastic composites samples based on their physical and mechanical properties,

can be used in both indoor and outdoor density boards for general purpose requirements like paneling, ceiling and partitioning.

iv. For efficient and effective homogenous mixing and more production of the composite, Mixer machine is needed to be designed and construct

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