Chapter in Book

Fiberboard out of Plastic Waste and Dry Leaves

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Abstract: *The abundance of trees at Taguig Integrated School makes it an environmentally beneficial institution, yet one of its main problems is the daily accumulation of dry leaves on the ground. Furthermore, despite the school's constant encouragement to pick up their small trash, some students continue to throw their garbage, particularly plastics. As a result, the researchers were compelled to develop something that would help in conserving the trees while also minimizing, if not completely eliminating, the trash problem. The primary goal of the researchers was to create a fiberboard made of dry leaves and plastic waste. The researchers prepared the materials and samples needed. After getting the final product for each sample, the researchers, with the help of Department of Science and Technology (DOST) personnel, chose one sample for tensile and flexural testing. The fiberboard made from sample 2 was selected because it has a color and texture that is comparable to other fiberboards on the market. The DOST assisted in the thorough examination and testing of the product. Based on the results of the DOST tests, which demonstrated the product's tensile and flexural strength, the fiberboard (Sample 2), which contains a ratio of 60 grams of High Density Polyethylene (HDPE) plastic and 40 grams of dried leaves, is efficient and may be used as a substitute for other similar products on the market. It can now be confirmed that this kind of product is very advantageous to all schools in Taguig and in other places in terms of lowering the amount of trash, turning it into valuable resources, and aiding in the preservation of our home planet, Earth. Schools should not just dispose of their solid waste everywhere but instead create innovative ways to reduce their solid waste disposal.*

Keywords: Fiberboard, Environment, Plastic, and Leaves

1. INTRODUCTION

The Philippines' two biggest environmental issues are deforestation and inappropriate waste disposal. Poorer, third-world nations like the Philippines struggle greatly with illicit logging and trash dumping because they lack the legal framework, enforcement, and moral will to stop it (Wikipedia, 2021).

Many people rely on the benefits offered by plastic products. Plastic bags, food packaging, and containers are common plastics used in schools. Several methods for plastic reduction exist for schools, however, teachers, students, and school administrators can use creativity when developing reduction projects. While recycling bins offer a common approach to plastic recycling, the student body and staff can expand the reduction practice by reusing and reducing the amount of plastic in the school system (Hart, n.d.).

Schools are major property owners within the city and are important stakeholders in our urban forest. Most of us recognize the beauty of trees and their many other values. They help protect our waterways by intercepting storm water, stabilizing soil, and using nutrients that would otherwise wash into waterways. Environmental benefits such as clean air and water. Trees help moderate temperature and muffle noise. They even help improve air quality by absorbing some airborne compounds that could be harmful to us, and by giving off oxygen. Spending time around trees and in nature also makes us healthier and even improves our students' academic performances (City of Vancuover Washington, n.d.; Miguel, 2022)

Dry leaves and plastic are abundant in the typical school environment. Trees are being cut down because dried leaves are regarded as unattractive in school, we don't know what to do with all the shredding. Rubbish can be recycled to create usable everyday items rather than being dumped in landfills (Land, Buildings & Real Estate, n.d.). Schools can save money and have a less negative environmental impact by producing less waste. Waste can be a valuable resource. Together, educators and students can develop effective strategies for recycling plastic and other waste. In this study, leaves and plastic will have a better purpose than just being trash.

The purpose of this study is to determine whether plastic garbage and dried leaves can be combined to create an environmentally friendly composite board that will help cut down on school waste.

Specifically, this study seeks to answer the following queries:

1. Which combination of plastic trash and dried leaves produces a good quality fiberboard (Lawanit)?
2. How efficient is the environmentally friendly composite board in terms of its tensile and flexural strength?

From the stated problems, the hypotheses were:

1. The combination of the right amount of plastic and dried leaves produces a good quality fiberboard.
2. The fiberboard (Lawanit) made of plastic and dried leaves, is flexible and it can be stretched and bent.

This research revealed new possibilities for the creative use of dried leaves and plastic garbage. In addition to eradicating the problem of inappropriate garbage disposal, which includes plastics and dried leaves, the researchers sought to assist local schools and the general public in converting their waste into valuable resources. The study also hopes to inspire others, particularly students, to come up with innovative solutions to environmental issues and aid in saving the planet.

This research specializes in the production of fiberboard (lawanit) from dried leaves and plastic trash. This study also focuses on testing the tensile and flexural efficacy of fiberboard (lawanit) produced as an alternative to those sold for commercial usage. This study is limited only to the use of high-density polyethylene plastic bags (HDPE) and dried leaves of the Caimito tree found in Taguig Integrated School. Due to cost limitations, the research only examined one sample for tensile and flexural strength; the other two (2) produced samples of fiberboard were not tested.

2. METHOD & MATERIAL

The materials used by the researchers in creating an eco-friendly composite board are: scissors, used plastic bags, roll mill, sharp cutter, molder (steel), and compression machine.

With the permission of the school principal, used plastics and caimito (*Chrysophyllum cainito*) tree leaves from the Taguig Integrated School's schoolyard were collected. The plastic bags were carefully cleaned, washed, and dried so that no residue would remain on them. The gathered fallen leaves were dried in the sun. When both materials had dried, they were eventually put into small containers. The researchers weighed the materials to get the amount of plastic waste and dried leaves needed. Three containers held the various materials. In the first container (Sample 1), there were 70 grams of HDPE plastic and 40 grams of dried leaves; in the second (Sample 2), there were 60 grams of HDPE plastic and 40 grams of dried leaves; and in the third (Sample 3), there were 80 grams of HDPE plastic and 40 grams of dried leaves. In each container, the components are then mixed. The samples in each container were delivered to Taguig City's Department of Science and Technology (DOST), where they were finely crushed using a roll mill. Each sample was put in a steel mold before being placed under the compression machine. The researchers waited until the fiberboards from plastic trash and dried leaves were produced. After getting the final product for each container, the researchers, with the help of the DOST personnel, chose one fiberboard for tensile and flexural testing. Based on its physical attributes, the fiberboard made from sample 2 was selected because it has a color and texture that are comparable to other fiberboards on the market. Samples 1 and 3 of the generated fiberboard were not evaluated due to financial constraints, and only sample 2 was examined for tensile and flexural strength. The fiberboard (Sample 2) undergoes a series of tests to determine its efficiency in terms of tensile and flexural strength. With the help of the Standard Testing Division and Investigation (STDI) of DOST, the hardness, modulus of elasticity (tensile and flexure), and impact strength of the product were tested.

3. FINDINGS

Based on the results of the DOST tests, which demonstrated the product's tensile and flexural strength, the composite board (Sample 2), which contains a ratio of 60 grams of HDPE plastic and 40 grams of dried leaves, is efficient and may be used as a substitute for other similar products on the market.

4. DISCUSSION

As shown in Table 1, the three separate materials produced a variety of physical traits. The researchers used their sense of sight and touch to identify the physical characteristics of each sample. Sample 1, with 70 grams of HDPE plastic and 40 grams of dried leaves, has a light brown color and a slightly smooth texture. Sample 2, with 60 grams of HDPE plastic and 40 grams of dry leaves, is brown in color and has a rough texture. Sample 3, which has 80 grams of HDPE plastic and 40 grams of dried leaves, is white in color with a smooth, shiny finish.

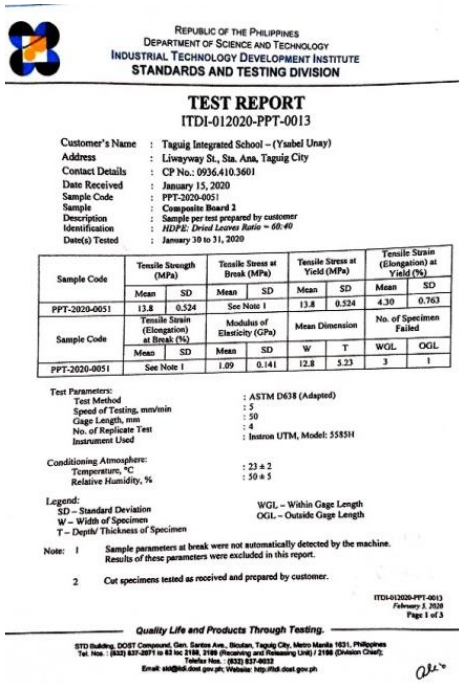
Table 1. Physical Characteristics of Lawanit Board out of Plastic Waste and Dried Leaves

Sample	Ratio	Machine Used	Results
# 1	70 grams HDPE plastic 40 grams dried leaves	Roll Mill Compression machine	Light Brown, slightly smooth
# 2	60 grams HDPE plastic 40 grams dried leaves	Roll Mill Compression machine	Brown, Rough

# 3	80 grams HDPE plastic 40 grams dried leaves	Roll Mill Compression machine	White, Smooth, glossy

Based on its physical characteristics, all the products produced are of good quality, but the fiberboard created from sample 2 was chosen for testing because it has a color and texture that are comparable to other similar products on the market (Gozdecki, Wilczynski, Kociszewski, & Zajchowski, 2014).

Table 2. Tensile Test Result



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TEST REPORT
ITDI-012020-PPT-0013

Customer's Name : Taguig Integrated School – (Ysabel Unay)
Address : Liwayway St., Sta. Ana, Taguig City
Contact Details : CP No.: 0936.410.3601
Date Received : January 15, 2020
Sample Code : PPT-2020-0051
Sample : **Composite Board 2**
Description : Sample per test prepared by customer
Identification : *HDPE: Dried Leaves Ratio = 60:40*
Date(s) Tested : January 30 to 31, 2020

Sample Code	Tensile Strength (MPa)		Tensile Stress at Break (MPa)		Tensile Stress at Yield (MPa)		Tensile Strain (Elongation) at Yield (%)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PPT-2020-0051	13.8	0.524	See Note 1		13.8	0.524	4.30	0.763

Sample Code	Tensile Strain (Elongation) at Break (%)		Modulus of Elasticity (GPa)		Mean Dimension		No. of Specimen Failed	
	Mean	SD	Mean	SD	W	T	WGL	OGL
PPT-2020-0051	See Note 1		1.09	0.141	12.8	5.23	3	1

Test Parameters:
Test Method : ASTM D638 (Adapted)
Speed of Testing, mm/min : 5
Gage Length, mm : 50
No. of Replicate Test : 4
Instrument Used : Instron UTM, Model: 5585H

Conditioning Atmosphere:
Temperature, °C : 23 ± 2
Relative Humidity, % : 50 ± 5

Legend:
SD – Standard Deviation
W – Width of Specimen
T – Depth/ Thickness of Specimen
WGL – Within Gage Length
OGL – Outside Gage Length

Note: 1 Sample parameters at break were not automatically detected by the machine. Results of these parameters were excluded in this report.

2 Cut specimens tested as received and prepared by customer.

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STD Building, DOST Compound, Gen. Santos Ave., Bicutan, Taguig City, Metro Manila 1631, Philippines
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Email: std@itdi.dost.gov.ph; Website: http://itdi.dost.gov.ph

Table 2 shows the tensile strength of a composite board made of dried leaves and HDPE in a 60:40 ratio. Based on the results provided by the DOST-STDI, the highest percentage of the sample (PPT-2020—0051) has reached the allowable maximum location of the UTM limit switch, which is 13.8 MPa. Therefore, it can no longer be stretched up to the point where it will break. As a result, the tensile stress at break has no value. On the other hand, the value of the tensile strength and tensile stress at yield are equal, which is also 13.8 MPa. In terms of elongation, at 4.30%, the material can sustain stretching forces without permanently deforming or reaching a point where it can no longer be stretched (Mijiyawa, Koffi, Kokta, & Erchiqui, 2014).

Table 3. Flexural Test Result

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Sample Code	Flexural Strength (MPa)		Flexural Stress at a Given Strain (MPa)				Flexural Stress at Break (MPa)		Flexural Modulus (GPa)	
			3.5%		5.0%					
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
PPT-2020-0051	20.3	0.784	18.7	0.774	20.2	0.766	-	-	1.10	0.066

Sample Code	Mean Dimension (mm)		No. of Specimen Failed			Rate of Crosshead Motion (mm/min)	Support Span Length (mm)
	W	T	Y	R	**		
PPT-2020-0051	12.1	5.11	0	0	4	21.8	81.9

Test Parameters:
Test Method : ASTM D790 / ISO 178 (Adapted)
Type of Procedure Used : B
No. of Replicate Test : 4
Support span-to-depth ratio : 16:1
Radius of Support/Loading Noses, mm : 5
Instrument Used : Shimadzu UTM, AGS-50kNXD

Conditioning Atmosphere:
Temperature, °C : 23 ± 2
Relative Humidity, % : 50 ± 5

Legend:
SD – Standard Deviation
W – Width of Specimen
T – Depth/Thickness of Specimen
R – Rupture
Y – Yield
(–) No data recorded by equipmen
** - Did not yield or rupture

Note: Cut specimens tested as received and prepared by customer.

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The flexural strength of the material is shown in Table 3. Flexural testing determines a material's stiffness or resistance to bending by measuring the force necessary to bend a plastic beam (Shrivastava, n.d.). The material's flexural strength, as determined by the results, is 20.3 MPa. The average result for flexural stress at a given strain is 18.7 MPa at 3.5% and 20.2 MPa at 5.0 %. This result shows the flexural strength of the product (Sample 2) tested. The product is hard to break, and even at a given pressure, it is difficult to crack due to its plasticity features, which are supported by the flexural test result (Migneault, Koubaab, Perré, & Riedld, 2015).

5. CONCLUSION

Used plastic bags and dried leaves work well together to create fiberboard (Lawanit out of plastic-dried leaves) because all the products produced from the study are of good quality.

According to the findings of the various tests carried out, including the product's modulus of elasticity (tensile and flexure), a fiberboard made from plastic waste and dried leaves can be used as an alternative to commercially available fiberboard.

It can now be confirmed that this kind of product is very advantageous to all schools in Taguig and in other places in terms of lowering the amount of trash, turning it into valuable resources, and aiding in the preservation of our home planet, Earth. Schools should not just dispose of their solid waste everywhere but instead create innovative ways to reduce their solid waste disposal.

The researchers may carry out additional experiments to find out whether the product is more resilient than commercially available fiberboard and whether it is water-resistant ([HSH Décor, 2021).

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References

City of Vancuover Washington (n.d.). *School Tree Planting*. Retrieved August 4, 2022, from https://www.cityofvancouver.us/publicworks/page/school-tree-planting

Environmental issues in the Philippines - Wikipedia. (2021, June 1). Environmental Issues in the Philippines - Wikipedia; en.wikipedia.org. https://en.wikipedia.org/wiki/Environmental_issues_in_the_Philippines

Gozdecki, C., Wilczynski, A., Kociszewski, M., & Zajchowski, S. (2014, October 11). *Properties of wood-plastic composites made of milled particleboard and polypropylene*. European Journal of Wood and Wood Products. https://link.springer.com/article/10.1007/s00107-014-0852-2

Hart, Kim. *Reducing and Recycling of Plastic Waste in Schools*. AAA State of Play. Retrieved August 4, 2022, from https://deq.nd.gov/Publications/WM/ReducingAndRecyclingPlasticWasteInSchools.pdf
HSH Décor. (2021, July 10). *Medium density fiberboard waterproof.* http://www.melaminepaper.com/medium-density-fiberboard-waterproof-or-not-a-comprehensive-guide.html

Land, Buildings & Real Estate. *Frequently Asked Questions: Benefits of Recycling | Land, Buildings & Real Estate*. (n.d.). Frequently Asked Questions: Benefits of Recycling | Land, Buildings & Real Estate; lbre.stanford.edu. Retrieved August 4, 2022, from https://lbre.stanford.edu/pssistanford-recycling/frequently-asked-questions/frequently-asked-questions-benefits-recycling

Migneault, S., Koubaab, A., Perré, P., and Riedld, B. (15 July 2015). Effects of wood fiber surface chemistry on strength of wood–plastic composites. *Applied Surface Science, 343*, 11-18. https://doi.org/10.1016/j.apsusc.2015.03.010.

Miguel, M. (2022, July 29). *Tree planting improves quality of life*. Tree Planting Improves Quality of Life; www.denr.gov.ph. https://www.denr.gov.ph/index.php/news-events/regional-releases/1873-tree-planting-improves-quality-of-life.

Mijiyawa, F., Koffi, D., Kokta, B. V., & Erchiqui, F. (2014, December 17). *Formulation and tensile characterization of wood–plastic composites: Polypropylene reinforced by birch and aspen fibers for gear applications*. Formulation and Tensile Characterization of Wood–Plastic Composites: Polypropylene Reinforced by Birch and Aspen Fibers for Gear Applications. https://journals.sagepub.com/doi/10.1177/0892705714563120

Shrivastava, A. *Flexural Testing - an Overview* | ScienceDirect Topics; www.sciencedirect.com. Retrieved August 5, 2022, from https://www.sciencedirect.com/topics/materials-science/flexural-testing