

THERMAL CONDUCTIVITY OF BIOMASS BASED INSULATOR

**TRIXIA L. CRISTOBAL
REIZZA JOY V. LATINA**

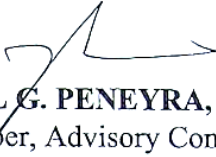
An Undergraduate Thesis Submitted to the Faculty of the Department of Agricultural and Biosystems Engineering, College of Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, Philippines
in Partial Fulfillment of the Requirements
for the Degree of

**BACHELOR OF SCIENCE IN AGRICULTURAL AND
BIOSYSTEMS ENGINEERING
(AB Structures and Environment Engineering)**

FEBRUARY 2024

ACCEPTANCE SHEET

This undergraduate thesis entitled **“THERMAL CONDUCTIVITY OF BIOMASS BASED ON INSULATOR,”** prepared and submitted by **TRIXIA L. CRISTOBAL and REIZZA JOY V. LATINA**, in partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB STRUCTURES AND ENVIRONMENT ENGINEERING)**, is hereby accepted:


RUEL G. PENEYRA, M.Sc.
Member, Advisory Committee


JONATHAN V. FABULA, Ph.D.
Member, Advisory Committee

Date Signed

Date Signed


MARLON T. DELOS SANTOS, M.Sc.
Chair, Advisory Committee


01-29-2024

Date Signed

Accepted as partial fulfillment of the requirements for the degree of **BACHELOR OF SCIENCE IN AGRICULTURAL AND BIOSYSTEMS ENGINEERING (AB STRUCTURES AND ENVIRONMENT ENGINEERING)**


ELMAR M. VILLOTA, Ph.D.
Chair, Department of Agricultural and Biosystems Engineering

Date Signed


THEODY B. SAYCO, Ph.D.
Dean, College of Engineering

Date Signed

BIOGRAPHICAL SKETCH

Trixia L. Cristobal was born on July 13, 2000, in San Mateo, Isabela. She is the only child of Mr. Jojo T. Cristobal and Mrs. Virginia L. Cristobal. She is currently residing in Salinungan East, San Mateo, Isabela.

She finished her primary education at Salinungan East Elementary School and completed her junior high school and two years of senior high school at Divine Word High School – Sanchez Mira, Cagayan. Currently, she is a senior student pursuing a Bachelor's degree in Agricultural and Biosystems Engineering at Central Luzon State University (CLSU).

During her college days, she attended some seminars like Kubota-Saka AgriTalk 2022: A Product Awareness and Training Program for Agricultural Tractor, Rice iv Transplanter, Automatic Seeder, and Combine Harvester on October 4-5, 2022, at the Philippine-Sino Center for Agricultural Technology (PhilSCAT), Central Luzon State University (CLSU), Science City of Muñoz, Nueva Ecija. She also attended a TESDA training entitled Farmer Field School (FFS) on Production of High-Quality Inbred Rice and Seed Certification, and Farm Mechanization at A.R. Santiago Fish Farm which is located in Gaddanan, San Mateo, Isabela. She also received an award from the Department of Trade and Industry, Isabela for participating on a training entitled Entrepreneurial Development Training on How to Start and Sustain a Business cum Agri Business Opportunities at San Mateo, Isabela.

BIOGRAPHICAL SKETCH

Reizza Joy Villa Latina was born on December 30, 1999, at San Jose City General Hospital. She lives in Brgy. Tondod, San Jose City, Nueva Ecija with her parents, Robert B. Latina and Jovy V. Latina, and with her older sister, Kimberly Villa Latina.

She completed her primary education at Tondod Elementary School as an honor student and received awards from extra-curricular activities (S.Y. 2006-2012). She was able to finish Junior High School at Tondod High School from S.Y. 2012 to S.Y. 2016. As an active student, she was awarded as an Athlete of the Year. From A.Y. 2016 to 2018, she continued her Senior High School journey at Central Luzon State University under the program of Science, Technology, Engineering and Mathematics. With that, she decided to pursue Bachelor of Science in Agricultural and Biosystems Engineering at Central Luzon State University. For her OJT, she was able to make a narrative report on the online immersion program undertaken in the City Agriculture Office of Cauayan, Isabela.

During her college days, she managed to be a student-athlete, who studies during the day and attend trainings during night. Reizza is a passionate student studying agricultural and biosystems engineering. She combines her academic interests with a practical devotion to contemporary farming on her family's property. Reizza's athleticism is evident in her involvement as a student athlete during her time in college, highlighting her dedication, teamwork, and resilience on and off the field. Her commitment to excellence extends to both academics and sports, embodying a well-rounded approach to life's pursuits. Reizza hopes to modernize their family farm and pave the path for a time when technology and agriculture combine in the future by using her engineering background to create efficient and sustainable techniques.

ACKNOWLEDGMENT

First and foremost, the authors are grateful to the Almighty God for giving them the courage and discernment to undertake this research.

The authors would like to warmly and sincerely thank everyone who contributed their expertise, time, and effort to the completion of this study: To Engr. The Advisory Committee's Chair, Marlon T. Delos Santos, for his understanding, monitoring, and criticism during the course of the study as well as his kind and giving advice;

To the members of the Advisory Committee, Dr. Jonathan V. Fabula and Mr. Ruel G. Peneyra, for their unwavering support, guidance, and expertise throughout the entire process and writing this study. Their invaluable insights, constructive feedback, and commitment to my academic growth have played a pivotal role in shaping this study. She is truly fortunate to have had the privilege of working under their mentorship; To the author's parents, Mr. Jojo T. Cristobal and Mrs. Virginia L. Cristobal, for their unwavering love, support, and guidance. To their siblings and family members for their encouragement, support, and prayers. Daisy, Gwen, Alona, Clever, Jerome, Nathaniel, Vincent, Jayson, and Kennedy, their classmates and friends, for your inspiration, support, lending a hand, and special moments.

Thank you and to God be all the glory.

TRIXIA LORENZO CRISTOBAL

ACKNOWLEDGMENT

The author is privileged to thank all the people behind the success and outcome of this research.

The authors extend heartfelt gratitude to those who generously contributed their knowledge, time, and effort to this study. Special thanks to Engr. Marlon T. Delos Santos, the Chairperson of the Advisory Committee, for his comments, suggestion, advice, and guidance, for his academic expertise and for his genuine support to improve and finish this study.

To Mr. Ruel G. Peneyra and Dr. Jonathan V. Fabula, Members of the Advisory Committee, for their considerate guidance, invaluable suggestions, constructive criticism, supervision, and unwavering support during the entire process of conducting and completing this research study.

To Central Luzon State University, for serving as her training ground by providing quality education.

To Almira, for became her helping hands while doing some paper works, being supportive, for her encouragement and understanding throughout the duration of the study.

To her beloved family, Mr. Robert and Mrs. Jovy, Ms. Kimberly, for providing all her necessities physically, financially, and morally. For being an inspiration and reason to strive more.

Above all, to the Almighty Father, for His unconditional love that never ceases. With love and appreciation, the author praises Him for wisdom and guidance.

REIZZA JOY VILLA LATINA

TABLE OF CONTENTS

	PAGE
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF APPENDIX TABLES	xi
LIST OF APPENDIX FIGURES	xii
ABSTRACT	xiv
INTRODUCTION	1
Background of the Study	1
Statement of the Problem	2
Objectives of the Study	3
Significance of the Study	3
Scope and Limitations of the Study	4
Time and Place of the Study	5
REVIEW OF RELATED LITERATURE	2
Biomass	2
Sugarcane Bagasse	2
Insulator	7
Cellulose-Based Insulator	8
Straw-Based Insulator	8
Hemp-Based Insulator	8
Cork-Based Insulator	8
Coconut-Based Insulator	9
Testing of Insulators	9

Thermal Diffusivity	10
Production of Making Insulators	10
METHODOLOGY	6
Conceptualization of the Study	6
Materials and Equipment	14
Preparation of Materials	15
Adhesive and Additives Preparation	15
Mixing Process of Different Biomass and Epoxy Binders	16
Fabrication of Metal Mold	17
Amount of Pressure and Force Exerted in the Compression	18
Conditioning of the Board	19
Evaluation of Insulators	20
Thermal Test	20
Thermal Conductivity	21
Thermal Diffusivity	22
Layout of Insulator	24
Layout of Molder	24
RESULTS AND DISCUSSIONS	11
Production Process of Biomass-based Insulator Board	11
Thermal Conductivity of Biomass-Based Insulators	28
Thermal Diffusivity	30
Simple Cost Analysis	31
SUMMARY, CONCLUSION, AND RECOMMENDATIONS	26
Summary	26
Conclusion	36
Recommendations	37
LITERATURE CITED	35
APPENDICES	41

LIST OF TABLES

TABLE		PAGE
1	Problems, Research Gaps, Interventions and Impact in Biomass-Based Insulator Study	13
2	Materials and Equipment	14
3	Proportion and Amount of Biomass and Binder Materials	17
4	Thermal Conductivity of Biomass-Based Insulators in Control Room	28
5	Analysis of Variance (ANOVA) for Thermal Conductivity	29
6	Measurement of Thermal Diffusivity of Biomass-Based Insulators	30
7	Assumptions Used in the Cost Analysis of Biomass-based Insulator	31
8	Cost Charges in Producing Biomass-based Insulators	32
9	Economic Indicator for Using Biomass-based Insulator	32

LIST OF FIGURES

FIGURE		PAGE
1	Conceptual Framework of the Study	12
2	Mixing of Different Biomass Individually with the Adhesive and Additives	16
3	Mild Steel Mold	17
4	Weighing of Insulators	19
5	Testing of Insulators	20
6	Layout of Insulator	24
7	Layout of Molder	24
8	Process in Production of Insulators	26

LIST OF APPENDIX TABLES

APPENDIX TABLE		PAGE
1	Thermal Conductivity of Biomass-Based in Control Room	42
2	Analysis of Variance (ANOVA) for Thermal Conductivity Comparison of Biomass-based Insulator	42
3	Measurement of thermal diffusivity of Biomass-Based Insulators	42
4	Assumption used in the cost analysis of biomass-based insulator	43
5	Cost Charges in Producing Biomass-based Insulator	43
6	Economic Indicator for using Biomass-based Insulator	44

LIST OF APPENDIX FIGURES

APPENDIX FIGURE		PAGE
1	Collecting of raw materials	45
2	Drying of sugarcane bagasse and coconut husk	45
3	Transferring of raw materials from CLSU to PhilRice for shredding	46
4	Shredding of biomass at PhilRice	46
5	Shredded coconut husk	47
6	Shredded rice straw	47
7	Shredded sugarcane bagasse	48
8	Construction of prototype of building	49
9	Temperature Sensor Set-Up	50
10	Coconut Husk with Heat Source 200W	51
11	Coconut Husk in Control Room 200W	51
12	Coconut Husk with Heat Source 150W	52
13	Coconut Husk in Control Room 150W	52
14	Coconut Husk with Heat Source 100W	53
15	Coconut Husk in Control Room 100W	53
16	Rice Straw with Heat Source 200W	54
17	Rice Straw in Control Room 200W	54
18	Rice straw with Heat Source 150W	55
19	Rice straw in Control Room 150W	55

20	Rice straw with Heat Source 100W	56
21	Rice straw in Control Room 100W	56
22	Sugarcane Bagasse with Heat Source 200W	57
23	Sugarcane Bagasse in Control Room 200W	57
24	Sugarcane Bagasse with Heat Source 150W	58
25	Sugarcane Bagasse in Control Room 150W	58
26	Sugarcane Bagasse with Heat Source 100W	59
27	Sugarcane Bagasse in Control Room 100W	59

ABSTRACT

CRISTOBAL, TRIXIA L. and **LATINA, REIZZA JOY V.**, Department of Agricultural and Biosystems Engineering, Central Luzon State University, Science City of Muñoz, Nueva Ecija, **February 2024**, **THERMAL CONDUCTIVITY OF BIOMASS BASED INSULATOR**

Adviser: MARLON T. DELOS SANTOS M.Sc.

This study aimed to analyze the thermal properties of coconut husk, sugarcane bagasse, and rice straw boards considering their effectiveness. The need for ecologically sustainable and energy-efficient building solutions is on the rise globally, encouraging the investigation of substitute insulation materials based on biomass wastes. Because biomass is abundant, and a renewable resource, it offers a viable option as material for sustainable insulation.

The study was conducted at College of Engineering Workshop, Central Luzon State University, Science City of Muñoz, Nueva Ecija. Thermal insulation board was produced by formulating and mixing selected raw materials such as sugarcane bagasse, rice straw, and coconut husk, molding, curing, and shaping processes. Additives were introduced for enhanced properties, and comprehensive characterization, including thermal conductivity and thermal diffusivity, was conducted, and the boards underwent testing in laboratory set-up.

The measured thermal conductivities were 2.39 W/m·K for sugarcane bagasse, 2.99 W/m·K for rice straw and 2.79 W/m·K for coconut husk. Statistical analysis showed no significant difference among the thermal conductivities. The low value at thermal conductivity suggests the potential application of the produced board as thermal insulators.

The measured thermal diffusivities were 6.71762×10^{-8} m²/s for sugarcane bagasse, $6.709233333 \times 10^{-8}$ m²/s for rice straw and $6.699016667 \times 10^{-8}$ m²/s for coconut husk revealed slow diffusion of heat across the material. The cost of producing one unit of this board measuring 1.25 cm x 30 cm x 30 cm amounts to Php 14.29/pc.

LITERATURE CITED

- "Making Insulation from Waste Biomass Materials." Pacific Northwest National Laboratory. Accessed May 10, 2023. A review. *Renewable and Sustainable Energy Reviews*, 135, 110165.
- An, X., Wang, Y., Jiang, D., Xiang, Y., & Zhang, Y. (2019). Mechanical properties of porcelain insulators under different loads. *IEEE Transactions on Dielectrics and Electrical Insulation*, 26(2), 492-501. doi:10.1109/TDEI.2018.007928
- Abdulkareem, S., Ogunmodede, S., Aweda, J. O., Abdulrahim, A. T., Ajiboye, T. K., Ahmed, I. I., & Adebisi, J. A. (2016). Investigation of thermal insulation properties of biomass composites. *International Journal of Technology*, 6, 989-999.
- Babu, B. V., & Chaurasia, A. S. (2004). Parametric study of thermal and thermodynamic properties on pyrolysis of biomass in thermally thick regime. *Energy Conversion and Management*, 45(1), 53-72. \
- Chen, S., Sun, Q., & Guo, H. (2021). Insulation materials made from biomass:
- Chen, D., Liu, X., & Zhu, X. (2013). A one-step non-isothermal method for the determination of effective moisture diffusivity in powdered biomass. *Biomass and Bioenergy*, 50, 81-86.
- Demirbas, A. (2010). Production of biodiesel from algae oils. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 32(13), 1191-1199.
- Dieste, M., de Brito, J., & Castro-Gomes, J. P. (2021). Cork insulation panels: Characterization of thermal and acoustic properties. *Journal of Building Engineering*, 38, 102168.
- Franklin, B. (1750). *Experiments and observations on electricity made at Philadelphia in America*. E. Cave.
- Habert, G., Arnaud, L., & Roussel, N. (2016). Development of insulation materials from agricultural waste. *Journal of Cleaner Production*, 113, 548-554.
- Huang, Y., Chen, Y., & Wei, L. (2018). A review on biomass as a source of energy.
- Lavery, N. P., Hunt, J. D., & Laycock, P. (2019). The role of bio-based materials in the circular economy of construction. *Journal of cleaner production*, 220, 1014-10

- Li, X., Wang, Y., Wang, H., & Lu, X. (2020). Investigation of composite insulators under salt-fog, thermal cycling and acid rain tests. *High Voltage*, 5(4), 428-436. doi:10.1049/hve2.12
- Lstiburek, J. (2006). Cellulose Insulation: A Smart Choice for Builders and Homeowners. *Building Science Insights*, 79.
- Maguire, K., & Robinson, D. (2014). Straw bale construction and sustainable building design: A review of recent developments. *Renewable and Sustainable Energy Reviews*, 31, 160-177.
- Okoye, P.U., Adedeji, A.O., & Omoleye, J.A. (2018). Investigation of sugarcane bagasse/polyurethane foam composite as insulation board. *Journal of Renewable Materials*, 6(5), 467-474.
- Ozden, S., & Aksu, A. (2017). Experimental investigation of thermal insulation properties of nanoclay reinforced vacuum insulation panels. *Applied Thermal Engineering*, 114, 1436-1444.
- Ramli, M., Bakar, A. A., Kamarudin, N. H. N., & Saat, A. (2021). Investigation on the performance of coconut fiber insulation on the building wall panel. *Journal of Building Engineering*, 40, 102879. *Renewable and Sustainable Energy Reviews*, 91, 122-137
- Rodrigues, J.R., Felisberto, R., Frollini, E., & Savastano Jr, H. (2020). Thermal conductivity and compressive strength of sugarcane bagasse reinforced composites for building applications. *Construction and Building Materials*, 249, 118833. To field-Pasche, N., Olofsson, T., van der Meer, J., & Haas, E. M. (2020). A review of hemp as a sustainable building material: Mechanical and environmental properties. *Journal of Cleaner Production*, 257, 120529.
- Wang, H., Tang, Q., Zhao, X., Zhang, L., & Jiang, Y. (2021). Biomass-based insulation materials: A review of environmental and thermal properties. *Journal of Cleaner Production*, 278, 123912
- Wang, X., Li, H., Lu, H., Li, M., & Li, X. (2019). Influence of different molding techniques on the performance of polymer insulators. *Polymer Testing*, 74, 61-
- Yang, C. W., & Miao, Y. (2010). Thermal and electrical insulation properties of silicone rubber-based composites containing coated hollow glass microspheres. *Journal of Materials Science*, 45(12), 3343-3349

Zhang, M., Wu, D., Xu, Y., Li, Z., & Liu, Y. (2021). Preparation and characterization of sugarcane bagasse-based thermal insulation board. *Journal of Renewable Materials*, 9(3), 483-495