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**FACULTY OF ENGINEERING**

**DEPARTMENT OF TEXTILE AND GINNING ENGINEERING**

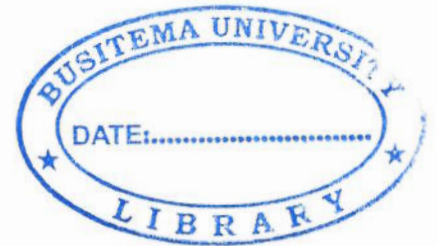
**PRODUCTION OF HANDMADE PAPER FROM RICE STRAW USING ECO-  
FRIENDLY METHODS**

**BY**

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**A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF TEXTILE AND  
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**MAY 2015**

**DECLARATION**

I **Nalubega Shamim**, declare that the work presented in this report is my own and has never been presented to any University or higher institute of learning for any academic award.

Signature..........

Date..... 09/06/2015 .....



**APPROVAL**

This research project report has been submitted to the Department of Textile and Ginning Engineering for examination with approval from the following supervisors:

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All glory and thanks go to ALLAH, who has granted me the gift of life and a chance to reach this moment of writing this report.

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Lastly to all my fellow students who rendered all that was within their reach towards the accomplishment of this project, only ALLAH the almighty can reward you generously for only HE knows how to reward the good work of HIS creations.

## **DEDICATION**

I dedicate this report to my beloved parents Mr. and Mrs. Mazinga Muhammad who have seen me through my academic trying moments.

## ABSTRACT

Environmentally beneficial paper can be made by replacing wood fibres with various types of cellulosic fibres such as straw fibres using eco-friendly methods. Rice straw fibres are good candidates since they are abundantly available and inexpensive.

The research was carried out to investigate the potential of producing handmade paper from rice straws using eco-friendly methods. Preliminary pulping studies were made on rice straw which is an agricultural waste from rice plantations.

The rice straw fibers were pulped using different eco-friendly compounds that is; wood ash, soda ash (magadi salt), urea, potassium hydroxide and marcel soap. Paper samples were produced using each of the eco-friendly compounds at different concentrations (ranging from 12%, 10%, 8%, 6% and 4%). All paper samples were produced using the same conditions. The adhesives that was used was starch and other chemicals such as rosin and alum.

The properties that is; basis weight, water absorbency and tensile breaking strength were determined for each of the paper samples produced. The basis weight of paper produced using wood ash was found out to be the highest than that of the paper produced from urea, soda ash, potassium hydroxide and marcel soap. The degree of water absorbency of paper produced using marcel soap was the lowest than that of the paper produced from wood ash, urea, soda ash and potassium hydroxide. The tensile breaking strength of paper produced using marcel soap was the highest than that of the paper produced from wood ash, urea, soda ash and potassium hydroxide.

It was found out that the higher concentrations of the eco-friendly compounds, the better the properties of the paper produced. At a concentration of 12%, the basis weight was high, the degree of water absorbency was low and the tensile breaking strength was high while at a concentration of 4%, the basis weight was low, the degree of water absorbency was high and the tensile breaking strength was low.

The findings in this research provide an opportunity to use rice straw fiber as a raw material for the production of handmade paper in Uganda.

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## **LIST OF ACRONYMS AND ABBREVIATIONS**

UBOS – Uganda bureau of Statistics

TAPPI – Technical Association of the Pulp and Paper Industry

ISO – International Organization for Standardization

GSM – Grams per Square Meter

BC – Before Christ

FAOSTAT – Food and Agricultural Organization Corporate Statistical Database

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## CHAPTER ONE: INTRODUCTION

### Preamble

This presents the general information about the research topic giving its background, problem statement, objectives, study scope and its justification.

### 1.1 Back ground

Paper is a fundamental part of most aspects of the society; worldwide a total of approximately 300million tons of paper are produced each day and approximately 90% of this paper is produced from mature pulp wood (Muraleedharan *et al.*, 2010). In addition, the demand of paper is expected to increase to approximately 490 tons by 2020 (John, 2006) because today's activities require a high consumption of paper to an extent that little can be done without it even with the increasing use of electronics.

Today the finest of papers are produced all over the world but one dismaying fact is that millions of trees are cut in a day to make paper. Increased demands of paper production and limited wood resources have directed researchers to look for appropriate additional resources of non-wood materials and agricultural residues for pulp and paper manufacturing. Several kinds of non-wood lingo cellulosic by-products of agricultural cultivation have been investigated by the researchers. They include rice straws, cotton wastes, banana fibres, jute wastes, wheat straws, elephant grass, among others. (Atuheire, 2012)

Handmade paper is defined as a sheet of paper or board produced by hand. It is a thin layer mostly of cellulose fiber uniformly interlocked and produced on a screen by slurry of fibrous pulp in water (Atuheire, 2012). The raw materials used in handmade papermaking are the waste products of the textile industries, agricultural residues, secondary and primary fibres. (Khandekar. *et al.*, 1995). Among all the agricultural residues, rice straw appears to be a promising material because it is inexpensive and abundantly available (Joseph *et al.*, 2002).

## REFERENCES

1. Aziz, S, H and Ansell, M.P. (2004). The effect of alkalization and fiber alignment on the mechanical and physical properties of kenaf and hemp bast fibres: *Composites: science and technology* 64(9), 1219- 130
2. Anon (2005), Uganda districts information handbook, expanded edition 2005-2006, Fountain Publishers, Uganda.
3. Baley, C, Busnel, F, Grohens, Y and Sire. (2006). Influence of chemical treatments on surface properties and adhesion of flax fibre- polyester resin, *Applied Science and manufacturing* 37(10), 1626-1637.
4. Bruenner, R. (1994), Fiber supply crisis in the Pacific NW. TAPPI Pacific Section Seminar, Seattle, WA.
5. Chenxia Wang, (2010), The Chemical Composition in the Raw Materials for Papermaking
6. Christie, Elizabeth and Gillian McEachern. (2000). *Pulping the Law: How Pulp Mills are Ruining Canadian Water with Impunity*. Vancouver, B.C.: Sierra Legal Defence Fund.
7. Dr. Hari Muraleedhan, Sr. Programme Officer Dr. K. Perumal, Dy. Director (R&D Admin), (2010) 'Eco- Friendly Handmade paper' Shri AMM Murugappa chettiar Research Centre, Taramani, Chennai 600 113
8. Dr. S.V.Subrahmanyam, Dr.- Ravi Godiya J, Mr. Vipul Janbade at Mr. Arvind Sharma, (2004), Preparation of monograph of different fibrous raw materials used by indian paper industry; central pulp and paper research institute, u.p., india
9. D.H. Page. (1969), A theory for the tensile strength of paper. *Tappi* (54): 674
10. Dinwoodie, J.M., (1965). The relationship between fiber morphology and paper properties: A review of literature. *Tappi* 48 (8), 440-447.
11. G.K Atuheire, (2012), handmade paper; a guide to its production and uses.

12. Gloria Zmolek Smith. (1995), *Teaching Handmade paper making: paper press Cedar Rapids*
13. Horn, R.A. and V.C. Setterholm. (1990), *Fiber morphology and new crops*. p. 270-275
14. Horn, R.A., (1978), *Morphology of pulp fiber from hardwoods and influence on paper strength*.
15. Hurter, R.W., Ricciò, F.A., (1998), *Why CEOs don't want to hear about nonwoods or should they?* In: *TAPPI Proceedings, NA Nonwood Fiber Symposium, Atlanta, GA, USA*, pp. 1-11.
16. Islam J. (1994). *Sustainable Development of Pulp and Paper industry: Indian Perspective*. IPPTA. 6(1)
17. Joseph, K, Paul, A and Thomas, S. (1997). *Effect of surface treatments on the electrical properties of low density polyethylene composites reinforced with short sisal fibres*; *Composites Science and Technology* 57, 67-79
18. Joseph, S., Sreekala, M.S., Oomzen, Z., Koshy, P., and Thomas. (2002). *A comparison of the mechanical properties of phenol formadehyde composites reinforced with banana and glass fibres*, *Composites Science and Techinology* 62, 1857- 1868
19. J.P, Casey (1966), *Pulp and paper*, Interscience publishers, Newyork.
20. James S. Han, Research Chemist, (1999), *USDA Forest Service Forest Products Laboratory*.
21. Joseph Atchison, (1994). "Present Status and Future Prospects for Use of Nonwood Plant Fibers for Paper Grade Pulps," *Presentation at American Forest & Paper Association 1994 Pulp and Fiber Fall Seminar, Tucson, Arizona, November 14-16.*
22. Joseph Atchison, (1983). *Properties of Fibrous Raw Materials and their Preparation for Pulping, Volume I (Atlanta: TAPPI Press.)*, Chapter 17;

23. Kijima Y, Otsuka K & Sserunkuuma D. (2008). Assessing the impact of NERICA on income and Poverty in Central and Western Uganda. *Agricultural Economics* 38:327–37.
24. Khandekar V, Bhoomaiah, Singh SN, Panda A (1995), *Handmade Papermaking in India-Prospects*
25. Kellogg, R.M., Thykeson, E., (1975). Predicting Kraft mill paper strength from fiber properties. *Tappi* 58 (4), 131–135
26. Kerekes, R. J. and Schell, (1995). C. J., *J. Pulp Paper Science*. 18(1): 32
27. Manandhar, B. R. (2003) Assessment of contribution of open biomass burning to the air pollution burden in the Bangkok Metropolitan Region. M. Eng. Thesis, Asian Institute of Technology, Thailand, August 2002.
28. Madakadze, I.C., Radiotis, T., Li, J., Goel, K., Smith, D.L., (1999). Kraft pulping characteristics and pulp of warm season grasses. *Bioresour. Technol.* 69, 75–85.
29. Matolcsy, G.A. (1975). Correlation of fiber dimensions and wood properties with the physical properties of Kraft pulp of *Abies balsamea* L. (Mill.). *Tappi* 58 (4), 136–141.
30. Misra, D. K. (1987). Cereal Straw: Chapter VI in *Pulp and Paper Manufacture; Secondary Fibers and Non-Wood Fibers*, F. Hamilton and B. Leopold, eds, TAPPI, Atlanta, GA.
31. Ogbonnaya, C.I., Roy-Macauley, H., Nwalozie, M.C., Annerose, D.J.M., (1997). Physical and histochemical properties of kenaf (*Hibiscus cannabinus* L.) grown under water deficit on a sandy soil. *Ind. Crops Prod.* 7, 9–18.
32. Robert W. Hurter, *Agricultural Residues*", TAPPI (1997) *Nonwood Fibers Short Course Notes*, August 2001.



33. Stocchi, A., Lauke, B., Vazquez, and Bernal, C. (2007). A novel fibre treatment applied to woven jute fabric/ Vinyl ester laminates, *Applied Science and Manufacturing* 38(5), 1337-1343
34. Smith, Bruce D. (1998), *the Emergence of Agriculture*, Scientific American Library
35. Sun, j.X., Sun, X.F., Zhao, H. and Sun, (2004). R.C Isolation and characterization of cellulose from sugarcane bagasse. *Polymer Degradation and Stability.*, 84, 331-339
36. Saikia, S.N., Goswami, T., Ali, F., (1997), Evaluation of pulp and Paper making characteristics of certain fast growing plants: *Wood Sci. Technol.* 31, 467–475.
37. *Secondary Fibers and Nonwood Pulping*, (1987). Volume 3: Pulp and Manufacture, Third Edition, (Atlanta: Joint)
38. Tipayarom, D. (2004) Development of a management program to reduce impacts of open agro-residue burning on air quality. M. Eng. Thesis, Asian Institute of Technology, Thailand, August 2002.
39. White Paper 13 July, (1996). Non-Wood Plant Fibers as Alternative Fiber Sources for Papermaking
40. Zakaria Mohd Nazarudin, Jamaluddin Mohd Ariff, Masitah Abu Kassim, Othman Maizatunisa, Mohd Nasir Syaidatul Hazira, Mohamad Nurul Azman Mohammad Taib, (2013), The Effect of Alkaline Treatment on Water Absorption and Tensile Properties of Non-Woven Kenaf Polyester Composite, *Advanced Materials Research (Volume 812)*, 258-262