Casuarina Textiles: Wearing Out an Invasive Species

Adriana Kyncl, Sofia Sharp, Dylan Lyons, Sam Bebergal, Sam Alvin, Damian Hendricks
Advisors: Dorlan Curtis Jr. & Alex Cook

Introduction

The Casuarina research team has been working towards creating sustainable, eco-friendly, and renewable textiles from invasive Casuarina (*Casuarina equisetifolia*) woody biomass. The group has been successful in extracting fibers and creating paper sheets with the Casuarina. The initial goal was to take the Casuarina fibers and use them to create clothing and t-shirts while collaborating with Querencia Studio, an eco-friendly clothing company based in New York City, which provides clothing for The Island School store. Over time, the group has decided to focus more on making products such as artisan paper and other textiles due to the excess chemical demand of creating wood-based textiles like Rayon. Along with this project came the opportunity to enter the textile industry. The textile industry is one of the world's biggest polluters, and notorious for its labor exploitation. The industry is not environmentally friendly, and most materials that are used are not renewable. The project gives us potential to take a new path in the industry, using environmentally friendly materials, production methods, and giving workers fair treatment. Casuarina trees can fit into this mission, because they do not need to be cultivated, saving a lot of labor, and are an organic material that can be recycled back into the Earth.

Research Objectives

For this project the three main research objectives were:

- Finding ideal soda pulping conditions for Casuarina woody biomass
- Investigating biomass feedstocks to produce bio-based products
- Converting invasive Casuarina into a fiber suitable for making textiles

Methods

The experiment design consisted of these steps: Biomass Preparation, Soda Pulping, Washing & Filtration, and Paper Making.

Image 1: Preparing the biomass to be processed into woodchips for the soda cook

Image 2: Measurements being taken for density and pH of black liquor during the soda cook

Image 3: Pulp before and after being flushed

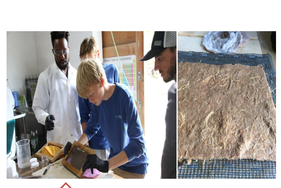

Image 4: Pressing pulp sheet to remove water to create a thinner sheet

Soda pulping is the process of cooking the Casuarina wood chips in White liquor; cook conditions are varied (Fig. 1) to determine maximum pulp yield. Each cook used 30g of woodchips, and a 10:1 liquor:wood ratio. The resulting soda pulp is washed with hot distilled water, over a vacuum filter, to remove the black liquor. Next, the paper making process starts off with blending the washed pulp, and then spreading this pulp slurry onto a deckle where it is then manually pressed to dewater it. Once dewatered, the formed paper is air-dried.

White liquor concentration (%w/v NaOH)	Reaction time (min.)
15	80
20	100
30	

Figure 1: White liquor concentration in terms of reaction time

Research Problem

Invasive species are organisms that are found in regions that are outside of their native ranges and spatially compete with other species due to their high reproduction rate. Typically they have no natural regulators which make them difficult to manage or eradicate. Casuarina leaf litter acidifies soil and blocks sunlight from other species of plants which disrupts important ecosystems. Additionally, they accelerate beach erosion because their shallow root systems topple over during high winds.

Pros:

- The Casuarina tree is a sustainable forest product due to its fast growth rate
- Unlike other feedstocks, it doesn't require irrigation or pesticides
- Manage where it grows to provide economic activity as well as a constant supply of raw materials
- Higher standing biomass density (20 Mtons/ha yr) compared to other sources of fibers such as bamboo

Cons:

- Accidental seed dispersal during transportation to processing facilities.
- It is illegal to cultivate Casuarina trees in The Bahamas (Bahamas Plant Protection Act 2015).

Image 5: Invasive Casuarina

Background

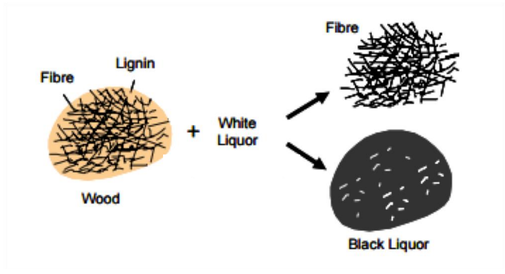

Image 6: Separation of wood fibers during soda pulping

The Casuarina research team is looking to harness the Casuarina tree, an invasive species in the Bahamas, in order to create textiles. Casuarina can be used to make paper sheets and other forms of fuel. The tree consists of two fibers (cellulose and hemicellulose), and the plant heteropolymer, lignin. The soda pulping pretreatment that is used, separates the cellulose, hemicellulose and lignin.

Image 7: Casuarina woodchips used for soda pulping trials

Research Key

Biomass: all organic matter that is living or was once living such as wood, plants, manure and agricultural residues.

Biomass pretreatment: the first step in breaking down biomass into its individual components of lignin, cellulose and hemicellulose by chemical, biological or mechanical means.

Soda pulping: a chemical pretreatment that cooks biomass in sodium hydroxide in order to isolate the cellulose fibers.

White liquor: a liquid solution of sodium hydroxide used as the cooking liquor in soda pulping

Black Liquor: lignin rich white liquor resulting from the soda cook.

H-factor: a calculated value used to determine the efficiency of lignin removal (rate of reaction) in soda pulping. It specifically looks at the reaction temperature and time to determine the rate at which the lignin is removed.

Image 8: Team standing in front of invasive Casuarina

Future Research

The Casuarina team hopes to continue soda pulping experiments to improve the cook and finished paper quality, rather than continuing to make textiles for it is not environmentally friendly. The team will continue to research the manufacture of wood-based products such as charcoal, firewood, and artisan paper, as well as using mycelium to create vegan leathers and biobased construction bricks.

Results & Analysis

Image 9: Black liquor samples collected during the soda cook. The transition from white to black liquor over reaction time is evident with change in liquor color; indicative of lignin dissolution and increasing liquor density.

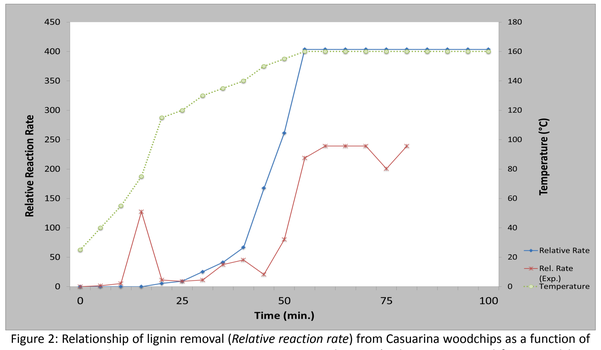

Figure 2: Relationship of lignin removal (*Relative reaction rate*) from Casuarina woodchips as a function of reaction time and temperature. As reaction temperature hits 100°C, lignin is removed from woodchips and the cellulose fibers begin to be liberated.

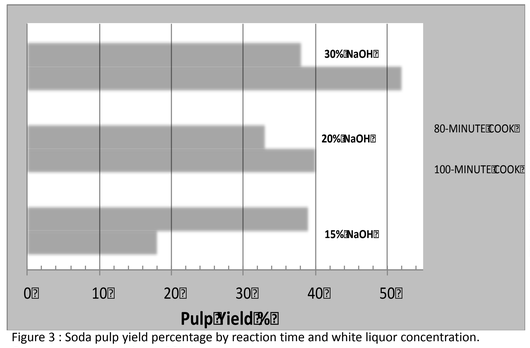

Figure 3 : Soda pulp yield percentage by reaction time and white liquor concentration. Overall average pulp yield = 38%

Image 10: Depiction of the Casuarina in the different stages of the soda pulping cook. The left sample is the Casuarina woodchips, the middle sample is partially digested woodchips, and the right sample is washed Casuarina soda pulp.

Cited Literature & Acknowledgements

Zhang, B,. Shahbazi, A. (2011) Recent Developments in Pretreatment Technologies for Production of Lignocellulosic Biofuels. *Petroleum and Environmental Biotechnology, pp.1-6.*

Vuletich, C., & Earley, R. (2015). Holistic Fashion Design: My INNER/OUTER Journey- *Elin Lindquist's Acceptance Speech for the Noble Peace Price in 2030, pp.1-8.*

Schneider, B., Huttl, R., & Gusavius, H., (2006). Lignocellulosic Feedstock Biorefinery - Combination of technologies of agroforestry and a biobased substance and energy economy. p. 53-62

Quinn, L., Endres, B., & Viogt, T. (2013). Why not harvest existing invaders for bioethanol? Perspectives and paradigms, pp. 1-6

Koszewska, M. (2018) Circula Economy - Challenges for the Textile and Clothing Industry. AUTEX Research Journal, pp. 1-11

The research team would like to thank our research advisors Alex Cook and Dorlan Curtis Jr., Querencia Studio for their guidance with the project and sustainable fashion, the CSD Permaculture team for supplying Casuarina woody biomass, and Kate Kincaid.