Research Article

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Potential of Using Sugarcane Leaves to Produce Pulp for Paper Making

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Abstract

The search for alternative fiber sources among which non-wood materials have found wide application in pulp and paper production. Sugarcane leaves can be among non-wood sources for papermaking. Tanzania has a lot of sugarcane leaves, which are burned during harvesting period in sugar industries. Therefore, this study aimed at investigating the Potential of using sugarcane leaves to produce pulp for papermaking. This will lead to reduced wood consumption as well as minimization of global warming impact resulting from CO_2 emissions as a result of burning of sugarcane fields before harvesting. Pulping of sugarcane leaves was achieved through chemical pulping method (Soda pulping) with two different effective alkali charges (EA-12% and EA-18%) and the pulp obtained were tested for their Kappa number (33.9, 20.9), Pulp yield (35.8%, 27.2%), and Freeness (520CSF and 490CSF). The resulting pulp was used for hand sheet making and the papers obtained were tested for their mechanical properties; Grammage (58.5, 59.4) g/m2, Tensile index (30.5, 41.1) Nm/g, Tear index (9.4, 9.5) Nm2/g, burst index (3.3, 4.7) k.pa.m2/g and Elongation at break (2.57, 2.75) %, for papers made from sugarcane leaves pulp with two different treatments respectively. The overall results showed that Tanzanian sugarcane leaves has a promising potential as alternatives fibers for pulp and paper making industry.

Key words: Sugarcane Leaves, Paper, Mechanical Properties of Paper

Introduction

Wood from mature trees is still the major source of pulp for paper production and contributes to about 80-90% of the conventional raw material worldwide. However, depletion of forest resources to obtain wood has made an impact on the human and environment like deforestation. Tanzania has abundance of sugarcane leaves, which, are not utilized by the sugarcane factories. Sugarcane leaves are the waste materials from sugarcane plants, usually attached alternatively to the node of the sugarcane stalk. It consists of cellulose, hemicellulose and lignin [1].

Due to the environmental concerns and wood resource depletion, more attention was being paid to non-wood resources which are renewable materials. The increase demand of paper consumption from virgin pulp is the main cause for the usage of wood species as the main raw material leading to massive deforestation. Massive deforestation altered the ecological balance and contributed to the climate change (such as increase in temperature) [2]. This has made the search for alternative fiber sources among which non-wood materials have found wide application in pulp and paper production. Non-wood fiber resources are innovative ways of utilization new alternative cellulosic fiber resources. Sugarcane leaves can be among non-wood sources for papermaking. Tanzania has a lot of sugarcane leaves, which are burned during harvesting period in sugar industries. This will lead to promote the concept of "from waste to wealth" which is aimed to build a sustainable development through the effective use of resources [2].

According to Sugar Board of Tanzania data of 2018, the four (4) major sugar industries (Kilombero, TPC, Kagera and Mtibwa) were producing 353,960 metric tons of sugar. For each ton of sugar produced there is a potential of producing a ton of dry leaves [3]. Assuming 50% of the leaves can be made available for pulp production as the rest is left in the farm for nutrient retention, therefore about 176,980 tons of dry sugarcane leaves can be utilized annually for production of paper. Currently sugarcane leaves are burned during harvesting period in sugar industries. Tanzania has abundance of sugarcane leaves, which, are not utilized by the sugar factories. Therefore, this study investigated the potential of using sugarcane leaves to produce pulp for paper making. This will lead to reduced wood consumption as well as a positive impact on the environmental problems through CO_2 emissions from burning of sugarcane. Also use of sugarcane leaves could protect people who live who live in areas near to where the field is burned.

Sugarcane Harvesting

Sugarcane leaves and tops become more available in the field due to mechanical harvesting. One ton of sugarcane, after harvesting, leaves a residue of around 140 kg oven dry leaves (280 kg of leaves and tops with 50% moisture) in the field. Also one ton of sugarcane produces 140 kg of sugar [3].

Benefit of Green Cane (Unburnt Cane) Harvesting

There are economic benefits to be gained by leaving the leaves and tops on the field without burning the field. These benefits are:

i. Green cane harvesting allows for the recycling of nitrogen in the plant by leaving trash (leaves and tops) cuttings in the field, also keeps the humidity or moisture level in the soil and reduces the use of herbicides as weeds are significantly decreased [4].

ii. Green cane harvesting savings in fertilizer costs and conservation of soil health by returning organic material to the field, also prevents soil erosion [3].

iii. Cane that has been harvested green (unburnt cane) after removing leaves and tops is generally lower in non-sucrose constituents (ethanol, glucose and fructose, and color) [3].

Commercial and Potential Methods for Pulping Non-Wood Raw Materials

Normally, in pulp and paper industries, pulping process is necessary. Pulping is a process of delignification, whereby the fibers in a raw material are separated [5]. Fibers separation (pulping) could be conducted through chemical, semi-chemical, and mechanical (like thermo-mechanical) pulping processes [6].

There are different processes suitable for pulping non-wood plants, but only few of them are commonly used commercially. The most used methods include alkaline processes (such as Sulphate (Kraft), Caustic Soda (NaOH) methods, and oxygen alkali method), sulfite methods (such as neutral sulfite and alkaline sulfite pulping), Organosolv pulping (Pulping with organic solvents such as alcohol solvents like methanol and ethanol, Organic acids solvent like formic acid, acetic acid, and formic acid + acetic acid, Ester organic solvent like ethyl acetate, Compound organic solvent like methanol+ acetic acid and ethyl acetate + ethanol + acetic acid, Phenol organic solvents like phenol, and Active organic solvents [7].

In this project, dried sugarcane leaves were pulped using soda pulping liquor as it contributes to higher paper strength produced (including tearing and tensile strength) and also it produces pulp yield with better quality than other pulping processes [8].

Material and Methods

Materials

Fresh leaves of five different species of sugarcane leaves (N 25, N 12, N 41, R 570, and R 579) (Figure 1) were collected from the local farmers and Mtibwa sugarcane fields at Msimbazi-Dar es Salaam and Turiani-Morogoro respectively.

(a) (b)

Figure 1: Sample of (a) Fresh Sugarcane Leaves on the Cane Stalks (b) Harvested Sugarcane Leaves

Methods

Sample Preparation

Collected samples of sugarcane leaves were first chipped into small pieces using knife and scissor as cutting tools and thereafter the chipped sample was sun-dried for 3 days (Figure 2). The samples were evaluated for their moisture content after 3 days using gravimetric method.

Figure 2: Dried Sugarcane Leaves

Pulping Process

Dried sugarcane leaves were pulped using soda pulping liquor at effective alkali concentrations of 12 and 18% with liquor ratio of 4:1. The cooking was carried out in a Mathis labomat machine (Figure 3) at 140◦C for 240 minutes.

Figure 3: Mathis Labomat Machine

Pulp Washing and Preparation

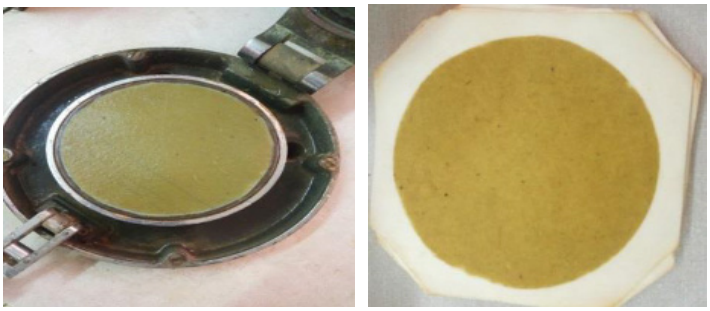
Pulp obtained was carefully washed under running water (tap water) to remove residual chemicals still present that would contaminate the pulp during the subsequent processing steps, pulp samples were separated in a disintegrator, for 15 minutes and the screening was done by sieving through a sieve wire. After screening, the pulp kappa number and yield were determined and pulp freeness test was carried out.

(a) (b)

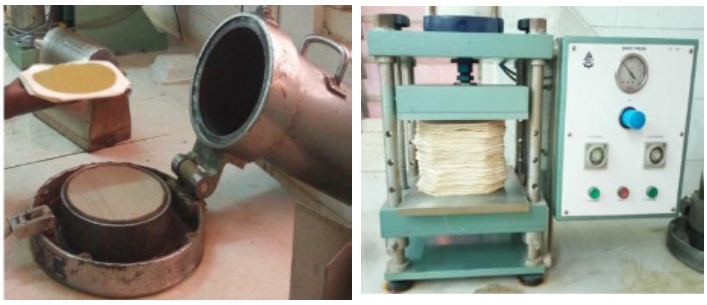
Figure 4: Sample of (a) Unbleached Pulp After Washing and Screening (b) Disintegrated Pulp

Production of Handmade Paper

Paper sheets (Figure 5A and Figure 6) were produced from unbleached pulps using a handmade paper mould (Figure 5B). Pulp suspension equivalent to 1.2 g oven dry pulps (fibers) were dispersed inside clean water contained in the paper mould and agitated using agitator to achieve uniformity of pulp suspension. Water was then allowed to drain off downward through a sieve wire and the aligned fibers were remained on top of the sieve wire. Aligned fibers onto a sieve wire were removed by using a blotter paper and chrome plate and then pressed with a pressing machine for about 5 minutes. After pressing, the paper samples were then air dried for about 12 hours.



(a)



(b) (c)

Figure 5: (a) Handmade Paper Before Drying (b) Handmade Paper (c) Pressing Machine

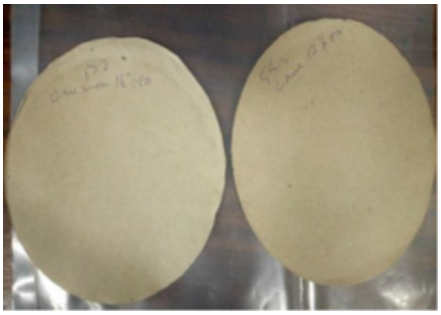


Figure 6: Air Dried Handmade Paper

Paper Characterization

Paper characterization was done using a Universal Testomeric Machine to determine the grammage, tensile index, tear index, burst index and elongation at break (stretch).

Results and Discussions

Table 1: Results of the measurement made

S/N	DESCRIPTION	UNIT	SUGARCANE LEAVES	
			E.A 12%	E.A 18%
1	Sun dried raw material weight	Grams	253	368
2	Moisture content of sun dried raw material	%	9.32	9.32
3	Oven dried raw material weight	Grams	229	334
4	Cooked and washed pulp oven dry weight	Grams	82	91
5	Pulp yield	%	35.8	27.2
6	Kappa number of disintegrated pulp	Number	33.9	20.9
7	Lignin content of disintegrated pulp	%	5.1%	3.1%
8	Pulp freeness after disintegration (4500 revolutions)	Csf	520	490
9	Grammage (gsm)	g/m^2	58.5	59.4
10	Burst index	K.Pa. m^2/g	3.3	4.7
11	Tear index	Nm^2/Kg	9.4	9.5
12	Tensile index	Nm^2/g	30.5	41.1
13	Stretch (elongation)	%	2.57	2.75

The results show that sugarcane leaves pulp contains low lignin content of approximately 33.9 and 20.9 for E.A-12% and 18% respectively) whereby lignin content decrease with increase in

effective alkali dose. Low lignin content is one of the advantages inherent in the use of non-wood materials for pulp and paper production. Also, materials with low lignin contents require relatively small amount of chemical for pulping. Lower lignin content is easier to discard from the pulp compared to that with higher lignin content from other non-wood or wood materials.

The result also shows that pulp yield which is important parameter in determining the suitability of a material in pulp and papermaking was 35.5% and 27.2% for E.A-12% and 18% respectively.

Freeness Test: The result shows that the more concentration of effective alkali on pulp film, the fine fibers becomes and hence degree of freeness on a pulp film decreases and vice versa is true. This because the fine fibers form strong bond during alignment and finally very small pores is created on surface of the pulp firm which allow little water penetration.

Tensile Strength and Stretch (Elongation): The result of tensile strength and elongation at break indicates that the stretch and strength properties of paper were reduced at high lignin content. High lignin content means low fiber to fiber bonding hence less stretch and tensile strength of the paper at high kappa number. As higher amount of lignin remaining in the paper sheet causes the paper to become brittle and hence constitutes to lower strength properties. These conclude that the tensile strength of the paper is dependent upon the lignin content, where the reduction of lignin increases the tensile strength and produced better paper quality.

Burst Strength: The result shows that burst strength of Hand sheet paper is dependent upon the effective alkali charge (EA). High EA charge leads to lower kappa number. Lower kappa number means more fiber to fiber bonding which increase burst strength properties of the paper.

Tearing Resistance: The result of tearing strength shows that the tearing strength of hand sheet is less affected by the effective alkali charge (EA). Tear strength remained almost unchanged for both two effective alkalis (EA 12% and 18%).

Conclusion

The results obtained from this study have shown that sugarcane leaves are potential non-wood raw materials for pulp and paper making. The obtained yield of around 30% can lead to production of about 53,000 tons of unbleached pulp per year correspond to about 176 tons of pulp per day based on sugar production data in Tanzania of 2018 of about 353,960 tons per year.

Also five sugar species (R570, R579, N41, N12, and N25) from Mtibwa sugar were investigated for their potential to produce pulp. They were all found to have almost the same pulp yield of more than 30% with effective alkali concentration of 12%.

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