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Review Article

Meta-analysis on the Retting of Plant Fibres

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Abstract *- The objective of this study was to carry out a synthesis of the knowledge on the retting of plant-based fibers in the literature. The methodology used was to search articles, theses, dissertations, and patents available in databases such as (Science Direct, researchgate, and Google scholar) that deal with the issue of retting of plant fibers. The results obtained show that water retting, enzymatic retting, and field or soil retting are biochemical rettings. Both water retting and field or soil retting involve microorganisms in the process of degrading the fiber aggregate, with the only difference being that the former is anaerobic and the latter aerobic. Enzymatic retting should be done with an SPS-ase enzyme. The fastest retting is the hot water retting which is done in 5 hours maximum, and the slowest is the land retting which can go up to 8 weeks. A plan of experimentation should be studied for each type of retting in order to know not only the retting time for each specific fiber but also the quantities of materials and equipment to be used in order not to deteriorate the fiber. The color of the fiber depends on the type of retting. Regardless of the type of retting, the vegetable textile fiber will consist of cellulose, hemicelluloses, lignin, pectin, and wax. Amylase retting deserves a careful study of fiber deterioration because plant fibers are made up of a large majority of celluloses. Both cellulose and starch are made up of D-glucose, with the only difference being that the D-glucose molecules of starch are linked together by alpha 1,4 bonds, whereas cellulose is linked together by beta 1,4 bonds.*

Keywords - *Fibre retting, Plant fiber retting, and Plant fiber extraction*

I. INTRODUCTION

Mechanical extraction processes suffer from two major problems. The first is the high risk of a drop in the mechanical properties of the fibers as a result of mechanical stresses that can be aggressive and alter the intrinsic characteristics of the fiber, whatever the method of separation used [1][7]. The second is the high cost of the extraction lines and their size, which is not always profitable when it comes to small productions [7]. According to a study by ATB (Agrartechnik Bornim - Germany), the yield threshold is estimated at 3 tons/hour [7]. Retting is the process applied to cortical fiber plants to facilitate the extraction of lignocellulosic fibers [1]. The degradation of the natural types of cement (pectins and waxes) allows the separation of the fiber bundles from the stem as well as the elementary fibers within the bundles [2][3][4]. This process degrades the natural types of cement that bind the fiber bundles to the stem [4][5]. Retting is a process designed to promote fiber extraction [5]. It avoids the disadvantages of mechanical extraction [4]. The aim of this study is to summarise the knowledge of retting plant fibers in the literature. Ultimately, the aim is to develop tools to take better advantage of the best retting methods, to improve our environment, to have good quality textile fibers and at reasonable costs.

II. METHODOLOGY

A. Data collection and knowledge synthesis on retting extraction of plant fibers

The synthesis of knowledge on the retting of plant fibers was based on articles, theses, dissertations, and patents. It covered the last 10 years, since 2011. In particular, databases (ScienceDirect, Google Scholar, and ResearchGate) were used to access scientific and technical journals dealing with the issue of retting of plant fibers (Journal of Minerals and Materials Characterization and Engineering, Journal of Textile Science & Engineering, Journal of Industrial Textiles,...), dissertations and theses dealing with retting. A series of keywords were used to carry out this information search. These keywords are

- Fiber retting
- Vegetable fiber retting
- Plant fibre extraction

B. Inclusion criteria

The research works that have been included in this meta-analysis are those dealing with retting. These include soil retting, cold water retting, boiling water retting, amylase or enzyme retting, caustic soda retting, microbial retting, and microwave retting. These studies provide a formal methodology that allows data from different studies to be collated and analyzed on the basis of transparent criteria.

C. Exclusion criteria

Articles and theses that discuss cutting of plant fibers, ginning of plant fibers, shaving of fibers, secretion of fibers, and molding of fibers (melt molding, wet and dry solution molding) were excluded from this meta-analysis.

III. RESULTS

A total of 18 studies offered accessible results, but only 13 presented usable numerical data, i.e., evaluated retting types on the basis of retting time, the crystallinity of retted fibers, Fourier Transform Infrared,..(Figure 1).

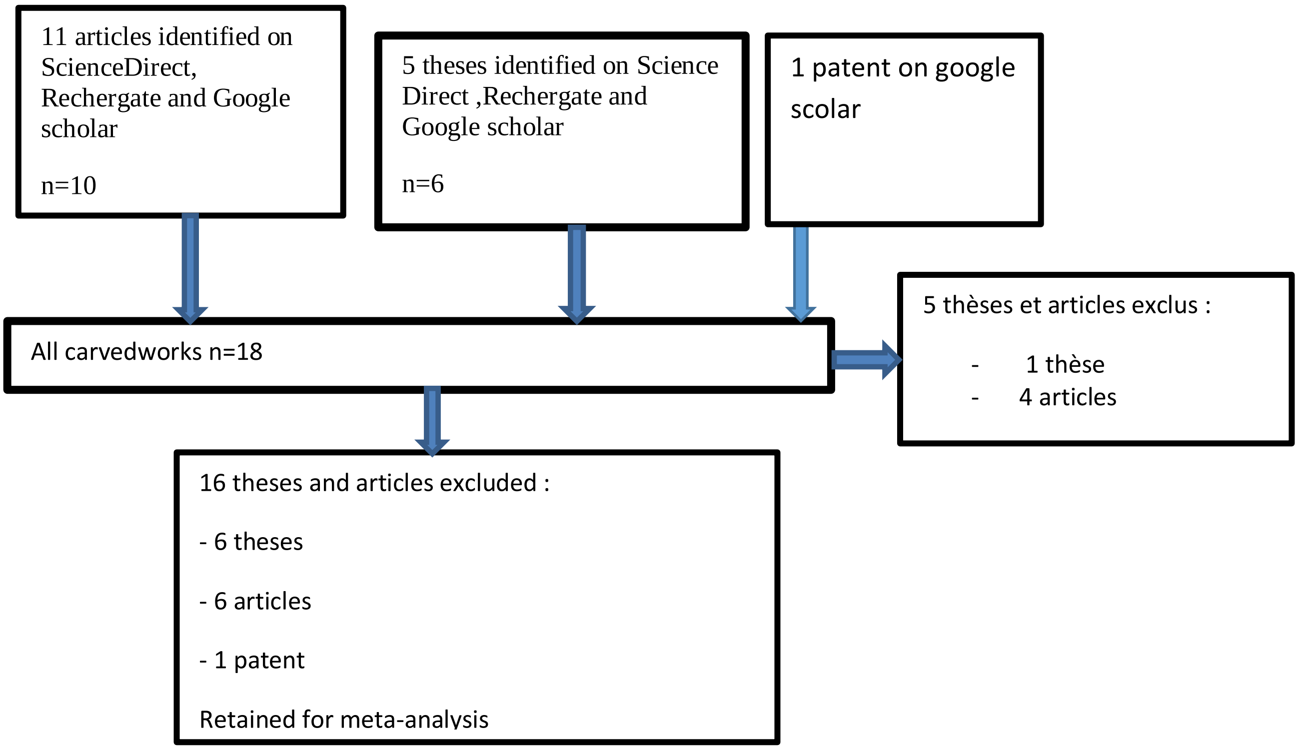

Figure 1: Flow Chart of articles, theses, dissertations, and patents included in the study.

Identification of retting types: Retting is one of the methods of extracting bast fibers. Table 1 presents the types of retting, principles, retted fibers, retting time.

Table 1: Presentation of different types of retting

Type of retting	Principles	Coated fibers	Retting time	References
Cold Water Rewinding	Immerse the stems in water. This immersion allows anaerobic pectolytic bacteria to grow on the stem. The bacteria, in the absence of oxygen in the water, decompose the stem	• Flax, • hemp, • Kenaf, • Sida rhombifolia, • Rhecktophyllumcamerunense • Cola lepidota Stem • Pineapplecomosus- • Jute	one to three weeks	[4] [5] [6] [7] [8] [11][12]
Hot Water Rewinding	Boil the stem to soften	Alfa	3 hours maximum	[12]
Enzymaticretting	Degradation of fiber-aggregating elements in bundles	• Chanvre • Lin • Jute	2 days maximum	[12][7][6]

Caustic soda and sulphuric acid retting	NaOH accelerates the extraction of lignin and hemicellulose to 2%. H_2SO_4 for 10 min to neutralize the traces of NaOH remaining on the surface of the stems	ampelodesmosmauritanicus (DISS plant)	2 days maximum	[10] [11]
Rolling in the field or on the ground	The freshly pulled stems are spread out on the ground, preferably damp, where the microorganisms degrade the pectin types of cement. Rain, dew, wind, and sun alternating are factors that favor the pullulation of microorganisms	• Flax • hemp • ramie • jute • kenaf	5 to 8 weeks	[9] [11] [12]

From Table 1, we can see that water retting, enzyme retting, and field or soil retting are biochemical retting processes. Both water retting and field retting involve microorganisms in the process of degrading the fiber aggregate, the only difference being that the former is anaerobic and the latter aerobic. Enzymatic retting should be done with an SPS-ase enzyme. The SPS-ase enzyme used for this purpose is specific for non-cellulosic fiber constituents and welds the fibers together within the fiber bundle [13]. Table 1 shows that the fastest retting is hot water retting which takes 1 day, and the slowest is land retting which can take up to 8 weeks. The other types of retting are caustic retting (2 days), hot water retting (3 hours), enzyme retting (2 days), and cold water retting (3 weeks). We have studied the retting time and the different retting principles. In the following, we will evaluate low-cost retting techniques that do not modify the fiber structure and are environmentally friendly. Table 1 does not allow us to see the best retting techniques in terms of strengthening the crystallinity of the fibers, respecting the environment, and in terms of cost. Table 2 will allow us to study the textile in this sense.

Analysis of retted fibers by different types of retting: Table 2 presents the Colour of the retted fiber, Fourier Transform Infrared, Fibre crystallinity, Impact of effluents on the environment, and Retting cost for each type of retting.Table 1Characteristics of each type of retting.

Table 2: **shows that other retting processes besides soda retting weaken the crystallinity of the fibers [7].**

Types of retting	**Colour of the retted fiber**	**Fourier transform infrared**	**Fiber crystallinity**	**Impact of effluents on the environment**	**Rustingcost**	**References**
Enzymaticretting	Yellow fiber	Cellulose Hemicelluloses Lignin Pectin Wax	Fragilisation of the crystallinity of the fiber	The use of enzymes is environmentally friendly	Purchase of the enzyme	[4] [5] [6] [7] [8] [11][12]
Caustic soda retting	Brilliant Fibre	Cellulose Hemicelluloses Lignin Pectin Wax	Strengthening the crystallinity of the fibres	Minimum environmental impact	Purchase of soda	[10][11]
Cold Water Rewinding	Darkgrey	Cellulose Hemicelluloses Lignin Pectin Wax	Fragilisation of the crystallinity of the fibre	respects the environment		[4] [5] [6] [7] [8] [11][12]
Ground	Darkgrey	Cellulose	Fragilisation of	respects the		[4] [5] [6] [7]

Rolling		Hemicelluloses Lignin Pectin Wax	the crystallinity of the fibre	environment		[8] [11][12]
Hot Water Rewinding	Clear fibre	Cellulose Hemicelluloses Lignin Pectin Wax		respects the environment		[3]

Therefore, the retting time must be well known. In the case of hot water retting, not only the retting time but also the boiling temperature must be known. An experimental design should be studied for each retting in order to know not only the retting time for each type of retting for each specific fiber but also the quantities of materials to be used in order not to damage the fiber. Table 2 informs us that soda retting increases the crystallinity of the fibers. This confirms the work of John Mercer in 1884, who confirmed that soda increases the strength of the plant fibers while also making them shiny. Table 2 informs us that whatever the type of retting, the plant textile fiber will be made up of cellulose, hemicelluloses, lignin, pectin, and wax. From Table 2, we know that the color of the fiber depends on the type of retting.

IV. DISCUSSIONS

This research aims at advancing the knowledge on the retting methods of plant fibers in order to not only promote the best retting technique, reduce the cost and promote sustainable development, but also to improve the process in order to have a fiber that has not been weakened due to retting. It reveals that water retting, enzymatic retting, and field or earth retting are biochemical rettings. Both water retting and field/earth retting involve microorganisms in the process of degrading the fiber aggregate, with the only difference being that the former is anaerobic and the latter aerobic. The retting time varies according to the type of retting. Field or earth retting is the slowest, followed by cold water retting, and the fastest retting is hot water retting, followed by soda retting and enzyme retting. But beyond the retting time, apart from soda retting, the other types of retting weaken the crystallinity of the fibers [7]. An experimental design should be studied for each retting process in order to know not only the retting time for each type of retting for each specific fiber but also the number of materials and equipment to be used in order not to damage the fiber. For soda retting John Mercer (1884) already confirmed that caustic soda reinforces the crystallinity of the fiber by making it shiny, hence the word "Mercerissage", also known as caustification. The enzymes used must be very specific such as Pectinelase or SPS-ase enzyme [12], to avoid considerable deterioration of the fiber. Thus, retting with amylase deserves a careful study on fiber deterioration because plant fibers are mostly made of cellulose [14][15]. Both cellulose and starch are made up of D-glucose, with the only difference being that the D-glucose molecules of starch are linked together by alpha 1.4 bonds, whereas cellulose is linked together by beta 1.4 bonds. From this discussion, it is clear that caustic retting is the only process that does not improve the physical characteristics of the fiber at the moment, but caustic soda can sometimes have an impact on the environment as it is corrosive.

V. CONCLUSION

We have come to the end of this work, the objective of which was to produce a synthesis of knowledge on the retting of plant fibers. The results obtained are as follows: that water retting, enzymatic retting, and field or soil retting are biochemical retting processes. Both water retting and field or soil retting involve microorganisms in the process of degrading the fiber aggregate, with the only difference being that the former is anaerobic and the latter aerobic. Enzymatic retting should be done with an SPS-ase enzyme. The SPS-ase enzyme used for this purpose is specific for non-cellulosic fiber constituents and welds the fibers together within the fiber bundle [13]. The fastest retting is hot water retting which takes 1 day, and the slowest is land retting which can take up to 8 weeks. Other types of retting are caustic retting (2 weeks), hot water retting (3 weeks), enzyme retting (2 weeks), and cold water retting (3 weeks). All other retting processes apart from soda retting weaken the crystallinity of the fibers [7]. Therefore, the retting time should be well known. In the case of hot water retting, not only the retting time but also the boiling temperature must be known. Regardless of the type of retting, the vegetable textile fiber will consist of cellulose, hemicelluloses, lignin, pectin, and wax. The color of the fiber depends on the type of retting. The enzymes used must be very specific such as Pectinelase or SPS-ase enzyme [12], to avoid considerable deterioration of the fiber. Thus, amylase retting deserves a careful study on fiber deterioration because plant fibers are mostly made of cellulose. Both cellulose and starch are made up of D-glucose, with the only difference being that the D-glucose molecules of starch are linked together by alpha 1,4 bonds, whereas cellulose is linked by beta 1,4 bonds.

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