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Scope and Effect of Retting Treatment on Tensile Characteristics of Natural Fiber Extracted from Phragmites Australis (Naanal)

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ABSTRACT

Phragmites Australis is a perennial grass that grows in wetland or near inland waterways. The preferred common name of phagmites Australis is common reed (Naanal). Due to its fast growing properties and low content of nutrients and water, it is used for many applications. An attempt has been taken for the extraction of fibers from the reed. The chemical retting process is adopted for the extraction of fibers from the plant. There are three concentrations of NaOH, namely 3%, 4% and 6% has been taken for fiber extraction process. Based on result, as the concentration of NaOH increases, the strength (N) and elongation (%) of the reed fiber also increased.

Keywords: Phagmites Australis, Natural Fiber Extract

1. INTRODUCTION

The natural fibers are categorized as wood fiber, stalk fiber, fruit fiber, seed fiber, leaf fiber and bast fiber. Rattan, Hemp, Linen, Jute, Ramic, Banana, Flax, Sugar cane, Kenaf and Roselle are the bast fibers. Wetland plants are found all over the world and are known to be easily noticeable component of the ecosystem. They can be defined as the plants that grow in water or a surface that is intermittently lacking oxygen as a result of extravagant water content. They form the base of the food chain and are the main reason for energy flow in the ecosystem. They can improve water quality since they absorb metals and other contaminants in the water. The authors (K. P. Ashik et al.,[1]) studied the composition of various natural fibers Table 1 shows the proximate tensile and other characteristics of pharagmites Australis family plant. Phragmites can settle as a group in permanent, semi-permanent and temporary wetland varieties which include deltas, marshes, lake belts, river edges, roadsides and ditches (Keith et al.,[8]). Wetland plants are found in almost all continents and hence they are classified as cosmopolitan and occur in river deltas, lakes, tidal zones, coastal areas etc. (Julie K. Cronk et al.,[7]). They are classified based on their form of growth as emergent, submerged, floating-leaved and floating plants. The roots of the

plants usually are not attached to the sediments so they tend to move on the water surface due to the winds and water currents. Phragmites is a perennial grass that can reach 15 or 16 feet in height and tends to grow in dense. The stem is straight and usually about 15mm in diameter. They arise from a rhizome that are wide, stout and spreaded both ways (i.e., vertically and horizontally) which is shown in Figure 1. The initial flower head looks purplish in color but the matured flower looks white and fluffy. They can tolerate high concentration of salt in the water and a wide pH range of 4.2-8.2 and seem to thrive in fresh water (Reference [9]).

Table 1. Characteristics of Pharagmites Australis (Naanal)

Particulars	Reed
Density (Kg/m^3)	490
Water absorption (%)	100
Modulus of elasticity (GPa)	37
Tensile Strength (MPa)	70-140

The proximate composition percentage in phragmites Australis plant is the protein content which was found to be high in stem about 20.12, 18 in leaf and 12.2 in root. The ash content of leaf, stem and root are 9.4, 7.3, 9.2. The fiber content was high in stem about 9.12, 7.4 in leaf and 6.4 in root. The fat content was low in root about 2.99, 5.4 in leaf and 3.9 in stem. As a whole plant, Phragmites had high protein content about 19.65 and low moisture content about 1.65 (Muhammad Akmal et al[5]) The moisture content was high in root about 7.2, 6.4 in stem and 3.2 in leaf. The carbon, oxygen and silicon are the major elements in the reed. The contents of the elements are varied from the lower stalk to upper stalk. The silicon content in lower stalk has more than that of upper stalk. The individual fibers mean diameter is 13.4 μm and fiber is an irregular polygon, these are exhibited as a multilayered structure. The cell wall has several layer and the center part of the cell is lumen (Xinzhou Wang et al,[3]).

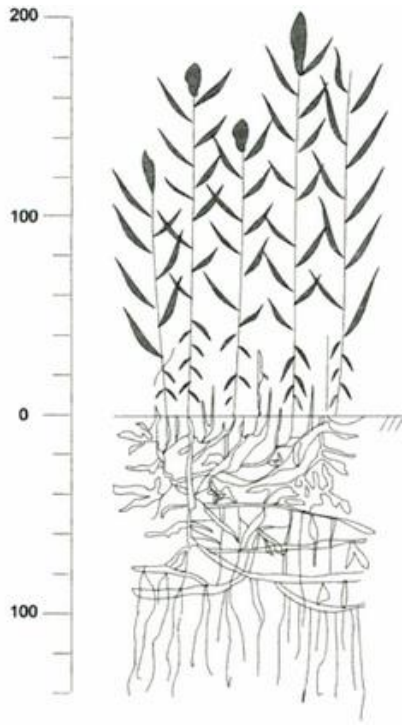

Figure 1. Phragmites Australis (Naanal)

The authors (Xinzhou Wang et al.,[3]) reported the mechanical properties of the reed fiber cell wall is affected by the type of plant, chemical composition, density and microfibril angle (MFA) and others. The increased angle of microfibril decreases the mechanical properties. The elastic modulus and harness of the upper stalk is higher compared to lower stalk fiber, which is decreased when the MFA of the fiber is increased. Due to lignification process the fiber becomes stiffer. The content of lignin in upper stalk is highly influenced than silica content of the fiber.

The authors (K. P. Ashik et al.,[1]) reported that the chemical retting for different natural fibers such as hemp, sisal, kapok and jute are treated with various concentrations of NaOH and concluded that 6% of NAOH is optimum concentration to clean the surfaces of the fiber bundle.

The application of phragmites Australis involves various fields such as industrial, agriculture and medicinal. The phragmites has numerous traditional applications, such as handicrafts, roofs, baskets and beach umbrellas. The stems and leaves are mostly used for weaving mats,

baskets, nets, building a habitation, fences, outdoor garden frame, fuel etc. The stems can be used as insulation material for walls and roofs. The heat conductivity (λ) of the reed is 0.055 W m^{-1} K^{-1}. They are poor conductor of heat but a good conductor of humidity. The dry flowers or seed heads of the reed are used as kindling applications. Panels where thick, dry stems are compressed and knitted with wire and weaving in a loom are fixed to the wall and covered with clay. The specific tensile strength and lower density of the reed is used as reinforcement material for the production composites studied and reported by (Adil M. Abdullatif et al.,[6]). The flowering stalks also produce a fiber that is used for making ropes. Leaves are mostly used in weaving applications (Hans Brix et al.,[10]). The major popular uses include thatching and raw material for manufacturing paper. Phragmites comes under common nonwoods or hardwood substitutes category in nonwood plant fiber pulps (Reference [11]). For papermaking, all parts of the plant that are above the ground can be used and also has a high ratio of short fibers and hence they are often mixed with long softwood fibers to get a paper with good thickness (J.F. Kobbing et al.,[4]). In paper manufacturing the fiber deposited over the cloth are separated by pressing the cloth with high temperature (Hans Brix et al.,[10]).

Till late 1800[s] Phragmites was one of the two available roofing materials along the seashore (S.M.Haslam[12]). Phragmites can improve the water quality and reduce the water pollutants because a rhizome acts as a medium that breaks down organic and inorganic substances (Reference [13]).

Figure 3. Soft baskets

The flowers that are arranged along a single central axis are made into brooms and used for decoration. Rafts are made by hollow stems. Thin sections of the stem were used to make pens. Stems are also used as linear measuring device and also in the manufacture of cardboard, cellophane and synthetic fibers, paper pulp. The pulp can be made into a fibrous material and can be used as a fill up material in upholstery. The fiber is 0.8 - 3.0 mm in length and 5.0 - 30.5 µm in diameter. The authors reported that Phragmites Australis is also used for the basket making as shown in Figure 2. The straws are woven in to soft baskets without twisting of straws, this kind of basket is used for draining the water from the seeds as shown in figure 3. The stems, which makes possible the exchange of metabolic gases between the atmosphere and shore sediments in winter seasons (Hans Brix et al.,[10]). The parts of Phragmites are also used for creation of fire drills, arrow shafts, snares, splints for broken limbs, fishing poles, fire fuels, ropes and cords, flutes and whistles, light spears and ear ornaments and necklaces, prayer sticks and smoking pipes.

The plant has very strong, active and running rootstock which is useful for binding the soil along the stream sides. All the parts of the plant are used as remedy for many diseases. The major edible use is sweetener. Phragmites is still widely used as a fodder plant for water buffalo, cows, sheep, cattle, goats and donkeys. It is cheap and easily available in some countries but it has lower nutritive value compared to other plants (J.F. Kobbing et al.,[4]) (Muhammad Akmal et al.,[5]).

Figure 2. Bolga baskets

2. MATERIALS AND METHODS

The phragmites Australis were collected from the noyal river beds in south India. The stem part is extracted free from leaves and other particulars. Then the stalk of the plant is immersed in a stagnant water for retting of three to five days and during that period, the water has been changed every day with new water. The retted Phragmites Australis stems are carried out for flattening process using roller mill machine where the moisture particles are removed from the stem and the fibers are loosened in the stem. The loosened stem is taken for the chemical retting using crystallized sodium hydroxide (alkaline process) treatment. Here three concentrations of NaOH were taken for the study, which is shown in Table 2. After alkaline treatment the neutralization process were done followed by cold water rinsing. For neutralization, acetic acid – 50 ml, water-250 ml with room temperature were followed for the process. Then the neutralized samples were rinsed and taken to shade drying for three days. The various wet processing treatment of reed fiber during the process of fiber extraction is shown in Figure 4.

Table 2: Alkalization concentration and recipe

S. No	Specimen Reference Code	NaOH (%)	Water (ml)	Temperature (°C)	Time (hrs.)
1	N-L	3	300	100	2
2	N-M	4			
3	N-H	6			

3. TESTING

(a) During stagnant water retting (b) After alkalization (c) After neutralization

Figure 4. Stages of Phragmites australis in processing

The fiber samples were taken to tensile properties –strength & elongation testing. The Instron single fiber strength testing instrument is used for the testing of fibers characteristics. The standard followed for the test is D3822 and the 5mm per minute speed is maintained for the test. In each sample category ten readings were taken for the tensile (N) and Elongation (%) test. The test result is as shown in the Table 3.

Table 3: Tensile properties of Pharagmites Australis (Naanal)

Particulars	Tensile Strength (N)			Elongation (%)		
	N-L	N-M	N-H	N-L	N-M	N-H
AVG	2.00	1.86	2.02	3.37	3.77	6.57
SD	0.92	0.52	0.90	0.78	0.68	1.44
Variance	0.85	0.27	0.81	0.60	0.46	2.07

4. RESULT AND DISCUSSIONS

The mean tensile strength of the reed fiber is shown in Table 3. The strength of N-H sample shows higher value as compared to N-L and N-M, but the test results shows there is no significance difference between the results of tensile strength (N). When NaOH up to optimum concentration is increased in chemical process, the removal of impurities and other content in the fiber surfaces also increased, simultaneously increasing the strength of the fiber. The content of impurities is varied from top to bottom of the stalk. The Table 4 shows the one way anova analysis, the P-value is higher than 5% level (0.05<0.886). The 6% concentration of NaOH shows better results than other concentrations. This test resultant statement coincides with the statement of the author (K. P. Ashik et al.,[1]) on natural fiber chemical retting.

Table 4 - One way Anova Analysis - Tensile Strength(N)

Variance Analysis	*Sum of square value (SS)*	*Mean square value (MS)*	*F - Value*	*P-value*	*F crit*
Between N-L, N-M & N-H	0.156	0.078	$F_{(2, 27)}$ 0.1216	0.886	3.354
Within N-L, N-M & N-H	17.390	0.644			

Table 5 - One way Anova Analysis -Elongation(%)

Variance Analysis	*Sum of square value (SS)*	*Mean square value (MS)*	*F - Value*	*P-value*	*F crit*
Between N-L, N-M & N-H	60.8	30.4	$F_{(2, 27)}$ 29.062	1.852E-07	3.354
Within N-L, N-M & N-H	28.243	1.046			

The elongation of reed fiber samples were done in percentage as shown in Table 3. The test results revealed that the N-H sample has higher elongation (%) when compared to N-M and N-L samples. Based on (Xinzhou Wang et al.,[3]) the content of lignin in the stalk, the elongation varies. The lignin is the binder between the layer of fibril and when the content of the lignin is high, the elongation of the fiber is limited. Higher content of silica in the fiber reveals lower flexibility as well as higher stiffness. The one way analysis also confirmed that the elongation % of the between fibers has significant differences which were $F_{(2,27)}$ > F-value or P-value<5% . The test of significance-Turkey's method also proved that there is a significance difference at 95% confident level between the fiber mean values N-L with N-H (2.8>5% level) and N-M with N-H (3.2>5% level). There is no significant difference between other fibers (N-L with N-M = 0.4<5% level) of mean elongation %.

The shape of the curve in the Figure 5. shows that the plastic deformation

phenomenon, the trend of the pharagmites Australis fiber tensile strength and elongation is linear. The multi-layer arrangement of cell in the fiber proves stiffer and good flexibility. Once the elongation percentage is achieved, the elastic recovery rate percentage is very less reported by (Xinzhou Wang et al.,[3]).

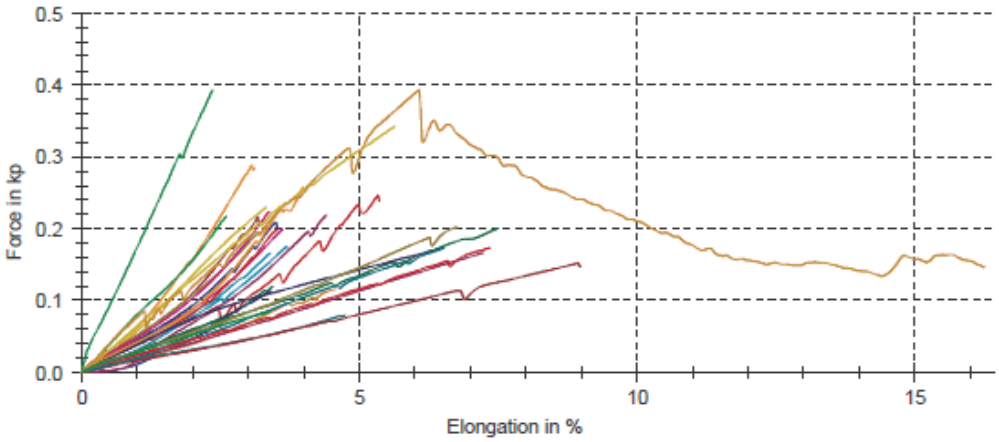

Figure 5. Trend of tensile properties of Pharagmites australis (Naanal)

5. CONCLUSION

The extraction of fibers from the pharagmites Australis stalk has done with alkaline retting process and based on tensile properties of the test results the following conclusions were derived. The concentration of the caustic soda in alkalization process increases the tensile properties and the elongation percentage of the reed fiber is also increased but the elongation percentage of the reed fiber has no significant differences between alkaline processes. Depending on the part of the fibers from the stalk, the mechanical properties of the reed fiber may vary. With the lower thermal conductivity and density of the fiber, pharagmites Australis (Naanal) is suitable for production of low density flexible composites for good insulation application.

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